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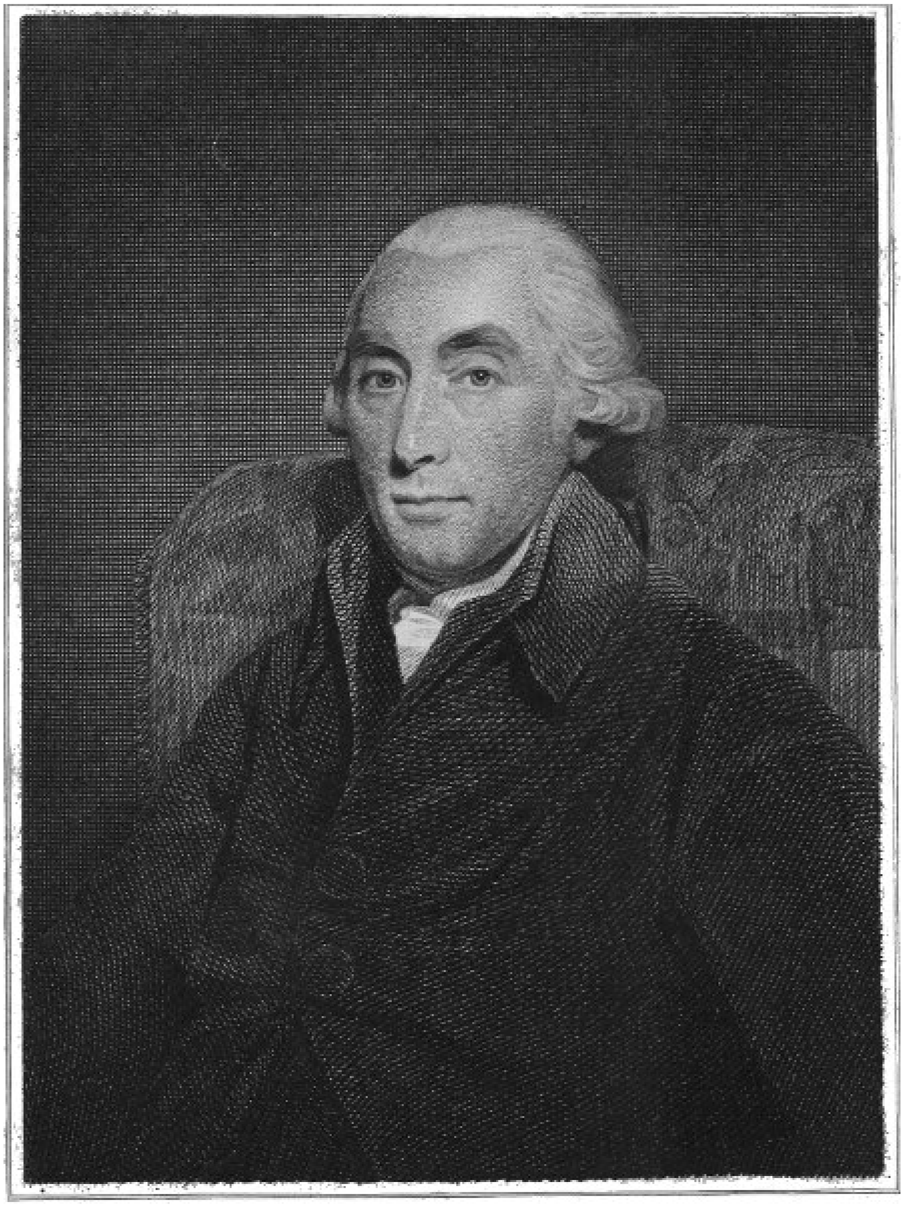
The History of Chemistry

by ThomasThomson, M.D. F.R.S.E.



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JOSEPH BLACK, M.D. F.R.S.E.

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THE

HISTORY

OF

CHEMISTRY.

BY

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IN TWO VOLUMES.

VOL. I.

LONDON:

HENRY COLBURN, AND RICHARD BENTLEY,

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1830.

C. WHITING, BEAUFORT HOUSE, STRAND. i

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PREFACE.

It may be proper, perhaps, to state here, in a very few words, the objects which the author had in view in drawing up the following History of Chemistry. Alchymy, or the art of making gold, with which the science originated, furnishes too curious a portion of the aberrations of the human intellect to be passed over in silence. The writings of the alchymists are so voluminous and so mystical, that it would have afforded materials for a very long work. But I was prevented from extending this part of the subject to any greater iii length than I have done, by considering the small quantity of information which could have been gleaned from the reveries of these fanatics or impostors; I thought it sufficient to give a general view of the nature of their pursuits: but in order to put it in the power of those who feel inclined to prosecute such investigations, I have given a catalogue of the most eminent of the alchymists and a list of their works, so far as I am acquainted with them. This catalogue might have been greatly extended. Indeed it would have been possible to have added several hundred names. But I think the works which I have quoted are more than almost any reasonable man would think it worth his while to peruse; and I can state, from experience, that the information gained by such a perusal will very seldom repay the trouble.

The account of the chemical arts, with which the ancients were acquainted, is necessarily imperfect; because all arts and trades were held in so much contempt by them that they did not think it worth their while to make themselves acquainted with the processes. My chief guide has been Pliny, but many of his descriptions are unintelligible, iv obviously from his ignorance of the arts which he attempts to describe. Thus circumstanced, I thought it better to be short than to waste a great deal of paper, as some have done, on hypothesis and conjecture.

The account of the Chemistry of the Arabians is almost entirely limited to the works of Geber, which I consider to be the first book on Chemistry that ever was published, and to constitute, in every point of view, an exceedingly curious performance. I was much struck with the vast number of facts with which he was acquainted, and which have generally been supposed to have been discovered long after his time. I have, therefore, been at some pains in endeavouring to convey a notion of Geber's opinions to the readers of this history; but am not sure that I have succeeded. I have generally given his own words, as literally as possible, and, wherever it would answer the purpose, have employed the English translation of 1678.

Paracelsus gave origin to so great a revolution in medicine and the sciences connected with it, that it would have been unpardonable not to have attempted to lay his opinions and views before the reader; but, after perusing several of his most important treatises, I found it almost impossible to form accurate notions on the subject. I have, therefore, endeavoured to make use of his own words as much as possible, that the want of consistency and the mysticism of his opinions may fall upon his own head. Should the reader find any difficulty in understanding the philosophy of Paracelsus, he will be in no worse a situation than every one has been who has attempted to delineate the principles of this prince of quacks and impostors. Van Helmont's merits were of a much higher kind, and I have endeavoured to do him justice; though his weaknesses are so visible that it requires much candour and patience to discriminate accurately between his excellencies and his foibles. v

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The history of Iatro-chemistry forms a branch of our subject scarcely less extraordinary than Alchymy itself. It might have been extended to a much greater length than I have done. The reason why I did not enter into longer details was, that I thought the subject more intimately connected with the history of medicine than of chemistry: it undoubtedly contributed to the improvement of chemistry; not, however, by the opinions or the physiology of the iatro-chemists, but by inducing their contemporaries and successors to apply themselves to the discovery of chemical medicines. vi

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The History of Chemistry, after a theory of combustion had been introduced by Beccher and Stahl, becomes much more important. It now shook off the trammels of alchymy, and ventured to claim its station among the physical sciences. I have found it necessary to treat of its progress during the eighteenth century rather succinctly, but I hope so as to be easily intelligible. This made it necessary to omit the names of many meritorious individuals, who supplied a share of the contributions which the science was continually receiving from all quarters. I have confined myself to those who made the most prominent figure as chemical discoverers. I had no other choice but to follow this plan, unless I had doubled the size of this little work, which would have rendered it less agreeable and less valuable to the general reader. vii

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With respect to the History of Chemistry during that portion of the nineteenth century which is already past, it was beset with several difficulties. Many of the individuals, of whose labours I had occasion to speak, are still actively engaged in the prosecution of their useful works. Others have but just left the arena, and their friends and relations still remain to appreciate their merits. In treating of this branch of the science (by far the most important of all) I have followed the same plan as in the history of the preceding century. I have found it necessary to omit many names that would undoubtedly have found a place in a larger work, but which the limited extent to which I was obliged to confine myself, necessarily compelled me to pass over. I have been anxious not to injure the character of any one, while I have rigidly adhered to truth, so far as I was acquainted with it. Should I have been so unfortunate as to hurt the feelings of any individual by any remarks of mine in the following pages, it will give me great pain; and the only alleviation will be the consciousness of the total absence on my part of any malignant intention. To gratify the wishes of every individual may, perhaps, be impossible; but I can say, with truth, that my uniform object has viii
been to do justice to the merits of all, so far as my own limited knowledge put it in my power to do. ix

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HISTORY OF CHEMISTRY.

INTRODUCTION.

Chemistry, unlike the other sciences, sprang originally from delusion and superstition, and was at its commencement exactly on a level with magic and astrology. Even after it began to be useful to man, by furnishing him with better and more powerful medicines than the ancient physicians were acquainted with, it was long before it could shake off the trammels of alchymy, which hung upon it like a nightmare, cramping and blunting all its energies, and exposing it to the scorn and contempt of the enlightened part of mankind. It was not till about the middle of the eighteenth century that it was able to free itself from these delusions, and to venture abroad in all the native dignity of a useful science. It was then that its utility and its importance began to attract the attention of the world; that it drew within its vortex some of the greatest and most active men in every country; and that it advanced towards perfection with an accelerated pace. The field which it now presents to our view is vast and imposing. Its paramount utility is universally acknowledged. It has become a necessary part of education. It has contributed as much to the progress of society, 2
and has done as much to augment the comforts and conveniences of life, and to increase the power and the resources of mankind, as all the other sciences put together.

It is natural to feel a desire to be acquainted with the origin and the progress of such a science; and to know something of the history and character of those numerous votaries to whom it is indebted for its progress and improvement. The object of this little work is to gratify these laudable wishes, by taking a rapid view of the progress of Chemistry, from its first rude and disgraceful beginnings till it has reached its present state of importance and dignity. I shall divide the subject into fifteen chapters. In the first I shall treat of Alchymy, which may be considered as the inauspicious commencement of the science, and which, in fact, consists of little else than an account of dupes and impostors; every where so full of fiction and obscurity, that it is a hopeless and almost impossible task to reach the truth. In the second chapter I shall endeavour to point out the few small chemical rills, which were known to the ancients. These I shall follow in their progress, in the succeeding chapters, till at last, augmented by an infinite number of streams flowing at once from a thousand different quarters, they have swelled to the mighty river, which now flows on majestically, wafting wealth and information to the civilized world. 3

CHAPTER I.
OF ALCHYMY.

The word *chemistry* (χημεια, *chemeia*) first occurs in Suidas, a Greek writer, who is supposed to have lived in the eleventh century, and to have written his lexicon during the reign of Alexius Comnenus.[1] Under the word χημεια in his dictionary we find the following passage:

"Chemistry, the preparation of silver and gold. The books on it were sought out by Dioclesian and burnt, on account of the new attempts made by the Egyptians against him. He treated them with cruelty and harshness, as he sought out the books written by the ancients on the chemistry (Περι χημειας) of gold and silver, and burnt them. His object was to prevent the Egyptians from becoming rich by the knowledge of this art, lest, emboldened by abundance of wealth, they might be induced afterwards to resist the Romans."[2] 4

Under the word Δερας, *deras* (*a skin*), in the lexicon, occurs the following passage: "Δερας, the golden fleece, which Jason and the Argonauts (after a voyage through the Black Sea to Colchis) took, together with Medea, daughter of Ætes, the king. But this was not what the poets represent, but a treatise written on skins (δερμασι), teaching how gold might be prepared by chemistry. Probably, therefore, it was called by those who lived at that time, *golden*, on account of its great importance."[3]

From these two passages there can be no doubt that the word *chemistry* was known to the Greeks in the eleventh century; and that it signified, at that time, the art of making gold and silver. It appears, further, that in Suidas's opinion, this art was known to the Egyptians in the time of Dioclesian; that Dioclesian was convinced of its reality; and that, to put an end to it, he collected and burnt all the chemical writings to be found in Egypt. Nay, Suidas affirms that a book, describing the art of making gold, existed at the time of the Argonauts: and that the object of Jason and his followers was to get possession of that invaluable treatise, which the poets disguised under the term *golden fleece*.

The first meaning, then, of chemistry, was the *art of making gold*. And this art, in the opinion of Suidas, was understood at least as early as one thousand two hundred and 5
twenty-five years before the Christian era: for that is the period at which the Argonautic expedition is commonly fixed by chronologists.

Though the lexicon of Suidas be the first printed book in which the word Chemistry occurs, yet it is said to be found in much earlier tracts, which still continue in manuscript. Thus Scaliger informs us that he perused a Greek manuscript of Zosimus, the Panapolite, written in the fifth century, and deposited in the King of France's library. Olaus Borrichius mentions this manuscript; but in such terms that it is difficult to know whether he had himself read it; though he seems to insinuate as much.[4] The title of this manuscript is said to be "A faithful Description of the sacred and divine Art of making Gold and Silver, by

Zosimus, the Panapolite."[5] In this treatise, Zosimus distinguishes the art by the name χημια, *chemia*. From a passage in this manuscript, quoted by Scaliger, and given also by Olaus Borrichius, it appears that Zosimus carries the antiquity of the art of making gold and silver, much higher than Suidas has ventured to do. The following is a literal translation of this curious passage:

"The sacred Scriptures inform us that there exists a tribe of genii, who make use of women. Hermes mentions this circumstance in his Physics; and almost every writing (λογος), whether sacred (φανερος) or apocryphal, states the same thing. The ancient and divine Scriptures inform us, that the angels, captivated by women, taught them all the operations of nature. Offence being taken at this, they remained out of heaven, because they had taught mankind all manner of evil, and things which could not be advantageous to their 6
souls. The Scriptures inform us that the giants sprang from these embraces. Chema is the first of their traditions respecting these arts. The book itself they called Chema; hence the art is called *Chemia*."

Zosimus is not the only Greek writer on Chemistry. Olaus Borrichius has given us a list of thirty-eight treatises, which he says exist in the libraries of Rome, Venice, and Paris: and Dr. Shaw has increased this list to eighty-nine.[6] But among these we find the names of Hermes, Isis, Horus, Democritus, Cleopatra, Porphyry, Plato, &c.—names which undoubtedly have been affixed to the writings of comparatively modern and obscure authors. The style of these authors, as Borrichius informs us, is barbarous. They are chiefly the production of ecclesiastics, who lived between the fifth and twelfth centuries. In these tracts, the art of which they treat is sometimes called *chemistry* (χημεια); sometimes the *chemical art* (χημευτικα); sometimes the *holy art*; and the *philosopher's stone*.

It is evident from this, that between the fifth century and the taking of Constantinople in the fifteenth century, the Greeks believed in the possibility of making gold and silver artificially; and that the art which professed to teach these processes was called by them Chemistry.

These opinions passed from the Greeks to the Arabians, when, under the califs of the family of Abassides, they began to turn their attention to science, about the beginning of the ninth century; and when the enlightened zeal of the Fatimites in Africa, and the Ommiades in Spain, encouraged the cultivation of the sciences. From Spain they gradually made their way into the different Christian kingdoms of Europe. From the eleventh to the sixteenth century, the art of making gold and silver was cultivated in Germany, Italy, France, and 7
England, with considerable assiduity. The cultivators of it were called *Alchymists*; a name obviously derived from the Greek word *chemia*, but somewhat altered by the Arabians. Many alchymistical tracts were written during that period. A considerable number of them were collected by Lazarus Zetzner, and published at Strasburg in 1602, under the title of "Theatrum Chemicum, præcipuos selectorum auctorum tractatus de Chemiæ et Lapidis Philosophici Antiquitate, veritate, jure, præstantia, et operationibus continens in gratiam veræ Chemiæ et Medicinæ Chemicæ Studiosorum (ut qui uberrimam unde optimorum remediorum messem facere poterunt) congestum et in quatuor partes seu volumina digestum." This book contains one hundred and five different alchymistical tracts.

In the year 1610 another collection of alchymistical tracts was published at Basil, in three volumes, under the title of "Artis Auriferæ quam Chemiam vocant volumina tria." It contains forty-seven different tracts.

In the year 1702 Mangetus published at Geneva two very large folio volumes, under the name of "Bibliotheca Chemica Curiosa, seu rerum ad Alchymiam pertinentium thesaurus instructissimus, quo non tantum Artis Auriferæ ac scriptorum in ea nobiliorum Historia traditur; lapidis veritas Argumentis et Experimentis innumeris, immo et Juris

Consultorum Judiciis evincitur; Termini obscuriores explicantur; Cautiones contra Impostores et Difficultates in Tinctura Universali conficienda occurrentes declarantur: verum etiam Tractatus omnes Virorum Celebriorum, qui in Magno sudarunt Elixyre, quique ab ipso Hermete, ut dicitur, Trismegisto, ad nostra usque tempora de Chrysopoea scripserunt, cum præcipuis suis Commentariis, concinno ordine dispositi exhibentur.” This Bibliotheca contains one hundred and twenty-two alchymistical treatises, many of them of considerable length. 8

Two additional volumes of the Theatrum Chemicum were afterwards published; but these I have never had an opportunity of seeing.

From these collections, which exhibit a pretty complete view of the writings of the alchymists, a tolerably accurate notion may be formed of their opinions. But before attempting to lay open the theories and notions by which the alchymists were guided, it will be proper to state the opinions which were gradually adopted respecting the origin of Alchymy, and the contrivances by which these opinions were supported.

Zosimus, the Panapolite, in a passage quoted above informs us, that the art of making gold and silver was not a human invention; but was communicated to mankind by angels or demons. These angels, he says, fell in love with women, and were induced by their charms to abandon heaven altogether, and take up their abode upon earth. Among other pieces of information which these spiritual beings communicated to their paramours, was the sublime art of Chemistry, or the fabrication of gold and silver.

It is quite unnecessary to refute this extravagant opinion, obviously founded on a misunderstanding of a passage in the sixth chapter of Genesis. “And it came to pass, when men began to multiply on the face of the earth, and daughters were born unto them, that the sons of God saw the daughters of men, that they were fair; and they took them wives of all which they chose.—There were giants in the earth in those days; and also after that, when the sons of God came in unto the daughters of men, and they bare *children* to them; the same became mighty men, which were of old, men of renown.”

There is no mention whatever of angels, or of any information on science communicated by them to mankind.

Nor is it necessary to say much about the opinion advanced by some, and rather countenanced by Olaus Borrichius, that the art of making gold was the invention of Tubal- 9
cain, whom they represent as the same as Vulcan. All the information which we have respecting Tubal-cain, is simply that he was an instructor of every artificer in brass and iron.[7] No allusion whatever is made to gold. And that in these early ages of the world there was no occasion for making gold artificially, we have the same authority for believing. For in the second chapter of Genesis, where the garden of Eden is described, it is said, “And a river went out of Eden to water the garden; and from thence it was parted, and came into four heads: the name of the first is Pison, that is it which encompasseth the whole land of Havilah, where there is gold. And the gold of that land is good: there is bdellium and onyx-stone.”

But the most generally-received opinion is, that alchymy originated in Egypt; and the honour of the invention has been unanimously conferred upon Hermes Trismegistus. He is by some supposed to be the same person with Chanaan, the son of Ham, whose son Mizraim first occupied and peopled Egypt. Plutarch informs us, that Egypt was sometimes called *Chemia*.[8] This name is supposed to be derived from Chanaan (ןענכ); thence it was believed that Chanaan was the true inventor of alchymy, to which he affixed his own name. Whether the Hermes (Ἑρμης) of the Greeks was the same person with Chanaan or his son Mizraim, it is impossible at this distance of time to decide; but to Hermes is assigned the invention of alchymy, or the art of making gold, by almost the unanimous consent of the adepts.

Albertus Magnus informs us, that “Alexander the Great discovered the sepulchre of Hermes, in one of his journeys, full of all treasures, not metallic, but golden, written on a table of *zatadi*, which others call emerald.” This passage occurs in a tract of Albertus *de* 10
secretis chemicis, which is considered as supposititious. Nothing is said of the source whence the information contained in this passage was drawn: but, from the quotations produced by Kriegsmann, it would appear that the existence of this emerald table was alluded to by Avicenna and other Arabian writers. According to them, a woman called Sarah took it from the hands of the dead body of Hermes, some ages after the flood, in a cave near Hebron. The inscription on it was in the Phœnician language. The following is a literal translation of this famous inscription, from the Latin version of Kriegsmann:[9]

1. I speak not fictitious things, but what is true and most certain. 11

2. What is below is like that which is above, and what is above is similar to that which is below, to accomplish the miracles of one thing.

3. And as all things were produced by the meditation of one Being, so all things were produced from this one thing by adaptation.

4. Its father is *Sol*, its mother *Luna*; the wind carried it in its belly, the earth is its nurse.

5. It is the cause of all perfection throughout the whole world.

6. Its power is perfect, if it be changed into earth.

7. Separate the earth from the fire, the subtile from the gross, acting prudently and with judgment.

8. Ascend with the greatest sagacity from the earth to heaven, and then again descend 12
to the earth, and unite together the powers of things superior and things inferior. Thus you will possess the glory of the whole world; and all obscurity will fly far away from you.

9. This thing has more fortitude than fortitude itself; because it will overcome every subtile thing, and penetrate every solid thing.

10. By it this world was formed.

11. Hence proceed wonderful things, which in this wise were established.

12. For this reason I am called Hermes Trismegistus, because I possess three parts of the philosophy of the whole world.

13. What I had to say about the operation of *Sol* is completed.

Such is a literal translation of the celebrated inscription of Hermes Trismegistus upon the emerald tablet. It is sufficiently obscure to put it in the power of commentators to affix almost any explanation to it that they choose. The two individuals who have devoted most time to illustrate this tablet, are Kriegsmann and Gerard Dorneus, whose commentaries may be seen in the first volume of Mangetus’s Bibliotheca Chemica. They both agree that it refers to the *universal medicine*, which began to acquire celebrity about the time of Paracelsus, or a little earlier.

This exposition, which appears as probable as any other, betrays the time when this celebrated inscription seems to have been really written. Had it been taken out of the hands of the dead body of Hermes by Sarah (obviously intended for the wife of Abraham) as is affirmed by Avicenna, it is not possible that Herodotus, and all the writers of antiquity, both Pagan and Christian, should have entirely overlooked it; or how could Avicenna have learned what was unknown to all those who lived nearest the time when the discovery was supposed to have been made? Had it been discovered in Egypt by Alexander the Great,
would it have been unknown to Aristotle, and to all the numerous tribe of writers whom the 13
Alexandrian school produced, not one of whom, however, make the least allusion to it? In short, it bears all the marks of a forgery of the fifteenth century. And even the tract ascribed to Albertus Magnus, in which the tablet of Hermes is mentioned, and the discovery related, is probably also a forgery; and doubtless a forgery of the same individual who fabricated the tablet itself, in order to throw a greater air of probability upon a story which he wished to palm upon the world as true. His object was in some measure accomplished; for the authenticity of the tablet was supported with much zeal by Kriegsmann, and afterwards by Olaus Borrichius.

There is another tract of Hermes Trismegistus, entitled "Tractatus Aureus de Lapidis Physici Secreto;" on which no less elaborate commentaries have been written. It professes to teach the process of making the *philosopher's stone*; and, from the allusions in it, to the use of this stone, as a universal medicine, was probably a forgery of the same date as the emerald tablet. It would be in vain to attempt to extract any thing intelligible out of this Tractatus Aureus: it may be worth while to give a single specimen, that the reader may be able to form some idea of the nature of the style.

"Take of moisture an ounce and a half; of meridional redness, that is the soul of the sun, a fourth part, that is half an ounce; of yellow seyr, likewise half an ounce; and of auripigmentum, a half ounce, making in all three ounces. Know that the vine of wise men is
extracted in threes, and its wine at last is completed in thirty."[10] 14

Had the opinion, that gold and silver could be artificially formed originated with Hermes Trismegistus, or had it prevailed among the ancient Egyptians, it would certainly have been alluded to by Herodotus, who spent so many years in Egypt, and was instructed by the priests in all the science of the Egyptians. Had *chemistry* been the name of a science, real or fictitious, which existed as early as the expedition of the Argonauts, and had so many treatises on it, as Suidas alleges existed in Egypt before the reign of Dioclesian, it could hardly have escaped the notice of Pliny, who was so curious and so indefatigable in his researches, and who has collected in his natural history a kind of digest of all the knowledge of the ancients in every department of practical science. The fact that the term chemistry (χημεια) never occurs in any Greek or Roman writer prior to Suidas, who wrote so late as the eleventh century, seems to overturn all idea of the existence of that pretended science among the ancients, notwithstanding the elaborate attempts of Olaus Borrichius to prove the contrary.

I am disposed to believe, that chemistry or alchymy, understanding by the term the *art of making gold and silver*, originated among the Arabians, when they began to turn their attention to medicine, after the establishment of the caliphs; or if it had previously been cultivated by Greeks (as the writings of Zosimus, the Panapolite, if genuine, would lead us to suppose), that it was taken up by the Arabians, and reduced by them into regular form and order. If the works of Geber be genuine, they leave little doubt on this point. Geber is supposed to have been a physician, and to have written in the seventh century. He admits, as a first principle, that metals are compounds of mercury and sulphur. He talks of the philosopher's stone; professes to give the mode of preparing it; and teaches the way of
converting the different metals, known in his time, into medicines, on whose efficacy he 15

bestows the most ample panegyrics. Thus the principles which lie at the bottom of alchymy were implicitly adopted by him. Yet I can nowhere find in him any attempt to make gold artificially. His chemistry was entirely devoted to the improvement of medicine. The subsequent pretensions of the alchymists to convert the baser metals into gold are no where avowed by him. I am disposed from this to suspect, that the theory of gold-making was started after Geber's time, or at least that it was after the seventh century, before any alchymist ventured to affirm that he himself was in possession of the secret, and could fabricate gold artificially at pleasure. For there is a wide distance between the opinion that gold may be made artificially and the affirmation that we are in possession of a method by which this transmutation of the baser metals into gold can be accomplished. The first may be adopted and defended with much plausibility and perfect honesty; but the second would require a degree of skill far exceeding that of the most scientific votary of chemistry at present existing.

The opinion of the alchymists was, that all the metals are compounds; that the baser metals contain the same constituents as gold, contaminated, indeed, with various impurities, but capable, when their impurities are removed or remedied, of assuming all the properties and characters of gold. The substance possessing this wonderful power they distinguish by the name of *lapis philosophorum*, or, philosopher's stone, and they usually describe it as a red powder, having a peculiar smell. Few of the alchymists who have left writings behind them boast of being possessed of the philosopher's stone. Paracelsus, indeed, affirms, that he was acquainted with the method of making it, and gives several processes, which, however, are not intelligible. But many affirm that they had seen the philosopher's stone; 16
that they had portions of it in their possession; and that they had seen several of the inferior metals, especially lead and quicksilver, converted by means of it into gold. Many stories of this kind are upon record, and so well authenticated, that we need not be surprised at their having been generally credited. It will be sufficient if we state one or two of those which depend upon the most unexceptionable evidence. The following relation is given by Mangetus, on the authority of M. Gros, a clergyman of Geneva, of the most unexceptionable character, and at the same time a skilful physician and expert chemist:

"About the year 1650 an unknown Italian came to Geneva, and took lodgings at the sign of the *Green Cross*. After remaining there a day or two, he requested De Luc, the landlord, to procure him a man acquainted with Italian, to accompany him through the town and point out those things which deserved to be examined. De Luc was acquainted with M. Gros, at that time about twenty years of age, and a student in Geneva, and knowing his proficiency in the Italian language, requested him to accompany the stranger. To this proposition he willingly acceded, and attended the Italian every where for the space of a fortnight. The stranger now began to complain of want of money, which alarmed M. Gros not a little—for at that time he was very poor—and he became apprehensive, from the tenour of the stranger's conversation, that he intended to ask the loan of money from him. But instead of this, the Italian asked him if he was acquainted with any goldsmith, whose bellows and other utensils they might be permitted to use, and who would not refuse to supply them with the different articles requisite for a particular process which he wanted to perform. M. Gros named a M. Bureau, to whom the Italian immediately repaired. He readily furnished crucibles, pure tin, quicksilver, and the other things required by the Italian. The 17
goldsmith left his workshop, that the Italian might be under the less restraint, leaving M. Gros, with one of his own workmen, as an attendant. The Italian put a quantity of tin into one crucible, and a quantity of quicksilver into another. The tin was melted in the fire and the mercury heated. It was then poured into the melted tin, and at the same time a red powder enclosed in wax was projected into the amalgam. An agitation took place, and a great deal of smoke was exhaled from the crucible; but this speedily subsided, and the whole being poured out, formed six heavy ingots, having the colour of gold. The goldsmith was called in by the Italian, and requested to make a rigid examination of the smallest of

these ingots. The goldsmith, not content with the touchstone and the application of aqua fortis, exposed the metal on the cupel with lead, and fused it with antimony, but it sustained no loss. He found it possessed of the ductility and specific gravity of gold; and full of admiration, he exclaimed that he had never worked before upon gold so perfectly pure. The Italian made him a present of the smallest ingot as a recompence, and then, accompanied by M. Gros, he repaired to the Mint, where he received from M. Bacuet, the mintmaster, a quantity of Spanish gold coin, equal in weight to the ingots which he had brought. To M. Gros he made a present of twenty pieces, on account of the attention that he had paid to him; and, after paying his bill at the inn, he added fifteen pieces more, to serve to entertain M. Gros and M. Bureau for some days, and in the mean time he ordered a supper, that he might, on his return, have the pleasure of supping with these two gentlemen. He went out, but never returned, leaving behind him the greatest regret and admiration. It is needless to add, that M. Gros and M. Bureau continued to enjoy themselves at the inn till the fifteen 18
pieces, which the stranger had left, were exhausted."[11]

Mangetus gives also the following relation, which he states upon the authority of an English bishop, who communicated it to him in the year 1685, and at the same time gave him about half an ounce of the gold which the alchymist had made:

A stranger, meanly dressed, went to Mr. Boyle, and after conversing for some time about chemical processes, requested him to furnish him with antimony, and some other common metallic substances, which then fortunately happened to be in Mr. Boyle's laboratory. These were put into a crucible, which was then placed in a melting-furnace. As soon as these metals were fused, the stranger showed a powder to the attendants, which he projected into the crucible, and instantly went out, directing the servants to allow the crucible to remain in the furnace till the fire went out of its own accord, and promising at the same time to return in a few hours. But, as he never fulfilled this promise, Boyle ordered the cover to be taken off the crucible, and found that it contained a yellow-coloured metal, possessing all the properties of pure gold, and only a little lighter than the weight of the materials originally put into the crucible.[12]

The following strange story is related by Helvetius, physician to the Prince of Orange, in his Vitulus Aureus: Helvetius was a disbeliever of the philosopher's stone, and the universal medicine, and even turned Sir Kenelm Digby's sympathetic powder into ridicule. On the 27th of December, 1666, a stranger called upon him, and after conversing for some time about a universal medicine, showed a yellow powder, which he affirmed to be the philosopher's stone, and at the same time five large plates of gold, which had been made by 19
means of it. Helvetius earnestly entreated that he would give him a little of this powder, or at least that he would make a trial of its power; but the stranger refused, promising however to return in six weeks. He returned accordingly, and after much entreaty he gave to Helvetius a piece of the stone, not larger than the size of a rape-seed. When Helvetius expressed his doubt whether so small a portion would be sufficient to convert four grains of lead into gold, the adept broke off one half of it, and assured him that what remained was more than sufficient for the purpose. Helvetius, during the first conference, had concealed a little of the stone below his nail. This he threw into melted lead, but it was almost all driven off in smoke, leaving only a vitreous earth. When he mentioned this circumstance, the stranger informed him that the powder must be enclosed in wax, before it be thrown into the melted lead, lest it should be injured by the smoke of the lead. The stranger promised to return next day, and show him the method of making the projection; but having failed to make his appearance, Helvetius, in the presence of his wife and son, put six drachms of lead into a crucible, and as soon as it was melted he threw into it the fragment of philosopher's stone in his possession, previously covered over with wax. The crucible was now covered with its lid, and left for a quarter of an hour in the fire, at the end of which time he found the whole lead converted into gold. The colour was at first a deep green; being poured into a

conical vessel, it assumed a blood-red colour; but when cold, it acquired the true tint of gold. Being examined by a goldsmith, he considered it as pure gold. He requested Porelius, who had the charge of the Dutch mint, to try its value. Two drachms of it being subjected to quartation, and solution in aqua fortis, were found to have increased in weight by two scruples. This increase was doubtless owing to the silver, which still remained enveloped in 20
the gold, after the action of the aqua fortis. To endeavour to separate the silver more completely, the gold was again fused with seven times its weight of antimony, and treated in the usual manner; but no alteration took place in the weight.[13]

It would be easy to relate many other similar narratives; but the three which I have given are the best authenticated of any that I am acquainted with. The reader will observe, that they are all stated on the authority, not of the persons who were the actors, but of others to whom they related them; and some of these, as the English bishop, perhaps not very familiar with chemical processes, and therefore liable to leave out or misstate some essential particulars. The evidence, therefore, though the best that can be got, is not sufficient to authenticate these wonderful stories. A little latent vanity might easily induce the narrators to suppress or alter some particulars, which, if known, would have stripped the statements of every thing marvellous which they contain, and let us into the secret of the origin of the gold, which these alchymists boasted that they had fabricated. Whoever will read the statements of Paracelsus, respecting his knowledge of the philosopher's stone, which he applied not to the formation of gold but to medicine, or whoever will examine his formulas for making the stone, will easily satisfy himself that Paracelsus possessed no real knowledge on the subject.[14]

But to convey as precise ideas on this subject as possible, it may be worth while to state a few of the methods by which the alchymists persuaded themselves that they could convert the baser metals into gold.

In the year 1694 an old gentleman called upon Mr. Wilson, at that time a chemist in
London, and informed him that at last, after forty years' search, he had met with an ample 21
recompence for all his trouble and expenses. This he confirmed with some oaths and imprecations; but, considering his great weakness and age, he looked upon himself as incapable to undergo the fatigues of the process. "I have here," says he, "a piece of sol (*gold*) that I made from silver, about four years ago, and I cannot trust any man but you with so rare a secret. We will share equally the charges and profit, which will render us wealthy enough to command the world." The nature of the process being stated, Mr. Wilson thought it not unreasonable, especially as he aimed at no peculiar advantage for himself. He accordingly put it to the trial in the following manner:

1. Twelve ounces of Japan copper were beat into thin plates, and laid *stratum super stratum* with three ounces of flowers of sulphur, in a crucible. It was exposed in a melting-furnace to a gentle heat, till the sulphureous flames expired. When cold, the æs ustum (*sulphuret of copper*) was pounded, and stratified again; and this process was repeated five times. Mr. Wilson does not inform us whether the powder was mixed with flowers of sulphur every time that it was heated; but this must have been the case, otherwise the sulphuret would have been again converted into metallic copper, which would have melted into a mass. By this first process, then, bisulphuret of copper was formed, composed of equal weights of sulphur and copper.

2. Six pounds of iron wire were put into a large glass body, and twelve pounds of muriatic acid poured upon it. Six days elapsed (during which it stood in a gentle heat) before the acid was saturated with the iron. The solution was then decanted off, and filtered, and six pounds of new muriatic acid poured on the undissolved iron. This acid, after standing a sufficient time, was decanted off, and filtered. Both liquids were put into a large
retort, and distilled by a sand-heat. Towards the end, when the drops from the retort became 22

yellow, the receiver was changed, and the fire increased to the highest degree, in which the retort was kept between four and six hours. When all was cold, the receiver was taken off, and a quantity of flowers was found in the neck of the retort, variously coloured, like the rainbow. The yellow liquor in the receiver weighed ten ounces and a half; the flowers (*chloride of iron*), two ounces and three drams. The liquid and flowers were put into a clean bottle.

3. Half a pound of sal enixum (*sulphate of potash*) and a pound and a half of nitric acid were put into a retort. When the salt had dissolved in the acid, ten ounces of mercury (previously distilled through quicklime and salt of tartar) were added. The whole being distilled to dryness, a fine yellow mass (*pernitrate of mercury*) remained in the bottom of the retort. The liquor was returned, with half a pound of fresh nitric acid, and the distillation repeated. The distillation was repeated a third time, urging this last cohobation with the highest degree of fire. When all was cold, a various-coloured mass was found in the bottom of the retort: this mass was doubtless a mixture of sulphate of potash, and pernitrate of mercury, with some oxide of mercury.

4. Four ounces of fine silver were dissolved in a pound of aqua fortis; to the solution was added, of the bisulphuret of copper four ounces; of the mixture of sulphate of potash, pernitrate of mercury, and oxide of mercury one ounce and a half, and of the solution of perchloride of iron two ounces and a half. When these had stood in a retort twenty-four hours, the liquor was decanted off, and four ounces of nitric acid were poured upon the little matter that was not dissolved. Next morning a total dissolution was obtained. The whole of this dissolution was put into a retort and distilled almost to dryness. The liquid was poured back, and the distillation repeated three times; the last time the retort being urged by a very 23
strong fire till no fumes appeared, and not a drop fell.

5. The matter left in the bottom of the retort was now put into a crucible, all the corrosive fumes were gently evaporated, and the residue melted down with a fluxing powder.

This process was expected to yield five ounces of pure gold; but on examination the silver was the same (except the loss of half a pennyweight) as when dissolved in the aqua fortis: there were indeed some grains among the scoria, which appeared like gold, and would not dissolve in aqua fortis. No doubt they consisted of peroxide of iron, or, perhaps, persulphuret of iron.[15]

Mr. Wilson's alchymistical friend, not satisfied with this first failure, insisted upon a repetition of the process, with some alteration in the method and the addition of a certain quantity of gold. The whole was accordingly gone through again; but it is unnecessary to say that no gold was obtained, or at least, the two drams of gold employed had increased in weight by only two scruples and thirteen grains; this addition was doubtless owing to a little silver from which it had not been freed.[16]

I shall now give a process for making the philosopher's stone, which was considered by Mangetus as of great value, and on that account was given by him in the preface to his Bibliotheca Chemica.

1. Prepare a quantity of spirit of wine, so free from water that it is wholly combustible, and so volatile that when a drop of it is let fall it evaporates before it reaches the ground;—this constitutes the first menstruum.

2. Take pure mercury, revived in the usual manner from cinnabar, put it into a glass vessel with common salt and distilled vinegar; agitate violently, and when the vinegar acquires a black colour pour it off and add new vinegar; agitate again, and continue these 24

repeated agitations and additions till the vinegar ceases to acquire a black colour from the mercury: the mercury is now quite pure and very brilliant.

3. Take of this mercury four parts; of sublimed mercury[17] (*mercurii meteoresati*), prepared with your own hands, eight parts; triturate them together in a wooden mortar with a wooden pestle, till all the grains of running mercury disappear. This process is tedious and rather difficult.

4. The mixture thus prepared is to be put into an aludel, or a sand-bath, and exposed to a subliming heat, which is to be gradually raised till the whole sublimes. Collect the sublimed matter, put it again into the aludel, and sublime a second time; this process must be repeated five times. Thus a very sweet and crystallized sublimate is obtained: it constitutes the salt of wise men (*sal sapientum*), and possesses wonderful properties.[18]

5. Grind it in a wooden mortar, and reduce it to powder; put it into a glass retort, and pour upon it the spirit of wine (No. 1) till it stands about three finger-breadths above the powder; seal the retort hermetically, and expose it to a very gentle heat for seventy-four hours, shaking it several times a-day; then distil with a gentle heat and the spirit of wine will pass over, together with spirit of mercury. Keep this liquid in a well-stopped bottle, lest it should evaporate. More spirit of wine is to be poured upon the residual salt, and after digestion it must be distilled off as before; and this process must be repeated till the whole salt is dissolved, and distilled over with the spirit of wine. You have now performed a great work. The mercury is now rendered in some measure volatile, and it will gradually become fit to receive the tincture of gold and silver. Now return thanks to God, who has hitherto 25
crowned your wonderful work with success; nor is this great work involved in Cimmerian darkness, but clearer than the sun; though preceding writers have imposed upon us with parables, hieroglyphics, fables, and enigmas.

6. Take this mercurial spirit, which contains our magical steel in its belly, put it into a glass retort, to which a receiver must be well and carefully luted: draw off the spirit by a very gentle heat, there will remain in the bottom of the retort the quintessence or soul of mercury; this is to be sublimed by applying a stronger heat to the retort that it may become volatile, as all the philosophers express themselves—

Si fixum solvas faciesque volare solutum,
Et volucrum figas faciet te vivere tutum.

This is our luna, our fountain, in which the king and queen may bathe. Preserve this precious quintessence of mercury, which is very volatile, in a well-shut vessel for further use.

8. Let us now proceed to the operation of common gold, which we shall communicate clearly and distinctly, without digression or obscurity; that from vulgar gold we may obtain our philosophical gold, just as from common mercury we obtained, by the preceding processes, philosophical mercury.

In the name of God, then, take common gold, purified in the usual way by antimony, convert it into small grains, which must be washed with salt and vinegar, till it be quite pure. Take one part of this gold, and pour on it three parts of the quintessence of mercury; as philosophers reckon from seven to ten, so we also reckon our number as philosophical, and we begin with three and one; let them be married together like husband and wife, to produce children of their own kind, and you will see the common gold sink and plainly dissolve. Now the marriage is consummated; now two things are converted into one: thus the philosophical sulphur is at hand, as the philosophers say, *the sulphur being dissolved the* 26
stone is at hand. Take then, in the name of God, our philosophical vessel, in which the king

and queen embrace each other as in a bedchamber, and leave it till the water is converted into earth, then peace is concluded between the water and fire, then the elements have no longer any thing contrary to each other; because, when the elements are converted into earth they no longer oppose each other; for in earth all elements are at rest. For the philosophers say, "When you shall have seen the water coagulate itself, think that your knowledge is true, and that your operations are truly philosophical." The gold is now no longer common, but ours is philosophical, on account of our processes: at first exceedingly fixed; then exceedingly volatile, and finally exceedingly fixed; and the whole science depends upon the change of the elements. The gold at first was a metal, now it is a sulphur, capable of converting all metals into its own sulphur. Now our tincture is wholly converted into sulphur, which possesses the energy of curing all diseases: this is our universal medicine against all the most deplorable diseases of the human body; therefore, return infinite thanks to Almighty God for all the good things which he has bestowed upon us.

9. In this great work of ours, two modes of fermenting and projecting are wanting, without which the uninitiated will not easily follow our process. The mode of fermenting is as follows: Take of our sulphur above described one part, and project it upon three parts of very pure gold fused in a furnace; in a moment you will see the gold, by the force of the sulphur, converted into a red sulphur of an inferior quality to the first sulphur; take one part of this, and project it upon three parts of fused gold, the whole will be again converted into a sulphur, or a friable mass; mixing one part of this with three parts of gold, you will have a 27
malleable and extensible metal. If you find it so, well; if not add other sulphur and it will again pass into sulphur. Now the sulphur will be sufficiently fermented, or our medicine will be brought into a metallic nature.

10. The mode of projecting is this: Take of the fermented sulphur one part, and project it upon ten parts of mercury, heated in a crucible, and you will have a perfect metal; if its colour is not sufficiently deep, fuse it again, and add more fermented sulphur, and thus it will acquire colour. If it becomes frangible, add a sufficient quantity of mercury and it will be perfect.

Thus, friend, you have a description of the universal medicine, not only for curing diseases and prolonging life, but also for transmuting all metals into gold. Give therefore thanks to Almighty God, who, taking pity on human calamities, has at last revealed this inestimable treasure, and made it known for the common benefit of all.[19]

Such is the formula (slightly abridged) of Carolus Musitanus, by which the philosopher's stone, according to him, may be formed. Compared with the formulas of most of the alchymists, it is sufficiently plain. What the *sublimed mercury* is does not appear; from the process described we should be apt to consider it as *corrosive sublimate*; on that supposition, the sal sapientum formed in No. 5, would be calomel: the only objection to this supposition is the process described in No. 5; for calomel is not soluble in alcohol. The philosopher's stone prepared by this elaborate process could hardly have been any thing else than an *amalgam of gold*; it could not have contained chloride of gold, because such a preparation, instead of acting medicinally, would have proved a most virulent poison. There is no doubt that amalgam of gold, if projected into melted lead or tin, and afterwards 28
cupellated, would leave a portion of gold—all the gold of course that existed previously in the amalgam. It might therefore have been employed by impostors to persuade the ignorant that it was really the philosopher's stone; but the alchymists who prepared the amalgam could not be ignorant that it contained gold.

There is another process given in the same preface of a very different nature, but too long to be transcribed here, and the nature of the process is not sufficiently intelligible to render an account of it of much consequence.[20]

The preceding observations will give the reader some notion of the nature of the pursuits which occupied the alchymists: their sole object was the preparation of a substance to which they gave the name of the philosopher's stone, which possessed the double property of converting the baser metals into gold, and of curing all diseases, and of preserving human life to an indefinite extent. The experiments of Wilson, and the formula of Musitanus, which have been just inserted, will give the reader some notion of the way in which they attempted to manufacture this most precious substance. Being quite ignorant of the properties of bodies, and of their action on each other, their processes were guided by no scientific analogies, and one part of the labour not unfrequently counteracted another; it would be a waste of time, therefore, to attempt to analyze their numerous processes, even though such an attempt could be attended with success. But in most cases, from the unintelligible terms in which their books are written, it is impossible to divine the nature of 29
the processes by which they endeavoured to manufacture the philosopher's stone, or the nature of the substances which they obtained.[21]

In consequence of the universality of the opinion that gold could be made by art, there was a set of impostors who went about pretending that they were in possession of the philosopher's stone, and offering to communicate the secret of making it for a suitable reward. Nothing is more astonishing than that persons should be found credulous enough to be the dupes of such impostors. The very circumstance of their claiming a reward was a sufficient proof that they were ignorant of the secret which they pretended to reveal; for what motive could a man have for asking a reward who was in possession of a method of creating gold at pleasure? To such a person money could be no object, as he could procure it in any quantity. Yet, strange as it may appear, they met with abundance of dupes credulous enough to believe their asseverations, and to supply them with money to enable them to perform the wished-for processes. The object of these impostors was either to pocket the money thus furnished, or they made use of it to purchase various substances from which they extracted oils, acids, or similar products, which they were enabled to sell at a profit. To keep the dupes, who thus supplied them with the means of carrying on these processes, in good spirits, it was necessary to show them occasionally small quantities of the baser metals converted into gold; this they performed in various ways. M. Geoffroy, senior, who had an opportunity of witnessing many of their performances, has given us an account of a number 30
of their tricks. It may be worth while to state a few by way of specimen.

Sometimes they made use of crucibles with a false bottom; at the real bottom they put a quantity of oxide of gold or silver, this was covered with a portion of powdered crucible, glued together by a little gummed water or a little wax; the materials being put into this crucible, and heat applied, the false bottom disappears, the oxide of gold or silver is reduced, and at the end of the process is found at the bottom of the crucible, and considered as the product of the operation.

Sometimes they make a hole in a piece of charcoal and fill it with oxide of gold or silver, and stop up the mouth with a little wax; or they soak charcoal in solutions of these metals; or they stir the mixtures in the crucible with hollow rods containing oxide of gold or silver within, and the bottom shut with wax: by these means the gold or silver wanted is introduced during the process, and considered as a product of the operation.

Sometimes they have a solution of silver in nitric acid, or of gold in aqua regia, or an amalgam of gold or silver, which being adroitly introduced, furnishes the requisite quantity of metal. A common exhibition was to dip nails into a liquid, and take them out half converted into gold. The nails consisted of one-half gold, neatly soldered to the iron, and covered with something to conceal the colour, which the liquid removed. Sometimes they had metals one-half gold the other half silver, soldered together, and the gold side whitened with mercury; the gold half was dipped into the transmuting liquid and then the metal heated; the mercury was dissipated, and the gold half of the metal appeared.[22]

As the alchymists were assiduous workmen—as they mixed all the metals, salts, &c. with which they were acquainted, in various ways with each other, and subjected such 31
mixtures to the action of heat in close vessels, their labours were occasionally repaid by the discovery of new substances, possessed of much greater activity than any with which they were previously acquainted. In this way they were led to the discovery of sulphuric, nitric, and muriatic acids. These, when known, were made to act upon the metals; solutions of the metals were obtained, and this gradually led to the knowledge of various metalline salts and preparations, which were introduced with considerable advantage into medicine. Thus the alchymists, by their absurd pursuits, gradually formed a collection of facts, which led ultimately to the establishment of scientific chemistry. On this account it will be proper to notice, in this place, such of them as appeared in Europe during the darker ages, and acquired the highest reputation either on account of their skill as physicians, or their celebrity as chemists.[23]

1. The first alchymist who deserves notice is Albertus Magnus, or Albert Groot, a German, who was born, it is supposed, in the year 1193, at Bollstaedt, and died in the year 1282.[24] When very young he is said to have been so remarkable for his dulness, that he became the jest of his acquaintances. He studied the sciences at Padua, and afterwards taught at Cologne, and finally in Paris. He travelled through all Germany as Provincial of the order of Dominican Monks, visited Rome, and was made bishop of Ratisbon: but his passion for science induced him to give up his bishopric, and return to a cloister at Cologne, where he continued till his death.

Albertus was acquainted with all the sciences cultivated in his time. He was at once a 32
theologian, a physician, and a man of the world: he was an astronomer and an alchymist, and even dipped into magic and necromancy. His works are very voluminous. They were collected by Petr. Jammy, and published at Leyden in twenty-one folio volumes, in 1651. His principal alchymistical tracts are the following:

1. De Rebus Metallicis et Mineralibus.
2. De Alchymia.
3. Secretorum Tractatus.
4. Breve Compendium de Ortu Metallorum.
5. Concordantia Philosophorum de Lapide.
6. Compositum de Compositis.
7. Liber octo Capitum de Philosophorum Lapide.

Most of these tracts have been inserted in the Theatrum Chemicum. They are in general plain and intelligible. In his treatise De Alchymia, for example, he gives a distinct account of all the chemical substances known in his time, and of the manner of obtaining them. He mentions also the apparatus then employed by chemists, and the various processes which they had occasion to perform. I may notice the most remarkable facts and opinions which I have observed in turning over these treatises.

He was of opinion that all metals are composed of sulphur and mercury; and endeavoured to account for the diversity of metals partly by the difference in the purity, and partly by the difference in the proportions of the sulphur and mercury of which they are composed. He thought that water existed also as a constituent of all metals.

He was acquainted with the water-bath, employed alembics for distillation, and aludels for sublimation; and he was in the habit of employing various lutes, the composition of which he describes.

He mentions alum and caustic alkali, and seems to have known the alkaline basis of cream of tartar. He knew the method of purifying the precious metals by means of lead and of gold, by cementation; and likewise the method of trying the purity of gold, and of distinguishing pure from impure gold. 33

He mentions red lead, metallic arsenic, and liver of sulphur. He was acquainted with green vitriol and iron pyrites. He knew that arsenic renders copper white, and that sulphur attacks all the metals except gold.

It is said by some that he was acquainted with gunpowder; but nothing indicating any such knowledge occurs in any of his writings that I have had an opportunity of perusing.[25]

2. Albertus is said to have had for a pupil, while he taught in Paris, the celebrated Thomas Aquinas, a Dominican, who studied at Bologna, Rome, and Naples, and distinguished himself still more in divinity and scholastic philosophy than in alchymy. He wrote,

1. Thesaurum Alchymiæ Secretissimum.
2. Secreta Alchymiæ Magnalia.
3. De Esse et Essentia Mineralium; and perhaps some other works, which I have not seen.

These works, so far as I have perused them, are exceedingly obscure, and in various places unintelligible. Some of the terms still employed by modern chemists occur, for the first time, in the writings of Thomas Aquinas. Thus the term *amalgam*, still employed to denote a compound of mercury with another metal, occurs in them, and I have not observed it in any earlier author.

3. Soon after Albertus Magnus, flourished Roger Bacon, by far the most illustrious, the best informed, and the most philosophical of all the alchymists. He was born in 1214, in the county of Somerset. After studying in Oxford, and afterwards in Paris, he became a cordelier friar; and, devoting himself to philosophical investigations, his discoveries, 34 notwithstanding the pains which he took to conceal them, made such a noise, that he was accused of magic, and his brethren in consequence threw him into prison. He died, it is said, in the year 1284, though Sprengel fixes the year of his death to be 1285.

His writings display a degree of knowledge and extent of thought scarcely credible, if we consider the time when he wrote, the darkest period of the dark ages. In his small treatise De Mirabili Potestate Artis et Naturæ, he begins by pointing out the absurdity of believing in magic, necromancy, charms, or any of those similar opinions which were at that time universally prevalent. He points out the various ways in which mankind are deceived by jugglers, ventriloquists, &c.; mentions the advantages which physicians may derive from acting on the imaginations of their patients by means of charms, amulets, and infallible remedies: he affirms that many of those things which are considered as supernatural, are merely so because mankind in general are unacquainted with natural philosophy. To illustrate this he mentions a great number of natural phenomena, which had been reckoned miraculous; and concludes with several secrets of his own, which he affirms to be still more extraordinary imitations of some of the most singular processes of nature. These he delivers in the enigmatical style of the times; induced, as he tells us, partly by the conduct of other philosophers, partly by the propriety of the thing, and partly by the danger of speaking too plainly.

From an attentive perusal of his works, many of which have been printed, it will be seen that Bacon was a great linguist, being familiar with Latin, Greek, Hebrew, and Arabic; and that he had perused the most important books at that time existing in all these languages. He was also a grammarian; he was well versed in the theory and practice of perspective; he understood the use of convex and concave glasses, and the art of making 35 them. The camera obscura, burning-glasses, and the powers of the telescope, were known to him. He was well versed in geography and astronomy. He knew the great error in the Julian calendar, assigned the cause, and proposed the remedy. He understood chronology well; he was a skilful physician, and an able mathematician, logician, metaphysician, and theologist; but it is as a chemist that he claims our attention here. The following is a list of his chemical writings, as given by Gmelin, the whole of which I have never had an opportunity of seeing:

1. Speculum Alchymiæ.[26]
2. Epistola de Secretis Operibus Artis et Naturæ et de Nullitate Magiæ.
3. De Mirabili Potestate Artis et Naturæ.
4. Medulla Alchymiæ.
5. De Arte Chemiæ.
6. Breviorium Alchymiæ.
7. Documenta Alchymiæ.
8. De Alchymistarum Artibus.
9. De Secretis.
10. De Rebus Metallicis.
11. De Sculpturis Lapidum.
12. De Philosophorum Lapide.
13. Opus Majus, *or* Alchymia Major.
14. Breviarium de Dono Dei.
15. Verbum abbreviatum de Leone Viridi.
16. Secretum Secretorum.
17. Tractatus Trium Verborum.
18. Speculum Secretorum.

A number of these were collected together, and published at Frankfort in 1603, under the title of "Rogeri Baconis Angli de Arte Chemiæ Scripta," in a small duodecimo volume. The Opus Majus was published in London in 1733, by Dr. Jebb, in a folio volume. Several of his 36 tracts still continue in manuscript in the Harleian and Bodleian libraries at Oxford. He considered the metals as compound of mercury and sulphur. Gmelin affirms that he was aware of the peculiar nature of manganese, and that he was acquainted with bismuth; but after perusing the whole of the Speculum Alchymiæ, the third chapter of which he quotes as containing the facts on which he founds his opinion, I cannot find any certain allusion either to manganese or bismuth. The term *magnesia* indeed occurs, but nothing is said respecting its nature: and long after the time of Paracelsus, bismuth (*bisematum*) was considered as an impure kind of *lead*. That he was acquainted with the composition and properties of *gunpowder* admits of no doubt. In the sixth chapter of his epistle De Secretis Operibus Artis et Naturæ et de Nullitate Magiæ, the following passage occurs:

"For sounds like thunder, and coruscations like lightning, may be made in the air, and they may be rendered even more horrible than those of nature herself. A small quantity of matter, properly manufactured, not larger than the human thumb, may be made to produce a horrible noise and coruscation. And this may be done many ways, by which a city or an army may be destroyed, as was the case when Gideon and his men broke their pitchers and exhibited their lamps, fire issuing out of them with inestimable noise, destroyed an infinite number of the army of the Midianites." And in the eleventh chapter of the same epistle occurs the following passage: "Mix together saltpetre, luru vopo vir con utriet, and sulphur, and you will make thunder and lightning, if you know the method of mixing them." Here all the ingredients of gunpowder are mentioned except charcoal, which is doubtless concealed under the barbarous terms *luru vopo vir con utriet*.

But though Bacon was acquainted with gunpowder, we have no evidence that he was the inventor. How far the celebrated Greek fire, concerning which so much has been written, was connected with gunpowder, it is impossible to say; but there is good evidence to prove that gunpowder was known and used in China before the commencement of the Christian era; and Lord Bacon is of opinion that the thunder and lightning and magic stated by the Macedonians to have been exhibited in Oxydrakes, when it was besieged by Alexander the Great, was nothing else than gunpowder. Now as there is pretty good evidence that the use of gunpowder had been introduced into Spain by the Moors, at least as early as the year 1343, and as Roger Bacon was acquainted with Arabic, it is by no means unlikely that he might have become acquainted with the mode of making the composition, and with its most remarkable properties, by perusing some Arabian writer, with whom we are at present unacquainted. Barbour, in his life of Bruce, informs us that guns were first employed by the English at the battle of Werewater, which was fought in 1327, about forty years after the death of Bacon. 37

Two novelties that day they saw,
That forouth in Scotland had been nene;
Timbers for helmes was the ane
That they thought then of great beautie,
And also wonder for to see.
The other *crakys* were of war
That they before heard never air.

In another part of the same book we have the phrase *gynnys for crakys*, showing that the term crakys was used to denote a gun or musket of some form or other. It is curious that the English would seem to have been the first European nation that employed gunpowder in war; they used it in the battle of Crecy, fought in 1346, when it was unknown to the French, and it is supposed to have contributed materially to the brilliant victory which was obtained.

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4. Raymond Lully is said to have been a scholar and a friend of Roger Bacon. He was a most voluminous writer, and acquired as high a reputation as any of the alchymists. According to Mutius he was born in Majorca in the year 1235. His father was seneschal to King James the First of Arragon. In his younger days he went into the army; but afterwards held a situation in the court of his sovereign. Devoting himself to science he soon acquired a competent knowledge of Latin and Arabic. After studying in Paris he got the degree of doctor conferred upon him. He entered into the order of Minorites, and induced King James to establish a cloister of that order in Minorca. He afterwards travelled through Italy, Germany, England, Portugal, Cyprus, Armenia and Palestine. He is said by Mutius to have died in the year 1315, and to have been buried in Majorca. The following epitaph is given by Olaus Borrichius as engraven on his tomb:

Raymundus Lulli, cujus pia dogmata nulli
Sunt odiosa viro, jacet hic in marmore miro
Hic M. et CC. Cum P. cœpit sine sensibus esse.

M C C C in these lines denote 1300, and P which is the 15th letter of the alphabet denotes 15, so that if this epitaph be genuine it follows that his death took place in the year 1315.

It seems scarcely necessary to notice the story that Raymond Lully made a present to Edward, King of England, of six millions of pieces of gold, to enable him to make war on

the Saracens, which sum that monarch employed, contrary to the intentions of the donor, in his French wars. This story cannot apply to Edward III., because in 1315, at the time of Raymond's death, that monarch was only three years of age. It can scarcely apply to Edward II., who ascended the throne in 1305: but who had no opportunity of making war, either on the Saracens or French, being totally occupied in opposing the intrigues of his queen and rebellious subjects, to whom he ultimately fell a sacrifice. Edward the First made 39
war both upon the Saracens and the French, and lived during the time of Raymond: but his wars with the Saracens were finished before he ascended the throne, and during the whole of his reign he was too much occupied with his projected conquest of Scotland, to pay much serious attention to any French war whatever. The story, therefore, cannot apply to any of the three Edwards, and cannot be true. Raymond Lully is said to have been stoned to death in Africa for preaching Christianity in the year 1315. Others will have it that he was alive in England in the year 1332, at which time his age would have been 97.

The following table exhibits a list of his numerous writings, most of which are to be found in the Theatrum Chemicum, the Artis Auriferæ, or the Biblotheca Chemica.

1. Praxis Universalis Magni Operis.
2. Clavicula.
3. Theoria et Practica.
4. Compendium Animæ Transmutationis Artis Metallorum.
5. Ultimum Testamentum. Of this work, which professes to give the whole doctrine of alchymy, there is an English translation.
6. Elucidatio Testamenti.
7. Potestas Divitiorum cum Expositione Testamenti Hermetis.
8. Compendium Artis Magicæ, quoad Compositionem Lapidis.
9. De Lapide et Oleo Philosophorum.
10. Modus accipiendi Aurum Potabile.
11. Compendium Alchymiæ et Naturalis Philosophiæ.
12. Lapidarium.
13. Lux Mercuriorum.
14. Experimenta. 40
15. Ars Compendiosa vel Vademecum.
16. De Accurtatione Lapidis.

Several other tracts besides these are named by Gmelin; but I have never seen any of them. I have attempted several times to read over the works of Raymond Lully, particularly his Last Will and Testament, which is considered the most important of them all. But they are all so obscure, and filled with such unintelligible jargon, that I have found it impossible to understand them. In this respect they form a wonderful contrast with the works of Albertus Magnus and Roger Bacon, which are comparatively plain and intelligible. For an account, therefore, of the chemical substances with which he was acquainted, I am obliged to depend on Gmelin; though I put no great confidence in his accuracy.

Like his predecessors, he was of opinion that all the metals are compounds of sulphur and mercury. But he seems first to have introduced those hieroglyphical figures or symbols, which appear in such profusion in the English translation of his Last Will and Testament, and which he doubtless intended to illustrate his positions. Though what other purpose they could serve, than to induce the reader to consider his statements as allegorical, it is not easy to conjecture. Perhaps they may have been designed to impose upon his contemporaries by an air of something very profound and inexplicable. For that he possessed a good deal of charlatanry is pretty evident, from the slightest glance at his performances.

He was acquainted with cream of tartar, which he distilled: the residue he burnt, and observed that the alkali extracted deliquesced when exposed to the air. He was acquainted with nitric acid, which he obtained by distilling a mixture of saltpetre and green vitriol. He mentions its power of dissolving, not merely mercury, but likewise other metals. He could form aqua regia by adding sal ammoniac or common salt to nitric acid, and he was aware of 41 the property which it had of dissolving gold.

Spirit of wine was well known to him, and distinguished by him by the names of aqua vitæ ardens and argentum vivum vegetabile. He knew the method of rendering it stronger by an admixture of dry carbonate of potash, and of preparing vegetable tinctures by means of it. He mentions alum from Rocca, marcasite, white and red mercurial precipitate. He knew the volatile alkali and its coagulations by means of alcohol. He was acquainted with cupellated silver, and first obtained rosemary oil by distilling the plant with water. He employed a mixture of flour and white of egg spread upon a linen cloth to cement cracked glass vessels, and used other lutes for similar purposes.[27]

5. Arnoldus de Villa Nova is said to have been born at Villeneuve, a village of Provence, about the year 1240. Olaus Borrichius assures us, that in his time his posterity lived in the neighbourhood of Avignon; that he was acquainted with them, and that they were by no means destitute of chemical knowledge. He is said to have been educated at Barcelona, under John Casamila, a celebrated professor of medicine. This place he was obliged to leave, in consequence of foretelling the death of Peter of Arragon. He went to Paris, and likewise travelled through Italy. He afterwards taught publicly in the University of Montpelier. His reputation as a physician became so great, that his attendance was solicited in dangerous cases by several kings, and even by the pope himself. He was skilled in all the sciences of his time, and was besides a proficient in Greek, Hebrew, and Arabic. When at Paris he studied astrology, and calculating the age of the world, he found that it was to terminate in the year 1335. The theologians of Paris exclaimed against this and 42 several other of his opinions, and condemned our astrologer as a heretic. This obliged him to leave France; but the pope protected him. He died in the year 1313, on his way to visit Pope Clement V. who lay sick at Avignon. The following table exhibits a pretty full list of his works:

1. Antidotorium
2. De Vinis.
3. De Aquis Laxativis.
4. Rosarius Philosophorum.
5. Lumen Novum.
6. De Sigillis.
7. Flos Florum.
8. Epistolæ super Alchymia ad Regem Neapolitanum.
9. Liber Perfectionis Magisterii.
10. Succosa Carmina.
11. Questiones de Arte Transmutationis Metallorum.
12. Testamentum.
13. Lumen Luminum.
14. Practica.
15. Speculum Alchymiæ.
16. Carmen.
17. Questiones ad Bonifacium.
18. Semita Semitæ.
19. De Lapide Philosophorum.
20. De Sanguine Humano.
21. De Spiritu Vini, Vino Antimonii et Gemmorum Viribus.

Perhaps the most curious of all these works is the *Rosarium*, which is intended as a complete compend of all the alchymy of his time. The first part of it on the theory of the art is plain enough; but the second part on the practice, which is subdivided into thirty-two chapters, and which professes to teach the art of making the philosopher's stone, is in many places quite unintelligible to me. 43

He considered, like his predecessors, mercury as a constituent of metals, and he professed a knowledge of the philosopher's stone, which he could increase at pleasure. Gold and gold-water was, in his opinion, one of the most precious of medicines. He employed mercury in medicine. He seems to designate bismuth under the name *marcasite*. He was in the habit of preparing oil of turpentine, oil of rosemary, and spirit of rosemary, which afterwards became famous under the name of Hungary-water. These distillations were made in a glazed earthen vessel with a glass top and helm.

His works were published at Venice in a single folio volume, in the year 1505. There were seven subsequent editions, the last of which appeared at Strasburg in 1613.

6. John Isaac Hollandus and his countryman of the same name, were either two brothers or a father and son; it is uncertain which. For very few circumstances respecting these two laborious and meritorious men have been handed down to posterity. They were born in the village of Stolk in Holland, it is supposed in the 13th century. They certainly were after Arnoldus de Villa Nova, because they refer to him in their writings. They wrote many treatises on chemistry, remarkable, considering the time when they wrote, for clearness and precision, describing their processes with accuracy, and even giving figures of the instruments which they employed. This makes their books intelligible, and they deserve attention because they show that various processes, generally supposed of a more modern date were known to them. Their treatises are written partly in Latin and partly in German. The following list contains the names of most of them:

1. Opera Vegetabilia ad ejus alia Opera Intelligenda Necessaria.
2. Opera Mineralia seu de Lapide Philosophico Libri duo. 44
3. Tractat vom stein der Weisen.
4. Fragmenta Quædam Chemica.
5. De Triplice Ordine Elixiris et Lapidis Theorea.
6. Tractatus de Salibus et Oleis Metallorum.
7. Fragmentum de Opere Philosophorum.
8. Rariores Chemiæ Operationes.
9. Opus Saturni.
10. De Spiritu Urinæ.
11. Hand der Philosopher.

Olaus Borrichius complains that their *opera mineralia* abound with processes; but that they are ambiguous, and such that nothing certain can be deduced from them even after much labour. Hence they draw on the unwary tyro from labour to labour. I am disposed myself to draw a different conclusion, from what I have read of that elaborate work. It is true that the processes which profess to make the philosopher's stone, are fallacious, and do not lead to the manufacture of gold, as the author intended, and expected: but it is a great deal when alchymistical processes are delivered in such intelligible language that you know the substances employed. This enables us easily to see the results in almost every case, and to know the new compounds which were formed during a vain search for the philosopher's stone. Had the other alchymists written as plainly, the absurdity of their researches would have been sooner discovered, and thus a useless or pernicious investigation would have sooner terminated.

7. Basil Valentine is said to have been born about the year 1394, and is, perhaps, the most celebrated of all the alchymists, if we except Paracelsus. He was a Benedictine monk, at Erford, in Saxony. If we believe Olaus Borrichius, his writings were enclosed in the wall of a church at Erford, and were discovered long after his death, in consequence of the wall 45
having been driven down by a thunderbolt. But this story is not well authenticated, and is utterly improbable. Much of his time seems to have been taken up in the preparation of chemical medicines. It was he that first introduced antimony into medicine; and it is said, though on no good authority, that he first tried the effects of antimonial medicines upon the monks of his convent, upon whom it acted with such violence that he was induced to distinguish the mineral from which these medicines had been extracted, by the name of *antimoine* (hostile to monks). What shows the improbability of this story is, that the works of Basil Valentine, and in particular his Currus triumphalis Antimonii, were written in the German language. Now the German name for antimony is not *antimoine*, but *speissglass*. The Currus triumphalis Antimonii was translated into Latin by Kerkringius, who published it, with an excellent commentary, at Amsterdam, in 1671.

Basil Valentine writes with almost as much virulence against the physicians of his time, as Paracelsus himself did afterwards. As no particulars of his life have been handed down to posterity, I shall satisfy myself with giving a catalogue of his writings, and then pointing out the most striking chemical substances with which he was acquainted.

The books which have appeared under the name of Basil Valentine, are very numerous; but how many of them were really written by him, and how many are supposititious, is extremely doubtful. The following are the principal:

1. Philosophia Occulta.
2. Tractat von naturlichen und ubernaturlichen Dingen; auch von der ersten tinctur, Wurzel und Geiste der Metallen.
3. Von dern grossen stein der Uhralten. 46
4. Vier tractatlein vom stein der Weisen.
5. Kurzer anhang und klare repetition oder Wiederholunge vom grosen stein der Uhralten.
6. De prima Materia Lapidis Philosophici.
7. Azoth Philosophorum seu Aureliæ occultæ de Materia Lapidis Philosophorum.
8. Apocalypsis Chemica.
9. Claves 12 Philosophiæ.
10. Practica.
11. Opus præclarum ad utrumque, quod pro Testamento dedit Filio suo adoptivo.
12. Letztes Testament.
13. De Microcosmo.
14. Von der grosen Heimlichkeit der Welt und ihrer Arzney.
15. Von der Wissenschaft der sieben Planeten.
16. Offenbahrung der verborgenen Handgriffe.
17. Conclusiones or Schlussreden.
18. Dialogus Fratris Alberti cum Spiritu.
19. De Sulphure et fermento Philosophorum.
20. Haliographia.
21. Triumph wagen Antimonii.
22. Einiger Weg zur Wahrheit.
23. Licht der Natur.

The only one of these works that I have read with care, is Kerkringius's translation and commentary on the Currus triumphalis Antimonii. It is an excellent book, written with clearness and precision, and contains every thing respecting antimony that was known before the commencement of the 19th century. How much of this is owing to Kerkringius I cannot say, as I have never had an opportunity of seeing a copy of the original German work of Basil Valentine.

Basil Valentine, like Isaac Hollandus, was of opinion that the metals are compounds of salt, sulphur, and mercury. The philosopher's stone was composed of the same ingredients.
He affirmed, that there exists a great similarity between the mode of purifying gold and 47
curing the diseases of men, and that antimony answers best for both. He was acquainted with arsenic, knew many of its properties, and mentions the red compound which it forms with sulphur. Zinc seems to have been known to him, and he mentions bismuth, both under its own name, and under that of *marcasite*. He was aware that manganese was employed to render glass colourless. He mentions nitrate of mercury, alludes to corrosive sublimate, and seems to have known the red oxide of mercury. It would be needless to specify the preparations of antimony with which he was acquainted; scarcely one was unknown to him which, even at present, exists in the European Pharmacopœias. Many of the preparations of lead were also familiar to him. He was aware that lead gives a sweet taste to vinegar. He knew sugar of lead, litharge, yellow oxide of lead, white carbonate of lead; and mentions that this last preparation was often adulterated in his time. He knew the method of making green vitriol, and the double chloride of iron and ammonia. He was aware that iron could be precipitated from its solution by potash, and that iron has the property of throwing down copper. He was aware that tin sometimes contains iron, and ascribed the brittleness of Hungarian iron to copper. He knew that oxides of copper gave a green colour to glass; that Hungarian silver contained gold; that gold is precipitated from aqua regia by mercury, in the state of an amalgam. He mentions fulminating gold. But the important facts contained in his works are so numerous, while we are so uncertain about the genuineness of the writings themselves, that it will scarcely be worth while to proceed further with the catalogue.

Thus I have brought the history of alchymy to the time of Paracelsus, when it was
doomed to undergo a new and important change. It will be better, therefore, not to pursue 48
the history of alchymy further, but to take up the history of true chemistry; and in the first place to endeavour to determine what chemical facts were known to the Ancients, and how
far the science had proceeded to develop itself before the time of Paracelsus. 49

CHAPTER II.

OF THE CHEMICAL KNOWLEDGE POSSESSED BY THE ANCIENTS.

Notwithstanding the assertions of Olaus Borrichius, and various other writers who followed him on the same side, nothing is more certain than that the ancients have left no chemical writings behind them, and that no evidence whatever exists to prove that the science of chemistry was known to them. Scientific chemistry, on the contrary, took its origin from the collection and comparison of the chemical facts, made known by the practice and improvement of those branches of manufactures which can only be conducted by chemical processes. Thus the smelting of ores, and the reduction of the metals which they contain, is a chemical process; because it requires, for its success, the separation of certain bodies which exist in the ore chemically combined with the metals; and it cannot be

done, except by the application or mixture of a new substance, having an affinity for these substances, and capable, in consequence, of separating them from the metal, and thus reducing the metal to a state of purity. The manufacture of glass, of soap, of leather, are all chemical, because they consist of processes, by means of which bodies, having an affinity for each other, are made to unite in chemical combination. Now I shall in this chapter point out the principal chemical manufactures that were known to the ancients, that we may see 50
how much they contributed towards laying the foundation of the science. The chief sources of our information on this subject are the writings of the Greeks and Romans. Unfortunately the arts and manufactures stood in a very different degree of estimation among the ancients from what they do among the moderns. Their artists and manufacturers were chiefly slaves. The citizens of Greece and Rome devoted themselves to politics or war. Such of them as turned their attention to learning confined themselves to *oratory*, which was the most fashionable and the most important study, or to history, or poetry. The only scientific pursuits which ever engaged their attention, were politics, ethics, and mathematics. For, unless Archimedes is to be considered as an exception, scarcely any of the numerous branches of physics and mechanical philosophy, which constitute so great a portion of modern science, even attracted the attention of the ancients.

In consequence of the contemptible light in which all mechanical employments were viewed by the ancients, we look in vain in any of their writings for accurate details respecting the processes which they followed. The only exception to this general neglect and contempt for all the arts and trades, is Pliny the Elder, whose object, in his natural history, was to collect into one focus, every thing that was known at the period when he lived. His work displays prodigious reading, and a vast fund of erudition. It is to him that we are chiefly indebted for the knowledge of the chemical arts which were practised by the ancients. But the low estimation in which these arts were held, appears evident from the wonderful want of information which Pliny so frequently displays, and the erroneous statements which he has recorded respecting these processes. Still a great deal may be drawn from the information which has been collected and transmitted to us by this indefatigable natural historian. 51

I.—The ancients were acquainted with SEVEN METALS; namely, gold, silver, mercury, copper, iron, tin, and lead. They knew and employed various preparations of zinc, and antimony, and arsenic; though we have no evidence that these bodies were known to them in the metallic state.

1. Gold is spoken of in the second chapter of Genesis as existing and familiarly known before the flood.

“The name of the first is Pison; that is it which encompasseth the whole land of Havilah, where there is gold. And the gold of that land is good: there is bdellium and the onyx-stone.” The Hebrew word for gold, זהב (*zahav*) signifies to be clear, to shine; alluding, doubtless, to the brilliancy of that metal. The term *gold* occurs frequently in the writings of Moses, and the metal must have been in common use among the Egyptians, when that legislator led the children of Israel out of Egypt.[28] Gold is found in the earth almost always in a native state. There can be no doubt that it was much more abundant on the surface of the earth, and in the beds of rivers in the early periods of society, than it is at present: indeed this is obvious, from the account which Pliny gives of the numerous places in Asia and Greece, and other European countries, where gold was found in his time.

Gold, therefore, could hardly fail to attract the attention of the very first inhabitants of the globe; its beauty, its malleability, its indestructibility, would give it value: accident would soon discover the possibility of melting it by heat, and thus of reducing the grains or small pieces of it found on the surface of the earth into one large mass. It would be speedily made into ornaments and utensils of various kinds, and thus gradually would come into

common use. This we find to have occurred in America, when it was discovered by 52
Columbus. The inhabitants of the tropical parts of that vast continent were familiarly acquainted with gold; and in Mexico and Peru it existed in great abundance; indeed the natives of these countries seem to have been acquainted with no other metal, or at least no other metal was brought into such general use, except silver, which in Peru was, it is true, still more common than gold.

Gold, then, was probably the first metal with which man became acquainted; and that knowledge must have preceded the commencement of history, since it is mentioned as a common and familiar substance in the Book of Genesis, the oldest book in existence, of the authenticity of which we possess sufficient evidence. The period of leading the children of Israel out of Egypt by Moses, is generally fixed to have been one thousand six hundred and forty-eight years before the commencement of the Christian era. So early, then, we are certain, that not only gold, but the other six malleable metals known to the ancients, were familiar to the inhabitants of Egypt. The Greeks ascribe the discovery of gold to the earliest of their heroes. According to Pliny, it was discovered on Mount Pangæus by Cadmus, the Phœnician: but Cadmus's voyage into Greece was nearly coeval with the exit of the Israelites out of Egypt, at which time we learn from Moses that gold was in common use in Egypt. All that can be meant, then, is, that Cadmus first discovered gold in Greece; not that he made mankind first acquainted with it. Others say that Thoas and Eaclis, or Sol, the son of Oceanus, first found gold in Panchaia. Thoas was a contemporary of the heroes of the Trojan war, or at least was posterior to the Argonautic expedition, and consequently long posterior to Moses and the departure of the children of Israel from Egypt.

2. Silver also was not only familiarly known to the Egyptians in the time of Moses,
but, as we learn from Genesis, was coined into money before Joseph was set over the land 53
of Egypt by Pharaoh, which happened one thousand eight hundred and seventy-two years before the commencement of the Christian era, and consequently two hundred and twenty-four years before the departure of the children of Israel out of Egypt.

"And Joseph gathered up all the money that was found in the land of Egypt, and in the land of Canaan, for the corn which they bought; and Joseph brought the money into Pharaoh's house."[29] The Hebrew word כסף (*keseph*), translated *money*, signifies silver, and was so called from its pale colour. Silver occurs in many other passages of the writings of Moses.[30] The Greeks inform us, that Erichthonius the Athenian, or Ceacus, were the discoverers of silver; but both of these individuals were long posterior to the time of Joseph.

Silver, like gold, occurs very frequently in the metallic state. This, no doubt, was a still more frequent occurrence in the early ages of the world; it would therefore attract the attention of mankind as early as gold, and for the same reason. It is very ductile, very beautiful, and much more easily fused than gold: it would be therefore more easily reduced into masses, and formed into different utensils and ornaments than even gold itself. The ores of it which occur in the earth are heavy, and would therefore draw the attention of even rude men to them: they have, most of them at least, the appearance of being metallic, and the most common of them may be reduced to the state of metallic silver, simply by keeping them a sufficient time in fusion. Accordingly we find that the Peruvians, before they were overrun by the Spaniards, had made themselves acquainted with the mode of digging out
and smelting the ores of silver which occur in their country, and that many of their most 54
common utensils were made of that metal.

Silver and gold approached each other nearer in value among the ancients than at present: an ounce of fine gold was worth from ten to twelve ounces of fine silver, the variation depending upon the accidental relation of the supply of both metals. But after the discovery of America, the quantity of silver found in that continent, especially in Mexico, was so great, compared with that of the gold found, that silver became considerably cheaper; so that an ounce of fine gold came to be equivalent to about fourteen ounces and a half of fine silver. Of course these relative values have fluctuated a little according to the abundance of the supply of silver. Though the revolution in the Spanish American colonies has considerably diminished the supply of silver from the mines, that deficiency seems to have been supplied by other ways, and thus the relative proportion between the value of gold and silver has continued nearly unaltered.

3. That copper must have been known in the earliest ages of society, is sufficiently evident. It occurs frequently native, and could not fail to attract the attention of mankind, from its colour, weight, and malleability. It would not be difficult to fuse it even in the rudest ages: and when melted into masses, as it is malleable and ductile, it would not require much skill to convert it into useful and ornamental utensils. The Hebrew word נחשת (*nechooshat*) translated *brass*, obviously means *copper*. We have the authority of the Book of Genesis to satisfy us that copper was known before the flood, and probably as early as either silver or gold.

"And Zillah, she also bore Tubal-cain, an instructor of every artificer in brass (*copper*) and iron."[31] 55

The word *copper* occurs in many other passages of the writings of Moses.[32] That the Hebrew word translated *brass* must have meant copper is obvious, from the following passage: "Out of whose hills thou mayest dig brass."[33] Brass does not exist in the earth, nor any ore of it, it is always made artificially; it must therefore have been copper, or an ore of copper, that was alluded to by Moses.

Copper must have been discovered and brought into common use long before iron or steel; for Homer represents his heroes of the Trojan war as armed with swords, &c. of copper. Copper itself is too soft to be made into cutting instruments; but the addition of a little tin gives it the requisite hardness. Now we learn from the analyses of Klaproth, that the copper swords of the ancients were actually hardened by the addition of tin.[34]

Copper was the metal in common use in the early part of the Roman commonwealth. Romulus coined copper money alone. Numa established a college of workers in copper (*ærariorum fabrum*).[35]

The Latin word *æs* sometimes signifies copper, and sometimes brass. It is plain from what Pliny says on the subject, that he did not know the difference between copper and brass; he says, that an ore of *æs* occurs in Cyprus, called *chalcitis*, where *æs* was first discovered. Here *æs* obviously means copper. In another place he says, that *æs* is obtained from a mineral called *cadmia*. Now from the account of cadmia by Pliny and Dioscorides, there cannot be a doubt that it is the ore to which the moderns have given the name of *calamine*, by means of which brass is made. It is sometimes a silicate and sometimes a carbonate of zinc; for both of these ores are confounded together under the name of cadmia, 56
and both are employed in the manufacture of brass.

Solinus says, that *æs* was first made at Chalcis, a town in Eubœa. Hence the Greek name, χαλκος (*chalkos*), by which copper was distinguished.

The proper name for brass, by which is meant an alloy of copper and zinc, was *aurichalcum*, or golden, or yellow copper. Pliny says, that long before his time, the ore of aurichalcum was exhausted, so that no more of that beautiful alloy was made. Are we to conclude from this, that there once existed an ore consisting of calamine and ore of copper, mixed or united together? After the exhaustion of the aurichalcum mine, the *salustianum* became the most famous; but it soon gave place to the *livianum*, a copper-mine in Gaul, named after Livia, the wife of Augustus. Both these mines were exhausted in the time of

Pliny. The *æs marianum*, or copper of Cordova, was the most celebrated in his time. This last *æs*, he says, absorbs most cadmia, and acquires the greatest resemblance to aurichalcum. We see from this, that in Pliny's time brass was made artificially, and by a process similar to that still followed by the moderns.

The most celebrated alloy of copper among the ancients, was the *æs corinthium*, or Corinthian copper, formed accidentally, as Pliny informs us, during the burning of Corinth by Mummius in the year 608, after the building of Rome, or one hundred and forty-five years before the commencement of the Christian era. There were four kinds of it, of which Pliny gives the following description; not, however, very intelligible:

1. White. It resembled silver much in its lustre, and contained an excess of that metal.
2. Red. In this kind there is an excess of gold.
3. In the third kind, gold, silver, and copper are mixed in equal proportions. 57
4. The fourth kind is called *hepatizon*, from its having a liver colour. It is this colour which gives it its value.[36]

Copper was put by the ancients to almost all the uses to which it is put by the moderns. One of the great sources of consumption was bronze statues, which were first introduced into Rome after the conquest of Asia Minor. Before that time, the statues of the Romans were made of wood or stoneware. Pliny gives various formulas for making bronze for statues. Of these it may be worth while to put down the most material.

1. To new copper add a third part of old copper. To every hundred pounds of this mixture, twelve pounds and a half of tin[37] are added, and the whole melted together.

2. Another kind of bronze for statues was formed, by melting together

100lbs.copper,
10lbs.lead,
5lbs.tin.

3. Their copper-pots for boiling consisted of 100lbs. of copper, melted with three or four pounds of tin.

The four celebrated statues of horses which, during the reign of Theodosius II. were transported from Chio to Constantinople; and, when Constantinople was taken and plundered by the Crusaders and Venetians in 1204, were sent by Martin Zeno and set up by the doge, Peter Ziani, in the portal of St. Mark; were in 1798, transported by the French to Paris; and finally, after the overthrow of Buonaparte, and the restoration of the Bourbons in 1815, returned to Venice and placed upon their ancient pedestals. The metal of which these horses had been made was examined by Klaproth, and found by him composed of 58

Copper,	993
Tin,	7
	1000[38]

Klaproth also analyzed an ancient bronze statue in one of the German cabinets, and found it composed of

Copper,	916
Tin,	75
Lead,	97
	1000[39]

Several other old brass and bronze pieces of metal, very ancient, but found in Germany, were also analyzed by Klaproth. The result of his analyses was as follows:

The metal of which the altar of Krodo was made consisted of

Copper,	69
Zinc,	18
Lead,	13
	100[40]

The emperor's chair, which had in the eleventh century been transported from Harzburg to Goslar, where it still remains, was found to be composed of

Copper,	92·5
Tin,	5·0
Lead,	2·5
	100[41]

Another piece of metal, which enclosed the high altar in a church in Germany, was composed of 59

Copper,	75·0
Tin,	12·5
Lead,	12·5
	100[42]

These analyses, though none of them corresponds exactly with the proportions given by Pliny, confirms sufficiently his general statement, that the bronze of the ancients employed for statues was copper, alloyed with lead and tin.

Some of the bronze statues cast by the ancients were of enormous dimensions, and show decisively the great progress which had been made by them in the art of working and casting metals. The addition of the lead and tin would not only add greatly to the hardness of the alloy, but would at the same time render it more easily fusible. The bronze statue of Apollo, placed in the capitol at the time of Pliny, was forty-five feet high, and cost 500 talents, equivalent to about £50,000 of our money. It was brought from Apollonia, in Pontus, by Lucullus. The famous statue of the sun at Rhodes was the work of Chares, a disciple of Lysippus; it was ninety feet high, was twelve years in making, and cost 300 talents (about £30,000). It was made out of the engines of war left by Demetrius when he raised the siege of Rhodes. After standing fifty-six years, it was overthrown by an earthquake. It lay on the ground 900 years, and was sold by Mauvia, king of the Saracens, to a merchant, who loaded 900 camels with the fragments of it.

Copper was introduced into medicine at rather an early period of society, and various medicinal preparations of it are described by Dioscorides and Pliny. It remains for us to notice the most remarkable of these. Pliny mentions an institution, to which he gives the name of *Seplasia*; the object of which was, to prepare medicines for the use of medical men. 60
It seems, therefore, to have been similar to our apothecaries' shops of the present day. Pliny reprobates the conduct of the persons who had the charge of these Seplasiæ in his time. They were in the habit of adulterating medicines to such a degree, that nothing good or genuine could be procured from them.[43]

Both the oxides of copper were known to the ancients, though they were not very accurately distinguished from each other: they were known by the names *flos æris* and *scoria æris*, or *squama æris*. They were obtained by heating bars of copper red-hot and letting them cool, exposed to the air. What fell off during the cooling was the *flos*, what was driven off by blows of a hammer was the *squama* or *scoria æris*. It is obvious, that all these substances were nearly of the same nature, and that they were in reality mixtures of the black and red oxides of copper.

Stomoma seems also to have been an oxide of copper, which was gradually formed upon the surface of the metal, when it was kept in a state of fusion.

These oxides of copper were used as external applications in cases of polypi of the nose, diseases of the anus, ear, mouth, &c., seemingly as escharotics.

Ærugo, verdigris, was a subacetate of copper, doubtless often mixed with subacetate of zinc, as not only copper but brass also was used for preparing it. The mode of preparing this substance was similar to the process still followed. Whether verdigris was employed as a paint by the ancients does not appear; for Pliny takes no notice of any such use of it.

Chalcantum, called also *atramentum sutorium*, was probably a mixture of sulphate of copper and sulphate of iron. Pliny's account of the mode of procuring it is too imperfect to enable us to form precise ideas concerning it; but it was crystallized on strings, which were 61
extended for the purpose in the solution: its colour was blue, and it was transparent like glass. This description might apply to sulphate of copper; but as the substance was used for blackening leather, and on that account was called *atramentum sutorium*, it is obvious that it must have contained also *sulphate of iron*.

Chalcitis was the name for an ore of copper. The account given of it by Pliny agrees best with copper pyrites, which is now known to be a *sulphur salt*, composed of one atom of sulphide of copper (the acid) united to one atom of sulphide of iron (the base). Pliny informs us, that it is a mixture of *copper*, *misy*, and *sory*: its colour is that of honey. By age, he says, it changes into sory. I think it most probable that native sory, of which Pliny speaks, was sulphuret of copper, and artificial sory sulphate of copper. The native sory is said to constitute black veins in chalcitis. Pliny's description of misy (μισυ) best agrees with copper pyrites. Dioscorides describes it as hard, as having the colour of gold, and as shining like a star.[44] All this agrees pretty well with copper pyrites.

Scoleca (so called because it assumed the shape of a worm) was formed by triturating alumen, carbonate of soda, and white vinegar, till the matter became green. It was probably a mixture of sulphate of soda, acetate of soda, acetate of alumina, and acetate of copper, probably with more or less oxide of copper, &c., depending upon the proportions of the respective constituents employed.

Such are the preparations of copper, employed by the ancients. They were only used as external applications, partly as escharotics, and partly to induce ulcers to put on a healthy appearance. It does not appear that copper was ever used by the ancients as an internal
remedy. 62

4. Though *zinc* in the metallic state was unknown to the ancients, yet as they knew some of its ores, and employed preparations of it in medicine, and were in the habit of alloying copper with it, and converting it into brass, it will be proper to state here what was known to them concerning it.

Pliny nowhere makes us acquainted with the process by which copper was converted into brass, nor does he seem to have been acquainted with it; but from several facts incidentally mentioned by him, it is obvious that their process was similar to that which is followed at present by modern brass-makers. The copper in grains is mixed with a certain quantity of calamine (cadmia) and charcoal, and exposed for some time to a moderate heat in a covered crucible. The calamine is reduced to the metallic state, and imbibed by the copper grains. When the copper is thus converted into brass, the temperature is raised sufficiently high to melt the whole: it is then poured out and cast into a slab or ingot.

The cadmia employed by the ancients in medicine was not calamine, but oxide of zinc, which sublimed during the fusion of brass in an open vessel. It was distinguished by a variety of names, according to the state in which it was obtained: the lighter portion was called *capnitis*. *Botryitis* was the name of the portion in the interior of the chimney: the name was derived from some resemblance which it was supposed to have to a bunch of grapes. It had two colours, ash and red. The red variety was reckoned best. This red colour it might derive from some copper mixed with it, but more probably from iron; for a small quantity of oxide of iron is sufficient to give oxide of zinc a rather beautiful red colour. The portion collected on the sides of the furnace was called *placitis*: it constituted a crust, and was distinguished by different names, according to its colour; *onychitis* when it was blue externally, but spotted internally: *ostracitis*, when it was black and dirty-looking. This last 63
variety was considered as an excellent application to wounds. The best cadmia in Pliny's time was furnished by the furnaces of the Isle of Cyprus: it was used as an external application in ulcers, inflammations, eruptions, &c., so that its use in medicine was pretty much the same as at present. Sulphate and acetate of zinc were unknown to the ancients. No attempt seems to have been made by them to introduce any preparations of zinc as internal medicines.

Pompholyx was the name given to oxide of zinc, sublimed by the combustion of the zinc which exists in brass. *Spodos* seems to have been a mixture of oxides of zinc and copper. There were different varieties of it distinguished by various names.[45]

5. Iron exists very rarely in the earth in a metallic state, but most commonly in the state of an oxide; and the processes necessary to extract metallic iron from these ores are much more complicated, and require much greater skill, than the reduction of gold, silver, or copper from their respective ores. This would lead us to expect that iron would have been much longer in being discovered than the three metals whose names have been just given. But we learn from the Book of Genesis that iron, like copper and gold, was known before the flood, Tubal-cain being represented as an artificer in copper and iron.[46] The Hebrew word for iron, לזרב (*barzel*), is said to be derived from רב (*bar*), bright, לזנ (*nazal*), to melt; and would lead one to the suspicion, that it referred to *cast* iron rather than *malleable* iron. It is possible that in these early times native iron may have existed as well as native gold, silver, and copper; and in this way Tubal-cain may have become acquainted with the existence and properties of this metal. In the time of Moses, who was learned in all the wisdom of the Egyptians, iron must have been in common use in Egypt: for he mentions 64
furnaces for working iron;[47] ores from which it was extracted;[48] and tells us that swords,[49] knives,[50] axes,[51] and tools for cutting stones,[52] were then made of that metal. Now iron in its pure metallic state is too soft to be applied to these uses: it is obvious, therefore, that in Moses's time, not only iron but steel also must have been in common use in Egypt. From this we see how much further advanced the Egyptians were than the Greeks in the knowledge of the manufacture of this most important metal: for during the Trojan war, which was several centuries after the time of Moses, Homer represents his heroes as armed with swords of copper, hardened by tin, and as never using any weapons of iron whatever. Nay, in such estimation was it held, that Achilles, when he celebrated games in honour of Patrocles, proposes a ball of iron as one of his most valuable prizes.[53]

"Then hurl'd the hero, thundering on the ground,
A mass of iron (an enormous round),
Whose weight and size the circling Greeks admire,
Rude from the furnace and but shaped by fire.
This mighty quoit Ætion wont to rear,
And from his whirling arm dismiss'd in air;
The giant by Achilles slain, he stow'd
Among his spoils this memorable load.
For this he bids those nervous artists vie
That teach the disk to sound along the sky.
Let him whose might can hurl this bowl, arise;
Who farthest hurls it, takes it as his prize:
If he be one enrich'd with large domain
Of downs for flocks and arable for grain,
Small stock of iron needs that man provide,
His hinds and swains whole years shall be supplied
From hence: nor ask the neighbouring city's aid
For ploughshares, wheels, and all the rural trade."

The mass of iron was large enough to supply a shepherd or a ploughman with iron for 65
five years. This circumstance is a sufficient proof of the high estimation in which iron was held during the time of Homer. Were a modern poet to represent his hero as holding out a large lump of iron as a prize, and were he to represent this prize as eagerly contended for by kings and princes, it would appear to us perfectly ridiculous.

Hesiod informs us, that the knowledge of iron was brought over from Phrygia to Greece by the Dactyli, who settled in Crete during the reign of Minos I., about 1431 years before the commencement of the Christian era, and consequently about sixty years before the departure of the children of Israel from Egypt: and it does not appear, that in Homer's time, which was about five hundred years later, the art of smelting iron had been so much improved, as to enable men to apply it to the common purposes of life, as had long before been done by the Egyptians. The general opinion of the ancients was, that the method of smelting iron ore had been brought to perfection by the Chalybes, a small nation situated near the Black Sea,[54] and that the name *chalybs*, occasionally used for steel, was derived from that people.

Pliny informs us, that the ores of iron are scattered very profusely almost every where: that they exist in Elba; that there was a mountain in Cantabria composed entirely of iron ore; and that the earth in Cappadocia, when watered from a certain river, is converted into iron.[55] He gives no account of the mode of smelting iron ores; nor does he appear to have been acquainted with the processes; for he says that iron is reduced from its ore precisely in the same way as copper is. Now we know, that the processes for smelting copper and iron
are quite different, and founded upon different principles. He says, that in his time many 66
different kinds of iron existed, and they were *stricturæ*, in Latin *a stringenda acie*.

That steel was well known and in common use when Pliny wrote is obvious from many considerations; but he seems to have had no notion of what constituted the difference between iron and steel, or of the method employed to convert iron into steel. In his opinion it depended upon the nature of the water, and consisted in heating iron red-hot, and plunging it, while in that state, into certain waters. The waters at Bilbilis and Turiasso, in Spain, and at Comum, in Italy, possessed this extraordinary virtue. The best steel in Pliny's time came from China; the next best, in point of quality, was manufactured in Parthia.

It would appear, that at Noricum steel was manufactured directly from the ore of iron. This process was perfectly practicable, and it is said still to be practised in certain cases.

The ancients were acquainted with the method of rendering iron, or rather steel, magnetic; as appears from a passage in the fourteenth chapter of the thirty-fourth book of Pliny. Magnetic iron was distinguished by the name of *ferrum vivum*.

When iron is dabbed over with alumen and vinegar it becomes like copper, according to Pliny. Cerussa, gypsum, and liquid pitch, keep it from rusting. Pliny was of opinion that a method of preventing iron from rusting had been once known, but had been lost before his time. The iron chains of an old bridge over the Euphrates had not rusted in Pliny's time; but a few new links, which had been added to supply the place of some that had decayed, were become rusty.

It would appear from Pliny, that the ancients made use of something very like *tractors*; for he says that pain in the side is relieved by holding near it the point of a dagger that has wounded a man. Water in which red-hot iron had been plunged was recommended as a cure 67 for the dysentery; and the actual cautery with red-hot iron, Pliny informs us, prevents hydrophobia, when a person has been bitten by a mad dog.

Rust of iron and scales of iron were used by the ancients as astringent medicines.

6. Tin, also, must have been in common use in the time of Moses; for it is mentioned without any observation as one of the common metals.[56] And from the way in which it is spoken of by Isaiah and Ezekiel, it is obvious that it was considered as of far inferior value to silver and gold. Now tin, though the ores of it where it does occur are usually abundant, is rather a scarce metal: that is to say, there are but few spots on the face of the earth where it is known to exist. Cornwall, Spain, in the mountains of Gallicia, and the mountains which separate Saxony and Bohemia, are the only countries in Europe where tin occurs abundantly. The last of these localities has not been known for five centuries. It was from Spain and from Britain that the ancients were supplied with tin; for no mines of tin exist, or have ever been known to exist, in Africa or Asia, except in the East Indies. The Phœnicians were the first nation which carried on a great trade by sea. There is evidence that at a very early period they traded with Spain and with Britain, and that from these countries they drew their supplies of tin. It was doubtless the Phœnicians that supplied the Egyptians with this metal. They had imbibed strongly a spirit of monopoly; and to secure the whole trade of tin they carefully concealed the source from which they drew that metal. Hence, doubtless, the reason why the Grecian geographers, who derived their information from the Phœnicians, represented the Insulæ Cassiterides, or tin islands, as a set of islands lying off 68 the north coast of Spain. We know that in fact the Scilly islands, in these early ages, yielded tin, though doubtless the great supply was drawn from the neighbouring province of Cornwall. It was probably from these islands that the Greek name for *tin* was derived (κασσιτερος). Even Pliny informs us, that in his time tin was obtained from the Cassiterides, and from Lusitania and Gallicia. It occurs, he says, in grains in alluvial soil, from which it is obtained by washing. It is in black grains, the metallic nature of which is only recognisable by the great weight. This is a pretty accurate description of *stream tin*, which we know formerly constituted the only ore of that metal wrought in Cornwall. He says that the ore occurs also along with grains of gold; that it is separated from the soil by washing along with the grains of gold, and afterwards smelted separately.

Pliny gives no particulars about the mode of reducing the ore of tin to the metallic state; nor is it at all likely that he was acquainted with the process.

The Latin term for tin was *plumbum album*. *Stannum* is also used by Pliny; but it is impossible to understand the account which he gives of it. There is, he says, an ore consisting of lead, united to silver. When this ore is smelted, the first metal that flows out is *stannum*. What flows next is *silver*. What remains in the furnace is *galena*. This being smelted, yields *lead*.

Were we to admit the existence of an ore composed of lead and silver, it is obvious that no such products could be obtained by simply smelting it.

Cassiteros, or tin, is mentioned by Homer; and, from the way in which the metal is said by him to have been used, it is obvious that in his time it bore a much higher price, and, consequently, was more valued than at present. In his description of the breastplate of Agamemnon, he says that it contained ten bands of steel, twelve of gold, and twenty of tin 69
(κασσιτεροιο).[57] And in the twenty-third book of the Iliad (line 561), Achilles describes a copper breastplate surrounded with shining tin (φαεινου κασσιτεροιο). Pliny informs us, that in his time tin was adulterated by adding to it about one-third of white copper. A pound of tin, when Pliny lived, cost ten denarii. Now, if we reckon a denarius at 7¾*d.*, with Dr. Arbuthnot, this would make a Roman pound of tin to cost 6*s.* 5½*d.* But, as the Roman pound was only equal to three-fourths of our avoirdupois pound, it is plain that in the time of Pliny an avoirdupois pound of tin was worth 8*s.* 7¼*d.*, which is almost seven times the price of tin in the present day.

Tin, in the time of Pliny, was used for covering the inside of copper vessels, as it is at this day. And, no doubt, the process still followed is of the same nature as the process used by the ancients for tinning copper. Pliny remarks, with surprise, that copper thus tinned does not increase in weight. Now Bayen ascertained that a copper pan, nine inches in diameter, and three inches three lines in depth, when tinned, only acquired an additional weight of twenty-one grains. These measures and weights are French. When we convert them into English, we have a copper pan 9·59 inches in diameter, and 3·46 inches deep, which, when tinned, increased in weight 17·23 troy grains. Now the surface of the copper pan, thus tinned, was 176·468 square inches. Hence it follows, that a square inch of copper, when tinned, increases in weight only 0·097 grains. This increase is so small, that we may excuse Pliny, who probably had never seen the increase of weight determined, except by means of a rude Roman statera, for concluding that there was no increase of weight whatever.

Tin was employed by the ancients for mirrors: but mirrors of silver were gradually 70
substituted; and these in Pliny's time had become so common, that they were even employed by female servants or slaves.

That Pliny's knowledge of the properties of tin was very limited, and far from accurate, is obvious from his assertion that *tin* is less fusible than silver.[58] It is true that the ancients had no measure to determine the different degrees of heat; but as tin melts at a heat under redness, while silver requires a bright red heat to bring it into fusion, a single comparative trial would have shown him which was most fusible. This trial, it is obvious, had never been made by him.

The ancients seem to have been ignorant of the method of tinning iron. At least, no reference to *tin plate* is made by Pliny, or by any other ancient author, that I have had an opportunity of consulting.

It would appear from Pliny, that both copper and brass were tinned by the Gauls at an early period. Tinned brass was called *æra coctilia*, and was so beautiful that it almost passed for silver. *Plating* (or covering the metal with plates of silver), was gradually substituted for tinning; and finally *gilding* took the place of plating. The trappings of horses, chariots, &c., were thus ornamented. Pliny nowhere gives a description of the process of plating; but there can be little doubt that it was similar to that at present practised. Gilding was accomplished by laying an amalgam of gold on the copper or brass, as at present.

7. Lead appears also to have been in common use among the Egyptians, at the time of Moses.[59] It was distinguished among the Romans by the name of *plumbum nigrum*. In Pliny's time the lead-mines existed chiefly in Spain and Britain. In Britain lead was so 71
abundant, that it was prohibited to extract above a certain quantity in a year. The mines lay on the surface of the earth. Derbyshire was the county in which lead ores were chiefly wrought by the Romans. The rich mines in the north of England seem to have been unknown to them.

Pliny was of opinion that if a lead-mine, after being exhausted, be shut up for some time, the ore will be again renewed.

In the time of Pliny leaden pipes were commonly used for conveying water. The vulgar notion that the ancients did not know that water will always rise in pipes as high as the source from which it proceeds, and that it was this ignorance which led to the formation of aqueducts, is quite unfounded. Nobody can read Pliny without seeing that this important fact was well known in his time.

Sheet lead was also used in the time of Pliny, and applied to the same purposes as at present. But lead was much higher priced among the ancients than it is at present. Pliny informs us that its price was to that of tin as 7 to 10. Hence it must have sold at the rate of 6*s.* 0¼*d.* per pound. The present price of lead does not much exceed three halfpence the pound. It is therefore only 1-48th part of the price which it bore in the time of Pliny. This difference must be chiefly owing to the improvements made by the moderns in working the mines and smelting the ores of lead.

Tin, in Pliny's time, was used as a solder for lead. For this purpose it is well adapted, as it is so much easier smelted than lead. But when he says that lead is used also as a solder for tin, his meaning is not so clear. Probably he means an alloy of lead and tin, which, fusing at a lower point than tin, may be used to solder that metal. The addition of some bismuth reduces the fusing point materially; but that metal was unknown to the ancients. 72

Argentarium is an alloy of equal parts of lead and tin. *Tertiarium*, of two parts lead and one part tin. It was used as a solder.

Some preparations of lead were used by the ancients in medicine, as we know from the description of them given us by Dioscorides and Pliny. These preparations consisted chiefly of protoxide of lead and lead reduced to powder, and partially oxidized by triturating it with water in a mortar. They were applied to ulcers, and employed externally as astringents.

Molybdena was also employed in medicine. Pliny says it was the same as galena. From his description it is obvious that it was *litharge*; for it was in scales, and was more valued the nearer its colour approached to that of gold. It was employed, as it still is, for making plasters. Pliny gives us the process for making the plaster employed by the Roman surgeons. It was made by heating together

3lbs. molybdena or litharge,
1lb. wax,
3heminæ, or 1½ pint, of olive oil.

This process is very nearly the same as the one at present followed by apothecaries for making adhesive plaster.

Psimmythium, or *cerussa*, was the same as our *white lead*. It was made by exposing lead in sheets to the fumes of vinegar. It would seem probable from Pliny's account, though it is confused and inaccurate, that the ancients were in the habit of dissolving cerussa in vinegar, and thus making an impure acetate of lead.

Cerussa was used in medicine. It constituted also a common white paint. At one time, Pliny says, it was found native; but in his time all that was used was prepared artificially.

Cerussa usta seems to have been nearly the same as our *red lead*. It was formed accidentally from cerussa during the burning of the Pyræus. The colour was purple. It was imitated at Rome by burning *silis marmarosus*, which was probably a variety of some of our 73
ochres.

8. Besides the metals above enumerated, the ancients were also acquainted with quicksilver. Nothing is known about the first discovery of this metal; though it obviously precedes the commencement of history. I am not aware that the term occurs in the writings of Moses. We have therefore no evidence that it was known to the Egyptians at that early period; nor do I find any allusion to it in the works of Herodotus. But this is not surprising, as that author confines himself chiefly to subjects connected with history. Dioscorides and Pliny both mention it as common in their time. Dioscorides gives a method of obtaining it by sublimation from cinnabar. It is remarkable, because it constitutes the first example of a process which ultimately led to distillation.[60]

Cinnabar is also described by Theophrastus. The term *minium* was applied to it also, till in consequence of the adulteration of cinnabar with *red lead*, the term minium came at last to be restricted to that preparation of lead. Theophrastus describes an artificial cinnabar, which came from the country above Ephesus. It was a shining red-coloured sand, which was collected and reduced to a fine powder by pounding it in vessels of stone. We do not know what it was. The native cinnabar was found in Spain, and was used chiefly as a paint. Dioscorides employs *minium* as the name for what we at present call cinnabar, or bisulphuret of mercury. His cinnabar was a red paint from Africa, produced in such small quantity that painters could scarcely procure enough of it to answer their purposes.

Mercury is described by Pliny as existing native in the mines of Spain, and Dioscorides
gives the process for extracting it from cinnabar. It was employed in gilding precisely as it 74
is by the moderns. Pliny was aware of its great specific gravity, and of the readiness with which it dissolves gold. The amalgam was squeezed through leather, which separated most of the quicksilver. When the solid amalgam remaining was heated, the mercury was driven off and pure gold remained.

It is obvious from what Dioscorides says, that the properties of mercury were very imperfectly known to him. He says that it may be kept in vessels of glass, or of lead, or of tin, or of silver.[61] Now it is well known that it dissolves lead, tin, and silver with so much rapidity, that vessels of these metals, were mercury put into them, would be speedily destroyed. Pliny's account of quicksilver is rather obscure. It seems doubtful whether he was aware that native *argentum vivum* and the *hydrargyrum* extracted from cinnabar were the same.

Cinnabar was occasionally used as an external medicine; but Pliny disapproves of it, assuring his readers that quicksilver and all its preparations are virulent poisons. No other mercurial preparations except cinnabar and the amalgam of mercury seem to have been known to the ancients.[62]

9. The ancients were unacquainted with the metal to which we at present give the name of *antimony*; but several of the ores of that metal, and of the products of these ores were not altogether unknown to them. From the account of stimmi and stibium, by Dioscorides[63] and Pliny,[64] there can be little doubt that these names were applied to the mineral now called

sulphuret of antimony or crude antimony. It is found most commonly, Pliny says, among the ores of silver, and consists of two kinds, the male and the female; the latter of which is most valued. 75

This pigment was known at a very early period, and employed by the Asiatic ladies in painting their eyelashes, or rather the insides of their eyelashes, black. Thus it is said of Jezebel, that when Jehu came to Jezreel she painted her face. The original is, *she put her eyes in sulphuret of antimony*.[65] A similar expression occurs in Ezekiel, "For whom thou didst wash thyself, paintedst thy eyes"—literally, put thy eyes in sulphuret of antimony.[66] This custom of painting the eyes black with antimony was transferred from Asia to Greece, and while the Moors occupied Spain it was employed by the Spanish ladies also. It is curious that the term *alcohol*, at present confined to *spirit of wine*, was originally applied to the powder of sulphuret of antimony.[67] The ancients were in the habit of roasting sulphuret of antimony, and thus converting it into an impure oxide. This preparation was also called stimmi and stibium. It was employed in medicine as an external application, and was conceived to act chiefly as an astringent; Dioscorides describes the method of preparing it. We see, from Pliny's account of stibium, that he did not distinguish between sulphuret of antimony and oxide of antimony.[68]

9. Some of the compounds of arsenic were also known to the ancients; though they were neither acquainted with this substance in the metallic state, nor with its oxide; the nature of which is so violent that had it been known to them it could not have been omitted by Dioscorides and Pliny. 76

The word σανδαραχη (*sandarache*) occurs in Aristotle, and the term αρῥενιχον (*arrhenichon*) in Theophrastus.[69] Dioscorides uses likewise the same name with Aristotle. It was applied to a scarlet-coloured mineral, which occurs native, and is now known by the name of *realgar*. It is a compound of arsenic and sulphur. It was employed in medicine both externally and internally, and is recommended by Dioscorides, as an excellent remedy for an inveterate cough.

Auripigmentum and *arsenicum* were names given to the native yellow sulphuret of arsenic. It was used in the same way, and considered by Dioscorides and Pliny as of the same nature with realgar. But there is no reason for supposing that the ancients were acquainted with the compositions of either of these bodies; far less that they had any suspicion of the existence of the metal to which we at present give the name of arsenic.

Such is a sketch of the facts known to the ancients respecting metals. They knew the six malleable metals which are still in common use, and applied them to most of the purposes to which the moderns apply them. Scarcely any information has been left us of the methods employed by them to reduce these metals from their ores. But unless the ores were of a much simpler nature than the modern ores of these metals, of which we have no evidence, the smelting processes with which the ancients were familiar, could scarcely have been contrived without a knowledge of the substances united with the different metals in their ores, and of the means by which these foreign bodies could be separated, and the metals isolated from all impurities. This doubtless implied a certain quantity of chemical knowledge, which having been handed down to the moderns, served as a foundation upon which the modern science of chemistry was gradually reared: at the same time it will be 77 admitted that this foundation was very slender, and would of itself have led to little. Most of the oxides, sulphurets, &c., and almost all the salts into which these metallic bodies enter, were unknown to the ancients.

Besides the working in metals there were some other branches of industry practised by the ancients, so intimately connected with chemical science, that it would be improper to pass them over in silence. The most important of these are the following:

II.—COLOURS USED BY PAINTERS.

It is well known that the ancient Grecian artists carried the art of painting to the highest degree of perfection, and that their paintings were admired and sought after by the most eminent and accomplished men of antiquity; and Pliny gives us a catalogue of a great number of first-rate pictures, and a historical account of a vast many celebrated painters of antiquity. In his own time, he says, the art of painting had lost its importance, statues and tablets having came in place of pictures.

Two kinds of colours were employed by the ancients; namely, the florid and the austere. The florid colours, as enumerated by Pliny, were *minium*, *armenium*, *cinnaberis*, *chrysocolla*, *purpurissum*, and *indicum purpurissum*.

The word *minium* as used by Pliny means *red lead*; though Dioscorides employs it for bisulphuret of mercury or cinnabar.

Armenium was obviously an ochre, probably of a yellow or orange colour.

Cinnaberis was bisulphuret of mercury, which is known to have a scarlet colour. Dioscorides employs it to denote a vegetable red colour, probably similar to the resin at present called *dragon's blood*.

Chrysocolla was a green-coloured paint, and from Pliny's description of it, could have 78
been nothing else than carbonate of copper or malachite.

Purpurissum was a *lake*, as is obvious from the account of its formation given by Pliny. The colouring matter is not specified, but from the term used there can be little doubt that it was the liquor from the shellfish that yielded the celebrated purple dye of the Tyrians.

Indicum purpurissum was probably *indigo*. This might be implied from the account of it given by Pliny.

The austere colours used by the ancient painters were of two kinds, native and artificial. The native were *sinopis*, *rubrica*, *parætonium*, *melinum*, *eretria*, *auripigmentum*. The artificial were, *ochra*, *cerussa usta*, *sandaracha*, *sandyx*, *syricum*, *atramentum*.

Sinopis is the red substance now known by the name of reddle, and used for marking. On that account it is sometimes called *red chalk*. It was found in Pontus, in the Balearian islands, and in Egypt. The price was three denarii, or 1*s.* 11¼*d.* the pound weight. The most famous variety of *sinopis* was from the isle of Lemnos; it was sold sealed and stamped: hence it was called *sphragis*. It was employed to adulterate minium. In medicine it was used to appease inflammation, and as an antidote to poison.

Ochre is merely sinopis heated in a covered vessel. The higher the temperature to which it has been exposed the better it is.

Leucophorum is a compound of

6 lbs. sinopis of Pontus,
10 lbs. siris,
2 lbs. melinum,

triturated together for thirty days. It was used to make gold adhere to wood.

Rubrica from the name, was probably a red ochre.

Parætonium was a white colour, so called from a place in Egypt, where it was found. It was obtained also in the island of Crete, and in Cyrene. It was said to be a combination of the froth of the sea consolidated with mud. It consisted probably of carbonate of lime. Six pounds of it cost only one denarius. 79

Melinum was also a white-coloured powder found in Melos and Samos in veins. It was most probably a carbonate of lime.

Eretria was named from the place where it was found. Pliny gives its medical properties, but does not inform us of its colour. It is impossible to say what it was.

Auripigmentum was yellow sulphuret of arsenic. It was probably but little used as a pigment by the ancient painters.

Cerussa usta was red lead.

Sandaracha was red sulphuret of arsenic. The pound of sandaracha cost 5 as.: it was imitated by red lead. Both it and *ochra* were found in the island Topazos in the Red Sea.

Sandyx was made by torrefying equal parts of true sandaracha and sinopis. It cost half the price of sandaracha. Virgil mistook this pigment for a plant, as is obvious from the following line:

Sponte sua sandix, pascentes vestiet agnos.[70]

Siricum is made by mixing sinopis and sandyx.

Atramentum was obviously from Pliny's account of it *lamp-black*. He mentions ivory-black as an invention of Apelles: it was called *elephantinum*. There was a native atramentum, which had the colour of sulphur, and got a black colour artificially. It is not unlikely that it contained sulphate of iron, and that it got its black colour from the admixture of some astringent substance. 80

The ink of the ancients was lamp-black mixed with water, containing gum or glue dissolved in it. *Atramentum indicum* was the same as our *China ink*.

The *purpurissum* was a high-priced pigment. It was made by putting *creta argentaria* (a species of white clay) into the caldrons containing the ingredients for dying purple. The creta imbibed the purple colour and became *purpurissum*. The first portion of *creta* put in constituted the finest and highest-priced pigment. The portions put in afterwards became successively worse, and were, of consequence lower priced. We see, from this description, that it was a lake similar to our modern cochineal lakes.[71]

That the purpurissum indicum was indigo is obvious from the statement of Pliny, that when thrown upon hot coals it gives out a beautiful purple flame. This constitutes the character of indigo. Its price in Pliny's time was ten denarii, or six shillings and five-pence halfpenny the Roman pound; which is equivalent to 8*s.* 7⅓*d.* the avoirdupois.

Though few or none of the ancient pictures have been preserved, yet several specimens of the colours used by them still remain in Rome and in the ruins of Herculaneum. Among others the fresco paintings, in the baths of Titus, still remain; and as these were made for a Roman emperor, we might expect to find the most beautiful and costly colours employed in them. These paints, and some others, were examined by Sir Humphrey Davy, in 1813, while he was in Rome. From his researches we derive some pretty accurate information respecting the colours employed by the painters of Greece and Rome.

1. *Red paints.* Three different kinds of red were found in a chamber opened in 1811, in the baths of Titus, namely, a bright orange red, a dull red, and a brown red. The bright orange red was *minium*, or *red lead*; the other two were merely two varieties of iron ochres. 81
Another still brighter red was observed on the walls; it proved, on examination, to be *vermilion* or *cinnabar*.

2. *Yellow paints.* All the *yellows* examined by Davy proved to be *iron ochres*, sometimes mixed with a little *red lead*. Orpiment was undoubtedly employed, as is obvious from what Pliny says on the subject: but Davy found no traces of it among the yellow colours which he examined. A very deep yellow, approaching orange, which covered a piece of stucco in the ruins near the monument of Caius Cestius, proved to be protoxide of lead, or massicot, mixed with some red lead. The yellows in the Aldobrandini pictures were all ochres, and so were those in the pictures on the walls of the houses at Pompeii.

3. *Blue paints.* Different shades of blues are used in the different apartments of the baths of Titus, which are darker or lighter, as they contain more or less carbonate of lime with which the blue pigment had been mixed by the painter. This blue pigment turned out, on examination, to be a frit composed of alkali and silica, fused together with a certain quantity of oxide of copper. This was the colour called χυανος (*kyanos*) by the Greeks, and *cæruleum* by the Romans. Vitruvius gives the method of preparing it by heating strongly together sand, carbonate of soda, and filings of copper. Davy found that fifteen parts by weight of anhydrous carbonate of soda, twenty parts of powdered opaque flints, and three parts of copper filings, strongly heated together for two hours, gave a substance exactly similar to the blue pigment of the ancients, and which, when powdered, produced a fine deep blue colour. This cæruleum has the advantage of remaining unaltered even when the painting is exposed to the actions of the air and sun.

There is reason to suspect, from what Vitruvius and Pliny say, that glass rendered blue
by means of cobalt constituted the basis of some of the blue pigments of the ancients; but all 82
those examined by Davy consisted of glass tinged blue by copper, without any trace of cobalt whatever.

4. *Green paints.* All the green paints examined by Davy proved to be carbonates of copper, more or less mixed with carbonate of lime. I have already mentioned that verdigris was known to the ancients. It was no doubt employed by them as a pigment, though it is not probable that the acetic acid would be able to withstand the action of the atmosphere for a couple of thousand years.

5. *Purple paints.* Davy ascertained that the colouring matter of the ancient purple was combustible. It did not give out the smell of ammonia, at least perceptibly. There is little doubt that it was the *purpurissum* of the ancients, or a clay coloured by means of the purple of the buccinum employed by the Syrians in the celebrated purple dye.

6. *Black and brown paints.* The black paints were lamp-black: the browns were some of them ochres and some of them oxides of manganese.

7. *White paints.* All the ancient white paints examined by Davy were carbonates of lime.[72] We know from Pliny that white lead was employed by the ancients as a pigment; but it might probably become altered in its nature by long-continued exposure to the weather.

III.—GLASS.

It is admitted by some that the word which in our English Bible is translated crystal, means glass, in the following passage of Job: "The gold and the crystal cannot equal it."[73] Now although the exact time when Job was written is not known, it is admitted on all hands to be one of the oldest of the books contained in the Old Testament. There are strong 83 reasons for believing that it existed before the time of Moses; and some go so far as to affirm that there are several allusions to it in the writings of Moses. If therefore glass were known when the Book of Job was written, it is obvious that the discovery of it preceded the commencement of history. But even though the word used in Job should not refer to glass, there can be no doubt that it was known at a very early period; for glass beads are frequently found on the Egyptian mummies, and they are known to have been embalmed at a very remote period. The first Greek author who uses the word glass (ὑαλος, *hyalos*) is Aristophanes. In his comedy of The Clouds, act ii. scene 1, in the ridiculous dialogue between Socrates and Strepsiades, the latter announces a method which had occurred to him to pay his debts. "You know," says he, "the beautiful transparent stone used for kindling fire." "Do you mean glass (τον ὕαλον, *ton hyalon*)?" replied Socrates. "I do," was the answer. He then describes how he would destroy the writings by means of it, and thus defraud his creditors. Now this comedy was acted about four hundred and twenty-three years before the beginning of the Christian era. The story related by Pliny, respecting the discovery of this beautiful and important substance, is well known. Some Phœnician merchants, in a ship loaded with carbonate of soda from Egypt, stopped, and went ashore on the banks of the river Belus: having nothing to support their kettles while they were dressing their food, they employed lumps of carbonate of soda for that purpose. The fire was strong enough to fuse some of this soda, and to unite it with the fine sand of the river Belus: the consequence of this was the formation of glass.[74] Whether this story be entitled to credit or not, it is clear that the discovery must have originated in some such accident. 84 Pliny's account of the manufacture of glass, like his account of every other manufacture, is very imperfect: but we see from it that in his time they were in the habit of making coloured glasses; that colourless glasses were most highly prized, and that glass was rendered colourless then as it is at present, by the addition of a certain quantity of oxide of manganese. Colourless glass was very high priced in Pliny's time. He relates, that for two moderate-sized colourless drinking-glasses the Emperor Nero paid 6000 sistertii, which is equivalent to 25*l.* of our money.

Pliny relates the story of the man who brought a vessel of malleable glass to the Emperor Tiberius, and who, after dimpling it by dashing it against the floor, restored it to its original shape and beauty by means of a hammer; Tiberius, as a reward for this important discovery, ordered the artist to be executed, in order, as he alleged, to prevent gold and silver from becoming useless. But though Pliny relates this story, it is evident that he does not give credit to it; nor does it deserve credit. We can assign no reason why malleable substances may not be transparent; but all of them hitherto known are opaque. Chloride of silver, chloride of lead and iron constitute no exception, for they are not malleable, though by peculiar contrivances they may be extended; and their transparency is very imperfect.

Many specimens of the coloured glasses made by the ancients still remain, particularly the beads employed as ornaments to the Egyptian mummies. Of these ancient glasses several have been examined chemically by Klaproth, Hatchett, and some other individuals, in order to ascertain the substances employed to give colour to the glass. The following are the facts that have been ascertained:

1. *Red glass.* This glass was opaque, and of a lively copper-red colour. It was probably 85 the kind of red glass to which Pliny gave the name of hæmatinon. Klaproth analyzed it, and

obtained from 100 grains of it the following constituents:

Silica	71·0
Oxide of lead	10·0
Oxide of copper	7·5
Oxide of iron	1·0
Alumina	2·5
Lime	1·5
	93·5[75]

No doubt the deficiency was owing to the presence of an alkali. From this analysis we see that the colouring matter of this glass was *red oxide of copper*.

2. *Green glass.* The colour was light verdigris-green, and the glass, like the preceding, was opaque. The constituents from 100 grains were,

Silica	65·0
Black oxide of copper	10·0
Oxide of lead	7·5
Oxide of iron	3·5
Lime	6·5
Alumina	5·5
	98·0[76]

Thus it appears that both the red and green glass are composed of the same ingredients, though in different proportions. Both owe their colour to copper. The red glass is coloured by the red oxide of that metal; the green by the black oxide, which forms green-coloured compounds, with various acids, particularly with carbonic acid and with silica.

3. *Blue glass.* The variety analyzed by Klaproth had a sapphire-blue colour, and was only translucent on the edges. The constituents from 100 grains of it were, 86

Silica	81·50
Oxide of iron	9·50
Alumina	1·50
Oxide of copper	0·50
Lime	0·25
	93·25[77]

From this analysis it appears that the colouring matter of this glass was oxide of iron: it was therefore analogous to the lapis lazuli, or ultramarine, in its nature.

Davy, as has been formerly noticed, found another blue glass, or frit, coloured by means of copper; and he showed that the blue paint of the ancients was often made from this glass, simply by grinding it to powder.

Klaproth could find no cobalt in the blue glass which he examined; but Davy found the transparent blue glass vessels, which are along with the vases, in the tombs of Magna Græcia, tinged with cobalt; and he found cobalt in all the transparent ancient blue glasses with which Mr. Millingen supplied him. The mere fusion of these glasses with alkali, and subsequent digestion of the product with muriatic acid, was sufficient to produce a sympathetic ink from them.[78] The transparent blue beads which occasionally adorn the Egyptian mummies have also been examined, and found coloured by cobalt. The opaque glass beads are all tinged by means of oxide of copper. It is probable from this that all the transparent blue glasses of the ancients were coloured by cobalt; yet we find no allusion to cobalt in any of the ancient authors. Theophrastus says that copper (χαλκος, *chalcos*) was used to give glass a fine colour. Is it not likely that the impure oxide of cobalt, in the state in which they used it, was confounded by them with χαλκος (*chalcos*)? 87

IV.—VASA MURRHINA.

The Romans obtained from the east, and particularly from Egypt, a set of vessels which they distinguished by the name of *vasa murrhina*, and which were held by them in very high estimation. They were never larger than to be capable of containing from about thirty-six to forty cubic inches. One of the largest size cost, in the time of Pliny, about 7000*l.* Nero actually gave for one 3000*l.* They began to be known in Rome about the latter days of the republic. The first six ever seen in Rome were sent by Pompey from the treasures of Mithridates. They were deposited in the temple of Jupiter in the capitol. Augustus, after the battle of Actium, brought one of these vessels from Egypt, and dedicated it also to the gods. In Nero's time they began to be used by private persons; and were so much coveted that Petronius, the favourite of that tyrant, being ordered for execution, and conceiving that his death was owing to a wish of Nero to get possession of a vessel of this kind which he had, broke the vessel in pieces in order to prevent Nero from gaining his object.

There appear to have been two kinds of these vasa murrhina; those that came from Asia, and those that were made in Egypt. The latter were much more common, and much lower priced than the former, as appears from various passages in Martial and Propertius.

Many attempts have been made, and much learning displayed by the moderns to determine the nature of these celebrated vessels; but in general these attempts were made by individuals too little acquainted with chemistry and with natural history in general to qualify them for researches of so difficult a nature. Some will have it that they consisted of a kind of gum; others that they were made of glass; others, of a particular kind of shell. Cardan and 88
Scaliger assure us that they were *porcelain* vessels; and this opinion was adopted likewise by Whitaker, who supported it with his usual violence and arrogance. Many conceive them to have been made of some precious stone, some that they were of *obsidian*; Count de Veltheim thinks that they were made of the Chinese *agalmatolite*, or *figure stone*; and Dr. Hager conceives that they were made from the Chinese stone *yu*. Bruckmann was of opinion that these vessels were made of sardonyx, and the Abbé Winckelmann joins him in the same conclusion.

Pliny informs us that these vasa murrhina were formed from a species of stone dug out of the earth in Parthia, and especially in Carimania, and also in other places but little known.[79] They must have been very abundant at Rome in the time of Nero; for Pliny informs us that a man of consular rank, famous for his collection of vasa murrhina, having died, Nero forcibly deprived his children of these vessels, and they were so numerous that they filled the whole inside of a theatre, which Nero hoped to have seen filled with Romans when he came to it to sing in public.

It is clear that the value of these vessels depended on their size. Small vessels bore but a small price, while that of large vessels was very high; this shows us that it must have been difficult to procure a block of the stone out of which they were cut, of a size sufficiently great to make a large vessel.

These vessels were so soft that an impression might be made upon them with the teeth; for Pliny relates the story of a man of consular rank, who drank out of one, and was so enamoured with it that he bit pieces out of the lip of the cup: "Potavit ex eo ante hos annos consularis, ob amorem abraso ejus margine." And what is singular, the value of the cup, so 89 far from being injured by this abrasure, was augmented: "ut tamen injuria ilia pretium augeret; neque est hodie murrhini alterius præstantior indicatura."[80] It is clear from this that the matter of these vessels was neither rock crystal, agate, nor any precious stone whatever, all of which are too hard to admit of an impression from the teeth of a man.

The lustre was vitreous to such a degree that the name *vitrum murrhinum* was given to the artificial fabric, in Egypt.

The splendour was not very great, for Pliny observes, "Splendor his sine viribus nitorque verius quam splendor."

The colours, from their depth and richness, were what gave these vessels their value and excited admiration. The principal colours were purple and white, disposed in undulating bands, and usually separated by a third band, in which the two colours being mixed, assumed the tint of flame: "Sed in pretio varietas colorum, subinde circumagentibus se maculis in purpuram candoremque, et tertium ex utroque ignescentem, velut per transitum coloris, purpura rubescente, aut lacte candescente."

Perfect transparency was considered as a defect, they were merely translucent; this we learn not merely from Pliny, but from the following epigram of Martial:

> Nos bibimus vitro, tu murra, Pontice: quare?
> Prodat perspicuus ne duo vina calix.

Some specimens, and they were the most valued, exhibited a play of colour like the rainbow: Pliny says they were very commonly spotted with "sales, verrucæque non eminentes, sed ut in corpore etiam plerumque sessiles." This, no doubt, refers to foreign bodies, such as grains of pyrites, antimony, galena, &c., which were often scattered through 90 the substances of which the vessels were made.

Such are all the facts respecting the vasa murrhina to be found in the writings of the ancients; they all apply to fluor spar, and to nothing else; but to it they apply so accurately as to leave little doubt that they were in reality vessels of fluor spar, similar to those at present made in Derbyshire.[81]

The artificial vasa murrhina made at Thebes, in Egypt, were doubtless of glass, coloured to imitate fluor spar as much as possible, and having the semi-transparency which distinguishes that mineral. The imitations being imperfect, these factitious vessels were not much prized nor sought after by the Romans, they were rather distributed among the Arabians and Ethiopians, who were supplied with glass from Egypt.

Rock crystal is compared by Pliny with the stone from which the vasa murrhina were made; the former, in his opinion, had been coagulated by cold, the latter by heat. Though the ancients, as we have seen, were acquainted with the method of colouring glass, yet they prized colourless glass highest on account of its resemblance to rock crystal; cups of it, in Pliny's time, had supplanted those of silver and gold; Nero gave for a crystal cup 150,000 sistertii, or 625*l.*

V.—DYEING AND CALICO-PRINTING.

Very little has been handed down by the ancients respecting the processes of dyeing. It is evident, from Pliny, that they were acquainted with madder, and that preparations of iron were used in the black dyes. The most celebrated dye of all, the *purple*, was discovered by 91
the Tyrians about fifteen centuries before the Christian era. This colour was given by various kinds of shellfish which inhabit the Mediterranean. Pliny divides them into two genera; the first, comprehending the smaller species, he called *buccinum*, from their resemblance to a hunting-horn; the second, included those called *purpura*: Fabius Columna thinks that these were distinguished also by the name of *murex*.

These shellfish yielded liquor of different shades of colour; they were often mixed in various proportions to produce particular shades of colour. One, or at most two drops of this liquor were obtained from each fish, by extracting and opening a little reservoir placed in the throat. To avoid this trouble, the smaller species were generally bruised whole, in a mortar; this was also frequently done with the large, though the other liquids of the fish must have in some degree injured the colour. The liquor, when extracted, was mixed with a considerable quantity of salt to keep it from putrifying; it was then diluted with five or six times as much water, and kept moderately hot in leaden or tin vessels, for eight or ten days, during which the liquor was often skimmed to separate all the impurities. After this, the wool to be dyed, being first well washed, was immersed and kept therein for five hours; then taken out, cooled, and again immersed, and continued in the liquor till all the colour was exhausted.[82]

To produce particular shades of colour, carbonate of soda, urine, and a marine plant called *fucus*, were occasionally added: one of these colours was a very dark reddish violet —“Nigrantis rosæ colore sublucens.”[83] But the most esteemed, and that in which the Tyrians particularly excelled, resembled coagulated blood—“laus ei summa in colore 92
sanguinis concreti, nigricans aspectu, idemque suspectu refulgens.”[84]

Pliny says that the Tyrians first dyed their wool in the liquor of the purpura, and afterwards in that of the buccinum; and it is obvious from Moses that this purple was known to the Egyptians in his time.[85] Wool which had received this double Tyrian dye (*dia bapha*) was so very costly that, in the reign of Augustus, it sold for about 36*l.* the pound. But lest this should not be sufficient to exclude all from the use of it but those invested with the very highest dignities of the state, laws were made inflicting severe penalties, and even death, upon all who should presume to wear it under the dignity of an emperor. The art of dyeing this colour came at length to be practised by a few individuals only, appointed by the emperors, and having been interrupted about the beginning of the twelfth century all knowledge of it died away, and during several ages this celebrated dye was considered and lamented as an irrecoverable loss.[86] How it was afterwards recovered and made known by Mr. Cole, of Bristol, M. Jussieu, M. Reaumur, and M. Duhamel, would lead us too far from our present object, were we to relate it: those who are interested in the subject will find an historical detail in Bancroft’s work on Permanent Colours, just referred to.

There is reason to suspect that the Hebrew word translated *fine linen* in the Old Testament, and so celebrated as a production of Egypt, was in reality *cotton*, and not linen. From a curious passage in Pliny, there is reason to believe that the Egyptians in his time, and probably long before, were acquainted with the method of calico-printing, such as is still practised in India and the east. The following is a literal translation of the passage in 93
question:

“There exists in Egypt a wonderful method of dyeing. The white cloth is stained in various places, not with dye stuffs, but with substances which have the property of absorbing (*fixing*) colours, these applications are not visible upon the cloth; but when they are dipped into a hot caldron of the dye they are drawn out an instant after dyed. The remarkable circumstance is, that though there be only one dye in the vat, yet different colours appear upon the cloth; nor can the colour be afterwards removed."[87]

It is evident enough that these substances applied were different mordants which served to fix the dye upon the cloth; the nature of these mordants cannot be discovered, as nothing specific seems to have been known to Pliny. The modern mordants are solutions of alumina; of the oxide of tin, oxide of iron, oxide of lead, &c.: and doubtless these, or something equivalent to these, were the substances employed by the ancients. The purple dye required no mordant, it fixed itself to the cloth in consequence of the chemical affinity which existed between them. Whether indigo was used by the ancients as a dye does not appear, but there can be no doubt, at least, that its use was known to the Indians at a very remote period.

From these facts, few as they are, there can be little doubt that dyeing, and even calico-printing, had made considerable progress among the ancients; and this could not have taken place without a considerable knowledge of colouring matters, and of the mordants by which these colouring matters were fixed. These facts, however, were probably but imperfectly understood, and could not be the means of furnishing the ancients with any accurate chemical knowledge. 94

VI.—SOAP.

Soap, which constitutes so important and indispensable an article in the domestic economy of the moderns, was quite unknown to the ancient inhabitants of Asia, and even of Greece. No allusion to it occurs in the Old Testament. In Homer, we find Nausicaa, the daughter of the King of the Phæacians, using nothing but water to wash her nuptial garments:

> They seek the cisterns where Phæacian dames
> Wash their fair garments in the limped streams;
> Where gathering into depth from falling rills,
> The lucid wave a spacious bason fills.
> The mules unharness'd range beside the main,
> Or crop the verdant herbage of the plain.
> Then emulous the royal robes they lave,
> And plunge the vestures in the cleansing wave.
> *Odyssey*, vi. 1. 99.

We find, in some of the comic poets, that the Greeks were in the habit of adding wood-ashes to water to make it a better detergent. Wood-ashes contain a certain portion of carbonate of potash, which of course would answer as a detergent; though, from its caustic qualities, it would be injurious to the hands of the washerwomen. There is no evidence that carbonate of soda, the *nitrum* of the ancients, was ever used as a detergent; this is the more surprising, because we know from Pliny that it was employed in dyeing, and one cannot see how a solution of it could be employed by the dyers in their processes without discovering that it acted powerfully as a detergent.

The word *soap* (*sapo*) occurs first in Pliny. He informs us that it was an invention of the Gauls, who employed it to render their hair shining; that it was a compound of wood-ashes and tallow, that there were two kinds of it, *hard* and *soft* (*spissus et liquidus*); and that

the best kind was made of the ashes of the beech and the fat of goats. Among the Germans it 95
was more employed by the men than the women.[88] It is curious that no allusion whatever is made by Pliny to the use of soap as a detergent; shall we conclude from this that the most important of all the uses of soap was unknown to the ancients?

It was employed by the ancients as a pomatum; and, during the early part of the government of the emperors, it was imported into Rome from Germany, as a pomatum for the young Roman beaus. Beckmann is of opinion that the Latin word *sapo* is derived from the old German word *sepe*, a word still employed by the common people of Scotland.[89]

It is well known that the state of soap depends upon the alkali employed in making it. *Soda* constitutes a *hard* soap, and *potash* a *soft* soap. The ancients being ignorant of the difference between the two alkalies, and using wood-ashes in the preparation of it, doubtless formed soft soap. The addition of some common salt, during the boiling of the soap, would convert the soft into hard soap. As Pliny informs us that the ancients were acquainted both with hard and soft soap, it is clear that they must have followed some such process.

VII.—STARCH.

The manufacture of starch was known to the ancients. Pliny informs us that it was made from wheat and from *siligo*, which was probably a variety or sub-species of wheat. The invention of starch is ascribed by Pliny to the inhabitants of the island of Chio, where in his time the best starch was still made. Pliny's description of the method employed by the
ancients of making starch is tolerably exact. Next to the China starch that of Crete was most 96
celebrated; and next to it was the Egyptian. The qualities of starch were judged of by the weight; the lightest being always reckoned the best.

VIII.—BEER.

That the ancients were acquainted with wine is universally known. This knowledge must have been nearly coeval with the origin of society; for we are informed in Genesis that Noah, after the flood, planted a vineyard, and made wine, and got intoxicated by drinking the liquid which he had manufactured.[90] Beer also is a very old manufacture. It was in common use among the Egyptians in the time of Herodotus, who informs us that they made use of a kind of wine made from barley, because no vines grew in their country.[91] Tacitus informs us, that in his time it was the drink of the Germans.[92] Pliny informs us that it was made by the Gauls, and by other nations. He gives it the name of *cerevisia* or *cervisia*; the name obviously alluding to the grain from which it was made.

But though the ancients seem acquainted with both wine and beer, there is no evidence of their having ever subjected these liquids to distillation, and of having collected the products. This would have furnished them with ardent spirits or alcohol, of which there is every reason to believe they were entirely ignorant. Indeed, the method employed by Dioscorides to obtain mercury from cinnabar, is a sufficient proof that the true process of
distillation was unknown to them. He mixed cinnabar with iron filings, put the mixture into 97
a pot, to the top of which a cover of stoneware was luted. Heat was applied to the pot, and when the process was at an end, the mercury was found adhering to the inside of the cover. Had they been aware of the method of distilling the quicksilver ore into a receiver, this imperfect mode of collecting only a small portion of the quicksilver, separated from the cinnabar, would never have been practised. Besides, there is not the smallest allusion to

ardent spirits, either in the writings of the poets, historians, naturalists, or medical men of ancient Greece; a circumstance not to be accounted for had ardent spirits been known, and applied even to one-tenth of the uses to which they are put by the moderns.

IX.—STONEWARE.

The manufacture of stoneware vessels was known at a very early period of society. Frequent allusions to the potter's wheel occur in the Old Testament, showing that the manufacture must have been familiar to the Jewish nation. The porcelain of the Chinese boasts of a very high antiquity indeed. We cannot doubt that the processes of the ancients were similar to those of the moderns, though I am not aware of any tolerably accurate account of them in any ancient author whatever.

Moulds of plaster of Paris were used by the ancients to take casts precisely as at present.[93]

The sand of Puzzoli was used by the Romans, as it is by the moderns, to form a mortar capable of hardening under water.

Pliny gives us some idea of the Roman bricks, which are known to have been of an excellent quality. There were three sizes of bricks used by the Romans.

1. Lydian, which were 1½ foot long and 1 foot broad. 98

2. Tetradoron, which was a square of 16 inches each side.

3. Pentadoron, which was a square, each side of which was 20 inches long.

Doron signifies the palm of the hand: of course it was equivalent to 4 inches.

X.—PRECIOUS STONES AND MINERALS.

Pliny has given a pretty detailed description of the precious stones of the ancients; but it is not very easy to determine the specific minerals to which he alludes.

1. The description of the diamond is tolerably precise. It was found in Ethiopia, India, Arabia, and Macedonia. But the Macedonian diamond, as well as the adamas cyprius and siderites, were obviously not diamonds, but soft stones.

2. The *emerald* of the ancients (*smaragdus*) must have varied in its nature. It was a green, transparent, hard stone; and, as colour was the criterion by which the ancients distinguished minerals and divided them into species, it is obvious that very different minerals must have been confounded together, under the name of emerald. Sapphire, beryl, doubtless fluor spar when green, and probably even serpentine, nephrite, and some ores of copper, seem to have occasionally got the same name. There is no reason to believe that the *emerald* of the moderns was known before the discovery of America. At least it has been only found in modern times in America. Some of the emeralds described by Pliny as losing their colour by exposure to the sun, must have been fluor spars. There is a remarkably deep and beautiful green fluor spar, met with some years ago in the county of Durham, in one of the Weredale mines that possesses this property. The emeralds of the ancients were of such a

size (13½ feet, large enough to be cut into a pillar), that we can consider them in no other light than as a species of rock. 99

3. Topaz of the ancients had a green colour, which is never the case with the modern topaz. It was found in the island Topazios, in the Red Sea.[94] It is generally supposed to have been the *chrysolite* of the moderns. But Pliny mentions a statue of it six feet long. Now chrysolite never occurs in such large masses. Bruce mentions a green substance in an emerald island in the Red Sea, not harder than glass. Might not this be the emerald of the ancients?

4. *Calais*, from the locality and colour was probably the Persian turquoise, as it is generally supposed to be.

5. Whether the *prasius* and *chrysoprasius* of Pliny were the modern stones to which these names are given, we have no means of determining. It is generally supposed that they are, and we have no evidence to the contrary.

6. The *chrysolite* of Pliny is supposed to be our *topaz*: but we have no other evidence of this than the opinion of M. Du Tems.

7. *Asteria* of Pliny is supposed by Saussure to be our sapphire. The lustre described by Pliny agrees with this opinion. The stone is said to have been very hard and colourless.

8. *Opalus* seems to have been our *opal*. It is called, Pliny says, *pæderos* by many, on account of its beauty. The Indians called it *sangenon*.

9. *Obsidian* was the same as the mineral to which we give that name. It was so called because a Roman named Obsidianus first brought it from Egypt. I have a piece of obsidian, which the late Mr. Salt brought from the locality specified by Pliny, and which possesses all the characters of that mineral in its purest state. 100

10. *Sarda* was the name of *carnelian*, so called because it was first found near Sardis. The *sardonyx* was also another name for *carnelian*.

11. Onyx was a name sometimes given to a rock, *gypsum*; sometimes it was a light-coloured *chalcedony*. The Latin name for chalcedony was *carchedonius*, so called because Carthage was the place where this mineral was exposed to sale. The Greek name for Carthage was Καρχηδων (*carchedon*).

12. *Carbunculus* was the garnet; and *anthrax* was a name for another variety of the same mineral.

13. The *oriental amethyst* of Pliny was probably a sapphire. The fourth species of amethyst described by Pliny, seems to have been our amethyst. Pliny derives the name from α (*a*) and μυθη (*mythe*), *wine*, because it has not quite the colour of wine. But the common derivation is from α and μυθυω, *to intoxicate*, because it was used as an amulet to prevent intoxication.

14. The *sapphire* is described by Pliny as always opaque, and as unfit for engraving on. We do not know what it was.

15. The *hyacinth* of Pliny is equally unknown. From its name it was obviously of a blue colour. Our hyacinth has a reddish-brown colour, and a great deal of hardness and lustre.

16. The *cyanus* of Pliny may have been our *cyanite*.

17. *Astrios* agrees very well, as far as the description of Pliny goes, with the variety of felspar called *adularia*.

18. *Belioculus* seems to have been our *catseye*.

19. *Lychnites* was a violet-coloured stone, which became electric by heat. Unless it was a *blue tourmalin*, I do not know what it could be.

20. The *jasper* of the ancients was probably the same as ours.

21. *Molochites* may have been our *malachite*. The name comes from the Greek word μολοχη, *mallow*, or *marshmallow*. 101

22. Pliny considers *amber* as the juice of a tree concreted into a solid form. The largest piece of it that he had ever seen weighed 13 lbs. Roman weight, which is nearly equivalent to 9¾ lbs. avoirdupois. *Indian amber*, of which he speaks, was probably *copal*, or some transparent resin. It may be dyed, he says, by means of *anchusa* and the *fat of kids*.

23. *Lapis specularis* was foliated sulphate of lime, or selenite.

24. *Pyrites* had the same meaning among the ancients that it has among the moderns; at least as far as iron pyrites or bisulphuret of iron is concerned. Pliny describes two kind of pyrites; namely, the *white* (*arsenical pyrites*), and the *yellow* (iron pyrites). It was used for striking fire with steel, in order to kindle tinder. Hence the name *pyrites* or *firestone*.

25. *Gagates*, from the account given of it by Pliny, was obviously pit-coal or jet.

26. *Marble* had the same meaning among the ancients that it has among the moderns. It was sawed by the ancients into slabs, and the action of the saw was facilitated by a sand brought for the purpose from Ethiopia and the isle of Naxos. It is obvious that this sand was powdered corundum, or emery.

27. *Creta* was a name applied by the ancients not only to chalk, but to *white clay*.

28. *Melinum* was an *oxide of iron*. Pliny gives a list of one hundred and fifty-one species of stones in the order of the alphabet. Very few of the minerals contained in this list can be made out. He gives also a list of fifty-two species of stones, whose names are derived from a fancied resemblance which the stones are supposed to bear to certain parts of animals. Of these, also, very few can be made out.

XI.—MISCELLANEOUS OBSERVATIONS.

The ancients seem to have been ignorant of the nature and properties of air, and of all gaseous bodies. Pliny's account of air consists of a single sentence: "Aër densatur nubibus; furit procellis." "Air is condensed in clouds, it rages in storms." Nor is his description of water much more complete, since it consists only of the following phrases: "Aquæ subeunt in imbres, rigescunt in grandines, tumescunt in fluctus, præcipitantur in torrentes."[95] "Water falls in showers, congeals in hail, swells in waves, and rushes down in torrents." In the thirty-eighth chapter of the second book, indeed, he professes to treat of *air*; but the chapter contains merely an enumeration of meteorological phenomena, without once touching upon the nature and properties of air. 102

Pliny, with all the philosophers of antiquity, admitted the existence of the four elements, fire, air, water, and earth; but though he enumerates these in the fifth chapter of his first book, he never attempts to explain their nature or properties. Earth, among the ancients, had two meanings, namely, the planet on which we live, and the soil upon which vegetables grow. These two meanings still exist in common language. The meaning afterwards given to the *term*, earth, by the chemists, did not exist in the days of Pliny, or, at least, was unknown to him; a sufficient proof that chemistry, in his time, had made no progress as a science; for some notions respecting the properties and constituents of those supposed four elements must have constituted the very foundation of scientific chemistry.

The ancients were acquainted with none of the acids which at present constitute so numerous a tribe, except *vinegar*, or *acetic acid*; and even this acid was not known to them in a state of purity. They knew none of the saline bases, except lime, soda, and potash, and these very imperfectly. Of course the whole tribe of salts was unknown to them, except a very few, which they found ready formed in the earth, or which they succeeded in forming 103
by the action of vinegar on lead and copper. Hence all that extensive and most important branch of chemistry, consisting of the combinations of the acids and bases, on which scientific chemistry mainly depends, must have been unknown to them.

Sulphur occurring native in large quantities, and being remarkable for its easy combustibility, and its disagreeable smell when burning, was known in the very earliest ages. Pliny describes four kinds of sulphur, differing from each other, probably, merely in their purity. These were

1. Sulphur vivum, or apyron. It was dug out of the earth solid, and was doubtless pure, or nearly so. It alone was used in medicine.
2. Gleba—used only by fullers.
3. Egula—used also by fullers.
Pliny says, it renders woollen stuffs white and soft. It is obvious from this, that the ancients knew the method of bleaching flannel by the fumes of sulphur, as practised by the moderns.
4. The fourth kind was used only for sulphuring matches.

Sulphur, in Pliny's time, was found native in the Æolian islands, and in Campania. It is curious that he never mentions Sicily, whence the great supply is drawn for modern manufacture.

In medicine, it seems to have been only used externally by the ancients. It was considered as excellent for removing eruptions. It was used also for fumigating.

The word *alumen*, which we translate *alum*, occurs often in Pliny; and is the same substance which the Greeks distinguished by the name of στυπτηρια (*stypteria*). It is described pretty minutely by Dioscorides, and also by Pliny. It was obviously a natural production, dug out of the earth, and consequently quite different from our alum, with which the ancients were unacquainted. Dioscorides says that it was found abundantly in 104
Egypt; that it was of various kinds, but that the slaty variety was the best. He mentions also many other localities. He says that, for medical purposes, the most valued of all the varieties of alumen were the *slaty*, the *round*, and the *liquid*. The slaty alumen is very white, has an exceedingly astringent taste, a strong smell, is free from stony concretions, and gradually cracks and emits long capillary crystals from these rifts; on which account it is sometimes called *trichites*. This description obviously applies to a kind of slate-clay, which probably contained pyrites mixed with it of the decomposing kind. The capillary crystals were probably similar to those crystals at present called *hair-salt* by mineralogists, which exude pretty abundantly from the shale of the coal-beds, when it has been long exposed to the air. *Hair-salt* differs very much in its nature. Klaproth ascertained by analysis, that the *hair-salt*

from the quicksilver-mines in Idria is sulphate of magnesia, mixed with a small quantity of sulphate of iron.[96] The *hair-salt* from the abandoned coal-pits in the neighbourhood of Glasgow is a double salt, composed of sulphate of alumina, and sulphate of iron, in definite proportions; the composition being

1	atom protosulphate of iron,
1½	atom sulphate of alumina,
15	atoms water.

I suspect strongly that the capillary crystals from the schistose alumen of Dioscorides were nearly of the same nature.

From Pliny's account of the uses to which alumen was applied, it is quite obvious that it must have varied very much in its nature. *Alumen nigrum* was used to strike a black colour, and must therefore have contained iron. It was doubtless an impure native sulphate 105
of iron, similar to many native productions of the same nature still met with in various parts of the world, but not employed; their use having been superseded by various artificial salts, more definite in their nature, and consequently more certain in their application, and at the same time cheaper and more abundant than the native.

The alumen employed as a mordant by the dyers, must have been a sulphate of alumina more or less pure; at least it must have been free from all sulphate of iron, which would have affected the colour of the cloth, and prevented the dyer from accomplishing his object.[97]

What the *alumen rotundum* was, is not easily conjectured. Dioscorides says, that it was sometimes made artificially; but that the artificial alumen rotundum was not much valued. The best, he says, was full of air-bubbles, nearly white, and of a very astringent taste. It had a slaty appearance, and was found in Egypt or the Island of Melos.

The *liquid alumen* was limpid, milky, of an equal colour, free from hard concretions, and having a fiery shade of colour.[98] In its nature, it was similar to the alumen candidum; it must therefore have consisted chiefly, at least, of sulphate of alumina.

Bitumen and naphtha were known to the ancients, and used by them to give light instead of oil; they were employed also as external applications in cases of disease, and were considered as having the same virtues as sulphur. It is said, that the word translated *salt* in the New Testament—"Ye are the salt of the earth: but if the salt have lost his savour, wherewith shall it be salted? It is henceforth good for nothing, but to be cast out, and to be trodden under foot of men"[99]—it is said, that the word salt in this passage refers to asphalt, 106
or bitumen, which was used by the Jews in their sacrifices, and called *salt* by them. But I have not been able to find satisfactory evidence of the truth of this opinion. It is obvious from the context, that the word translated *salt* could not have had that meaning among the Jews; because salt never can be supposed to lose its savour. Bitumen, while liquid, has a strong taste and smell, which it loses gradually by exposure to the air, as it approaches more and more to a solid form.

Asphalt was one of the great constituents of the Greek fire. A great bed of it still existing in Albania, supplied the Greeks with this substance. Concerning the nature of the Greek fire, it is clear that many exaggerated and even fabulous statements have been published. The obvious intention of the Greeks being, probably, to make their invention as much dreaded as possible by their enemies. Nitre was undoubtedly one of the most important of its constituents; though no allusion whatever is ever made. We do not know when *nitrate of potash*, the nitre of the moderns, became known in Europe. It was discovered in the east; and was undoubtedly known in China and India before the commencement of the Christian era. The property of nitre, as a supporter of combustion, could not have remained long unknown after the discovery of the salt. The first person who threw a piece of it upon a red-hot coal would observe it. Accordingly we find that its use in fireworks was known very early in China and India; though its prodigious expansive power, by which it propels bullets with so great and destructive velocity, is a European invention, posterior to the time of Roger Bacon. 107

The word *nitre* (נתר) had been applied by the ancients to *carbonate of soda*, a production of Egypt, where it is still formed from sea-water, by some unknown process of nature in the marshes near Alexandria. This is evident, not merely from the account given of it by Dioscorides and Pliny; for the following passage, from the Old Testament, shows that it had the same meaning among the Jews: “As he that taketh away a garment in cold weather, is as vinegar upon nitre: so is he that singeth songs to a heavy heart.”[100] Vinegar poured upon saltpetre produces no sensible effect whatever, but when poured upon carbonate of soda, it occasions an *effervescence*. When saltpetre came to be imported to Europe, it was natural to give it the same name as that applied to carbonate of soda, to which both in taste and appearance it bore some faint resemblance. Saltpetre possessing much more striking properties than carbonate of soda much more attention was drawn to it, and it gradually fixed upon itself the term *nitre*, at first applied to a different salt. When this change of nomenclature took place does not appear; but it was completed before the time of Roger Bacon, who always applies the term *nitrum* to our nitrate of potash and never to carbonate of soda.

In the preceding history of the chemical facts known to the ancients, I have taken no notice of a well-known story related of Cleopatra. This magnificent and profligate queen boasted to Antony that she would herself consume a million of sistertii at a supper. Antony smiled at the proposal, and doubted the possibility of her performing it. Next evening a magnificent entertainment was provided, at which Antony, as usual, was present, and expressed his opinion that the cost of the feast, magnificent as it was, fell far short of the sum specified by the queen. She requested him to defer computing till the dessert was 108
finished. A vessel filled with vinegar was placed before her, in which she threw two pearls, the finest in the world, and which were valued at ten millions of sistertii; these pearls were dissolved by the vinegar,[101] and the liquid was immediately drunk by the queen. Thus she made good her boast, and destroyed the two finest pearls in the world.[102] This story, supposing it true, shows that Cleopatra was aware that vinegar has the property of dissolving pearls. But not that she knew the nature of these beautiful productions of nature. We now know that pearls consist essentially of carbonate of lime, and that the beauty is owing to the thin concentric laminæ, of which they are composed.

Nor have I taken any notice of lime with which the ancients were well acquainted, and which they applied to most of the uses to which the moderns put it. Thus it constituted the base of the Roman mortar, which is known to have been excellent. They employed it also as a manure for the fields, as the moderns do. It was known to have a corrosive nature when taken internally; but was much employed by the ancients externally, and in various ways as an application to ulcers. Whether they knew its solubility in water does not appear; though, from the circumstance of its being used for making mortar, this fact could hardly escape them. These facts, though of great importance, could scarcely be applied to the rearing of a chemical structure, as the ancients could have no notion of the action of acids upon lime, or of the numerous salts which it is capable of forming. Phenomena which must have remained unknown till the discovery of the acids enabled experimenters to try their effects upon limestone and quicklime. Not even a conjecture appears in any ancient writer that I have looked into, about the difference between quicklime and limestone. This difference is so 109
great that it must have been remarked by them, yet nobody seems ever to have thought of

attempting to account for it. Even the method of burning or calcining lime is not described by Pliny; though there can be no doubt that the ancients were acquainted with it.

Nor have I taken any notice of leather or the method of tanning it. There are so many allusions to leather and its uses by the ancient poets and historians, that the acquaintance of the ancients with it is put out of doubt. But so far as I know, there is no description of the process of tanning in any ancient author whatever. 110

CHAPTER III.

CHEMISTRY OF THE ARABIANS.

Hitherto I have spoken of Alchymy, or of the chemical manufactures of the ancients. The people to whom scientific chemistry owes its origin are the Arabians. Not that they prosecuted scientific chemistry themselves; but they were the first persons who attempted to form chemical medicines. This they did by mixing various bodies with each other, and applying heat to the mixture in various ways. This led to the discovery of some of the mineral acids. These they applied to the metals, &c., and ascertained the effects produced upon that most important class of bodies. Thus the Arabians began those researches which led gradually to the formation of scientific chemistry. We must therefore endeavour to ascertain the chemical facts for which we are indebted to the Arabians.

When Mahomet first delivered his dogmas to his countrymen they were not altogether barbarous. Possessed of a copious and expressive language, and inhabiting a burning climate, their imaginations were lively and their passions violent. Poetry and fiction were cultivated by them with ardour, and with considerable success. But science and inductive philosophy, had made little or no progress among them. The fatalism introduced by Mahomet, and the blind enthusiasm which he inculcated, rendered them furious bigots and 111
determined enemies to every kind of intellectual improvement. The rapidity with which they overran Asia, Africa, and even a portion of Europe, is universally known. At that period the western world, was sunk into extreme barbarism, and the Greeks, with whom the remains of civilization still lingered, were sadly degenerated from those sages who graced the classic ages. Bent to the earth under the most grinding but turbulent despotism that ever disgraced mankind, and having their understandings sealed up by the most subtle and absurd, and uncompromising superstition, all the energy of mind, all the powers of invention, all the industry and talent, which distinguished their ancestors, had completely forsaken them. Their writers aimed at nothing new or great, and were satisfied with repeating the scientific facts determined by their ancestors. The lamp of science fluttered in its socket, and was on the eve of being extinguished.

Nothing good or great could be expected from such a state of society. It was, therefore, wisely determined by Providence that the Mussulman conquerors, should overrun the earth, sweep out those miserable governors, and free the wretched inhabitants from the trammels of despotism and superstition. As a despotism not less severe, and a superstition still more gloomy and uncompromising, was substituted in their place, it may seem at first sight, that the conquests of the Mahometans brought things into a worse state than they found them. But the listless inactivity, the almost deathlike torpor which had frozen the minds of mankind, were effectually roused. The Mussulmans displayed a degree of energy and activity which have few parallels in the history of the world: and after the conquests of the Mahometans were completed, and the Califs quietly seated upon the greatest and most powerful throne that the world had ever seen; after Almanzor, about the middle of the eighth century, had founded the city of Bagdad, and settled a permanent and flourishing peace, the arts and sciences, which usually accompany such a state of society, began to make their appearance. 112

That calif founded an academy at Bagdad, which acquired much celebrity, and gradually raised itself above all the other academies in his dominions. A medical college was established there with powers to examine all those persons who intended to devote themselves to the medical profession. So many professors and pupils flocked to this celebrated college, from all parts of the world, that at one time their number amounted to no fewer than six thousand. Public hospitals and laboratories were established to facilitate a knowledge of diseases, and to make the students acquainted with the method of preparing medicines. It was this last establishment which originated with the califs that gave a first beginning to the science of chemistry.

In the thirteenth century the calif Mostanser re-established the academy and the medical college at Bagdad: for both had fallen into decay, and had been replaced by an infinite number of Jewish seminaries. Mostanser gave large salaries to the professors, collected a magnificent library, and established a new school of pharmacy. He was himself often present at the public lectures.

The successor of Mostanser was the calif Haroun-Al-Raschid, the perpetual hero of the Arabian tales. He not only carried his love for the sciences further than his predecessors, but displayed a liberality and a tolerance for religious opinions, which was not quite consistent with Mahometan bigotry and superstition. He drew round him the Syrian Christians, who translated the Greek classics, rewarded them liberally, and appointed them instructors of his Mahometan subjects, especially in medicine and pharmacy. He protected the Christian school of Dschondisabour, founded by the Nestorian Christians, before the time of 113
Mahomet, and still continuing in a flourishing state: always surrounded by literary men, he frequently condescended to take a part in their discussions, and not unfrequently, as might have been expected from his rank, came off victorious.

The most enlightened of all the califs was Almamon, who has rendered his name immortal by his exertions in favour of the sciences. It was during his reign that the Arabian schools came to be thoroughly acquainted with Greek science; he procured the translation of a great number of important works. This conduct inflamed the religious zeal of the faithful, who devoted him to destruction, and to the divine wrath, for favouring philosophy, and in that way diminishing the authority of the Koran. Almamon purchased the ancient classics, from all quarters, and recommended the care of doing so in a particular manner to his ambassadors at the court of the Greek emperors. To Leo, the philosopher, he made the most advantageous offers, to induce him to come to Bagdad; but that philosopher would not listen to his invitation. It was under the auspices of this enlightened prince, that the celebrated attempt was made to determine the size of the earth by measuring a degree of the meridian. The result of this attempt it does not belong to this work to relate.

Almotassem and Motawakkel, who succeeded Almamon, followed his example, favoured the sciences, and extended their protection to men of science who were Christians. Motawakkel re-established the celebrated academy and library of Alexandria. But he acted with more severity than his predecessors with regard to the Christians, who may perhaps have abused the tolerance which they enjoyed.

The other vicars of the prophet, in the different Mahometan states, followed the fine
example set them by Almamon. Already in the eighth century the sovereigns of Mogreb and 114
the western provinces of Africa showed themselves the zealous friends of the sciences. One of them called Abdallah-Ebn-Ibadschab rendered commerce and industry flourishing at Tunis. He himself cultivated poetry and drew numerous artists and men of science into his

state. At Fez and in Morocco the sciences flourished, especially during the reign of the Edrisites, the last of whom, Jahiah, a prince possessed of genius, sweetness, and goodness, changed his court into an academy, and paid attention to those only who had distinguished themselves by their scientific knowledge.

But Spain was the most fortunate of all the Mahometan states, and had arrived at such a degree of prosperity both in commerce, manufactures, population, and wealth, as is hardly to be credited. The three Abdalrahmans and Alhakem carried, from the eighth to the tenth century, the country subject to the Calif of Cordova to the highest degree of splendour. They protected the sciences, and governed with so much mildness, that Spain was probably never so happy under the dominion of any Christian prince. Alhakem established at Cordova an academy, which for several ages was the most celebrated in the whole world. All the Christians of Western Europe repaired to this academy in search of information. It contained, in the tenth century, a library of 280,000 volumes. The catalogue of this library filled no less than forty-four volumes. Seville, Toledo, and Murcia, had likewise their schools of science and their libraries, which retained their celebrity as long as the dominion of the Moors lasted. In the twelfth century there were seventy public libraries in that part of Spain which belonged to the Mahometans. Cordova had produced one hundred and fifty authors, Almeria fifty-two, and Murcia sixty-two.

The Mahometan states of the east continued also to favour the sciences. An emir of Irak, Adad-El-Daula by name, distinguished himself towards the end of the tenth century by 115
the protection which he afforded to men of science. To him almost all the philosophers of the age dedicated their works. Another emir of Irak, Saif-Ed-Daula, established schools at Kufa and at Bussora, which soon acquired great celebrity. Abou-Mansor-Baharam, established a public library at Firuzabad in Curdistan, which at its very commencement contained 7000 volumes. In the thirteenth century there existed a celebrated school of medicine in Damascus. The calif Malek-Adel endowed it richly, and was often present at the lectures with a book under his arm.

Had the progress of the sciences among the Arabians been proportional to the number of those who cultivated them, we might hail the Saracens as the saviours of literature during the dark and benighted ages of Christianity; but we must acknowledge with regret, that notwithstanding the enlightened views of the califs, notwithstanding the multiplicity of academies and libraries, and the prodigious number of writers, the sciences received but little improvement from the Arabians. There are very few Arabian writers in whose works we find either philosophical ideas, successful researches, new facts, or great and new and important truths. How, indeed, could such things be expected from a people naturally hostile to mental exertion; professing a religion which stigmatizes all exercise of the judgment as a crime, and weighed down by the heavy yoke of despotism? It was the religion of the Arabians, and the despotism of their princes, that opposed the greatest obstacles to the progress of the sciences, even during the most flourishing period of their civilization.[103]
Fortunately chemistry was the branch of science least obnoxious to the religious prejudices 116
of the Mahometans. It was in it, therefore, that the greatest improvements were made: of these improvements it will be requisite now to endeavour to give the reader some idea. Astrology and alchymy, they both derived from the Greeks: neither of them were inconsistent with the taste of the nation—neither of them were anathematized by the Mahometan creed, though Islamism prohibited magic and all the arts of divination. Alchymy may have suggested the chemical processes—but the Arabians applied them to the preparation of medicines, and thus opened a new and most copious source of investigation.

The chemical writings of the Arabians which I have had an opportunity of seeing and perusing in a Latin dress, being ignorant of the original language in which they were written, are those of Geber and Avicenna.

Geber, whose real name was Abou-Moussah-Dschafar-Al-Soli, was a Sabean of Harran, in Mesopotamia, and lived during the eighth century. Very little is known respecting the history of this writer, who must be considered as the patriarch of chemistry. Golius, professor of the oriental languages in the University of Leyden, made a present of Geber's work in manuscript to the public library. He translated it into Latin, and published it in the same city in folio, and afterwards in quarto, under the title of "Lapis Philosophorum."[104] It was translated into English by Richard Russel in 1678, under the title of, "The Works of Geber, the most famous Arabian Prince and Philosopher."[105] The works of Geber, so far as they appeared in Latin or English, consist of four tracts. The first is entitled, "Of the 117
Investigation or Search of Perfection." The second is entitled, "Of the Sum of Perfection, or of the perfect Magistery." The third, "Of the Invention of Verity or Perfection." And the last, "Of Furnaces, &c.; with a Recapitulation of the Author's Experiments."

The object of Geber's work is to teach the method of making the philosopher's stone, which he distinguishes usually by the name of *medicine of the third class*. The whole is in general written with so much plainness, that we can understand the nature of the substances which he employed, the processes which he followed, and the greater number of the products which he obtained. It is, therefore, a book of some importance, because it is the oldest chemical treatise in existence,[106] and because it makes us acquainted with the processes followed by the Arabians, and the progress which they had made in chemical investigations. I shall therefore lay before the reader the most important facts contained in Geber's work.

1. He considered all the metals as compounds of mercury and sulphur: this opinion did not originate with him. It is evident from what he says, that the same notion had been adopted by his predecessors—men whom he speaks of under the title of the *ancients*.

2. The metals with which he was acquainted were *gold*, *silver*, *copper*, *iron*, *tin*, and *lead*. These are usually distinguished by him under the names of *Sol*, *Luna*, *Venus*, *Mars*, *Jupiter*, and *Saturn*. Whether these names of the planets were applied to the metals by 118
Geber, or only by his translators, I cannot say; but they were always employed by the alchymists, who never designated the metals by any other appellations.

3. Gold and silver he considered as perfect metals; but the other four were imperfect metals. The difference between them depends, in his opinion, partly upon the proportions of mercury and sulphur in each, and partly upon the purity or impurity of the mercury and sulphur which enters into the composition of each.

Gold, according to him, is created of the most subtile substance of mercury and of most clear fixture, and of a small substance of sulphur, clean and of pure redness, fixed, clear, and changed from its own nature, tinging that; and because there happens a diversity in the colours of that sulphur, the yellowness of gold must needs have a like diversity.[107] His evidence that gold consisted chiefly of mercury, is the great ease with which mercury dissolves gold. For mercury, in his opinion, dissolves nothing that is not of its own nature. The lustre and splendour of gold is another proof of the great proportion of mercury which it contains. That it is a fixed substance, void of all burning sulphur, he thinks evident by every operation in the fire, for it is neither diminished nor inflamed. His other reasons are not so intelligible.[108]

Silver, like gold, is composed of much mercury and a little sulphur; but in the gold the sulphur is red; whereas the sulphur that goes to the formation of silver is white. The sulphur in silver is also clean, fixed, and clear. Silver has a purity short of that of gold, and a more gross inspissation. The proof of this is, that its parts are not so condensed, nor is it so fixed as gold; for it may be diminished by fire, which is not the case with gold.[109] 119

Iron is composed of earthy mercury and earthy sulphur, highly fixed, the latter in by far the greatest quantity. Sulphur, by the work of fixation, more easily destroys the easiness of liquefaction than mercury. Hence the reason why iron is not fusible, as is the case with the other metals.[110]

Sulphur not fixed melts sooner than mercury; but fixed sulphur opposes fusion. What contains more fixed sulphur, more slowly admits of fusion than what partakes of burning sulphur, which more easily and sooner flows.[111]

Copper is composed of sulphur unclean, gross and fixed as to its greater part; but as to its lesser part not fixed, red, and livid, in relation to the whole not overcoming nor overcome and of gross mercury.[112]

When copper is exposed to ignition, you may discern a sulphureous flame to arise from it, which is a sign of sulphur not fixed; and the loss of the quantity of it by exhalation through the frequent combustion of it, shows that it has fixed sulphur. This last being in abundance, occasions the slowness of its fusion and the hardness of its substance. That copper contains red and unclean sulphur, united to unclean mercury, is, he thinks, evident, from its sensible qualities.[113]

Tin consists of sulphur of small fixation, white with a whiteness not pure, not overcoming but overcome, mixed with mercury partly fixed and partly not fixed, white and impure.[114] That this is the constitution of tin he thinks evident; for when calcined, it emits a sulphureous stench, which is a sign of sulphur not fixed: it yields no flame, not because the sulphur is fixed, but because it contains a great portion of mercury. In tin there is a twofold sulphur and also a twofold mercury. One sulphur is less fixed, because in calcining it gives out a stench as sulphur. The fixed sulphur continues in the tin after it is calcined. He thinks 120
that the twofold mercury in tin is evident, from this, that before calcination it makes a crashing noise when bent, but after it has been thrice calcined, that crashing noise can no longer be perceived.[115] Geber says, that if lead be washed with mercury, and after its washing melted in a fire not exceeding the fire of its fusion, a portion of the mercury will remain combined with the lead, and will give it the crashing noise and all the qualities of tin. On the other hand, you may convert tin into lead. By manifold repetition of its calcination, and the administration of fire convenient for its reduction, it is turned into lead.[116]

Lead, in Geber's opinion, differs from tin only in having a more unclean substance commixed of the two more gross substances, sulphur and mercury. The sulphur in it is burning and more adhesive to the substance of its own mercury, and it has more of the substance of fixed sulphur in its composition than tin has.[117]

Such are the opinions which Geber entertained respecting the composition of the metals. I have been induced to state them as nearly in his own words as possible, and to give the reasons which he has assigned for them, even when his facts were not quite correct, because I thought that this was the most likely way of conveying to the reader an accurate notion of the sentiments of this father of the alchymists, upon the very foundation of the whole doctrine of the transmutation of metals. He was of opinion that all the imperfect metals might be transformed into gold and silver, by altering the proportions of the mercury and sulphur of which they are composed, and by changing the nature of the mercury and sulphur so as to make them the same with the mercury and sulphur which constitute gold 121
and silver. The substance capable of producing these important changes he calls sometimes the *philosopher's stone*, but generally the *medicine*. He gives the method of preparing this important *magistery*, as he calls it. But it is not worth while to state his process, because he leaves out several particulars, in order to prevent the foolish from reaping any benefit from his writings, while at the same time those readers who possess the proper degree of sagacity

will be able, by studying the different parts of his writings, to divine the nature of the steps which he omits, and thus profit by his researches and explanations. But it will be worth while to notice the most important of his processes, because this will enable us to judge of the state of chemistry in his time.

4. In his book on furnaces, he gives a description of a furnace proper for calcining metals, and from the fourteenth chapter of the fourth part of the first book of his Sum of Perfection, it is obvious that the method of calcining or oxidizing iron, copper, tin, and lead, and also mercury and arsenic were familiarly known to him.

He gives a description of a furnace for distilling, and a pretty minute account of the glass or stoneware, or metallic aludel and alembic, by means of which the process was conducted. He was in the habit of distilling by surrounding his aludel with hot ashes, to prevent it from being broken. He was acquainted also with the water-bath. These processes were familiar to him. The description of the distillation of many bodies occurs in his work; but there is not the least evidence that he was acquainted with ardent spirits. The term *spirit* occurs frequently in his writings, but it was applied to volatile bodies in general, and in particular to sulphur and white arsenic, which he considered as substances very similar in their properties. Mercury also he considered as a spirit.

The method of distilling *per descensum*, as is practised in the smelting of zinc, was 122
also known to him. He describes an apparatus for the purpose, and gives several examples of such distillations in his writings.

He gives also a description of a furnace for melting metals, and mentions the vessels in which such processes were conducted. He was acquainted with crucibles; and even describes the mode of making cupels, nearly similar to those used at present. The process of cupellating gold and silver, and purifying them by means of lead, is given by him pretty minutely and accurately: he calls it *cineritium*, or at least that is the term used by his Latin translator.

He was in the habit of dissolving salts in water and acetic acid, and even the metals in different menstrua. Of these menstrua he nowhere gives any account; but from our knowledge of the properties of the different metals, and from some processes which he notices, it is easy to perceive what his solvents must have been; namely, the mineral acids which were known to him, and to which there is no allusion whatever in any preceding writer that I have had an opportunity of consulting. Whether Geber was the discoverer of these acids cannot be known, as he nowhere claims the discovery: indeed his object was to slur over these acids, as much as possible, that their existence, or at least their remarkable properties, might not be suspected by the uninitiated. It was this affectation of secrecy and mystery that has deprived the earliest chemists of that credit and reputation to which they would have been justly entitled, had their discoveries been made known to the public in a plain and intelligible manner.

The mode of purifying liquids by filtration, and of separating precipitates from liquids by the same means, was known to Geber. He called the process *distillation through a filter*.

Thus the greater number of chemical processes, such as they were practised almost to
the end of the eighteenth century, were known to Geber. If we compare his works with those 123
of Dioscorides and Pliny, we shall perceive the great progress which chemistry or rather pharmacy had made. It is more than probable that these improvements were made by the Arabian physicians, or at least by the physicians who filled the chairs in the medical schools, which were under the protection of the califs: for as no notice is taken of these processes by any of the Greek or Roman writers that have come down to us, and as we find

them minutely described by the earliest chemical writers among the Arabians, we have no other alternative than to admit that they originated in the east.

I shall now state the different chemical substances or preparations which were known to Geber, or which he describes the method of preparing in his works.

1. Common salt. This substance occurring in such abundance in the earth, and being indispensable as a seasoner of food, was known from the earliest ages. But Geber describes the method which he adopted to free it from impurities. It was exposed to a red heat, then dissolved in water, filtered, crystallized by evaporation, and the crystals being exposed to a red heat, were put into a close vessel, and kept for use.[118] Whether the identity of sal-gem (*native salt*) and common salt was known to Geber is nowhere said. Probably not, as he gives separate directions for purifying each.

2. Geber gives an account of the two fixed alkalies, *potash* and *soda*, and gives processes for obtaining them. Potash was obtained by burning cream of tartar in a crucible, dissolving the residue in water, filtering the solution, and evaporating to dryness.[119] This would yield a pure carbonate of potash.

Carbonate of soda he calls *sagimen vitri*, and salt of soda. He mentions plants which yield it when burnt, points out the method of purifying it, and even describes the method of 124
rendering it caustic by means of quicklime.[120]

3. Saltpetre, or nitrate of potash, was known to him; and Geber is the first writer in whom we find an account of this salt. Nothing is said respecting its origin; but there can be little doubt that it came from India, where it was collected, and known long before Europeans were acquainted with it. The knowledge of this salt was probably one great cause of the superiority of the Arabians over Europeans in chemical knowledge; for it enabled them to procure *nitric acid*, by means of which they dissolved all the metals known in their time, and thus acquired a knowledge of various important saline compounds, which were of considerable importance.

There is a process for preparing saltpetre artificially, in several of the Latin copies of Geber, though it does not appear in our English translation. The method was to dissolve sagimen vitri, or carbonate of soda, in aqua fortis, to filter and crystallize by evaporation.[121] If this process be genuine, it is obvious that Geber must have been acquainted with nitrate of soda; but I have some doubts about the genuineness of the passage, because the term *aqua fortis* occurs in it. Now this term occurs nowhere else in Geber's work: even when he gives the process for procuring nitric acid, he calls it simply water; but observes, that it is a water possessed of much virtue, and that it constitutes a precious instrument in the hands of the man who possesses sagacity to use it aright.

4. Sal ammoniac was known to Geber, and seems to have been quite common in his time. There is no evidence that it was known to the Greeks or Romans, as neither Dioscorides nor Pliny make any allusion to it. The word in old books is sometimes *sal armoniac*, sometimes *sal ammoniac*. It is supposed to have been brought originally from the 125
neighbourhood of the temple of Jupiter Ammon: but had this been the case, and had it occurred native, it could scarcely have been unknown to the Romans, under whose dominions that part of Africa fell. In the writings of the alchymists, sal ammoniac is mentioned under the following whimsical names:

Anima sensibilis,
Aqua duorum fratrum ex sorore,
Aquila,
Lapis aquilinis,

Cancer,
Lapis angeli conjungentis,
Sal lapidum,
Sal alocoph.

Geber not only knew sal ammoniac, but he was aware of its volatility; and gives various processes for subliming it, and uses it frequently to promote the sublimation of other bodies, as of oxides of iron and copper. He gives also a method of procuring it from urine, a liquid which, when allowed to run into putrefaction, is known to yield it in abundance. Sal ammoniac was much used by Geber, in his various processes to bring the inferior metals to a state of greater perfection. By adding it or common salt to aqua fortis, he was enabled to dissolve gold, which certainly could not be accomplished in the time of Dioscorides or Pliny. The description, indeed, of Geber's process for dissolving gold is left on purpose in a defective state; but an attentive reader will find no great difficulty in supplying the defects, and thus understanding the whole of the process.

5. Alum, precisely the same as the alum of the moderns, was familiarly known to Geber, and employed by him in his processes. The manufacture of this salt, therefore, had been discovered between the time when Pliny composed his Natural History and the eighth 126 century, when Geber wrote; unless we admit that the mode of making it had been known to the Tyrian dyers, but that they had kept the secret so well, that no suspicion of its existence was entertained by the Greeks and Romans. That they employed *alumina* as a mordant in some of their dyes, is evident; but there is no proof whatever that *alum*, in the modern sense of the word, was known to them.

Geber mentions three alums which he was in the habit of using; namely, icy alum, or Rocca alum; Jamenous alum, or alum of Jameni, and feather alum. *Rocca*, or *Edessa*, in Syria, is admitted to have been the place where the first manufactory of alum was established; but at what time, or by whom, is quite unknown: we know only that it must have been posterior to the commencement of the Christian era, and prior to the eighth century, when Geber wrote. Jameni must have been another locality where, at the time of Geber, a manufactory of alum existed. *Feather alum* was undoubtedly one of the native impure varieties of *alum*, known to the Greeks and Romans. Geber was in the habit of distilling alum by a strong heat, and of preserving the water which came over as a valuable menstruum. If alum be exposed to a red heat in glass vessels, it will give out a portion of sulphuric acid: hence water distilled from alum by Geber was probably a weak solution of sulphuric acid, which would undoubtedly act powerfully as a solvent of iron, and of the alkaline carbonates. It was probably in this way that he used it.

6. Sulphate of iron or copperas, as it is called (*cuperosa*), in the state of a crystalline salt, was well known to Geber, and appears in his time to have been manufactured.

7. Baurach, or borax, is mentioned by him, but without any description by which we can know whether or not it was our borax: the probability is that it was. Both glass and 127 borax were used by him when the oxides of metals were reduced by him to the metallic state.

8. Vinegar was purified by him by distilling it over, and it was used as a solvent in many of his processes.

9. Nitric acid was known to him by the name of *dissolving water*. He prepared it by putting into an alembic one pound of sulphate of iron of Cyprus, half a pound of saltpetre, and a quarter of a pound of alum of Jameni: this mixture was distilled till every thing liquid was driven over. He mentions the red fumes which make their appearance in the alembic during the process.[122] This process, though not an economical one, would certainly yield

nitric acid; and it is remarkable, because it is here that we find the first hint of the knowledge of chemists of this most important acid, without which many chemical processes of the utmost importance could not be performed at all.

10. This acid, thus prepared, he made use of to dissolve silver: the solution was concentrated till the nitrate of silver was obtained by him in a crystallized state. This process is thus described by him: "Dissolve silver calcined in solutive water (*nitric acid*), as before; which being done, coct it in a phial with a long neck, the orifice of which must be left unstopped, for one day only, until a third part of the water be consumed. This being effected, set it with its vessel in a cold place, and then it is converted into small fusible stones, like crystal."[123]

11. He was in the habit also of dissolving sal ammoniac in this nitric acid, and employing the solution, which was the aqua regia of the old chemists, to dissolve gold.[124] He assures us that this aqua regia would dissolve likewise sulphur and silver. The latter assertion is erroneous. But sulphur is easily converted into sulphuric acid by the action of 128
aqua regia, and of course it disappears or dissolves.

12. Corrosive sublimate is likewise described by Geber in a very intelligible manner. His method of preparing it was as follows: "Take of mercury one pound, of dried sulphate of iron two pounds, of alum calcined one pound, of common salt half a pound, and of saltpetre a quarter of a pound: incorporate altogether by trituration and sublime; gather the white, dense, and ponderous portions which shall be found about the sides of the vessel. If in the first sublimation you find it turbid or unclean (which may happen by reason of your own negligence), sublime a second time with the same fuses."[125] Still more minute directions are given in other parts of the work: we have even some imperfect account of the properties of corrosive sublimate.

13. Corrosive sublimate is not the only preparation of mercury mentioned by Geber. He informs us that when mercury is combined with sulphur it assumes a red colour, and becomes cinnabar.[126] He describes the affinities of mercury for the different metals. It adheres easily to three metals; namely, lead, tin, and gold; to silver with more difficulty. To copper with still more difficulty than to silver; but to iron it unites in nowise unless by artifice.[127] This is a tolerably accurate account of the matter. He says, that mercury is the heaviest body in nature except gold, which is the only metal that will sink in it.[128] Now this was true, applied to all the substances known when Geber lived.

He gives an account of the method of forming the peroxide of mercury by heat; that variety of it formerly distinguished by the name of *red precipitati per se*. "Mercury," he says, "is also coagulated by long and constant retention in fire, in a glass vessel with a very 129
long neck and round belly; the orifice of the neck being kept open, that the humidity may vanish thereby."[129] He gives another process for preparing this oxide, possible, perhaps, though certainly requiring very cautious regulation of the fire. "Take," says he, "of mercury one pound, of vitriol (sulphate of iron) rubified two pounds, and of saltpetre one pound. Mortify the mercury with these, and then sublime it from rock alum and saltpetre in equal weights."[130]

14. Geber was acquainted with several of the compounds of metals with sulphur. He remarks that sulphur when fused with metals increases their weight.[131] Copper combined with sulphur becomes yellow, and mercury red.[132] He knew the method of dissolving sulphur in caustic potash, and again precipitating it by the addition of an acid. His process is as follows: "Grind clear and gummose sulphur to a most subtile powder, which boil in a lixivium made of ashes of *heartsease* and quicklime, gathering from off the surface its oleaginous combustibility, until it be discerned to be clear. This being done, stir the whole with a stick, and then warily take off that which passeth out with the lixivium, leaving the

more gross parts in the bottom. Permit that extract to cool a little, and upon it pour a fourth part of its own quantity of distilled vinegar, and then will the whole suddenly be congealed as milk. Remove as much of the clear lixivium as you can; but dry the residue with a gentle fire and keep it."[133]

15. It would appear from various passages in Geber's works that he was acquainted with arsenic in the metallic state. He frequently mentions its combustibility, and considers it 130
as the *compeer* of sulphur. And in his book on *Furnaces*, chapter 25 (or 28 in some copies), he expressly mentions *metallic arsenic* (*arsenicum metallinum*), in a preparation not very intelligible, but which he considered of great importance. The white oxide of arsenic or arsenious acid, was obviously well known to him. He gives more than one process for obtaining it by sublimation.[134] He observes in his Sum of Perfection, book i. part iv. chap. 2, which treats of sublimation, "Arsenic, which before its sublimation was evil and prone to adustion, after its sublimation, suffers not itself to be inflamed; but only resides without inflammation."

Geber states the fact, that when arsenic is heated with copper that metal becomes white.[135] He gives also a process by which the white arseniate of iron is obviously made. "Grind one pound of iron filings with half a pound of sublimed arsenic (arsenious acid). Imbibe the mixture with the water of saltpetre, and salt-alkali, repeating this imbibation thrice. Then make it flow with a violent fire, and you will have your iron white. Repeat this labour till it flow sufficiently with peculiar dealbation."[136]

16. He mentions oxide of copper under the name of *æs ustum*, the red oxide of iron under the name of *crocus* of iron. He mentions also litharge and red lead.[137] But as all these substances were known to the Greeks and Romans, it is needless to enter into any particular details.

17. I am not sure what substance Geber understood by the word *marchasite*. It was a substance which must have been abundant, and in common use, for he refers to it frequently, and uses it in many of his processes; but he nowhere informs us what it is. I suspect it may have been sulphuret of antimony, which was certainly in common use in Asia 131
long before the time of Geber. But he also makes mention of antimony by name, or at least the Latin translator has made use of the word *antimonium*. When speaking of the reduction of metals after heating them with sulphur, he says, "The reduction of tin is converted into clear antimony; but of lead, into a dark-coloured antimony, as we have found by proper experience."[138] It is not easy to conjecture what meaning the word antimony is intended to convey in this passage. In another passage he says, "Antimony is calcined, dissolved, clarified, congealed, and ground to powder, so it is prepared."[139]

18. Geber's description of the metals is tolerably accurate, considering the time when he wrote. As an example I shall subjoin his account of gold. "Gold is a metallic body, yellow, ponderous, mute, fulged, equally digested in the bowels of the earth, and very long washed with mineral water; under the hammer extensible, fusible, and sustaining the trial of the cupel and cementation."[140] He gives an example of copper being changed into gold. "In copper-mines," he says, "we see a certain water which flows out, and carries with it thin scales of copper, which (by a continual and long-continued course) it washes and cleanses. But after such water ceases to flow, we find these thin scales with the dry sand, in three years time to be digested with the heat of the sun; and among these scales the purest gold is found: therefore we judge those scales were cleansed by the benefit of the water, but were equally digested by heat of the sun, in the dryness of the sand, and so brought to equality."[141] Here we have an example of plausible reasoning from defective premises. The 132
gold grains doubtless existed in the sand before, while the scales of copper in the course of three years would be oxidized and converted into powder, and disappear, or at least lose all their metallic lustre.

Such are the most remarkable chemical facts which I have observed in the works of Geber. They are so numerous and important, as to entitle him with some justice to the appellation of the father and founder of chemistry. Besides the metals, sulphur and salt, with which the Greeks and Romans were acquainted, he knew the method of preparing sulphuric acid, nitric acid, and aqua regia. He knew the method of dissolving the metals by means of these acids, and actually prepared nitrate of silver and corrosive sublimate. He was acquainted with potash and soda, both in the state of carbonates and caustic. He was aware that these alkalies dissolve sulphur, and he employed the process to obtain sulphur in a state of purity.

But notwithstanding the experimental merit of Geber, his spirit of philosophy did not much exceed that of his countrymen. He satisfied himself with accounting for phenomena by occult causes, as was the universal custom of the Arabians; a practice quite inconsistent with real scientific progress. That this was the case will appear from the following passage, in which Geber attempts to give an explanation of the properties of the *great elixir* or *philosopher's stone*: "Therefore, let him attend to the properties and ways of action of the composition of the greater elixir. For we endeavour to make one substance, yet compounded and composed of many, so permanently fixed, that being put upon the fire, the fire cannot injure; and that it may be mixed with metals in flux and flow with them, and enter with that which in them is of an ingressible substance, and be fermented with that which in them is of a permixable substance; and be consolidated with that which in them is of a consolidable 133
substance; and be fixed with that which in them is of a fixable substance; and not be burnt by those things which burn not gold and silver; and take away consolidation and weights with due ignition."[142]

The next Arabian whose name I shall introduce into this history, is Al-Hassain-Abou-Ali-Ben-Abdallah-Ebn-Sina, surnamed Scheik Reyes, or prince of physicians, vulgarly known by the name of *Avicenna*. Next to Aristotle and Galen, his reputation was the highest, and his authority the greatest of all medical practitioners; and he reigned paramount, or at least shared the medical sceptre till he was hurled from his throne by the rude hands of Paracelsus.

Avicenna was born in the year 978, at Bokhara, to which place his father had retired during the emirate of the calif Nuhh, one of the sons of the celebrated Almansor. Ali, his father, had dwelt in Balkh, in the Chorazan. After the birth of Avicenna he went to Asschena in Bucharia, where he continued to live till his son had reached his fifteenth year. No labour nor expense was spared on the education of Avicenna, whose abilities were so extraordinary that he is said to have been able to repeat the whole Koran by heart at the age of ten years. Ali gave him for a master Abou-Abdallah-Annatholi, who taught him grammar, dialectics, the geometry of Euclid, and the astronomy of Ptolemy. But Avicenna quitted his tuition because he could not give him the solution of a problem in logic. He attached himself to a merchant, who taught him arithmetic, and made him acquainted with the Indian numerals from which our own are derived. He then undertook a journey to Bagdad, where he studied philosophy under the great Peripatician, Abou-Nasr-Alfarabi, a disciple of Mesue the elder. At the same time he applied himself to medicine, under the tuition of the Nestorian, Abou-Sahel-Masichi. He informs us himself that he applied with an extraordinary ardour to the 134
study of the sciences. He was in the habit of drinking great quantities of liquids during the night, to prevent him from sleeping; and he often obtained in a dream a solution of those problems at which he had laboured in vain while he was awake. When the difficulties to be surmounted appeared to him too great, he prayed to God to communicate to him a share of his wisdom; and these prayers, he assures us, were never offered in vain. The metaphysics of Aristotle was the only book which he could not comprehend, and after reading them over forty times, he threw them aside with great anger at himself.

Already, at the age of sixteen, he was a physician of eminence; and at eighteen he performed a brilliant cure on the calif Nuhh, which gave him such celebrity that Mohammed, Calif of Chorazan, invited him to his palace; but Avicenna rather chose to reside at Dschordschan, where he cured the nephew of the calif Kabus of a grievous distemper.

Afterwards he went to Ray, where he was appointed physician to Prince Magd-Oddaula. Here he composed a dictionary of the sciences. Sometime after this he was raised to the dignity of vizier at Hamdan; but he was speedily deprived of his office and thrown into prison for having favoured a sedition. While incarcerated he wrote many works on medicine and philosophy. By-and-by he was set at liberty, and restored to his dignity; but after the death of his protector, Schems-Oddaula, being afraid of a new attempt to deprive him of his liberty, he took refuge in the house of an apothecary, where he remained long concealed and completely occupied with his literary labours. Being at last discovered he was thrown into the castle of Berdawa, where he was confined for four months. At the end of that time a fortunate accident enabled him to make his escape, in the disguise of a monk. He repaired to Ispahan, where he lived much respected at the court of the calif Ola-Oddaula. 135
He did not live to a great age, because he had worn out his constitution by too free an indulgence of women and wine. Having been attacked by a violent colic, he caused eight injections, prepared from long pepper, to be thrown up in one day. This excessive use of so irritating a remedy, occasioned an excoriation of the intestines, which was followed by an attack of epilepsy. A journey to Hamdan, in company with the calif, and the use of mithridate, into which his servant by mistake had put too much opium, contributed still further to put an end to his life. He had scarcely arrived at the town when he died in the fifty-eighth year of his age, in the year 1036.

Avicenna was the author of the immense work entitled "Canon," which was translated into Latin, and for five centuries constituted the great standard, the infallible guide, the confession of faith of the medical world. All medical knowledge was contained in it; and nothing except what was contained in it was considered by medical men as of any importance. When we take a view of the Canon, and compare it with the writings of the Greeks, and even of the Arabians, that preceded it, we shall find some difficulty in accounting for the unbounded authority which he acquired over the medical world, and for the length of time during which that authority continued.

But it must be remembered, that Avicenna's reign occupies the darkest and most dreary period of the history of the human mind. The human race seems to have been asleep, and the mental faculties in a state of complete torpor. Mankind, accustomed in their religious opinions to obey blindly the infallible decisions of the church, and to think precisely as the church enjoined them to think, would naturally look for some means to save them the trouble of thinking on medical subjects; and this means they found fortunately in the canons of Avicenna. These canons, in their opinion, were equally infallible with the decisions of the 136
holy father, and required to be as implicitly obeyed. The whole science of medicine was reduced to a simple perusal of Avicenna's Canon, and an implicit adherence to his rules and directions.

When we compare this celebrated work with the medical writings of the Greeks, and even of the Arabians, the predecessors of Avicenna, we shall be surprised that it contains little or nothing which can be considered as original; the whole is borrowed from the writings of Galen, or Ætius, or Rhazes: scarcely ever does he venture to trust his own wings, but rests entirely on the sagacity of his Greek and Arabian predecessors. Galen is his great guide; or, if he ever forsake him, it is to place himself under the direction of Aristotle.

The Canon contains a collection of most of the valuable information contained in the writings of the ancient Greek physicians, arranged, it must be allowed, with great clearness.

The Hhawi of Razes is almost as complete; but it wants the *lucidus ordo* which distinguishes the Canon of Avicenna. I conceive that the high reputation which Avicenna acquired, was owing to the care which he bestowed upon his arrangement. He was undoubtedly a man of abilities, but not of inventive genius. There is little original matter in the Canon. But the physicians in the west, while Avicenna occupied the medical sceptre, had no opportunity of judging of the originality of their oracle, because they were unacquainted with the Greek language, and could not therefore consult the writings of Galen or Ætius, except through the corrupt medium of an Arabian version.

But it is not the medical reputation of Avicenna that induced me to mention his name here. Like all the Arabian physicians, he was also a chemist; and his chemical tracts having been translated into Latin, and published in Western Europe, we are enabled to judge of 137
their merit, and to estimate the effect which they may have had upon the progress of chemistry. The first Latin translation of the chemical writings of Avicenna was published at Basil in 1572; they consist of two separate books; the first, under the name of "Porta Elementorum," consists of a dialogue between a master and his pupil, respecting the mysteries of Alchymy. He gives an account of the four elements, fire, air, water, earth, and gives them their usual qualities of dry, moist, hot, and cold. He then treats of air, which, he says, is the food of fire, of water, of honey, of the mutual conversion of the elements into each other; of milk and cheese, of the mixture of fire and water, and that all things are composed of the four elements. There is nothing in this tract which has any pretension to novelty; he merely retails the opinions of the Greek philosophers.

The other treatise is much larger, and professes to teach the whole art of alchymy; it is divided into ten parts, entitled "Dictiones." The first diction treats of the philosopher's stone in general; the second diction treats of the method of converting light things into heavy, hard things into soft; of the mutation of the elements; and of some other particulars of a nature not very intelligible. The third diction treats of the formation of the elixir; and the same subject is continued in the fourth.

The fifth diction is one of the most important in the whole treatise; it is in general intelligible, which is more than can be said of those that precede it. This diction is divided into twenty-eight chapters: the first chapter treats of copper, which, he says, is of three kinds; permenian copper, natural copper, and Navarre copper. But of these three varieties he gives no account whatever; though he enlarges a good deal on the qualities of copper—not its properties, but its supposed medicinal action. It is hot and dry, he says, but in the calx of 138
it there is humidity. His account of the composition of copper is the same with that of Geber.

The second chapter treats of lead, the third of tin, and in the remaining chapters he treats successively of brass, iron, gold, silver, marcasite, sulphuret of antimony, which is distinguished by the name of alcohol; of soda, which he says is the juice of a plant called *sosa*. And he gives an unintelligible process by which it is extracted from that plant, without mentioning a syllable about the combustion to which it is obvious that it must have been subjected.

In the twelfth chapter he treats of saltpetre, which, he says, is brought from Sicily, from India, from Egypt, and from Herminia. He describes several varieties of it, but mentions nothing about its characteristic property of deflagrating upon burning coals. He then treats successively of common salt, of sal-gem, of vitriol, of sulphur, of orpiment, and of sal ammoniac, which, he says, comes from Egypt, from India, and from Forperia. In the nineteenth and subsequent chapters he treats of aurum vivum, of hair, of urine, of eggs, of blood, of glass, of white linen, of horse-dung, and of vinegar.

The sixth diction, in thirty-three chapters, treats of the calcination of the metals, of sublimation, and of some other processes. I think it unnecessary to be more particular, because I cannot perceive any thing in it that had not been previously treated of by Geber.

The seventh diction treats of the preparation of blood and eggs, and the method of dividing them into their four elements. It treats also of the elixir of silver, and the elixir of gold; but it contains no chemical fact of any importance.

The eighth diction treats of the preparation of the ferment of silver, and of gold. The ninth diction treats of the whole magistery, and of the nuptials of the sun and moon; that is, 139
of gold and silver. The tenth diction treats of weights.

The chemical writings of Avicenna are of little value, and apply chemistry rather to the supposed medical qualities of the different substances treated of, than to the advancement of the science. All the chemical knowledge which he possesses is obviously drawn from Geber. Geber, then, may be looked upon as the only chemist among the Arabians to whom we are indebted for any real improvements and new facts. It is true that the Arabian physicians improved considerably the materia medica of the Greeks, and introduced many valuable medicines into common use which were unknown before their time. It is enough to mention corrosive sublimate, manna, opium, asafœtida. It would be difficult to make out many of the vegetable substances used by the Arabian chemists; because the plants which they designated by particular names, can very seldom be identified. Botany at that time had made so little progress, that no method was known of describing plants so as to enable other
persons to determine what they were. 140

CHAPTER IV

OF THE PROGRESS OF CHEMISTRY UNDER PARACELSUS AND HIS DISCIPLES.

Hitherto we have witnessed only the first rude beginnings, or, as it were, the early dawn of the chemical day. It is from the time of Paracelsus that the true commencement of chemical investigations is to be dated. Not that Paracelsus or his followers understood the nature of the science, or undertook any regular or successful investigation. But Paracelsus shook the medical throne of Galen and Avicenna to its very foundation; he roused the latent energies of the human mind, which had for so long a period lain torpid; he freed medical men from those trammels, and put an end to that despotism which had existed for five centuries. He pointed out the importance of chemical medicines, and of chemical investigations, to the physician. This led many laborious men to turn their attention to the subject. Those metals which were considered as likely to afford useful medicines, mercury for example, and antimony, were exposed to the action of an infinite number of reagents, and a prodigious collection of new products obtained and introduced into medicine. Some of these were better, and some worse, than the preparations formerly employed; but all of them led to an increase of the stock of chemical knowledge, which now began to accumulate with considerable rapidity. It will be proper, therefore, to give a somewhat 141
particular account of the life and opinions of Paracelsus, so far as they can be made out from his writings, because, though he was not himself a scientific chemist, he may be truly considered as the man through whose means the stock of chemical knowledge was

accumulated, which was afterwards, by the ingenuity of Beccher, and Stahl, moulded into a scientific form.

Philippus Aureolus Theophrastus Paracelsus Bombast ab Hohenheim (as he denominates himself) was born at Einsideln, two German miles from Zurich. His father was called William Bombast von Hohenheim. He was a very near relation of George Bombast von Hohenheim, who became afterwards grand master of the order of Johannites. William Bombast von Hohenheim practised medicine at Einsideln.[143] After receiving the first rudiments of his education in his native city, he became a wandering scholastic, as was then the custom with poor scholars. He wandered from province to province, predicting the future by the position of the stars, and the lines on the hand, and exhibiting all the chemical processes which he had learned from founders and alchymists. For his initiation in alchymy, astrology, and medicine, he was indebted to his father, who was much devoted to these three sciences. Paracelsus mentions also the names of several ecclesiastics from whom he received chemical information; among others, Tritheimius, abbot of Spanheim; Bishop Scheit, of Stettbach; Bishop Erhart, of Laventall; Bishop Nicolas, of Hippon; and Bishop Matthew Schacht. He seems also to have served some years as an army surgeon, for he mentions many cures which he performed in the Low Countries, in the States of the Church, in the kingdom of Naples, and during the wars against the Venetians, the Danes, and the Dutch. 142

There is some uncertainty whether he received a regular college education, as was then the practice with all medical men. He acknowledges himself that his medical antagonists reproached him with never having frequented their schools; and he is perpetually affirming, that a physician should receive all his knowledge from God, and not from man. But if we can trust his own assertions, there can be no doubt that he took a regular medical degree, which implies a regular college education. He tells us, in his preface to his Chirurgia Magna, that he visited the universities of Germany, France, and Italy. He assures his readers, that he was the ornament of the schools where he studied. He even speaks of the oath which he was obliged to take when he received his medical degree; but where he studied, or where and when he received his medical degree, are questions which neither Paracelsus nor his disciples, nor his biographers, have enabled us to solve. If he ever attended a university, he must have neglected his studies, otherwise he could not have been ignorant, as he confessedly was, of the very first elements of the most common kinds of knowledge. But if he neglected the universities, he laboured long and assiduously with the rich Sigismond Fuggerus, of Schwartz, in order to learn the true secret of forming the philosopher’s stone.

He gives us some details of the numerous journeys that he made, as was customary with the alchymists of the time, into the mountains of Bohemia, the East, and Sweden, to inspect the mines, to get himself initiated into the mysteries of the eastern adepts, to inspect the wonders of nature, and to view the celebrated diamond mountain, the position of which, however, he unfortunately forgets to specify.

In the preface to his Chirurgia Magna, he informs us that he traversed Spain, Portugal, England, Prussia, Poland, and Transylvania; where he not only profited by the information of the medical men with whom he became acquainted, but that he drew much precious 143
information from old women, gipsies, conjurors, and chemists.[144] He spent several years in Hungary; and informs us that at Weissenburg, in Croatia, and in Stockholm, he was taught by several old women to prepare drinks capable of curing ulcers. He is said also to have made a voyage into Egypt, and even into Tartary; and he accompanied the son of the Kan of the Tartars to Constantinople, in order to learn the secret of the philosopher’s stone from Trismogin, who inhabited that capital. This prodigious activity, this constant motion from place to place, left him but little leisure for reading: accordingly he informs us himself, that during the space of ten years he never opened a book, and that his whole library consisted

only of six sheets. The inventory of his books, drawn up after his death, confirms this recital; for they consisted only of the Bible, the Concordance to the Bible, the New Testament, and the Commentaries of St. Jerome on the Evangelists.

We know not at what period he returned back to Germany; but at the age of thirty-three the great number of fortunate cures which he had performed rendered him an object of admiration to the people, and of jealousy to the rival physicians of the time. He assures us that he cured eighteen princes whose diseases had been aggravated by the practitioners devoted to the system of Galen. Among others he cured Philip, Margrave of Baden, of a dysentery, who promised him a great reward, but did not keep his promise, and even treated him in a way unworthy of that prince. This cure, however, and others of a similar nature, 144 added greatly to his celebrity; and in order to raise his reputation to the highest possible pitch, he announced publicly that he was able to cure all the diseases hitherto reckoned incurable; and that he had discovered an elixir, by means of which the life of man might be prolonged at pleasure to any extent whatever. He began the practice, which has since been so successfully followed in this country, of dispensing medicines gratuitously to the poor, in order to induce the rich to apply to him for assistance when they were overtaken with diseases.

In the year 1526 Paracelsus was appointed professor of physic and surgery in the University of Basil. This appointment was given him, it is said, by the recommendation of Œcolampadius. He introduced the custom of lecturing in the common language of the country, as is at present the universal practice: but during the time of Paracelsus, and long after indeed, all lectures were delivered in Latin. The new method which he followed in explaining the theory and practice of the art; the numerous fortunate cures which he stated in confirmation of his method of treatment; the emphasis with which he spoke of his secrets for prolonging life, and for curing every kind of disease without distinction, but still more his lecturing in a language which was understood by the whole population, drew to Bâle an immense crowd of idle, enthusiastic, and credulous hearers.

The lectures which he delivered on Practical Medicine still remain, written in a confused mixture of German and barbarous Latin, and containing little or nothing except a farrago of empirical remedies, advanced with the greatest confidence. They have a much greater resemblance to a collection of quack advertisements than to the sober lectures of a professor in a university. In the month of November, 1526, he wrote to Christopher Clauser, a physician in Zurich, that as Hippocrates was the first physician among the Greeks, 145 Avicenna among the Arabians, Galen among the Pergamenians, and Marsilius among the Italians, so he was beyond dispute the greatest physician among the Germans. Every country produces an illustrious physician, whose medicines are adapted to the climate in which he lived, but not suited to other countries. The remedies of Hippocrates were good to the Greeks, but not suitable to the Germans; thus it was necessary that an inspired physician should spring up in every country, and that he was the person destined to teach the Germans the art of curing all diseases.[145]

Paracelsus began his professorial career by burning publicly, in his class-room, and in the presence of his pupils, the works of Galen and Avicenna, assuring his hearers that the strings of his shoes possessed more knowledge than those two celebrated physicians. All the universities united had not, he assured them, as much knowledge as was contained in his own beard, and the hairs upon his neck were better informed than all the writers that ever existed put together. To give the reader an idea of the arrogant absurdity of his pretensions, I shall translate a few sentences of the preface to his tract, entitled “Paragranum,” where he indulges in his usual strain of rodomontade: “Me, me you shall follow, you Avicenna, you Galen, you Rhazes, you Montagnana, you Mesue. I shall not follow you, but you shall follow me. You, I say, you inhabitants of Paris, you inhabitants of Montpelier, you Suevi,

you Misnians, you inhabitants of Cologne, you inhabitants of Vienna; all you whom the Rhine and the Danube nourish, you who inhabit the islands of the sea; you also Italy, you 146
Dalmatia, you Athens, you Greek, you Arabian, you Israelite—I shall not follow you, but you shall follow me. Nor shall any one lurk in the darkest and most remote corner whom the dogs shall not piss upon. I shall be the monarch, the monarchy shall be mine. If I administer, and I bind up your loins, is he with whom you are at present delighted a Cacophrastus? This ordure must be eaten by you."

"What will your opinion be when you see your Cacophrastus constituted the chief of the monarchy? What will you think when you see the sect of Theophrastus leading on a solemn triumph, if I make you pass under the yoke of my philosophy? your Pliny will you call Cacopliny, and your Aristotle, Cacoaristotle? If I plunge them together with your Porphyry, Albertus, &c., and the whole of their compatriots into my *necessary*." But the terms become now so coarse and indelicate, that I cannot bring myself to proceed further with the translation. Enough has been given to show the extreme arrogance and folly of Paracelsus.

So far, however, was this impudence and grossness from injuring the interest of Paracelsus, that we are assured by Ramus and Urstisius that it contributed still further to increase it. The coarseness of his language was well suited to the vulgarity of the age; and his arrogance and boasting were considered, as usual, as a proof of superior merit. The cure which he performed on Frobenius, drew the attention of Erasmus himself, who consulted him about the diseases with which he was afflicted; and the letters that passed between them are still preserved. The epistle of Paracelsus is short, enigmatical, and unintelligible; that of Erasmus is distinguished by that clearness and elegance which characterize his writings.[146]
But Frobenius died in the month of October, 1527, and the antagonists of Paracelsus 147
attributed his death (and probably with justice) to the violent remedies which had been administered to a man whose constitution had been destroyed by the gout.

His death contributed not a little to tarnish the glory of Paracelsus: but he suffered the greatest injury from the habits of intoxication in which he indulged, and from the vulgarity of the way in which he spent his time. He hardly ever went into his class-room to deliver a lecture till he was half intoxicated, and scarcely ever dictated to his secretaries till he had lost the use of his reason by a too liberal indulgence in wine. If he was summoned to visit a patient, he scarcely ever went but in a state of intoxication. Not unfrequently he passed the whole night in the alehouse, in the company of peasants, and when morning came, was quite incapable of performing the duties of his station. On one occasion, after a debauch, which lasted the whole night, he was called next morning to visit a patient; on entering the room, he inquired if the sick person had taken any thing: "Nothing," was the answer, "except the body of our Lord." "Since you have already," says he, "provided yourself with another physician, my presence here is unnecessary," and he left the apartment instantly. When Albertus Basa, physician to the king of Poland, visited Paracelsus in the city of Basel, he carried him to see a patient whose strength was completely exhausted, and which, in his opinion, it was impossible to restore; but Paracelsus, wishing to make a parade of his skill, administered to him three drops of his laudanum, and invited him to dine with him next
day.[147] The invitation was accepted, and the sick man dined next day with his physician. 148

Towards the end of the year 1527 a disgraceful dispute into which he entered brought his career, as a professor, to a sudden termination. The canon Cornelius, of Lichtenfels, who had been long a martyr to the gout, employed him as his physician, and promised him one hundred florins if he could cure him. Paracelsus made him take three pills of laudanum, and having thus freed him from pain, demanded the sum agreed upon; but Lichtenfels refused to pay him the whole of it. Paracelsus summoned him before the court, and the magistrate of Basle decided that the canon was bound to pay only the regular price of the medicine administered. Irritated at this decision, our intoxicated professor uttered a most violent invective against the magistrate, who threatened to punish him for his outrageous conduct. His friends advised him to save himself by flight. He took their advice, and thus abdicated his professorship. But, by this time, his celebrity as a teacher had been so completely destroyed by his foolish and immoral conduct, that he had lost all his hearers. In consequence of this state of things, his flight from Basle produced no sensation whatever in that university.

Paracelsus betook himself, in the first place, to Alsace, and sent for his faithful follower, the bookseller, Operinus, together with the whole of his chemical apparatus. In 1528 we find him at Colmar, where he recommenced his ambulating life of a theosophist, which he had led during his youth. His book upon syphilis, known at that time by the name of Morbus Gallicus, was dedicated at Colmar, to the chief magistrate of Colmar, Hieronymus Bonerus.[148] In 1531 he was at Saint-Gallen; in 1535, at Pfeffersbade, and in 1536, at Augsburg, where he dedicated his Chirurgia Magna to Malhausen. At the request of 149
John de Leippa, Marshal of Bohemia, he undertook a journey into Moravia; as that nobleman, having been informed that Paracelsus understood the method of curing the gout radically, was anxious to put himself under his care. Paracelsus lived for a long time at Kroman, and its environs. John de Leippa, instead of receiving any benefit from the medicines administered to him, became daily worse, and at last died. This was the fate also of the lady of Zerotin, in whom the remedies of Paracelsus produced no fewer than twenty-four epileptic fits in one day. Paracelsus, instead of waiting the disgrace with which the death of this lady would have overwhelmed him, announced his intention of going to Vienna, that he might see how they would treat him in that capital.

It is said, that from Vienna he went into Hungary; but in 1538, we find him in Villach, where he dedicated his Chronica et Origo Carinthiæ to the states of Carinthia.[149] His book, De Natura Rerum, had been dedicated to Winkelstein, and the dedication is dated also at Villach, in the year 1537.[150] In 1540 he was at Mindelheim, and in 1541, at Strasburg, where he died, in St. Stephen’s hospital, in the forty-eighth year of his age.

To form an accurate idea of this most extraordinary man, we must attend to his habits, and to the situation in which he was placed. He had acquired such a habit of moving about, that he assures us himself he found it impossible for him to continue for any length of time in one place. He was always surrounded by a number of followers, whom neither his habits of intoxication, nor the foolish and immoral conduct in which he was accustomed to indulge, could induce to forsake him. The most celebrated of these was Operinus, a printer at Basle, on whom Paracelsus lavishes the most excessive praises, in his book De Morbo 150
Gallico. But Operinus loaded his master with obloquy, being provoked at him because he had not made him acquainted with the secret of the philosopher’s stone, as he had promised to do. We must therefore be cautious in believing the stories that he relates to the discredit of his master. We know the names of two others of his followers; Francis, who assures us that Paracelsus was devoted to the transmutation of metals; and George Vetter, who considered him as a magician; as was the opinion also of Operinus. Paracelsus himself, speaks of Dr. Cornelius, whom he calls his secretary, and in honour of whom he wrote several of his libels. Other libels are dedicated to Doctors Peter, Andrew, and Ursinus, to the licentiate Pancrace, and to Mr. Raphael. On this occasion he complains bitterly of the infidelity of his servants, who, he says, had succeeded in stealing from him several of his secrets; and had by this means been enabled to establish their reputation. He accuses equally the barbers and bathers that followed him, and is no less severe upon the physicians of every country through which he travelled.

When we attempt to form an accurate conception of the medical and philosophical opinions of this singular man, we find ourselves beset with almost insurmountable

difficulties. His statements are so much at variance with each other, in his different pieces, and so much confusion reigns with respect to the order of publication, that we know not what to fix on as his last and maturest opinions. His style is execrable; filled with new words of his own coining, and of mysticisms either introduced to excite the admiration of the ignorant, or from the fanaticism and credulity of the writer, who was undoubtedly, to a considerable extent, the dupe of his own impostures. That he was in possession of the
philosopher's stone, or of a medicine capable of prolonging life to an indefinite length, as he 151
all along asserted, he could not himself believe; but he had boasted so long and so loudly of his wonderful cures, and of the efficacy of his medicines, that there can be no doubt that he ultimately placed implicit faith in them. The blunders of the transcribers whom he employed to copy his works, may perhaps account for some of the contradictions which they contain. But how can we look for a regular system of opinions from a man who generally dictated his works when in a state of intoxication, and thus laboured under an almost constant deprivation of reason.

His obscurity was partly the effect of design, and no doubt was intended to exalt the notions entertained of his profundity. He uses common words in new significations, without giving any indication of the change which he introduced. Thus *anatomy*, in the writings of Paracelsus, signifies not the dissection of dead animals to determine their structure, but it means the nature, force, and magical designation of a thing. And as, according to the Platonic and Cabalistic theory, every earthly body is formed after the model of a heavenly body, Paracelsus calls *anatomy* the knowledge of that model, of that ideal, or of that paradigm after which all things are created. He terms the fundamental force of a thing *a star*, and defines alchymy the art of drawing out the stars of metals. The star is the source of all knowledge. When we eat, we introduce into our bodies *the star*, which is then modified, and favours nutrition.

It is probable that many of his obscure and unintelligible expressions are the fruit of ignorance. Thus he uses the term *pagoyus*, instead of *paganus*. He gives the name of *pagoyæ* to the four *entities*, or causes of diseases, founded on the influence of the stars, to the elementary qualities; to the occult qualities, and to the influence of spirits; because these had been already admitted by the *Pagans*. But the fifth *entity*, or cause of disease, which has
God immediately for its author, is *non pagoya*. The *undimia* of Paracelsus is our *œdema*; 152
only he applies the name to every kind of dropsy. The Latin word *tonitru*, we find is declined by Paracelsus. Thus he says, *lapis tonitrui*. The well-known line of Ovid,

Tollere nodosam nescit medicina podagram,

He travestied into

Nescit tartaream Roades curare podagram.[151]

Roades, he says, means medicines for horses; and if any person wishes a more elegant verse, he may make it for himself.[152] He employs, also, a great number of words to which no meaning whatever can be attached; and to which, in all probability, he himself had affixed none.

As is the case with all fanatics, he treated with contempt every kind of knowledge acquired by labour and application; and boasted that his wisdom was communicated to him directly by God Almighty. The theosophist who is worthy of partaking of the divine light, has no occasion for adopting a positive religion, nor of subjecting himself to any kind of religious ceremony. The divine light within, which assimilates him to the Deity, more than compensates for all these vulgar usages, and raises the illuminated votary far above the beggarly elements of external worship. Accordingly, Paracelsus has been accused of treating the public worship of the Deity with contempt. Not satisfied with the plain sense of

the book, he attempted to explain in a mystical manner the words and syllables of the Bible. He accused Luther of not going far enough. “Luther,” says he, “is not worthy of untying the strings of my shoes: should I undertake a reformation, I would begin by sending the pope and the reformers themselves to school.” God, says Paracelsus, is the first and most 153
excellent of writers. The Holy Scripture conducts us to all truth, and teaches us all things. But medicine, philosophy, and astronomy, are among the number of things. Therefore, when we want to know what magical medicine is, we must consult the Apocalypse. The Bible, with its paraphrases, is the key to the theory of diseases. It puts it in our power to understand St. John, who, like Daniel, Ezekiel, Moses, &c., was a magician, a cabalist, a diviner. The first duty of a physician is to study the Cabala, without which he must every moment commit a thousand blunders. “Learn,” says he, “the cabalistic art, which includes under it all the others.” “Man invents nothing, the devil invents nothing; it is God alone who unveils to us the light of nature.” “God honoured at first with his illumination the blind pagans, Apollo, Æsculapius, Machaon, Podalirius, and Hippocrates, and imparted to them the genius of medicine; their successors were the sophists.” One would suppose, from this passage, that Paracelsus had read and studied Hippocrates, and that he held him in high estimation. But the commentaries which he has left on some of the aphorisms, show evidently that he did not even understand the Greek physician. “The compassion of God,” says he, “is the only foundation of medical science, and not a knowledge of the great masters, or of the writings which they have left in Greek and Latin.” “God often acts in dreams by the light of nature, and points out to man the manner of curing diseases.” “This knowledge renders all those objects visible which would otherwise escape the sight; and when faith is joined with it, nothing is then impossible to the theosophist, who may transport the ocean to the top of Mount Ætna, and Olympus into the Red Sea.” Paracelsus predicts that by the year 1590 Christian theosophy would be generally spread over the
world, and that the Galenical schools would be almost or entirely overthrown. 154

We find in Paracelsus some traces of the opinions of the Gnostics and Arians, who considered Christ as the first emanation of the Deity. He calls the first man *parens hominis*; and makes all spirits emanate from him. He is the *limbus minor*, or the last creature, into whom enters the great *limbus*, or the seed of all the creatures, the infinite being. All the sciences, and all the arts of man, are derived from this great *limbus*; and he who can sink himself in the little *limbus*, that is to say, in Adam, and who can communicate by faith with Jesus Christ, may invoke all *spirits*. Those who owe their science to this *limbus*, are the best informed; those who derive it from the stars, occupy the last rank; and those who owe it to the light of nature, are intermediate between the preceding. Jesus Christ, in his capacity of *limbus minor* and first man, being always an emanation of the Divinity; and, consequently, a subordinate personage. These ideas explain to us why Paracelsus passed for an Arian, and was supposed not to believe in the Divinity of Jesus Christ. He was of opinion that the faithful performed miracles, and operated magical cures by their simple confidence in God the Father, and not by their faith in Christ; but he adds, however, that we ought to pray to Jesus, in order to obtain his intercession.

From the preceding attempt to explain the opinions of Paracelsus, it will be evident to the reader that he was both a fanatic and impostor, and that his theory (if such a name can be given to the reveries of a drunkard), consisted in uniting medicine with the doctrines of the Cabala. A few more observations will be necessary to develop his dogmas still further.

Every body, in his opinion, and man in particular, is double, consisting of a material
and spiritual substance.[153] The spiritual, which may be called the *sideric*, results from the 155
celestial influences; and we may trace after it a figure capable of producing all kinds of magical effects. When we can act upon the body itself, we act at the same time upon the spiritual form by characters and conjurations.[154] Yet, in another passage, he blames all magical ceremonies, and ascribes them to want of faith. The celestial intelligences impress

upon material bodies certain signs, which manifest their influence. The perfection of art consists in understanding the meaning of these signs, and in determining from them the nature, qualities, and essence of a body. Adam, the first man, had a perfect knowledge of the Cabala; he could interpret the signatures of all things. It was this which enabled him to assign to the animals names which suited them best. A man who renounces all sensuality, and is blindly obedient to the will of God, is capable of taking a share in the actions which celestial intelligences perform; and consequently is possessed of the philosopher's stone. Never does he want any thing; all creatures in earth and in heaven are obedient to him; he can cure all diseases, and prolong his life as long as he pleases; because he possesses the tincture which Adam and the patriarch's before the flood employed to prolong the term of their existence.[155] Beelzebub, the chief of the demons, is also subject to the power of magic: and who can blame the theosophist for believing in the devil? He ought, however, to take care to prevent this malignant spirit from commanding him. Paracelsus was often wont to say, "If God does not aid me, the devil will help me." 156

Pantheism was one of the principal dogmas of the Cabala; and Paracelsus adopts it in all its grossness. He affirms perpetually that every thing is animated in the universe; that every thing which exists, eats, drinks, and voids excrements: even minerals and liquids take food and void the digested remains of their nourishment.[156] This opinion leads necessarily to the admission of a great number of spiritual substances, intermediate between material and immaterial in every part of the sublunary world, in water, air, earth, and fire; who, as well as man, eat, drink, converse, beget children; but which approach pure spirits in this, that they are more transparent, and infinitely more agile than all other animal bodies. Man possesses a soul, of which these pure spirits are destitute. Hence it happens that these spiritual substances are at once body and spirit without a soul. When they die (for like the human race they are subject to death), no soul remains. Like us they are exposed to diseases. Their names vary according to the places that they occupy. When they inhabit the air, they are called *sylphs*; when the water, *nymphs*; when the earth, *pigmies*; when the fire, *salamanders*.[157] The inhabitants of the waters are also called *undinæ*, and those of the fire *vulcani*. The sylphs approach nearest to our nature, as they live in the air like us. The sylphs, nymphs, and pigmies, sometimes obtain permission from God to make themselves visible, to converse with men, to indulge in carnal pleasures, and to produce children. But the salamanders have no relation to man. These spiritual beings are acquainted with the future, and capable of revealing it to man. They appear under the form of *ignes fatui*. We have also the history of the fairies and the giants; and are told how these spiritual beings are 157 the guardians of concealed treasures; and how these sylphs, nymphs, pigmies, and salamanders, may be charmed, and their treasures taken from them.

This division of man into body and spirit, and of the things of nature into visible and invisible, has in all ages of the world, been adopted by fanatics, because it enabled them to explain the history of ghosts, and a thousand similar prejudices. Hence the distinction between soul and spirit, which is so very ancient; and hence the three following harmonies to which the successors of Paracelsus paid a particular attention:

Soul,	*Spirit*,	*Body*,
Mercury,	*Sulphur*,	*Salt*,
Water,	*Air*,	*Earth*.

The will and the imagination of man acts principally by means of the spirit. Hence the reason of the efficacy of sorcery and magic. The *nævi materni* are the impressions of these *vice-men*, and Paracelsus calls them *cocomica signa*. The *sideric* body of man draws to him, by imagination, all that surrounds him, and particularly the stars, on which it acts like a magnet. In this manner, women with child, and during the regular period of monthly evacuation, having a diseased imagination, are not only capable of poisoning a mirror by their breath, but of injuring the infants in their wombs, and even also of poisoning the moon. But it seems needless to continue this disagreeable detail of the absurd and ridiculous opinions which Paracelsus has consigned to us in his different tracts.

The Physiology of Paracelsus (if such a name can be applied to his reveries) is nothing else than an application of the laws of the Cabala to the explanation of the functions of the
body. There exists, he assures us, an intimate connexion between the sun and the heart, the 158
moon and the brain, Jupiter and the liver, Saturn and the spleen, Mercury and the lungs, Mars and the bile, Venus and the kidneys. In another part of his works, he informs us that the sun acts on the umbilicus and the middle parts of the abdomen, the moon on the spine, Mercury on the bowels, Venus on the organs of generation, Mars on the face, Jupiter on the head, and Saturn on the extremities. The pulse is nothing else than the measure of the temperature of the body, according to the space of the six places which are in relation to the planets. Two pulses under the sole of the feet belong to Saturn and Jupiter, two at the elbow to Mars and Venus, two in the temples to the moon and mercury. The pulse of the sun is found under the heart. The *macrocosm* has also seven pulses, which are the revolutions of the seven planets, and the irregularity or intermittence of these pulses, is represented by the eclipses. The moon and Saturn are charged in the macrocosm with thickening the water, which causes it to congeal. In like manner the moon of the microcosm, that is to say the brain, coagulates the blood. Hence *melancholy persons*, whom Paracelsus calls *lunatics*, have a thick blood. We ought not to say of a man that he has such and such a complexion; but that it is Mars, Venus, &c., so that a physician ought to know the planets of the microcosm, the arctic and antarctic pole, the meridian, the zodiac, the east and the west, before trying to explain the functions or cure the diseases.[158] This knowledge is acquired by a continual comparison of the macrocosm with the microcosm. What must have been the
state of medicine at the time when Paracelsus wrote, when the propagator of such opinions 159
could be reckoned one of the greatest of its reformers?

The system of Galen had for its principal basis the doctrine of the four elements, *fire*, *air*, *water*, and *earth*. Paracelsus neglected these elements, and multiplied the substances of the disease itself. He admits, strictly speaking, three or four elements; namely, the *star*, the *root*, the *element*, the *sperm*, which he distinguishes by the name of the *true seed*. All these elements were originally confounded together in the *chaos* or *yliados*. The *star* is the active force which gives form to matter. The *stars* are reasonable beings addicted to sodomy and adultery, like other creatures. Each of them draws at pleasure out of the *chaos*, the plant and the metal to which it has an affinity, and gives a *sideric* form to their *root*. There are two kinds of *seed*; the *sperm* is the vehicle of the true seed. It is engendered by speculation, by imagination, by the power of the *star*. The occult, invisible, *sideric* body produces the *true seed*, and the Adamic man secretes only the visible envelope of it. Putrefaction cannot give birth to a new body: the seed must pre-exist, and it is developed during putrefaction by the power of the stars. The generation of animals is produced by the concourse of the infinite number of seeds which detach themselves from all parts of the body. Thus the seed of the nose reproduces a nose, that of the eye the eye, and so on.

With respect to the elements themselves, Paracelsus admits occasionally their influence on the functions of the body, and the theory of diseases; but he deduces the faculties which they possess from the *stars*. It was he that first shook the doctrine of the four elements, originally contrived by Empedocles. Alchymy had introduced another set of elements, and the alchymists maintained that salt, sulphur, and mercury, were the true elements of things.
Paracelsus endeavoured to reconcile these chemical elements with his cabalistic ideas, and 160
to show more clearly their utility in the theory of medicine. He invented a *sideric salt*, which can only be perceived by the exquisite senses of a theosophist, elevated by the abnegation of all gross sensuality to a level with pure and spiritual demons. This *salt* is the

cause of the consistence of bodies, and it is it which gives them the faculty of being reproduced from their ashes.

Paracelsus imagined also a *sideric sulphur*, which being vivified by the influence of the stars, gives bodies the property of growing, and of being combustible. He admits also a *sideric mercury*, the foundation of fluidity and volatilization. The concourse of these three substances forms the body. In different parts of his works, Paracelsus says, that the *elements* are composed of these three principles. In plants he calls the salt *balsam*, the sulphur *resin* and the mercury *gotaronium*. In other passages he opposes the assertion of the Galenists, that *fire* is *dry* and *hot*, *air cold* and *moist*, *earth dry* and *cold*, *water moist* and *cold*. Each of these elements, he says, is capable of admitting all qualities, so that in reality there exists a *dry water*, a *cold fire*, &c.

I must not omit another remarkable physiological doctrine of Paracelsus, namely, that there exists in the stomach a demon called *Archæus*, who presides over the chemical operations which take place in it, separating the poisonous from the nutritive part of food, and furnishing the alimentary substances with the tincture, in consequence of which they become capable of being assimilated. This *ruler of the stomach*, who changes bread into blood, is the type of the physician, who ought to keep up a good understanding with him, and lend him his assistance. To produce a change in the humours ought never to be the object of the true physician, he should endeavour to concentrate all his operations on the stomach and the ruler who reigns in it. This Archæus to whom the name of *Nature* may also be given, produces all the changes by his own power. It is he alone who cures diseases. He 161
has a *head* and *hands*, and is nothing else than the *spirit of life*, the *sideric body* of man, and no other spirit besides exists in the body. Each part of the body has also a peculiar stomach in which the secretions are elaborated.

There are, he informs us, five different causes of diseases. The first is the *ens astrorum*. The constellations do not immediately induce diseases, but they alter and infect the air. This is what, properly speaking constitutes the *entity of the stars*. Some constellations *sulphurize* the atmosphere, others communicate to it *arsenical*, *saline*, or *mercurial* qualities. The arsenical astral entities injure the blood, the mercurial the head, the saline the bones and the vessels. Orpiment occasions tumours and dropsies, and the *bitter stars* induce fever.

The second morbific cause is the *ens veneni*, which proceeds from alimentary substances: when the archeus is languid putrefaction ensues, either *localiter* or *emuncturaliter*. This last takes place when those evacuations, which ought to be expelled by the nose, the intestines, or the bladder, are retained in the body. Dissolved mercury escapes through the pores of the skin, white sulphur by the nose, arsenic by the ears, sulphur diluted with water by the eyes, salt in solution by the urine, and sulphur deliquesced by the intestines.

The third morbific cause of disease is the *ens naturale*; but Paracelsus subjects to the ens astrorum the principles which the schools are in the habit of arranging among the number of natural causes. The *ens spirituale* forms the fourth species and the *ens deale* or *Christian entity* the fifth. This last class comprehends all the immediate effects of divine predestination.

It would lead us too far if I were to point out the strange methods which he takes to discover the cause of diseases. But his doctrine concerning *tartar* is too important, and does 162
our fanatic too much credit to be omitted. It is without doubt the most useful of all the innovations which he introduced. *Tartar* according to him, is the principle of all the maladies proceeding from the thickening of the humours, the rigidity of the solids, or the accumulation of earthy matter. Paracelsus thought the term *stone* not suitable to indicate that matter, because it applies only to one species of it. Frequently the principle proceeds from

mucilage, and mucilage is tartar. He calls this principle *tartar* (*tartarus*) because it burns like hellfire, and occasions the most dreadful diseases. As *tartar* (*bitartrate of potash*) is deposited at the bottom of the wine-cask, in the same way *tartar* in the living body is deposited on the surface of the teeth. It is deposited on the internal parts of the body when the archæus acts with too great impetuosity and in an irregular manner, and when it separates the nutritive principle with too much impetuosity. Then the saline spirit unites itself to it and coagulates the earthy principle, which is always present, but often in the state of *materia prima* without being coagulated.

In this manner tartar, in the state of *materia prima*, may be transmitted from father to son. But it is not hereditary and transmittable when it has already assumed the form of gout, of renal calculus, or of obstruction. The saline spirit which gives it its form, and causes its coagulation, is seldom pure and free from mixture; usually it contains alum, vitriol, or common salt; and this mixture contributes also to modify the tartarous diseases. The tartar may be likewise distinguished according as it comes from the blood itself, or from foreign matters accumulated in the humours. The great number of calculi which have been found in every part of the body, and the obstructions, confirm the generality of this morbific cause, to which are due most of the diseases of the liver. When the tartarous matter is increased by 163
certain articles of food, renal calculi are engendered, a calculous paroxysm is induced, and violent pain is occasioned. It acts as an emetic, and may even give occasion to death, when the saline spirit becomes corrosive; and when the tartar coagulated by it becomes too irritating.

Tartar, then, is always an excrementitious substance, which in many cases results from the too great activity of the digestive forces. It may make its appearance in all parts of the body, from the irregularity and the activity, too energetic or too indolent, of the archeus; and then it occasions particular accidents relative to each of the functions. Paracelsus enumerates a great number of diseases of the organs, which may be explained by that one cause; and affirms, that the profession of medicine would be infinitely more useful, if medical men would endeavour to discover the tartar before they tried to explain the affections.

Paracelsus points out, also, the means by which we can distinguish the presence of tartar in urine. For this it is necessary, not merely to inspect the urine, but to subject it to a chemical analysis. He declaims violently against the ordinary ouroscopy. He divides urine into internal and external; the internal comes from the blood, and the external announces the nature of the food and drink which has been employed. To the sediment of urine he gives the new name of *alcola*, and admits three species of it, namely, *hypostasis*, *divulsio*, and *sedimen*. The first is connected with the stomach, the second with the liver, and the third with the kidneys; and tartar predominates in all the three.

The Cabala constantly directs Paracelsus in his therapeutics and materia medica. As all terrestrial things have their image in the region of the stars, and as diseases depend also on the influence of the stars, we have nothing more to do, in order to obtain a certain cure for 164
these diseases, than to discover, by means of the Cabala, the harmony of the constellations. *Gold* is a specific against all diseases of the *heart*, because, in the mystic scale, it is in harmony with that viscus. The *liquor of the moon* and crystal cure the diseases of the *brain*. The liquor *alkahest* and *cheiri* are efficacious against those of the *liver*. When we employ vegetable substances, we must consider their harmony with the constellations, and their magical harmony with the parts of the body and the diseases, each star drawing, by a sort of magical virtue, the plant for which it has an affinity, and imparting to it its activity. So that plants are a kind of sublunary stars. To discover the virtues of plants, we must study their anatomy and cheiromancy; for the leaves are their hands, and the lines observable on them enable us to appreciate the virtues which they possess. Thus the anatomy of the *chelidonium*

shows us that it is a remedy for jaundice. These are the celebrated *signatures* by means of which we deduce the virtues of vegetables, and the medicines of analogy which they present in relation to their form. Medicines, like women, are known by the forms which they affect. He who calls in question this principle, accuses the Divinity of falsehood, the infinite wisdom of whom has contrived these external characters to bring the study of them more upon a level with the weakness of the human understanding. On the corolla of the euphrasia there is a black dot; from this we may conclude that it furnishes an excellent remedy against all diseases of the eye. The lizard has the colour of malignant ulcers, and of the carbuncle; this points out the efficacy which that animal possesses as a remedy.

These signatures were exceedingly convenient for the fanatics, since they saved them the trouble of studying the medical virtues of plants, but enabled them to decide the subject *à priori*. Paracelsus acted very considerately, when he ascribed these virtues principally to 165
the stars, and affirmed that the observation of favourable constellations is an indispensable condition in the employment of these medicines. “The remedies are subjected to the will of the stars, and directed by them; you ought therefore to wait till heaven is favourable, before ordering a medicine.”

Paracelsus considered all the effects of plants as specifics, and the use of them as secrets. The same notions explain the eulogy which he bestowed on the *elixir of long life*, and upon all the means which he employed to prolong the term of existence. He believed that these methods, which contained the *materia prima*, served to repair the constant waste of that matter in the human body. He was acquainted, he says, with four of these arcana, to which he applied the mystic terms, *mercury of life*, *philosopher's stone*, &c. The *polygonum persicaria* was an infallible specific against all the effects of magic. The method of using it is, to apply it to the suffering part, and then to bury it in the earth. It draws out the malignant spirits like a magnet, and it is buried to prevent these malignant spirits from making their escape.

The reformation of Paracelsus had the great advantage of representing *chemistry* as an indispensable art in the preparation of medicines. The disgusting decoctions and useless syrups gave place to *tinctures*, *essences*, and *extracts*. Paracelsus says, expressly, that the true use of chemistry is to prepare medicines, and not to make gold. He takes that opportunity of declaiming against cooks and innkeepers, who drown medicines in soup, and thus destroy all their properties. He blames medical men for prescribing simples, or mixtures of simples, and affirms that the object should always be to extract the quintessence of each substance; and he describes at length the method of extracting this quintessence. But he was very little scrupulous about the substances from which this quintessence was to be 166
extracted. The heart of a hare, the bones of a hare, the bone of the heart of a stag, mother-of-pearl, coral, and various other bodies may, he says, be used indiscriminately to furnish a quintessence capable of curing some of the most grievous diseases.

Paracelsus combats with peculiar energy the method of cure employed by the disciples of Galen, directed solely against the predominating humours, and the elementary qualities. He blames them for attempting to correct the action of their medicines, by the addition of useless ingredients. Fire and chemistry, he affirmed, are the sole correctives. It was Paracelsus that first introduced *tin* as a remedy for worms, though his mode of employing it was not good.

I have been thus particular in pointing out the philosophical and medical opinions of Paracelsus, because they were productive of such important consequences, by setting medical men free from the slavish deference which they had been accustomed to pay to the dogmas of Galen and Avicenna. But it was the high rank to which he raised chemistry, by making a knowledge of it indispensable to all medical men; and by insisting that the great importance of chemistry did not consist in the formation of gold, but in the preparation of medicines, that rendered the era of Paracelsus so important in the history of chemistry; for after his time the art of chemistry was cultivated by medical men in general—it became a necessary part of their education, and began to be taught in colleges and medical schools. The object of chemistry came to be, not to discover the philosopher's stone, but to prepare medicines; and a great number of new medicines, both from the mineral and vegetable kingdom—some of more, some of less, consequence, soon issued from the laboratories of the chemical physicians.

There can be little doubt that many chemical preparations were either first introduced 167 into medicine by Paracelsus, or at least were first openly prescribed by him: though from the nature of his writings, and the secrecy in which he endeavoured to keep his most valuable remedies, it is not easy to point out what these remedies were. Mercury is said to have been employed in medicine by Basil Valentine; but it was Paracelsus who first used it openly as a cure for the venereal disease, and who drew general attention to it by his encomiums on its medical virtues, and by the eclat of the cures which he performed by means of it, after all the Galenical prescriptions of the schools had been tried in vain.

He ascertained that alum contains, united to an acid, not a metallic oxide, but an earth. He mentions metallic arsenic; but there is some reason for believing that this metal was known to Geber and the Arabian physicians. Zinc is mentioned by him, and likewise bismuth, as substances not truly metallic, but approaching to metals in their properties: for malleability and ductility were considered by him as essential to the metals.[159] I cannot be sure of any other chemical fact which appears in Paracelsus, and which was not known before his time. The use of sal ammoniac in subliming several metallic calces, was familiar to him, but it had long ago been explained by Geber. It is clear also that Geber was acquainted with aqua regia, and that he employed it to dissolve gold. Paracelsus's reputation as a chemist, therefore, depends not upon any discoveries which he actually made, but upon 168 the great importance which he attached to the knowledge of it, and to his making an acquaintance with chemistry an indispensable requisite of a medical education.

Paracelsus, as the founder of a new system of medicine, the object of which was to draw chemistry out of that state of obscurity and degradation into which it had been plunged, and to give it the charge of the preparation of medicine, and presiding over the whole healing art, deserved a particular notice; and I have even endeavoured, at some length, to lay his system of opinions, absurd as it is, before the reader. But the same attention is not due to the herd of followers who adopted his absurdities, and even carried them, if possible, still further than their master: at the same time there are one or two particulars connected with the Paracelsian sect which it would be improper to omit.

The most celebrated of his followers was Leonhard Thurneysser-zum-Thurn, who was born in 1530, at Basle, where his father was a goldsmith. His life, like that of his master, was checkered with very extraordinary vicissitudes. In 1560 he was sent to Scotland to examine the lead-mines in that country. In 1558 he commenced miner and sulphur extractor at Tarenz on the Inn, and was so successful, that he acquired a great reputation. He had turned his attention to medicine on the Paracelsian plan, and in 1568 made himself distinguished by several important cures which he performed. In 1570 he published his Quinta Essentia, with wooden cuts, in Munster; from thence he went to Frankfort on the Oder, and published his Piso, a work which treats of *waters*, *rivers*, and *springs*. John George, Elector of Brandenburg, was at that time in Frankfort, and was informed that the treatise of Thurneysser pointed out the existence of a great deal of riches in the March of Brandenburg, till that time unknown. His courtiers, who were anxious to establish mines in 169 their possessions, united in recommending the author. He was consulted about a disease under which the wife of the elector was labouring, and having performed a cure, he was immediately named physician to this prince.

He turned this situation to the best account. He sold Spanish white, and other cosmetics, to the ladies of the court; and instead of the disgusting decoctions of the Galenists, he administered the remedies of Paracelsus under the pompous titles of *tincture of gold*, *magistery of the sun*, *potable gold*, &c. By these methods he succeeded in amassing a prodigious fortune, but was not fortunate enough to be able to keep it. Gaspard Hoffmann, professor at Frankfort, a well-informed and enlightened man, published a treatise, the object of which was to expose the extravagant pretensions and ridiculous ignorance of Thurneysser. This book drew the attention of the courtiers, and opened the eyes of the elector. Thurneysser lost much of his reputation; and the methods by which he attempted to bolster himself up, served only to sink him still lower in the estimation of men of sense. Among other things, he gave out that he was the possessor of a devil, which he carried about with him in a bottle. This pretended devil was nothing else than a scorpion, preserved in a phial of oil. The trick was discovered, and the usual consequences followed. He lost a process with his wife, from whom he was separated; this deprived him of the greatest part of his fortune. In 1584 he fled to Italy, where he occupied himself with the transmutation of metals, and he died at Cologne in 1595.

Thurneysser extols Paracelsus as the only true physician that ever existed. His Quintessence is written in verse. In the first book *The Secret* is the speaker. He is represented with a padlock in his mouth, a key in his hand, and seated on a coffer in a chamber, the windows of which are shut. This personage teaches that all things are 170 composed of salt, sulphur, and mercury, or of earth, air, and water; and consequently that *fire* is excluded from the number of the elements. We must search for the secret in the *Bible*, and then in the *stars* and the *spirits*. In the second book, *Alchymy* is the speaker. She points out the mode of performing the processes; and says that to endeavour to fix volatile substances, is the same thing as to endeavour to trace white letters on a wall with a piece of charcoal. She prohibits all long processes, because God created the world in six days.

His method of judging of the diseases from the urine of the patient deserves to be mentioned. He distilled the urine, and fixed to the receiver a tube furnished with a scale, the degrees of which consisted of all the parts of the body. The phenomena which he observed during the distillation of the urine, enabled him to draw inferences respecting the state of all these different organs.

I pass over Bodenstein, Taxites, and Dorn, who distinguished themselves as partisans of Paracelsus. Dorn derived the whole of chemistry from the first chapter of Genesis, the words of which he explained in an alchymistical sense. These words in particular, “And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament,” appeared to him to be an account of the *great work*. Severinus, physician to the King of Denmark, and canon of Roskild, was also a celebrated partisan of Paracelsus; but his writings do not show either that knowledge or stretch of thought which would enable us to account for the reputation which he acquired and enjoyed.

There were very few partisans of Paracelsus out of Germany. The most celebrated of his followers among the French, was Joseph du Chesne, better known by the name of Quercitanus, who was physician to Henry IV. He was a native of Gascony, and drew many 171 enemies upon himself by his arrogant and overbearing conduct. He pretended to be acquainted with the method of making gold. He was a thorough-going Paracelsian. He affirmed that diseases, like plants, spring from seeds. The word alchymy, according to him, is composed of the two Greek words ἅλς (salt) and χημεια, because the *great secret* is concealed in salt. All bodies are composed of three principles, as God is of three substances. These principles are contained in saltpetre, the salts of sulphur solid and volatile, and the volatile mercurial salt. He who possesses *sal generalis* may easily produce philosophical gold, and draw potable gold from the three kingdoms of nature. To prove the possibility of this transmutation, he cites an experiment very often repeated after him, and which some theologians have even employed as analogous to the resurrection of the dead; namely, the faculty which plants have of being produced from their ashes. His materia medica is founded on the *signatures* of plants, which he carries so far as to assert that male plants are more suitable to men, and female plants to women. Sulphuric acid, he says, has a magnetic virtue, in consequence of which it is capable of curing the epilepsy. He recommends the *magisterium cranii humani* as an excellent medicine, and boasts much of the virtues of antimony.

Du Chesne was opposed by Riolanus, who attacked chemical remedies with much bitterness. The medical faculty of Paris took up the cause of the Galenists with much zeal, and prohibited their fellows and licentiates from using any chemical medicines whatever. He had to sustain a dispute with Aubert relative to the origin and the transmutation of metals. Fenot came to the assistance of Aubert, and affirmed that gold possesses no medical properties whatever, that *crabs' eyes* are of no use when administered in intermittents, and that the laudanum of Paracelsus (being an opiate) is in reality hurtful instead of being 172
beneficial.

The decree of the medical faculty of Paris which placed antimony among the poisons, and which occasioned that of the Parliament of Paris, was composed by Simon Pietre, the elder, a man of great erudition and the most unimpeachable probity. Had it been literally obeyed it would have occasioned very violent proceedings; because chemical remedies, as they act more promptly and with greater energy, were getting daily into more general use. In 1603 the celebrated Theodore Turquet de Mayenne was prosecuted, because, in spite of the prohibition, he had sold antimonial preparations. The decree of the faculty against him exhibits a remarkable proof of the bigotry and intolerance of the times.[160] However Turquet does not seem to have been molested notwithstanding this decree. He ceased indeed to be professor of chemistry, but continued to practise medicine as formerly; and two members of the faculty, Seguin and Akakia, even wrote an apology for him. At last he went to England, whither he had been invited, to accept an honourable appointment. 173

The mystical doctrines of Paracelsus are supposed to have given origin to the sect of Rosecrucians, concerning which so much has been written and so little certain is known. It is not at all unlikely that the greatest part, if not the whole that has been stated about the antiquity, and extent, and importance of this sect, is mere fiction, and that the origin of the whole was nothing else than a ludicrous performance of Valentine Andreæ, an ecclesiastic of Calwe, in the country of Wirtemburg, a man of much learning, genius, and philanthropy. From his life, written by himself, and preserved in the library of Wolfenbuttel, we learn that in the year 1603 he drew up the celebrated Noce Chimique of Christian Rosenkreuz, in order to counteract the alchymistical and the theosophistical dogmas so common at that period. He was unable to restrain his risible faculties when he saw this *ludibrium juvenilis ingenii* adopted as a true history, while he meant it merely as a satire. It is believed that the Fama Fraternitatis is a production of this ecclesiastic, and that he published it in order to correct the chemists and enthusiasts of the time. He himself was called Andreæ, Knight of the Rose-cross (*rosæ crucis*) because he had engraven on his seal a cross with four roses.

It is true that Andreæ instituted, in 1620, a *fraternitas christiana*, but with quite other views than those which are supposed to have actuated the Rosecrucians. His object was to correct the religious opinions of the times, and to separate Christian theology from scholastic controversies, with which it had been unhappily intermixed. He himself, in different parts of his writings, distinguishes carefully between the Rosecrucians and his own society, and amuses himself with the credulity of the German theosophists, who adopted so readily his fiction for a series of truths. It would appear, therefore, that this secret order of

Rosecrucians, notwithstanding the brilliant origin assigned to it, really owes its birth to the pleasantry of a clergyman of Wirtemburg, who endeavoured by that means to set bounds to the chimeras of theosophy, but who unfortunately only increased still more the adherents of this absurd science. 174

A crowd of enthusiasts found it too advantageous to propagate the principles of the *rosa crux* not to endeavour to unite them into a sect. Valentine Weigel, a fanatical preacher at Tschoppau, near Chemnitz, left at his death a prodigious number of followers, who were already Rosecrucians, without bearing the name. Egidius Gutmann, of Suabia, was equally a Rosecrucian, without bearing the name; he condemned all pagan medicines, and affirmed that he possessed the universal remedy which ennobles man, cures all diseases, and gives man the power of fabricating gold. "To fly in the air, to transmute metals, and to know all the sciences," says he, "nothing more is requisite than faith."

Oswald Crollius, of Hesse, must also take his station in this honourable fraternity of enthusiasts. He was physician to the Prince of Anhalt, and afterwards a counsellor of the Emperor Rodolphus II. The introduction to his Basilica Chymica, contains a short but exact epitome of the opinions of Paracelsus. It is not worth while to give the reader a notion of his own opinions, which are quite as absurd and unintelligible as those of Paracelsus and his followers. As a preparer of chemical medicines he deserves more credit; *antimonium diaphoreticum* was a favourite preparation of his, and so was sulphate of potash, which was known at the time by the name of *specificum purgans Paracelsi*: he knew chloride of silver well, and first gave it the name of *luna cornea*, or *horn silver*: fulminating gold was known to him, and called by him *aurum volatile*.

This is the place to mention Andrew Libavius, of Halle, in Saxony, where he was a physician, and a professor in the gymnasium of Coburg, who was one of the most 175
successful opponents of the school of Paracelsus, and whose writings do him much credit. As a chemist, he deserves perhaps to occupy a higher rank than any of his contemporaries: he was, it is true, a believer in the possibility of transmuting metals, and boasted of the wonderful powers of *aurum potabile*; but he always distinguishes between rational alchymy and the *mental* alchymy of Paracelsus. He separated, with great care, *chemistry* from the reveries of the theosophists, and stands at the head of those who opposed most successfully the progress of superstition and fanaticism, which was making such an overwhelming progress in his time. His writings are very numerous and various, and were collected and published at Frankfort, in 1615, in three folio volumes, under the title of "Opera omnia Medico-chymica." Libavius himself died in 1616. It would occupy more space than we have room for, to attempt an abstract of his very multifarious works. A few observations will be sufficient: he wrote no fewer than five different tracts to expose the quackery of George Amwald, who had boasted that he was in possession of a panacea, by means of which he was enabled to perform the most wonderful cures, and which he was in the habit of selling to his patients at an enormous price; Libavius showed that this boasted panacea was nothing else than *cinnabar*, which neither possessed the virtues ascribed to it by Amwald, nor deserved to be purchased at so high a price. He entered also into a controversy with Crollius, and exposed his fanatical and absurd opinions. He engaged likewise in a dispute with Henning Scheunemann, a physician in Bamberg, who was a Rosecrucian, and, like the rest of his brethren, profoundly ignorant not merely of all science, but even of philology. The expressions of Scheunemann are so obscure, that we learn more of his opinions from Libavius than from his own writings. He divides the internal nature of man 176
into seven different degrees, from the seven changes it undergoes: these are, combustion, sublimation, dissolution, putrefaction, distillation, coagulation, and tincture. He gives us likewise an account of ten modifications which the three elements undergo; but as they are quite unintelligible, it is not worth while to state them. Libavius had the patience to analyze and expose all these gallimatias.

Libavius's system of chemistry, entitled "Alchymia è dispersis passim optimorum auctorum, veterum et recentiorum exemplis potissimum, tum etiam preceptis quibusdam operose collecta, adhibitisque ratione et experientia quanta potuit esse methodo accurate explicata et in integrum corpus redacta. Accesserunt tractati nonnulli physici chymici item methodistici." Frankfort, 1595, folio, 1597, 4to.—is really an excellent book, considering the period in which it was written, and deserves the attention of every person who is interested in the history of chemistry. I shall notice some of the most remarkable chemical facts which occur in Libavius, and which I have not observed in any preceding writer; who the actual discoverer of these facts really was, it is impossible to say, in consequence of the secrecy which at that time was affected, and the obscure terms in which chemical facts are in general stated.

He was aware that the fumes of sulphur have the property of blackening white lead. He was in the habit of purifying cinnabar by means of arsenic and oxide of lead. He knew the method of giving glass a red colour by means of gold or its oxide, and was aware of the method of making artificial gems, such as ruby, topaz, hyacinth, garnet, balass, by tinging glass by means of metallic oxides. He points out fluor spar as an excellent flux for various metals and their oxides. He knew that when metals were fused along with alkaline bodies, a certain portion of them was converted into slags, and this portion he endeavoured to recover 177
by the addition of iron filings. He was aware of the mode of acidifying sulphur by means of nitric acid. He knew that camphor is soluble in nitric acid, and forms with it a kind of oil. Of the perchloride of tin he was undoubtedly the discoverer, as it has continued ever since his time to pass by his name; namely, *fuming liquor of Libavius*. He was aware, that alcohol or spirits could be obtained by distilling the fermented juice of a great variety of sweet fruits. He procured sulphuric acid by the distillation of alum and sulphate of iron, as Geber had done long before his time; but he determined the nature of the acid with more care than had been done, and showed, that it was the same as that obtained by the combustion of sulphur along with saltpetre. To him, therefore, in some measure, are we indebted for the process of preparing sulphuric acid which is at present practised by manufacturers.

Libavius found a successor in Angelus Sala, of Vicenza, physician to the Duke of Mecklenburg-Schwerin, worthy of his enlightened views and indefatigable exertions to oppose the torrent of fanaticism which threatened to overwhelm all Europe. Sala was still more addicted to chemical remedies than Libavius himself; but he had abjured a multitude of prejudices which had distinguished the school of Paracelsus. He discarded *aurum potabile*, and considered fulminating gold as the only remedy of that metal that deserved to be prescribed by medical men. He treated the notion of the existence of a universal remedy with contempt. He described sulphuret of gold and glass of antimony with a good deal of precision. He recommended sulphuric acid as an excellent remedy, and showed that it might be formed indifferently from sulphur, or by distilling blue vitriol or green vitriol. He affirmed, that the essential salts obtained from plants had not the same virtues as the plants from which they are obtained. He showed that sal ammoniac is a compound of muriatic acid 178
and ammonia. To him, therefore, we are indebted for the first accurate mention of ammonia. It could not but have been noticed before by chemists, as it is procured with so much ease by the distillation of animal substances; but Sala is the first person who seems to have examined it with attention, and to have recognised its peculiar properties, and the readiness with which it saturates the different acids. He showed that iron has the property of precipitating copper from acid solutions: he pointed out also various precipitations of metals by other metals. He seems to have been acquainted with calomel, and to have been aware of at least some of its medical properties. He says, that fulminating gold loses its fulminating property when mixed with its own weight of sulphur, and the sulphur is burnt off it. Many other curious chemical facts occur in his writings, which it would be too tedious to particularize here. His works were collected and published in a quarto volume at Frankfort,

in 1647, under the title of "Opera Medico-chymica, quæ extant omnia." There was another edition in the same place in 1682, and an edition was published at Rome in 1650. 179

CHAPTER V.

OF VAN HELMONT AND THE IATRO-CHEMISTS.

Paracelsus first raised the dignity of chemistry, by pointing out the necessity of it for medical men, and by showing the superiority of chemical medicines over the disgusting decoctions of the Galenists. Libavius and Angelus Sala had carefully separated chemistry from the fanatical opinions of the followers of Paracelsus and the Rosecrucians. But matters were not doomed to remain in this state. Chemistry underwent a new revolution at this period, which shook the Spagirical system to its foundation; substituted other principles, and gave to medicine an aspect entirely new. This revolution was in a great measure due to the labours of Van Helmont.

John Baptist Van Helmont was a gentleman of Brabant, and Lord of Merode, of Royenboch, of Oorschot, and of Pellines. He was born in Brussels in 1577, and studied scholastic philosophy in Louvain till the age of seventeen. After having finished his *humanity* (as it was termed), he ought, according to the usage of the place, to have taken his degree of master of arts; but, having reflected on the futility of these ceremonies, he resolved never to solicit any academical honour. He next associated himself to the Jesuits, who then delivered courses of philosophy at Louvain, to the great displeasure of the professors of that city. One of the most celebrated of the Jesuits, Martin del Rio, even taught 180
him magic. But Van Helmont was disappointed in his expectations: instead of that true wisdom which he hoped to acquire, he met with nothing but scholastic dialectics, with all its usual subtilties. He was no better satisfied with the doctrines of the Stoics, who taught him his own weakness and misery.

At last the works of Thomas à Kempis, and John Taulerus fell into his hands. These sacred books of mysticism attracted his attention: he thought that he perceived that wisdom is the gift of the Supreme Being; that it must be obtained by prayer; and that we must renounce our own will, if we wish to participate in the influence of the divine grace. From this moment he imitated Jesus Christ, in his humility. He abandoned all his property to his sister, renouncing the privileges of his birth, and laying aside the rank which he had hitherto occupied in society. It was not long before he reaped the fruit of these abnegations. A genius appeared to him in all the important circumstances of his life. In the year 1633 his own soul appeared to him under the figure of a resplendent crystal.

The desire which he had of imitating in every respect the conduct of Christ, suggested to him the idea of practising medicine as a work of charity and benevolence. He began, as was then the custom of the time, by studying the art of healing in the writings of the ancients. He read the works of Hippocrates and Galen with avidity; and made himself so well acquainted with their opinions, that he astonished all the medical men by the profundity of his knowledge. But as his taste for mysticism was insatiable, he soon became disgusted with the writings of the Greeks; an accident led him to abandon them for ever. Happening to take up the glove of a young girl afflicted with the *itch*, he caught that disagreeable disease. The Galenists whom he consulted, attributed it to the combustion of 181
the bile, and the saline state of the phlegm. They prescribed a course of purgatives which

weakened him considerably, without effecting a cure. This circumstance disgusted him with the system of the humorists, and led him to form the resolution of reforming medicine, as Paracelsus had done. The works of this reformer, which he read with attention, awakened in him a spirit of reformation, but did not satisfy him; because his knowledge, being much greater than that of Paracelsus, he could not avoid despising the disgusting egotism, and the ridiculous ignorance of that fanatic. Though he had already refused a canonicate, he took the degree of doctor of medicine, in 1599, and afterwards travelled through the greatest part of France and Italy; and he assures us, that during his travels, he performed a great number of cures. On his return, he married a rich Brabantine lady, by whom he had several children; among others a son, afterwards celebrated under the name of Francis Mercurius, who edited his father's works, and who went a good deal further than his father had done, in all the branches of theosophy. Van Helmont passed the rest of his life on his estate at Vilvorde, almost constantly occupied with the processes of his laboratory. He died in the year 1644, on the 13th of December, at six o'clock in the evening, after having nearly reached the age of sixty-seven years.

The system of Van Helmont has for its basis the opinions of the spiritualists. He arranged even the influence of evil genii, the efforts of sorcerers, and the power of magicians among the causes which produce diseases. The archeus of Paracelsus constituted one of the capital points of his theory; but he ascribed to it a more substantial nature than Paracelsus had done. This archeus is independent of the elements; it has no form; for form constitutes the object of generation, or of production. These ideas are obviously borrowed 182
from the ancients. The *form* of Aristotle is not the μορφη, but the ενεργεια (*the power of acting*) which matter does not possess.

The archeus draws all the corpuscles of matter to the aid of *fermentation*. There are, properly speaking, only two causes of things; the cause *ex qua*, and the cause *per quam*. The first of these causes is *water*. Van Helmont considered water as the true principle of every thing which exists; and he brought forward very specious arguments in favour of his opinion, drawn both from the animal and vegetable kingdom. The reader will find his arguments on the subject, in his treatise entitled "Complexionum atque Mistionum elementalium Figmentum."[161] The only one of his experiments that, in the present state of our knowledge, possesses much plausibility, is the following: He took a large earthen vessel, and put into it 200 lbs. of earth, previously dried in an oven. This earth he moistened with rain-water, and planted in it a willow which weighed five pounds. After an interval of five years, he pulled up his willow and found that its weight amounted to 169 pounds, and about three ounces. During these five years, the earth in the pot was duly watered with rain or distilled water. To prevent the earth in which the willow grew from being mixed with new earth blown upon it by the winds, the pot was covered with tin plate, pierced with a great number of holes to admit the air freely. The leaves which fell every autumn during the vegetation of the willow in the pot, were not reckoned in the 169 lbs. 3 oz. The earth in the pot being again dried in the oven, was found to have lost about two ounces of its original weight. Thus 164 lbs. of wood, bark, roots, &c., were produced from water alone.[162] This, 183
and several other experiments which it is needless to state, satisfied him that all vegetable substances are produced from water alone. He takes it for granted that fish live (ultimately at least) on water alone; but they contain almost all the peculiar animal substances that exist in the animal kingdom. Hence he concludes that animal substances are derived also from pure water.[163] His reasoning with respect to sulphur, glass, stone, metals, &c., all of which he thinks may ultimately be resolved into water, is not so satisfactory.

Water produces elementary earth, or pure quartz; but this elementary earth does not enter into the composition of organic bodies. Van Helmont excludes *fire* from the number of elements, because it is not a substance, nor even the essential form of a substance. The matter of fire is compound, and differs entirely from the matter of light. Water gives origin also to the three chemical principles, salt, sulphur, and mercury, which cannot be considered as elements or active principles. I do not see clearly how he gets rid of *air*; for he says, that though water may be elevated in the form of vapour, yet that these vapours are no more air than the dust of marble is water.

According to Van Helmont, a particular disposition of matter, or a particular mixture of that matter is not necessary for the formation of a body. The archeus, by its sole power, draws all bodies from water, when the *ferment* exists. This *ferment*, in its quality of a mean which determines the action of the archeus, is not a formal being; it can neither be called a *substance*, nor an *accident*. It pre-exists in the seed which is developed by it, and which contains in itself a second ferment of the seed, the product of the first. The ferment exhales an odour, which attracts the generating spirit of the archeus. This spirit consists in an *aura* 184 *vitalis*, and it creates the bodies of nature in its own image, after its own *idea*. It is the true foundation of life, and of all the functions of organized bodies; it disappears only at the instant of death to produce a new creation of the body, which enters then, for the second time, into fermentation. The seed, then, is not indispensable to enable an animal to propagate its species; it is merely necessary that the archeus should act upon a suitable ferment. Animals produced in this manner are as perfect as those which spring from eggs.

When water, as an element, ferments, it develops a vapour, to which Van Helmont gave the name of *gas*, and which he endeavours to distinguish from *air*. This gas contains the chemical principles of the body from which it escapes in an aerial form by the impulse of the archeus. It is a substance intermediate between spirit and matter, the principle of action of life, and of generation of all bodies; for its production is the first result of the action of the vital spirit on the torpid ferment, and it may be compared to the *chaos* of the ancients.

The term *gas*, now in common use among chemists, and applied by them to all elastic fluids which differ in their properties from common air, was first employed by Van Helmont: and it is evident, from different parts of his writings, that he was aware that different species of gas exist. His *gas sylvestre* was evidently our *carbonic acid gas*, for he says, that it is evolved during the fermentation of wine and beer; that it is formed when charcoal is burnt in air; and that it exists in the Grotto del Cane. He was aware that this gas extinguishes a lighted candle. But he says that the gases from dung, and those formed in the large intestines, when passed through a candle, catch fire, and exhibit a variety of colours, like the rainbow.[164] To these combustible gases he gave the names of *gas pingue*, *gas* 185 *siccum*, *gas fuliginosum*, or *endimicum*.

Sal ammoniac, he says, may be distilled alone, without danger, and so may aqua fortis (*aqua chrysulca*), but if they be mixed together so much gas sylvestre is produced, that the vessels employed, however strong, will burst asunder, unless an opening be left for the escape of this gas.[165] In the same way cream of tartar cannot be distilled in close vessels without breaking them in pieces, an opening must be left for the escape of the *gas sylvestre*, which is generated in such abundance.[166] He says, also, that when carbonate of lime is dissolved in distilled vinegar, or silver in nitric acid, abundance of gas sylvestre is extricated. From these, and many other passages which might be quoted, it is evident that Van Helmont was aware of the evolution of gas during the solution of carbonates and metals in acids, and during the distillation of various animal and vegetable substances, that he had anticipated the experiments made so many years after by Dr. Hales, and for which that philosopher got so much credit. But it would be going too far to say, as some have done, that Van Helmont knew accurately the differences which characterize the different gases which he produced, or indeed that he distinguished accurately between them. For it is evident, from the passages quoted and from many others which occur in his treatise, De Flatibus, that carbonic acid, protoxide of azote, and deutoxide of azote, and probably also muriatic acid gas were all considered by him as constituting one and the same gas. How,

indeed, could he distinguish between different gases when he was not acquainted with the method of collecting them, or of determining their properties? These observations of Van Helmont, then, though they do him much credit, and show how far his chemical knowledge 186
was superior to that of the age in which he lived, take nothing from the merit or the credit of those illustrious chemists who, in the latter half of the eighteenth century, devoted themselves to the investigation of this part of chemistry, at that time attended with much difficulty, but intimately connected with the subsequent progress which the science has made.

Van Helmont was aware, also, that the bulk of air is diminished when bodies are burnt in it. He considered respiration to be necessary in this way: the air was drawn into the blood by the pulmonary arteries and veins, and occasioned a fermentation in it requisite for the continuance of life.

Gas, according to Van Helmont, has an affinity with the principle of the movement of the stars, to which he gave the name of *blas*. It had, he supposed, much influence on all sublunary bodies. He admitted in the ferment which gives birth to plants, a substance which, after the example of Paracelsus, he called *pessas*, and to the metallic ferment he gave the name of *bur*.[167]

The archeus of Van Helmont, like that of Paracelsus, has its seat in the stomach. It is the same thing as the sentient soul. This notion of the nature and seat of the archeus was founded on the following experiment: He swallowed a quantity of *aconitum* (*henbane*). In two hours he experienced the most disagreeable sensation in his stomach. His feeling and understanding seemed to be concentrated in that organ, for he had no longer the free use of his mental faculties. This feeling induced him to place the seat of understanding in the
stomach, of volition in the heart, and of memory in the brain. The faculty of desire, to which 187
the ancients had assigned the liver as its organ, he placed in the spleen. What confirmed him still more in the idea that the stomach is the seat of the soul, is the fact, that life sometimes continues after the destruction of the brain, but never, he alleges, after that of the stomach. The sentient soul acts constantly by means of the *vital spirits*, which are of a resplendent nature, and the nerves serve merely to moisten these spirits which constitute the mediums of sensation. By virtue of the archeus man is much nearer to the realm of spirits and the father of all the genii, than to the world. He thinks that Paracelsus's constant comparison of the human body with the world is absurd. Yet Van Helmont, at least in his youth, was a believer in magnetism, which he employed as a method of explaining the effect of sympathy.

The archeus exercises the greatest influence on digestion, and he has chiefly the stomach and spleen under his superintendence. These two organs form a duumvirate in the body; for the stomach cannot act alone and without the concurrence of the spleen. Digestion is produced by means of an acid liquor, which dissolves the food, under the superintendence of the archeus. Van Helmont assures us that he had himself tasted this acid liquor in the stomach of birds. Heat, strictly speaking, does not favour digestion; for we see no increase of the digestive powers during the most ardent fever. Nor are the powers of digestion wanting in fishes, although they want the animal heat which is requisite for mammiferous animals. Certain birds even digest fragments of glass, which, certainly, simple heat would not enable them to do. The pylorus is, in some measure, the director of digestion. It acts by a peculiar and immaterial power, in virtue of a *blas*, and not as a muscle. It opens and shuts
the stomach according to the orders of the archeus. It is in it, therefore, that the causes of 188
derangement of digestion must be sought for.

The duumvirate just spoken of is the cause of natural sleep, which does not belong to the soul, as far as it resides in the stomach. Sleep is a natural action, and one of the first vital actions. Hence the reason why the embryo sleeps without ceasing. At any rate it is not true that sleep is owing to vapours which mount to the brain. During sleep the soul is naturally occupied, and it is then that the deity approaches most intimately to man. Accordingly, Van Helmont informs us, that he received in dreams the revelation of several secrets, which he could not have learnt otherwise.

The duumvirate operates the *first* digestion, of which, Van Helmont enumerates six different species. When the acid, which is prepared for digestion, passes into the duodenum it is neutralized by the bile of the gall-bladder. This constitutes the second digestion. To the bile of the gall-bladder, Van Helmont gave the name of *fel*, and he carefully distinguished it from the biliary principle in the mass of the blood. This last he called *bile*. The *fel* is not an excrementitious matter, but a humour necessary to life, a true vital balsam. Van Helmont endeavoured to show by various experiments that it is not *bitter*.

The *third* digestion takes place in the vessels of the mesentery, into which the gall-bladder sends the prepared fluid. The *fourth* digestion is operated in the heart, where the red blood becomes more yellow and more volatile by the addition of the vital spirits. This is owing to the passage of the vital spirit from the posterior to the anterior ventricle, through the pores of the septum. At the same time the pulse is produced, which of itself develops heat; but does not regulate it in any manner, as the ancients pretended that it did. The *fifth* digestion consists in the conversion of the arterial blood into vital spirit. It takes place 189
principally in the brain, but is produced also throughout all the body. The *sixth* digestion consists in the elaboration of the nutritive principle in each member, where the archeus prepares its own nourishment by means of the vital spirits. Thus, there are six digestions: the number seven has been chosen by nature for a state of repose.

From the preceding sketch of the physiology of Van Helmont, it is evident that he paid little or no regard to the structure of the parts in explaining the functions. In his pathology we find the same passion for spiritualism. He admitted, indeed, the importance of anatomy, but he regretted that the pathological part of that science had been so little cultivated. As the archeus is the foundation of life and of all the functions, it is plain that the diseases can neither be derived from the four cardinal humours, nor from the disposition or the action of opposite things; the proximate cause of diseases must be sought for in the sufferings, the anger, the fear, and the other affections of the archeus, and their remote cause may be considered as the ideal seed of the archeus. Disease, in his opinion, is not a negative state or a mere absence of health, it is a substantial and active thing as well as a state of health. Most of the diseases which attack certain parts or members of the body result from an error in the archeus, who sends his ferment from the stomach in which he resides into the other parts of the body. Van Helmont explained in this way not only the epilepsy and madness, but likewise the *gout*, which does not proceed from a flux, and has not its seat in the limb in which the pain resides, but is always owing to an error in the vital spirit. It is true that the character of the gout acts upon the semen in which the vital spirit principally manifests its action, and that in this way diseases are propagated in the act of generation; but if, during 190
life instead of altering the semen it is carried to the liquid of the articulations, this is a proof of the prudence of nature, which lavishes all her cares on the preservation of the species, and loves better to alter the humours of the articulations than the semen itself. The gout acidifies the liquors of the articulations, which is then coagulated by the acids. The duumvirate is the cause of apoplexy, vertigo, and particularly of a species of asthma, which Van Helmont calls *caducus pulmonalis*. Pleurisy is produced in a similar way. The archeus, in a movement of rage, sends acrid acids to the lungs, which occasion an inflammation. Dropsy is also owing to the anger of the archeus, who prevents the secretions of the kidneys from going on in the usual way.

Of all the diseases, fever appeared to him most conformable to his notions of the unlimited power of the archeus. The causes of fever are all much more proper to offend the archeus, than to alter the structure of parts and the mixture of humours. The cold fit is owing to a state of fear and consternation, into which the archeus is thrown, and the hot stage results from his disordered movements. All fevers have their peculiar seat in the duumvirate.

Van Helmont was in general much more successful in refuting the scholastic opinions by which the practice of medicine was regulated in his time, than in establishing his own. We are struck with the force of his arguments against the Galenical doctrine of fever, and against the influence of the cardinal humours on the different kinds of fever. He refuted no less vehemently the idea of the putridity of the blood, while that liquid circulates in the vessels. Perhaps he carried the opposite doctrine too far; but his opinions have had a good effect upon subsequent medical theory, and medical men learned from them to make less use of the term putridity. The phrase *mixture of humours*, not more intelligible, however, 191
came to be substituted for it.

Van Helmont's theory of urinary calculi deserves peculiar attention, because it exhibits the germ of a more rational explanation of these concretions than had been previously attempted by physiologists. Van Helmont was aware that Paracelsus, who ascribed these concretions to tartar, had formed an idea of their nature, which a careful chemical analysis would immediately refute. He satisfied himself that urinary calculi differ completely from common stones, and that they do not exist in the food or drink which the calculous person had taken. Tartar, he says, precipitates from wine, not as an earth, but as a crystallized salt. In like manner, the natural salt of urine precipitates from that liquid, and gives origin to calculi. We may imitate this natural process by mixing spirit of urine with rectified alcohol. Immediately an *offa alba* is precipitated.

It is needless to observe that Van Helmont was mistaken, in supposing that this *offa* was the matter of calculus. Spirit of urine was a strong solution of carbonate of ammonia. The alcohol precipitated this salt; so that his *offa* was merely *carbonate of ammonia*. Nor is there the shadow of evidence that alcohol, as Van Helmont thought it did, ever makes its way into the mass of humours; yet his notion of the origin of calculi is not less accurate, though of course he was ignorant of the chemical nature of the various substances which constitute these calculi. From this reasoning Van Helmont was induced to reject the term *tartar*, employed by Paracelsus. To avoid all false interpretations he substitutes the word *duelech*, to denote the state in which the spirit of urine precipitates and gives origin to these calculous concretions.

As all diseases proceeded in his opinion from the archeus, the object of his treatment
was to calm the archeus, to stimulate it, and to regulate its movements. To accomplish these 192
objects he relied upon dietetics, and upon acting on the imaginations of his patients. He considered *certain words* as very efficacious in curing the diseases of the archeus. He admitted the existence of the universal medicine, to which he gave the names of *liquor alkahest*, *ens primum salium*, *primus metallus*. Mercurials, antimonials, opium, and wine, are particularly agreeable to the archeus, when in a state of delirium from fever.

Among the mercurial preparations, he praises what he calls *mercurius diaphoreticus* as the best. He gives no account of the mode of preparing it; but from some circumstances I think it must have been *calomel*. He considers it as a sovereign remedy in fevers, dropsies, diseases of the liver, and ulcers of the lungs. He employed the red oxide of mercury as an external application to ulcers. The principal antimonial preparations which he employed were the hydrosulphuret, or *golden sulphur*, and the deutoxide, or *antimonium diaphoreticum*. This last medicine was used in scruple doses—a proof of its great inertness compared with the protoxide of antimony.

Opium he considered as a fortifying and calming medicine. It contains an acrid salt and a bitter oil, which give it the virtue of putting a stop to the errors of the archeus, when it was sending its acid ferment into other acid parts of the body. Van Helmont assures us that he wrought many important cures by the employment of wine.

Such is a very short statement of the opinions of a man, who, notwithstanding his attachment to the fanatical opinions which distinguished the time in which he lived, had the merit of overturning a vast number of errors, both theoretical and practical; and of laying down many principles, which, for want of erudition, have been frequently assigned to modern writers. Van Helmont has been frequently placed on the same level with Paracelsus, and treated like him with contempt. But his claims upon the medical world are much higher, 193
and his merits infinitely greater. His notions, it is true, were fanatical; but his erudition was great, his understanding excellent, and his industry indefatigable. His writings did not become known till rather a late period; for, with the exception of a single tract, they were not published till 1648, by his son, after his death.

The decided preference given to chemical medicines by Van Helmont, and the uses to which he applies chemical theory, had a natural tendency to raise chemistry to a higher rank in the eyes of medical men than it had yet reached. But the man to whom the credit of founding the iatro-chemical sect is due, is Francis de le Boé Sylvius, who was born in the year 1614. While a practitioner of medicine at Amsterdam, he studied with profound attention the system of Van Helmont, and the rival and much more popular theory of Descartes: upon these he founded his own theory, which, in reality, contains little entitled to the name of original, notwithstanding the tone in which he speaks of it, and his repeated declarations that he had borrowed from no one. He was appointed professor of the theory and practice of medicine in the University of Leyden, where he taught with such eclat, and drew after him so great a number of pupils, that Boerhaave alone surpassed him in this respect. It was he that first introduced the practice of giving clinical lectures in the hospitals, on the cases treated in the presence of the pupils. This admirable innovation has been productive of much benefit to medicine. He greatly promoted anatomical studies, and inspected, himself, a vast number of dead bodies. This is the more remarkable, because his own system, like that of Van Helmont, from whom it was borrowed, was quite independent of the structure of the parts.

Every thing was explained by him according to the principles of chemistry, as they
were then understood. The celebrity of the university in which he taught, and the vast 194
number of his pupils, contributed to spread this theory into every part of the world, and to give it an eclat which is really surprising, when we consider it with attention. But he possessed the talents just suited for securing the reception of his opinions by his pupils as infallible oracles, and of being the idol of the university. Yet it is melancholy to be obliged to add, that few persons ever more abused the favours of nature, or the advantages of situation and elocution.

To form a clear idea of the principles of this founder of iatro-chemistry, we have only to call to mind the ferments of Van Helmont, which constitute the foundation-stone of the whole system. We cannot, says he, conceive a single change in the mixture of the humours, which is not the consequence of fermentation; and yet he assigns to this fermentation conditions which are scarcely to be found united in the living body. Digestion, in his opinion, is a true fermentation produced by the application of a ferment. Like Van Helmont, he admits a *triumvirate*; but places it in the humours; the effervescence or fermentation of which enabled him to explain most of the functions of the body. Digestion is the result of the mixture of the saliva with the pancreatic juice and the bile, and the fermentation of these humours. The saliva, as well as the pancreatic juice, contains an acidulous salt easily recognised by the taste. Here Sylvius derives advantage from the experiments of Regnier de Graaf on the pancreatic juice, which he had constantly found acid.

Sylvius, who affirmed that the bile contained an alkali, united with an oil and a volatile spirit, supposes an effervescence from the union of the alkali of the bile with the acid of the pancreatic juice, and this *fermentation* he considered as the cause of digestion. By this fermentation the *chyle* is produced, which is nothing else than the *volatile spirit* of the food 195
accompanied by an *oil* and an alkali, neutralized by a weak acid. The blood is more than completed (*plus quam perficitur*) in the spleen. It acquires its highest perfection by the addition of a certain quantity of vital spirits. The *bile* is not drawn from the blood in the liver, but pre-exists in the circulating fluid. It mixes with that fluid anew to be carried to the heart together with the *lymph*, equally mixed with the blood, and there it gives origin to a vital fermentation. In this way the blood becomes the centre of reunion of all the humours of the secretions, which mix together or separate, without the solids taking the smallest share in the operations. Indeed, so completely are the solids banished from the system of Sylvius that he attends to nothing whatever except the humours.

The formation and motion of the blood is explained by the fermentation of the oily volatile salt of the bile, and the dulcified acid of the lymph, which develops the vital heat, by which the blood is attenuated and becomes capable of circulating. This vital fire, quite different from ordinary fire is kept up in its turn by the uniform mixture of the blood. It attenuates the humours, not because it is *heat* but because it is composed of *pyramids*. This last notion is obviously borrowed from Descartes, just as the fermentation in the heart, as the cause of the motion of the blood, reminds us of the opinions of Van Helmont.

Sylvius explains the preparation of the vital spirits in the encephalos by distillation, and he finds a great resemblance between their properties and those of spirit of wine. The nerves conduct these spirits to the different parts, and they spread themselves in the substance of the organs to render them sensible. When they insinuate themselves into the glands the addition of the acid of the blood produces a liquid analogous to naphtha, which constitutes the *lymph*. Lymph, then, is a compound of the vital spirit and the acid of the 196
blood. *Milk* is formed in the mammæ by the afflux of a very mild acid, which gives a white colour to the red humour of the blood.

The theory of the natural functions was no less chemical. Even the diseases themselves were explained upon chemical principles. Sylvius first introduced the word *acridity* to denote a predominance of the chemical elements of the humours, and he looked upon these *acridities* as the proximate cause of all diseases. But as every thing acrid may be referred to one or other of two classes, acids and alkalies, there are only two great classes of diseases; namely, those proceeding from an *acid acridity*, and those proceeding from an *alkaline*.

Sylvius was not altogether ignorant of the constituent parts of the animal humours; but it is obvious, from the account of his opinions just given, that this knowledge was very incomplete; indeed the whole of his chemical science resolves itself into a comparison of the humours of the living body with chemical liquids. Perhaps his notions respecting such of the *gases*, as he had occasion to observe, were somewhat clearer than those of Van Helmont. He called them *halitus*, and takes some notice of their different chemical properties, and states the influence which he supposes them to exert in certain diseases.

In the human body he saw nothing but a magna of humours continually in fermentation, distillation, effervescence, or precipitation; and the physician was degraded by him to the rank of a distiller or a brewer.

Bile acquires different acridities, when bad food, altered air, or other similar causes act apon the body. It becomes *acid* or *alkaline*. In the former case it thickens and occasions obstructions; in the latter it excites febrile heat; and the viscid vapours elevated from it are the cause of the cold fit with which fever commences. All acute and continued fevers have their origin in this acridity of the bile. The vicious mixture of the bile with the blood, or its 197 specific acridity, produces *jaundice*, which is far from being always owing to obstructions in the liver. The vicious effervescence of the bile with the pancreatic juice produces almost all other diseases. But all these assertions of Sylvius are unsupported by evidence.

The acid acridity of the pancreatic juice, and the obstruction of the pancreatic ducts, which are produced by it, are considered by him as the cause of intermittent fevers. When the acid of the pancreatic juice acquires still more acridity, hypochondriasis and hysteria are the consequences of it. If, during the morbid effervescence of the pancreatic juice with the bile an acid and viscid humour arise, the vital spirits of the heart are overwhelmed during a certain time. This occasions syncope, palpitation of the heart, and other nervous affections.

When the acid acridity of the pancreatic juice or of the lymph (for both are similar) is deposited on the nerves, the consequence is spasms or convulsions; epilepsy in particular depends upon the acrid vapours produced by the morbid effervescence of the pancreatic juice with acrid bile. Gout has the same origin as intermittent fevers, for we must look for it in the obstruction of the pancreas and the lymphatic glands, accompanied with an acid acridity of the lymph. Rheumatism is owing to the acrid acid, deprived of the oil which dulcifies it. The smallpox is occasioned by an acid acridity in the lymph, which gives origin to the pustules. Indeed all suppuration in general is owing to a coagulating acid in the lymph. Syphilis results from a caustic acid in the lymph. The itch is produced by an acid acridity of the lymph. Dropsies are produced by the same acid acridity of the lymph. Urinary calculi are the consequences of a coagulating acid existing in the lymph and the pancreatic juice. Corrosive acids, and the loss of volatile spirits, occasion leucorrhœa. 198

From the preceding statement it would appear that almost all diseases proceed from acids. However, Sylvius informs us that malignant fevers are owing to a superabundance of volatile salts and to a too great tenuity of the blood. The vital spirits themselves give occasion to diseases. They are sometimes too aqueous, sometimes they effervesce too violently, and sometimes not at all. Hence all the nervous diseases, which Sylvius never considers as existing by themselves; but as always derived from the acid, acrid, or alkaline vapours which trouble the vital spirits.

The method of cure which Sylvius deduced from these absurd and contemptible hypotheses, was worthy of the hypotheses themselves; and certainly constitute the most detestable mode of treatment that ever has disgraced medical science. To diseases produced by the effervescence of the bile he opposed purgatives; because in his opinion emetics produced injurious effects. The reason was, that the emetics which he employed were too violent, consisting of antimonial preparations, particularly *powder of Algerotti*, or an impure protoxide of antimony. For though *emetic tartar* had been discovered in 1630, it does not seem to have come into use till a much later period. We do not find any notice of it in the *praxis chymiatrica* of Hartmann published in 1647, at Geneva.

He endeavoured to moderate the acridity of the bile by opiates and other narcotics. It will scarcely be believed, though it was a natural consequence of his opinions, when we state that he recommended ammoniacal preparations, particularly his oleaginous volatile salt, and spirit of hartshorn, &c., as cures for almost all diseases. Sometimes they were employed to correct the acidity of the lymph, sometimes to destroy the acid acridity of the pancreatic juice, sometimes to correct the inertness of the vital spirits, sometimes to promote the secretions, and to induce a flow of the menses. Volatile spirit of amber and opium were prescribed by him in intermittent fevers; and volatile salts in almost all acute 199
diseases. He united them with antivenomous potions, angelica, contrayerva, bezoard, crabs' eyes, and other similar substances. These absorbents seemed to him very necessary to correct the acidity of the pancreatic juice, and the acridity of the bile. In administering them he paid no attention to the regular course which acute diseases usually run; he neither inquired into the remote nor proximate causes of disease, nor to the symptoms: every thing

was neglected connected with induction, and his whole proceedings regulated by wild speculations and absurd theories, quite inconsistent with the phenomena of nature.

To attempt to refute these wild notions of Sylvius would be loss of time. It is extraordinary, and almost incredible, that he could have regulated his practice by them: and it is a still more incredible thing, and exhibits a very humiliating view of human nature, that these crudities and absurdities were swallowed with avidity by crowds of students, who placed a blind reliance on the dogmas of their master, and were initiated by him into a method of treating their patients, better calculated than any other that could easily have been devised, to aggravate all their diseases, and put an end to their lives. If any of the patients of the iatro-chemists ever recovered their health, well might it be said that their recovery was not the consequence of the prescriptions of their physicians, but that it took place in spite of them.[168] 200

It is a very remarkable circumstance, and shows clearly that mankind in general had become disgusted with the dogmas of the Galenists, that iatro-chemistry was adopted more or less completely by almost all physicians. There were, indeed, a few individuals who raised their voices against it; but, what is curious and inexplicable, they never attempted to start objections against the principles of the iatro-chemists, or to point out the futility of their hypothesis, and their inconsistency with fact. They combated them by arguments not more solid than those of their antagonists.

During the presidency of Riolan over the Medical College of Paris, that learned body set itself against all innovations. Guy Patin, who was a medical professor in the University of Paris, and a man of great celebrity, opposed the chemical system of medicine with much zeal. In his Martyrologium Antimonii he collects all the cases in which the use of antimony, as a medicine, had proved injurious to the patient. But in the year 1666, the dispute relative to antimony, and particularly relative to tartar emetic, became so violent, that all the doctors of the faculty of Paris were assembled by an order of the parliament, under the presidency of Dean Vignon, and after a long deliberation, it was concluded by a majority of ninety-two votes, that tartar emetic, and other antimonials, should not only be permitted, but even recommended. Patin after this decision pretended no longer to combat chemical medicine; but he did not remain inactive. One of his friends, Francis Blondel, demanded the resolution to be cancelled; but his exertions were unsuccessful; nor were the writings of Guillemeau and Menjot, who were also keen partisans of the views of Patin, attended with better success.

In England iatro-chemistry assumed a direction quite peculiar. It was embraced by a set of men who had cultivated anatomy with the most marked success, and who were quite 201 familiar with the experimental method of investigating nature. The most eminent of all the English supporters of iatro-chemistry was Thomas Willis, who was a contemporary of Sylvius.

Dr. Willis was born at Great Bodmin, in Wiltshire, in 1621. He was a student at Christchurch College, in Oxford, when that city was garrisoned for King Charles I. Like the other students, he bore arms for his Majesty, and devoted his leisure hours to the study of physic. After the surrender of Oxford to the parliament, he devoted himself to the practice of medicine, and soon acquired reputation. He appropriated a room as an oratory for divine service, according to the forms of the church of England, to which most of the loyalists of Oxford daily resorted. In 1660, he became Sedleian professor of natural philosophy, and the same year he took the degree of doctor of physic. He settled ultimately in London, and soon acquired a higher reputation, and a more extensive practice, than any of his contemporaries. He died in 1675, and was buried in Westminster Abbey. He was a first-rate anatomist. To him we are indebted for the first accurate description of the brain and nerves.

But it is as an iatro-chemist that he claims a place in this work. His notions approach nearer to those of Paracelsus than to the hypotheses of Van Helmont and Sylvius. He admits the three chemical elements of Paracelsus, salt, sulphur, and mercury, in all the bodies in nature, and employs them to explain their properties and changes; but he gives the name of *spirit* to the *mercury* of Paracelsus. He ascribes to it the virtue of volatilizing all the constituent parts of bodies: salt, on the other hand, is the cause of fixity in bodies; *sulphur* produces colour and heat, and unites the *spirit* to the *salt*. In the stomach there occurs an acid ferment, which forms the chyle with the sulphur of the aliments: this chyle enters into effervescence in the heart, because the salt and sulphur take fire together. From this results 202
the vital flame, which penetrates every thing. The vital spirits are secreted in the brain by a real distillation. The vessels of the testes draw an elixir from the constituent parts of the blood; but the spleen retains the earthy part, and communicates a new igneous ferment to the circulating fluid. On this account the blood must be considered as a humour, constantly disposed to fermentation, and in this respect it may be compared to wine. Every humour in which salt, sulphur, and spirit predominates in a certain manner, may be converted into a *ferment*. All diseases proceed from a morbid state or action of this ferment; and a physician may be compared to a wine-merchant; for, like him, he has nothing to do but to watch that the necessary fermentations take place with regularity, and that no foreign substance come to derange the operation.

At this period the mania of explaining every thing had proceeded to such a length, that no distinction was made between dead and living bodies. The chemical facts which were at that time known, were applied without hesitation to explain all the functions and all the diseases of the living body. According to Willis, fever is the simple result of a violent and preternatural effervescence of the blood and the other humours of the body, either produced by external causes, or by internal ferments, into which the chyle is converted when it mixes with the blood. The effervescence of the vital spirits is the source of quotidians; that of salt and sulphur produces continued fever; and external ferments of a malignant nature produce malignant fevers. Thus the smallpox is owing to the seeds of fermentation set in activity by an external principle of contagion. Spasms and convulsions are produced by an explosion of the salt and sulphur with the animal spirits. Hypochondriacal affections and hysteria depend originally on the morbid putrifaction of the blood in the spleen, or on a bad fermentescible 203
principle, loaded with salt and sulphur, which unites with the vital spirits and deranges them. Scurvy is owing to an alteration of the blood, which may then be compared to vapid or stale wine. The gout is merely the coagulation of the nutritive juices altered by the acidified animal spirits; just as sulphuric acid forms a coagulum with carbonate of potash.

The action of medicines is easily explained by the effects which they produce on the nourishing principles. Sudorifics are considered as cordials, because they augment the sulphur of the blood, which is the true food of the vital flame. Cordials purify the animal spirits, and fix the too volatile blood. Willis disagrees with the other iatro-chemists of his time in one thing: he recommends bleeding in the greater number of diseases, as an excellent method of diminishing unnatural fermentation.

Dr. Croone, a celebrated Fellow of the Royal Society, was another English iatro-chemist, who attempted to explain muscular motion by the effervescence of the nervous fluid, or animal spirits.

It is not worth while to notice the host of writers—English, French, Italian, Dutch, and German, who exerted themselves to maintain, improve, and defend, the chemical doctrines of medicine. The first person who attempted to overturn these absurd doctrines, and to introduce something more satisfactory in their place, was Mr. Boyle, at that time in the height of his celebrity.

Robert Boyle was born at Youghall, in the province of Munster, on the 25th of January, 1627. He was the seventh son, and the fourteenth child of Richard, Earl of Cork. He was partly educated at home, and partly at Eton, where he was under the tuition of Sir Henry Wotton. At the age of eleven, he travelled with his brother and a French tutor through France to Geneva, where he pursued his studies for twenty-one months, and then went to 204
Italy. During this period, he acquired the French and Italian languages; and, indeed, talked in the former with so much fluency and correctness, that he passed, when he thought proper, for a Frenchman. In 1642, his father's finances were deranged, by the breaking out of the great Irish rebellion. His tutor, who was a Genevese, was obliged to borrow, on his own credit, a sum of money sufficient to carry him home. On his arrival, he found his father dead; and, though two estates had been left to him, such was the state of the times, that several years elapsed before he could command the requisite sum of money to supply his exigencies. He retired to an estate at Stalbridge, in Dorsetshire.

In 1654 he went to Oxford, where he associated himself with a number of eminent men (Dr. Willis among others), who had constituted themselves into a combination for experimental investigations, distinguished by the name of the *Philosophical College*. This society was transferred to London; and, in 1663, was incorporated by Charles II. under the name of the *Royal Society*. In 1668 Mr. Boyle took up his residence in London, where he continued till the last day of December, 1691, assiduously occupied in experimental investigations, on which day he died, in the sixty-fifth year of his age.

We are indebted to Mr. Boyle for the first introduction of the air-pump and the thermometer into Britain, and for contributing so much, by means of Dr. Hooke, to the improvement of both. His hydrostatical and pneumatical investigations and experiments constitute the foundation of these two sciences. The thermometer was first made an accurate instrument of investigation by Sir Isaac Newton, in 1701. This he did by selecting as two fixed points the temperatures at which water freezes and boils; marking these upon the stem of the thermometer, and dividing the interval between them into a certain number of 205
degrees. All thermometers made in this way will stand at the same point when plunged into bodies of the same temperature. The number of divisions between the freezing and boiling points constitute the cause of the differences between different thermometers. In Fahrenheit's thermometer, which is used in Great Britain, the number of degrees, between the freezing and boiling points of water, is 180; in Reaumur's it is 80; in Celsius's, or the centigrade, it is 100; and in De Lisle's it is 150.

But my reason for mentioning Mr. Boyle here was, the attempt which he made in 1661, by the publication of his Sceptical Chemist, to overturn the absurd opinions of the iatro-chemists. He raises doubts, not only respecting the existence of the elements of the Peripatetics, but even of those of the chemists. The first elements of bodies, in his opinion, are *atoms*, of different shapes and sizes; the union of which gives origin to what we vulgarly call *elements*. We cannot restrain the number of these to four, as the Peripatetics do; nor to three, with the chemists: neither are they immutable, but convertible into each other. Fire is not the means that ought to be employed to obtain them; for the *salt* and *sulphur* are formed during its action by the union of different simple bodies.

Boyle shows, besides, that the chemical theory of qualities is exceedingly inaccurate and uncertain; because it takes for granted things which are very doubtful, and in many cases directly contrary to the phenomena of nature. He endeavours to prove the truth of these ideas, and particularly the production of the chemical principles, by a great number of convincing and conclusive experiments.

In another treatise, entitled "The Imperfections of the Chemical Doctrine of Qualities,"[169] he points out, in the second section, the insufficiency of the hypotheses of 206
Sylvius relative to the generality of acids and alkalies. He shows that the offices ascribed to

them are arbitrary, and the notions respecting them unsettled; that the hypotheses respecting them are needless, and insufficient, and afford but an unsatisfactory solution of the phenomena.

These arguments of Boyle did not immediately shake the credit of the chemical system. In the year 1691, a chemical academy was founded at Paris by Nicolas de Blegny, the express object of which was to examine these objections of Boyle, which by this time had attracted great attention. Boyle's experiments were repeated and confirmed; but the academicians, notwithstanding, came to the conclusion, that it is unnecessary to have recourse to the true elements of bodies; and that the phenomena which occur in the animal economy may be explained by the predominance of acids or alkalies. Various other publications appeared, all on the same side.

In Germany, Hermann Conringius, the most skilful physician of his time, opposed the chemical theory; and his opinions were impugned by Olaus Borrichius, who defended not only alchymy, but the chemical theory of medicine, with equal erudition and zeal.[170]

Towards the end of the sixteenth century, the chemists thought of examining the liquids of the living body, to ascertain whether they really contained the acids and alkalies which had been assigned them, and considered as the cause of all diseases. But at that time chemistry had made so little progress, and such was the want of skill of those who undertook these investigations, that they readily obtained every thing that was wanted to confirm their previous notions. John Viridet, a physician of Geneva, announced that he had found an acid in the saliva and the pancreatic juice, and an alkali in the gastric juice and the bile. But the most celebrated experiments of that period were those of Raimond Vieussens, 207
undertaken in 1698, in order to discover the presence of an acid spirit in the blood. His method was, to mix blood with a species of clay, called *bole*, and to subject the mixture to distillation. He found that the liquid distilled over was acid. Charmed with this discovery, which he considered as of first-rate importance, he announced it by letter to the different academies and colleges in Europe. Some doubts being raised about the accuracy of his experiment, it having been alleged that the acid came from the clay which he had mixed with the blood, and not from the blood itself, Vieussens purified the *bole* from all the acid which it could contain, and repeated his experiment again. The result was the same—the acrid salt of the fluid yielded an acid spirit.

It would be needless in the present state of our knowledge to point out the inaccuracy of such an experiment, or how little it contributed to prove that blood contains a free acid. It is now well known to chemists, that blood is remarkably free from acids; and, that if we except a little common salt, which exists in all the liquids of the human body, there is neither any acid nor salt whatever in that liquid.

Michael Ettmuller, at Leipsic, who was a chemist of some eminence in his day, and published a small treatise on the science, which was much sought after, was also a zealous iatro-chemist; but his opinions were obviously regulated by the researches of Boyle. He denies the existence of acids and alkalies in certain bodies, and distinguishes carefully between acid and putrid fermentation.

One of the most formidable antagonists to the iatro-chemical doctrines was Dr. Archibald Pitcairne, first a professor of medicine in the University of Leyden, and afterwards of Edinburgh, and one of the most eminent physicians of his time. He was born in Edinburgh, on the 25th of December, 1652. After finishing his school education in 208
Dalkeith, he went to the University of Edinburgh, where he improved himself in classical learning, and completed a regular course of philosophy. He turned his attention to the law, and prosecuted his studies with so much ardour and intensity that his health began to suffer. He was advised to travel, and set out accordingly for the South of France: by the time he

reached Paris he was so far recovered that he determined to renew his studies; but as there was no eminent professor of law in that city, and as several gentlemen of his acquaintance were engaged in the study of medicine, he went with them to the lectures and hospitals, and employed himself in this way for several months, till his affairs called him home.

On his return he applied himself chiefly to mathematics, in which, under the auspices of his friend, the celebrated Dr. David Gregory, he made uncommon progress. Struck with the charms of this science, and hoping by the application of it to medicine to reduce the healing art under the rigid rules of mathematical demonstration, he formed the resolution of devoting himself to the study of medicine. There was at that time no medical school in Edinburgh, and no hospital at which he could improve himself; he therefore repaired to Paris, and devoted himself to his studies with a degree of ardour that ensured an almost unparalleled success. In 1680 he received from the faculty of Rheims the degree of doctor of medicine, a degree also conferred on him in 1699 by the University of Aberdeen.

In the year 1691 his reputation was so high that the University of Leyden solicited him to fill the medical chair, at that time vacant; he accepted the invitation, and delivered a course of lectures at Leyden, which was greatly admired by all his auditors, among whom were Boerhaave and Mead. At the close of the session he set out for Scotland, to marry the 209
daughter of Sir Archibald Stevenson: his friends in his own country would not consent to part with him, and thus he was reluctantly obliged to resign his chair in the University of Leyden.

He settled as a physician in Edinburgh, where he was appointed titular professor of medicine. His practice extended beyond example, and he was more consulted by foreigners than any Edinburgh physician either before or after his time. He died in October, 1713, admired and regretted by the whole country. He was a zealous supporter of iatro-mathematics, and as such a professed antagonist of the iatro-chemists. He refuted their opinions with much strength of reasoning, while his high reputation gave his opinions an uncommon effect; so that he contributed perhaps as much as any one, to put a period to the most disgraceful, as well as dangerous, set of opinions that ever overspread the medical horizon.

Into the merits of the iatro-mathematicians it is not the business of this work to enter; they at least display science, and labour, and erudition, and in all these respects are far before the iatro-chemists. Perhaps their own opinions were not more agreeable to the real structure of the human body, nor their practice more conformable to reason, or more successful than those of the chemists. Probably the most valuable of all Dr. Pitcairne’s writings, is his vindication of the claims of Hervey to the great discovery of the circulation.

Boerhaave, the pupil of Pitcairne, and afterwards a professor in Leyden, was a no less zealous or successful opponent of the iatro-chemists.

Herman Boerhaave, perhaps the most celebrated physician that ever existed, if we
except Hippocrates, was born at Voorhout, a village near Leyden, in 1668, where his father 210
was the parish clergyman. At the age of sixteen he was left without parents, protection, advice, or fortune. He had already studied theology, and the other branches of knowledge that are considered as requisite for a clergyman, to which situation he aspired; and while occupied with these studies he supported himself at Leyden by teaching mathematics to the students—a branch of knowledge to which he had devoted himself with considerable ardour while living in his father’s house. But, a report being raised that he was attached to the doctrines of Spinoza, the clamour against him was so loud that he thought it requisite to renounce his intention of going into *orders*.[171] He turned his studies to medicine, and the branches of science connected with that pursuit, and these delightful subjects soon engrossed the whole of his attention. In 1693 he was created doctor of medicine, and began

to practise. He continued to teach mathematics for some time, till his practice increased sufficiently to enable him to live by his fees. His spare money was chiefly laid out upon books; he also erected a chemical laboratory, and though he had no garden he paid great attention to the study of plants. His reputation increased with considerable rapidity; but his fortune rather slowly. He was invited to the Hague by a nobleman, who stood high in the favour of William III., King of Great Britain; but he declined the invitation. His three great friends, to whom he was in some measure indebted for his success, were James Trigland, professor of theology, Daniel Alphen, and John Van den Berg, both of them successively 211
chief magistrates of Leyden, and men of great influence.

Van den Berg recommended him to the situation of professor of medicine in the University of Leyden, to which chair he was raised, fortunately for the reputation of the university, on the death of Drelincourt, in 1702. He not only gave public lectures on medicine, but was in the habit also of giving private instructions to his pupils. His success as a teacher was so great, that a report having been spread of his intention to quit Leyden, the curators of the university added considerably to his salary on condition that he would not leave them.

This first step towards fortune and eminence having been made, others followed with great rapidity. He was appointed successively professor of botany and of chemistry, while rectorships and deanships were showered upon him with an unsparing hand. And such was the activity, the zeal, and the ability with which he filled all these chairs, that he raised the University of Leyden to the very highest rank of all the universities of Europe. Students flocked to him from all quarters—every country of Europe furnished him with pupils; Leyden was filled and enriched by an unusual crowd of strangers. Though his class-rooms were large, yet so great was the number of students, that it was customary for them to keep places, just as is done in a theatre when a first-rate actor is expected to perform. He died in the year 1738, while still filling the three different chairs with undiminished reputation.

It is not our object here to speak of Boerhaave as a physician, or as a teacher of medicine, or of botany; though in all these capacities he is entitled to the very highest eulogium; his practice was as unexampled as his success as a teacher. It is solely as a chemist that he claims our attention here. His system of chemistry, published in two quarto volumes in 1732, and of which we have an excellent English translation by Dr. Shaw, 212
printed in 1741, was undoubtedly the most learned and most luminous treatise on chemistry that the world had yet seen; it is nothing less than a complete collection of all the chemical facts and processes which were known in Boerhaave’s time, collected from a thousand different sources, and from writings equally disgusting from their obscurity and their mysticism. Every thing is stated in the plainest way, stripped of all mystery, and chemistry is shown as a science and an art of the first importance, not merely to medicine, but to mankind in general. The processes given by him are too numerous and too tedious to have been all repeated by one man, how laborious soever he may have been: many of them have been taken upon trust, and, as no distinction is made in the book, between those which are stated upon his own authority and those which are merely copied from others, this treatise has been accused, and with some justice, as not always to be depended on. But the real information which it communicates is prodigious, and when we compare it with any other system of chemistry that preceded it, the superiority of Boerhaave’s information will appear in a very conspicuous point of view.

After a short but valuable historical introduction he divides his work into two parts; the first treats of the *theory of chemistry*, the second of the *practical processes*.

He defines chemistry as follows: “Chemistry is an art which teaches the manner of performing certain physical operations, whereby bodies cognizable to the senses, or capable of being rendered cognizable, and of being contained in vessels, are so changed by means of proper instruments, as to produce certain determinate effects; and at the same time discover the causes thereof; for the service of various arts."

This definition is not calculated to throw much light on chemistry to those who are unacquainted with its nature and object. Neither is it conformable to the modern notions 213
entertained of chemistry; but it is requisite to keep in mind Boerhaave's definition of chemistry, when we examine his system, that we may not accuse him of omissions and imperfections, which are owing merely to the state of the science when he gave his system to the world.

In his theory of chemistry he begins with the metals, which he treats of in the following order: Gold, mercury, lead, silver, copper, iron, tin. The account of them, though imperfect, is much fuller and more satisfactory than any that preceded it. He then treats of the salts, which are, common salt, saltpetre, borax, sal ammoniac and alum. This it will be admitted is but a meagre list. However other salts occur in different parts of the book which are not described here. He next gives an account of sulphur. Here he introduces *white arsenic*, obtained, he says, from cobalt, and not known for more than two hundred years. He considers it as a real sulphur, and takes no notice of metallic arsenic, though it had been already alluded to by Paracelsus. He then treats of bitumens, including under the name not merely bitumens liquid and solid, but likewise pit-coal, amber, and ambergris. An account of stones and earths comes next, and constitutes the most defective part of the book. It is very surprising that in this part of his work he takes no notice of *lime*. The semi-metals come next: they are, antimony, bismuth, zinc. Here he gives an account of the three vitriols or sulphates of iron, copper, and zinc. He knew the composition of sulphate of iron; but was ignorant of that of sulphate of copper and sulphate of zinc. He considers semi-metals as compounds of a true metal and sulphur, and therefore enumerates cinnabar among the semi-metals. Lastly he treats of vegetables and animals; and it is needless to say that his account
is very imperfect. 214

He next treats of the utility of chemistry, and shows its importance in natural philosophy, medicine, and the arts. Afterwards he describes the instruments of chemistry. This constitutes the longest and the most important part of the whole work. He first treats of fire at great length. Here we have an account of the thermometer, of the expansion produced by heat, of steam, and in fact the germ of many of the most important parts of the science of heat, which have since been expanded and applied to the improvement, not merely of chemistry, but of the arts and resources of human industry. The experiments of Fahrenheit related by him, on the change of temperature induced by agitating water and mercury together at different degrees of heat, gave origin to the whole doctrine of specific heats. Though Boerhaave himself seemed not aware of the importance of these experiments, or indeed even to have considered them with any attention. But when afterwards analyzed by Dr. Black, these experiments gave origin to one of the most important parts of the whole science of heat.

He next treats at great length on *fuel*. Here his opinions are often very erroneous, from his ignorance of a vast number of facts which have since come to light. It is curious that during the whole of his very long account of combustion he makes no allusion to the peculiar opinions of Stahl on the subject; though they were known to the public, and had been admitted by chemists in general, before his work was published. To what are we to ascribe this omission? It could scarcely have been owing to ignorance, Stahl's reputation being too high to allow his opinions to be treated with neglect. We must suppose, I think, that Boerhaave did not adopt Stahl's doctrine of combustion; but at the same time did not think it proper to enter into any controversy on the subject.

He next treats of the heat produced when different liquids are mixed, as alcohol and
water, &c. He gives many examples of such increase of temperature, and describes the 215

phenomena very correctly. But he was unable to assign the cause of the evolution of this heat. The subject was elucidated many years after by Dr. Irvine, who showed that it was owing to a diminution of the specific heat which takes place when liquids combine chemically together. It is in this part of his work that he gives an account of phosphorus, of the action of nitric acid on volatile oils, and he concludes, from all the facts which he states, that elementary fire is a corporeal body. His explanation of the combustion of Homberg's pyrophorus and of common phosphorus, shows clearly that he had no correct notion of the reason why air is necessary to maintain combustion, nor of the way in which that elastic fluid performs its part in the great phenomena of nature.

He next treats of the mode of regulating fire for chemical purposes: then he treats of *air*, his account being chiefly taken from Boyle. He ascribes the discovery of the law of the elasticity of air both to Boyle and Mariotte. Boyle, I believe, was the first discoverer of it. The French are in the habit of calling it the law of Mariotte. He then treats of *water*, and lastly of *earth*; but even here no mention whatever is made of lime. In the last part of the theory of chemistry he treats at great length of menstruums. These are water, oils, alcohol, alkalies, acids, and neutral salts. He mentions potash and ammonia, but takes no notice of soda; the difference between potash and soda not being accurately known. Nor can we expect any particular account of the difference between the properties of mild and caustic potash; as this subject was not understood till the time of Dr. Black. The only acids which he mentions are the *acetic*, *sulphuric*, *nitric*, *muriatic*, and *aqua regia*. He subjoins a disquisition on the alcahest or universal solvent, which it is obvious enough, however, from the way in which he speaks of it, that he was not a believer in. The object of his practical 216
part is to teach the method of making all the different chemical substances known when he wrote. This he does in two hundred and twenty-seven processes, in which all the manipulations are described with considerable minuteness. This part of the work must have been long considered as of great utility, and must have been long resorted to by the student as a mine of practical information upon almost every subject that could arrest his attention. So immense is the progress that chemistry has made since the days of Boerhaave, and so different are the researches that at present occupy chemists, and so much greater the degree of precision requisite to be attained, that his processes and directions are now of little or no use to a practical student of chemistry, as they convey little or none of the knowledge which it is requisite for him to possess.

Boerhaave made a set of most elaborate experiments, to refute the ideas of the alchymists respecting the possibility of fixing mercury. He put a quantity of pure mercury into a glass vessel, and kept it for fifteen years at a temperature rather higher than 100°. It underwent no alteration whatever, excepting that a small portion of it was converted into a black powder. But this black powder was restored to the state of running mercury by trituration in a mortar. In this experiment the air had free access to the mercury. It was repeated in a close vessel with the same result, excepting that the mercury was kept hot for only six months instead of fifteen years.

To show that mercury cannot be obtained from metals by the processes recommended by the alchymists, he dissolved pure nitrate of lead in water, and, mixing the solution with sal ammoniac, chloride of lead precipitated. Of this chloride he put a quantity into a retort, and poured over it a strong lixivium of caustic potash, The whole was digested at the temperature of 96° for six months and six days. It was then distilled in a glass retort, by a 217
temperature gradually raised to redness, but not a particle of mercury was evaporated, as it had been alleged by the alchymists would be the case.

Isaac Hollandus had stated that mercury could be easily obtained from the salt of lead made by means of distilled vinegar. To prove this he calcined a quantity of acetate of lead, ground the residue to powder, and triturated it with a very strong alkaline lixivium, and kept the lixivium over it covered with paper for months, taking care to add water in proportion as it evaporated. The calx was then distilled in a heat gradually raised to redness; but not a particle of mercury was obtained.[172]

These were not the only laborious experiments which he made with this metal. He distilled it above five hundred times, and found that it underwent no alteration. When long agitated in a glass bottle it is convertible into a black acrid powder, obviously protoxide of mercury. This black powder, when distilled, is converted into running mercury. Exposure of mercury for some months in a heat of 180°, converts it also into protoxide; and if the heat be higher than this, the mercury is converted into a red acrid substance, obviously peroxide of mercury. But this peroxide, by simple distillation, is again reduced into the state of running mercury.[173]

Boerhaave combated the opinions of the iatro-chemists with great eloquence, and with a weight derived from his high reputation, and the extraordinary veneration in which his opinions were held by his disciples. His efforts were assisted by those of Bohn, who combated the medical opinions by arguments drawn both from experience and observation, and perfectly irresistible; and the ruin of the chemical sect was consummated by the 218
exertions of the celebrated Frederick Hoffmann, the founder of the most perfect and satisfactory system of medicine that has ever appeared. His efforts were probably roused into action by a visit which he paid to England in 1683, during which he got acquainted with Boyle and with Sydenham; the former the greatest experimentalist, and the latter the greatest physician of the time; and both of whom were declared enemies to iatro-chemistry. 219

CHAPTER VI.

OF AGRICOLA AND METALLURGY.

I have been induced by a wish to prosecute the history of the opinions first supported by Paracelsus, and carried so much further by Van Helmont and Sylvius, to give a connected view of their effects upon medical practice and medical theory; and I have come to the commencement of the eighteenth century, without taking notice of one of the most extraordinary men, and one of the greatest promoters of chemistry that ever existed: I mean George Agricola. I shall consecrate the whole of this chapter to his labours, and those of his immediate successors.

George Agricola was born at Glaucha, in Misnia, in the year 1494. When a young man he acquired such a passion for mining and minerals, by frequenting the mountains of Bohemia, that he could not be persuaded to relinquish the study. He settled, indeed, as a physician, at Joachimstal; but his favourite study engrossed so much of his attention, that he succeeded but ill in his medical capacity. This induced him to withdraw to Chemnitz, where he devoted himself to his favourite pursuits. He studied the mineralogical writings of the ancients with the most minute accuracy; but not satisfied with this, he visited the mines in person, examined the processes followed by the miners in extracting the different ores, and 220
in washing and sorting them. He made collections of all the different ores, and studied their nature and properties attentively: he likewise collected information about the methods of smelting them, and extracting from them the metals in a state of purity. The information which he collected, respecting the mines wrought in the different countries of Europe, is quite wonderful, if we consider the period in which he lived, the little intercourse which

existed between nations, and the total want of all those newspapers and journals which now carry every new scientific fact with such rapidity to every part of the world.

Agricola died at Chemnitz in the year 1555, after he had reached the sixty-first year of his age. Maurice, the celebrated Elector of Saxony, settled on him a pension, the whole of which he devoted to his metallurgic pursuits. To him we find him dedicating the edition of his works which he published in the year of his death, and which is dated the fourteenth before the calends of April, 1555. He even spent a considerable proportion of his own estate in following out his favourite investigations. In the earlier part of his life he had expressed himself rather favourable to the protestant opinions; but in his latter days he had attacked the reformed religion. This rendered him so odious to the Lutherans, at that time predominant in Chemnitz, that they suffered his body to remain unburied for five days together; so that it was necessary to remove it from Chemnitz to Zeitz, where it was interred in the principal church.

His great work is his treatise De Re Metallica, in twelve books. In this work he gives an account of the instruments and machines, and every thing connected with mining and metallurgy; and even gives figures of all the different pieces of apparatus employed in his time. He has also exhibited the Latin and German names for all these different utensils. This work may be considered as a very complete treatise on metallurgy, as it existed in the 221
sixteenth century. The first six books are occupied with an account of mining and smelting. In the seventh book he treats of *docimasy*, or the method of determining the quantity of metal which can be extracted from every particular ore. This he does so completely, that most of his processes are still followed by miners and smelters. He gives a minute and accurate account of the furnaces, muffles, crucibles, &c., almost such as are still employed, with minute directions for preparing the ores which are to be subjected to examination, the fluxes with which they must be mixed, and the precautions necessary in order to obtain a satisfactory result. In short, this book may be considered as a complete manual of docimasy. How much of the methods given originated with Agricola it is impossible to say. He probably did little more than collect the scattered processes employed by the smelters of metals, in different parts of the world, and reduce the whole to a regular system. But this was a great deal. Perhaps it is not saying too much, that the great progress made in the chemical investigation of the metals, was owing in a great measure to the labours of Agricola. Certainly the progress made by the moderns, in the difficult arts of mining and metallurgy, must in a great measure be ascribed to the labours of Agricola.

In the eighth book he describes the mechanical preparation of the ores, and the mode of roasting them, either in the open air or in furnaces. The ninth book is occupied with an account of smelting-furnaces. It contains also a description of the processes for obtaining mercury, antimony, and bismuth, from their ores. The tenth book treats of the separation of silver and gold from each other, by means of nitric acid and aqua regia: minute directions for the preparation of which are given. The modes of purifying the precious metals by means of sulphur, antimony, and cementations, are also described. In the eleventh book he 222
treats of the method of purifying silver from copper and iron, by means of lead. He gives an account also of the processes employed for smelting and purifying copper. In the twelfth book he treats of the methods of preparing common salt, saltpetre, alum, and green vitriol, or sulphate of iron: of the preparation and purification of sulphur, and of the mode of manufacturing glass. In short, Agricola's work De Re Metallica is beyond comparison the most valuable chemical work which the sixteenth century produced, and places the author very high indeed among the list of the improvers of chemistry.

The other works of Agricola are his treatise De Natura Fossilium, in ten books; De Ortu et Causis Subterraneorum, in five books; De Natura eorum quæ effluunt ex Terra, in four books; De veteribus et novis Metallis, in two books; and his Bermannus sive de re

metallica Dialogus. The treatise De veteribus et novis Metallis is amusing. He not only collects together all the historical facts on record, respecting the first discoverers of the different metals and the first workers of mines, but he gives many amusing anecdotes nowhere else to be found, respecting the way in which some of the most celebrated German mines were discovered. In the second book he takes a geographical view of every part of the known world, and states the mines wrought and the metals found in each. We must not suppose that all his statements in this historical sketch are accurate: to admit it would be to allow him a greater share of information than could possibly belong to any one man. He frequently gives us the authority upon which his statements are founded; but he often makes statements without any authority whatever. Thus he says, that a mine of quicksilver had been recently discovered in Scotland: the fact however, is, that no quicksilver-mine ever existed in any part of Britain. There was, indeed, a foolish story circulated about thirty years 223
ago, about a vein of quicksilver found under the town of Berwick-upon-Tweed; but it was an assertion unsupported by any authentic evidence.

Many years elapsed before much addition was made to the processes described by Agricola. In the year 1566, Pedro Fernandes de Velasco introduced a method of extracting gold and silver from their ores in Mexico and Peru by means of quicksilver. But I have never seen a description of his process. Alonzo Barba claims for himself, and seemingly with justice, the method of amalgamating the ores of gold and silver by boiling. Barba was a Spanish priest, who lived about the year 1609, at Tarabuco, a market-town in the province of Charcso, eight miles from Plata, in South America. In the year 1615 he was curate at Tiaguacano, in the Province of Pacayes, and in 1617, he lived at Lepas in Peru. He is said to have been a native of Lepe, a small township in Andalusia, and had for many years the living of the church of St. Bernard at Potosi. His work on the amalgamation of gold and silver ores appeared at Madrid in the year 1640, in quarto.[174] In the year 1629 a new edition of it appeared with an appendix, under the title of "Trattado de las Antiquas Minas de España de Alonzo Carillo Lasso." The English minister at the Court of Madrid, the Earl of Sandwich, published the first part of it in an English translation at London, in 1674, under the title of "The First Book of the Art of Metals, in which is declared the manner of their generation, and the concomitants of them, written in Spanish by Albaro Alonzo Barba. By E. Earl of Sandwich."

The next improver of metallurgic processes was Lazarus Erckern, who was upper bar-
master at Kuttenberg, in the year 1588, and was superintendent of the mines in Germany, 224
Hungary, Transylvania, the Tyrol, &c., to three successive emperors. His work has been translated into English under the title of "Heta Minor; or the laws of art and nature in knowing, judging, assaying, fining, refining, and enlarging the bodies of confined metals. To which are added essays on metallic words, illustrated with sculptures. By Sir J. Pettus. London, 1683, folio." But this translation is a very bad one. Erckern gives a plain account of all the processes employed in his time without a word of theory or reasoning. It is an excellent practical book; though it is obvious enough that the author was inferior in point of abilities to Agricola. His treatment of Don Juan de Corduba, who offered, in 1588, to put the Court of Vienna in possession of the Spanish method of extracting gold and silver from the ores by amalgamation, as related by Baron Born in his work on amalgamation, shows very clearly that Erckern was a very illiberal-minded man, and puffed up with an undue conceit of his own superior knowledge.[175] Had he condescended to assist the Spaniard, and to furnish him with proper materials to work upon, the Austrians might have been in possession of the process of amalgamation with all its advantages a couple of centuries before its actual introduction.

I need not take any notice of the docimastic treatises of Schindlers and Schlutter, which are of a much later date, and both of which have been translated into French, the former by Geoffroy, junior; the latter by Hellot. This last translation, in two large quartos, published in

1764, constitutes a very valuable book, and exhibits all the docimastic and metallurgic processes known at that period with much fidelity and minuteness. Very great improvements have taken place since that period, but I am not aware of any work published in any of the 225
European languages, that is calculated to give us an exact idea of the present state of the various mining and metallurgic processes—important as they are to civilized society.

Gellert's Metallurgic Chemistry, so far as it goes, is an excellent book. 226

CHAPTER VII.

OF GLAUBER, LEMERY, AND SOME OTHER CHEMISTS OF THE END OF THE SEVENTEENTH CENTURY.

Hitherto I have treated of the alchymists, or iatro-chemists, and have brought the history of chemistry down to the beginning of the eighteenth century. But during the seventeenth century there existed several laborious chemists, who contributed very materially by their exertions, either to extend the bounds of the science, or to increase its popularity and respectability in the eyes of the world. Of some of the most eminent of these it is my intention to give an account in this chapter.

Of John Rudolf Glauber, the first of these meritorious men in point of time, I know very few particulars. He was a German and a medical man, and spent most of his time at Salzburg, Ritzingen, Frankfort on the Maine, and at Cologne. Towards the end of his life he went to Holland, but during the greatest part of his residence in that country he was confined to a sick-bed. He died at Amsterdam in 1668, after having reached a very advanced age. Like Paracelsus, whom he held in high estimation, he was in open hostility with the Galenical physicians of his time. This led him into various controversies, and induced him to publish various apologies; most of which still remain among his writings. One of the most curious of these apologies is the one against Farmer. To this man Glauber had communicated certain secrets of his own, which were at that time considered as of great 227
value; Farrner binding himself not to communicate them to any person. This obligation he not only broke, but publicly deprecated the skill and integrity of Glauber, and offered to communicate to others, for stipulated sums, a set of secrets of his own, which he vaunted of as particularly valuable. Glauber examines these secrets, and shows that every one of them possessed of any value, had been communicated by himself to Farrner, and to put an end to Farrner's unfair attempt to make money by selling Glauber's secrets, he in this apology communicates the whole processes to the public.

Glauber's works were published in Amsterdam, partly in Latin, and partly in the German language. In the year 1689 an English translation of them was published in London by Mr. Christopher Packe, in one large folio volume. Glauber was an alchymist and a believer in the universal medicine. But he did not confine his researches to these two particulars, but endeavoured to improve medicine and the arts by the application of chemical processes to them. In his treatise of *philosophical furnaces* he does not confine himself to a description of the method of constructing furnaces, and explaining the use of them, but gives an account of a vast many processes, and medicinal and chemical preparations, which he made by means of these furnaces. One of the most important of these preparations was muriatic acid, which he obtained by distilling a mixture of common salt, sulphate of iron, and alum, in one of the furnaces which he describes.

He makes known the method of dissolving most of the metals in muriatic acid, and the resulting chlorides, which he denominates oils of the respective metals, constitute in his opinion valuable medicines. He mentions particularly the chloride of gold, and from the mode of preparing it, the solution must have been strong. Yet he recommends it as an 228
internal medicine, which he says may be taken with safety, and is a sovereign remedy in old ulcers of the mouth, tongue, and throat, arising from the French pox, leprosy, scorbute, &c. Thus we see the use of gold as a remedy for the venereal disease did not originate with M. Chretiens, of Montpelier. This chloride of gold is so violent a poison that it is remarkable that Glauber does not specify the dose that patients labouring under the diseases for which he recommends it ought to take.—The sesqui-chloride of iron he recommends as a most excellent application to ill-conditioned ulcers and cancers. We see from this that the use of iron in cancers, lately recommended, is not so new a remedy as has been supposed.

He mentions the violent action of chloride of mercury (obviously corrosive sublimate), and says that he saw a woman suddenly killed by it, being administered internally by a surgeon. Butter of antimony he first recognised as nothing else than a combination of chlorine and antimony; before his time it had been always supposed to contain mercury.

He describes the method of obtaining sulphuric acid by distilling sulphate of iron; gives an account of the mode of obtaining sulphate of iron and sulphate of copper, in crystals: the method of obtaining nitric acid from nitre by means of alum, was much improved by him. He gives a particular detail of the way of obtaining fulminating gold. This fulminating gold he says is of little use in medicine; but he gives a method of preparing from it a red tincture of gold, which he considers as one of the most useful and efficacious of all medicines: this tincture is nothing else than chloride of gold. It would take up too much space to attempt an analysis of all the curious facts and preparations described in this treatise on philosophical furnaces; but it will repay the perusal of any person who will take the trouble to look into it. All the different pharmacopœias of the seventeenth century 229
borrowed from it largely. The third part of this treatise is peculiarly interesting. It will be seen that Glauber had already thought of the peculiar efficacy of applying solutions of sulphur, &c. to the skin, and had anticipated the various vapour and gaseous baths which have been introduced in Vienna and other places, during the course of the present century, and considered as new, and as constituting an important era in the healing art. In the fourth part he not only treats of the docimastic processes, so well described by Agricola and Erckern, but gives us the method of making glass, and of imitating the precious stones by means of coloured glasses. The fifth part is peculiarly valuable; in it he treats of the methods of preparing lutes for glass vessels, of the construction and qualities of crucibles, and of the vitrification of earthen vessels.

Another of his tracts is called "The Mineral Work;" the object of which is to show the method of separating gold from flints, sand, clay, and other minerals, by the spirit of salt (*muriatic acid*), which otherwise cannot be purged; also a panacea, or universal antimonial medicine. This panacea was a solution of deutoxide of antimony in pyrotartaric acid; Glauber gives a most flattering account of its efficacy in removing the most virulent diseases, particularly all kinds of cutaneous eruptions. The second and third parts of The Mineral Work are entirely alchymistical. In the treatise called "Miraculum Mundi," his chief object is to write a panegyric on *sulphate of soda*, of which he was the discoverer, and to which he gave the name of *sal mirabile*. The high terms in which he speaks of this innocent salt are highly amusing, and serve well to show the spirit of the age, and the dreams which still continued to haunt the most laborious and sober-minded chemists. The *sal mirabile* was not merely a purgative, a virtue which it certainly possesses in a high degree, being as mild a purgative, perhaps the very best, of all the saline preparations yet tried; but it was a universal medicine, a panacea, a cure for all diseases: nor was Glauber contented with this, but pointed out many uses in the various arts and manufactures for which in his opinion it was admirably fitted. But by far the fullest account of this *sal mirabile* is given by him in his treatise on the nature of salts. 230

I shall satisfy myself with giving the titles of his other tracts. Every one of them contains facts of considerable importance, not to be found in any chemical writings that preceded him; but to attempt to connect these facts into one point of view would be needless, because they are not such as would be likely to interest the general reader.

1. The Consolation of Navigators. This gives an account of a method by which sailors may carry with them a great deal of nourishment in very small bulk. The method consists in evaporating the wort of malt to dryness, and carrying the dry extract to sea. This method has been had recourse to in modern times, and has been found to furnish an effectual remedy against the scurvy. He recommends also the use of muriatic acid as a remedy for thirst, and a cure for the scurvy.

2. A true and perfect Description of the extracting good Tartar from the Lees of Wine.

3. The first part of the Prosperity of Germany; in which is treated of the concentration of wine, corn, and wood, and the more profitable use of them than has hitherto been.

4. The second part of the Prosperity of Germany; wherein is shown by what means minerals may be concentrated by nitre, and turned into metallic and better bodies.

5. The third part of the Prosperity of Germany; in which is delivered the way of most easily and plentifully extracting saltpetre out of various subjects, every where obvious and at hand. Together with a succinct explanation of Paracelsus's prophecy; that is to say, in 231
what manner it is to be understood the northern lion will institute or plant his political or civil monarchy; and that Paracelsus himself will not abide in his grave; and that a vast quantity of riches will offer itself. Likewise who the artist Elias is, of whose coming in the last days, and his disclosing abundance of secrets, Paracelsus and others have predicted.

6. The fourth part of the Prosperity of Germany; in which are revealed many excellent, useful secrets, and such as are serviceable to the country; and withal several preparations of efficacious cates extracted out of the metals and appointed to physical uses; as also various confections of golden potions. To which is also adjoined a small treatise which maketh mention of my laboratory; in which there shall be taught and demonstrated (for the public good and benefit of mankind) wonderful secrets, and unto every body most profitable but hitherto unknown.

7. The fifth part of the Prosperity of Germany; clearly and solidly demonstrating and as it were showing with the fingers, what alchymy is, and what benefit may, by the help thereof, be gotten every where and in most places of Germany. Written and published to the honour of God, the giver of all good things, primarily; and to the honour of all the great ones of the country; and for the health, profit, and assistance against foreign invasions, of all their inhabitants that are by due right and obedience subject unto them.

8. The sixth and last part of the Prosperity of Germany; in which the arcanas already revealed in the fifth part, are not only illustrated and with a clear elucidation, but also such are manifested as are most highly necessary to be known for the defence of the country against the Turks. Together with an evident demonstration adjoined, showing, that both a particular and universal transmutation of the imperfect metals into more perfect ones by salt and fire, is most true; and withal, by what means any one, that is endued with but a mean 232

knowledge in managing the fire, may experimentally try the truth hereof in twenty-four hours' space.

9. The first century of Glauber's wealthy Storehouse of Treasures.—Many of the processes given in this treatise are mystically stated, or even concealed.

10. The second, third, fourth, and fifth century of Glauber's wealthy Storehouse of Treasures.

11. New chemical Light; being a revelation of a certain new invented secret, never before manifested to the world.—This was a method of extracting gold from stones. Probably the gold found by Glauber in his processes existed in some of the reagents employed; this, at least, is the most natural way of accounting for the result of Glauber's trials.

15. The spagyrical Pharmacopœia, or Dispensatory.—In this book he treats chiefly of medicines peculiarly his own; one of those, on which he bestows the greatest praise, is *secret sal ammoniac*, or sulphate of ammonia. He describes the method of preparing this salt, by saturating sulphuric acid with ammonia. He informs us that it was much employed by Paracelsus and Van Helmont, who distinguished it by the name of *alkahest*.

13. Book of Fires.—Full of enigmas.

14. Treatise of the three Principles of Metals; viz. sulphur, mercury, and salt of philosophers; how they may be profitably used in medicine, alchymy, and other arts.

15. A short Book of Dialogues. Chiefly relating to alchymy.

16. Proserpine, or the Goddess of Riches.

17. Of Elias the Artist.

18. Of the three most noble Stones generated by three Fires.

19. Of the Purgatory of Philosophers.

20. Of the secret Fire of Philosophers. 233

21. A Treatise concerning the Animal Stone.

John Kunkel, who acquired a high reputation as a chemist, was born in the Duchy of Sleswick; in the year 1630: his father was a trading chemist, or apothecary; and Kunkel himself had, in his younger years, paid great attention to the business of an apothecary: he had also diligently studied the different processes of glass-making; and had paid particular attention to the assaying of metals. In the year 1659, he was chamberlain, chemist, and superintendent of apothecaries to the dukes Francis Charles and Julius Henry, of Lauenburg. While in this situation, he examined many pretended transmutations of metals, and undertook other researches of importance. From this situation he was invited, by John George II., Elector of Saxony, on the recommendation of Dr. Langelott and Counsellor Vogt, as chamberlain and superintendent of the elector's laboratory, with a considerable salary. From this situation he went to Berlin, where he was chemist to the elector Frederick William; after whose death, his laboratory and glass-house were accidentally burnt. From Berlin he was invited to Stockholm by Charles XI., King of Sweden, who gave him the title of counsellor of metals, and raised him to the rank of a nobleman: here he died, in 1702, in the seventy-second year of his age. Kunkel's greatest discovery was, the method of extracting phosphorus from urine. This curious substance had been originally discovered by

Brandt, a chemist, of Hamburg, in the year 1669, as he was attempting to extract from human urine a liquid capable of converting silver into gold. He showed a specimen of it to Kunkel, with whom he was acquainted: Kunkel mentioned the fact as a piece of news to one Kraft, a friend of his in Dresden, where he then resided: Kraft immediately repaired to Hamburg, and purchased the secret from Brandt for 200 rix-dollars, doubtless exacting from him, at the same time, a promise not to reveal it to any other person. Soon after, he 234
exhibited the phosphorus publicly in Britain and in France; whether for money, or not, does not appear. Kunkel, who had mentioned to his friend his intention of getting possession of the process, being vexed at the treacherous conduct of Kraft, attempted to discover it himself, and, after three or four years labour, he succeeded, though all that he knew from Brandt was, that urine was the substance from which the phosphorus was procured. In consequence of this success, phosphorus was at first distinguished by the epithet of *Kunkel* added to the name.

Kunkel published, in 1678, a treatise on phosphorus, in which he describes the properties of this substance, at that time a subject of great wonder and curiosity. In this treatise, he proposes phosphorus as a remedy of some efficacy, and gives a formula for preparing pills of it, to be taken internally. It is therefore erroneous to suppose, as has been done, that the introduction of this dangerous remedy into medicine is a modern discovery. Kunkel appears to have been acquainted with nitric ether. One of the most valuable of his books, is his treatise on glass-making, which was translated into French; and which, till nearly the end of the eighteenth century, constituted by far the best account of glass-making in existence. The following is a list of the most important of his works:

1. Observations on fixed and volatile Salts, potable Gold and Silver, Spiritus Mundi, &c.; also of the colour and smell of metals, minerals, and bitumens.—This tract was published at Hamburg, in 1678, and has been several times reprinted since.

2. Chemical Remarks on the chemical Principles, acid, fixed and volatile alkaline Salts, in the three kingdoms of nature, the mineral, vegetable, and animal; likewise concerning their colour and smell, &c.; with a chemical appendix against non-entia chymica.

3. Treatise of the Phosphorus mirabilis, and its wonderful shining Pills; together with a discourse on what was formerly rightly named nitre, but is now called the *blood of nature*. 235

4. An Epistle against Spirit of Wine without an acid.

5. Touchstone de Acido et Urinoso, Sale calido et frigido.

6. Ars Vitraria experimentalis.

7. Collegium Physico-chymicum experimentale, *or* Laboratorium chymicum.[176]

Nicolas Lemery, the first Frenchman who completely stripped chemistry of its mysticism, and presented it to the world in all its native simplicity, deserves our particular attention, in consequence of the celebrity which he acquired, and the benefits which he conferred on the science. He was born at Rouen on the 17th of November, 1645. His father, Julian Lemery, was *procureur* of the Parliament of Normandy, and a protestant. His son, when very young, showed a decided partiality for chemistry, and repaired to an apothecary in Rouen, a relation of his own, in hopes of being initiated into the science; but finding that little information could be procured from him, young Lemery left him in 1666, and went to Paris, where he boarded himself with M. Glaser, at that time demonstrator of chemistry at the Jardin du Roi.

Glaser was a *true chemist*, according to the meaning at that time affixed to the term—full of obscure notions—unwilling to communicate what knowledge he possessed—and not at all sociable. In two months Lemery quitted his house in disgust, and set out with a resolution to travel through France, and pick up chemical information as he best could, from those who were capable of giving him information on the subject. He first went to Montpelier, where he boarded in the house of M. Vershant, an apothecary in that town. With 236 his situation there he was so much pleased, that he continued in it for three years: he employed himself assiduously in the laboratory, and in teaching chemistry to a number of young students who boarded with his host. Here his reputation gradually increased so much, that he drew round him the professors of the faculty of medicine of Montpelier, and all the curious of the place, to witness his experiments. Here, too, he practised medicine with considerable success.

After travelling through all France, he returned to Paris in 1672. Here he frequented the different scientific meetings at that time held in that capital, and soon distinguished himself by his chemical knowledge. In a few years he got a laboratory of his own, commenced apothecary, and began to give public lectures on chemistry, which were speedily attended by great crowds of students from foreign countries. For example, we are told that on one occasion forty Scotchmen repaired to Paris on purpose to hear his lectures, and those of M. Du Verney on anatomy. The medicines which he prepared in his laboratory became fashionable, and brought him a great deal of money. The magistery of bismuth (or pearl-white), which he prepared as a cosmetic, was sufficient, we are told, to support the whole expense of his house. In the year 1675 he published his Cours de Chimie, certainly one of the most successful chemical books that ever appeared; it ran through a vast number of editions in a few years, and was translated into Latin, German, Spanish, and English.

In 1681 he began to be troubled in consequence of his religious opinions. Louis XIV. was at that time in the height of his glory, entirely under the control of his priests, and zealously bent upon putting an end to the reformed religion in his dominions. Indeed, from the infamous conduct of Charles II. of England, and the bigotry of his successor, a prospect was opened to him, and of which he was anxious to avail himself, of annihilating the 237 reformed religion altogether, and of plunging Europe a second time into the darkness of Roman Catholicism.

Lemery found it expedient, in 1683, to pass over into England. Here he was well received by Charles II.: but England was at that time convulsed with those religious and political struggles, which terminated five years afterwards in the revolution. Lemery, in consequence of this state of things, found it expedient to leave England, and return to France. He took a doctor’s degree at Caen, in Normandy; and, returning to Paris, he commenced all at once practitioner in medicine and surgery, apothecary, and lecturer on chemistry. The edict of Nantes was revoked in 1685, when James II. had assured Louis of his intention to overturn the established religion, and bring Great Britain again under the dominion of the pope. Lemery was obliged to give up practice and conceal himself, in order to avoid persecution. Finding his success hopeless, as long as he continued a protestant, he changed his religion in 1686, and declared himself a Roman catholic. This step secured his fortune: he was now as much caressed and protected by the court and the clergy, as he had been formerly persecuted by them. In 1699 when the Academy of Sciences was new modelled, he was appointed associated chemist, and, on the death of Bourdelin, before the end of that year, he became a pensioner. He died on the 19th of June, 1715, at the age of seventy, in consequence of an attack of palsy, which terminated in apoplexy.

Besides his System of Chemistry, which has been already mentioned, he published the following works:

1. Pharmacopée universelle, contenant toutes les Operations de Pharmacie qui sont en usage dans la Médicine.

2. Traité universelle des Drogues simples mis en ordre alphabétique. 238

3. Traité de l'Antimoine, contenant l'analyse chimique de ce mineral.

Besides these works, five different papers by Lemery were printed in the Memoirs of the French Academy, between 1700 and 1709 inclusive. These are as follow:

1. Explication physique et chimique des Feux souterrains, des tremblemens de Terre, des Ouragans, des Eclairs et du Tonnere.—This explanation is founded on the heat and combustion produced by the mutual action of iron filings and sulphur on each other, when mixed in large quantities.

2. Du Camphre.

3. Du Miel et de son analyse chimique.

4. De l'Urine de Vache, de ses effets en médicine et de son analyse chimique.

5. Reflexions et Experiences sur le Sublimé Corrosive.—It appears from this paper, that in 1709, when Lemery wrote, corrosive sublimate was considered as a compound of mercury with the sulphuric and muriatic acids. Lemery's statement, that he made corrosive sublimate simply by heating a mixture of mercury and decrepitated salt, is not easily explained. Probably the salt which he had employed was impure. This is the more likely, because, from his account of the matter which remained at the bottom of the matrass after sublimation, it must have either contained peroxide of iron or peroxide of mercury, for its colour he says was red.

M. Lemery left a son, who was also a member of the French Academy; an active chemist, and author of various papers, in which he endeavours to give a mechanical explanation of chemical phenomena.

Another very active member of the French Academy, at the same time with Lemery, was M. William Homberg, who was born on the 8th of January, 1652, at Batavia, in the island of Java. His father, John Homberg, was a Saxon gentleman, who had been stripped of 239
all his property during the thirty years war. After receiving some education by the care of a relation, he went into the service of the Dutch East India Company, and got the command of the arsenal at Batavia. There he married the widow of an officer, by whom he had four children, of whom William was the second.

His father quitted the service of the India Company and repaired to Amsterdam with his family. Young Homberg studied with avidity: he devoted himself to the law, and in 1674 was admitted advocate of Magdeburg; but his taste for natural history and science was great. He collected plants in the neighbourhood, and made himself acquainted with their names and uses. At night he studied the stars, and learned the names and positions of the different constellations. Thus he became a self-taught botanist and astronomer. He constructed a hollow transparent celestial globe, on which, by means of a light placed within, the principal fixed stars were seen in the same relative positions as in the heavens.

Otto Guericke was at that time burgomaster of Magdeburg. His experiments on a vacuum, and his invention of the air-pump, are universally known. Homberg attached himself to Otto Guericke, and this philosopher, though fond of mystery, either explained to him his secrets, in consequence of his admiration of his genius, or was unable to conceal

them from his penetration. At last Homberg, quite tired of his profession of advocate, left Magdeburg and went to Italy. He sojourned for some time at Padua, where he devoted himself to the study of medicine, anatomy, and botany. At Bologna he examined the famous Bologna stone, the nature of which had been almost forgotten, and succeeded in making a pyrophorus out of it. At Rome he associated particularly with Marc-Antony Celio, famous for the large glasses for telescopes which he was able to grind. Nor did he neglect painting, 240
sculpture, and music; pursuits in which, at that time, the Italians excelled all other nations.

From Italy he went to France, and thence passed into England, where he wrought for some time in the laboratory of Mr. Boyle, at that time one of the most eminent schools of science in Europe. He then passed into Holland, studied anatomy under De Graaf, and after visiting his family, went to Wittemberg, where he took the degree of doctor of medicine.

After this he visited Baldwin and Kunkel, to get more accurate information respecting the phosphorus which each had respectively discovered. He purchased a knowledge of Kunkel's phosphorus, by giving in exchange a meteorological toy of Otto Guericke, now familiarly known, by which the moisture or dryness of the air was indicated—a little man came out of his house and stood at the door in dry weather, but retired under cover in moist weather. He next visited the mines of Saxony, Bohemia, and Hungary: he even went to Sweden, to visit the copper-mines of that country. At Stockholm he wrought in the chemical laboratory, lately established by the king, along with Hjerna, and contributed considerably to the success of that new establishment.

He repaired a second time to France, where he spent some time, actively engaged with the men of science in Paris. His father strongly pressed him to return to Holland and settle as a physician: he at last consented, and the day of his departure was come, when, just as he was going into his carriage, he was stopped by a message from M. Colbert on the part of the king. Offers of so advantageous a nature were made him if he would consent to remain in France, that, after some consideration, he was induced to embrace them. 241

In 1682 he changed his religion and became Roman catholic: this induced his father to disinherit him. In 1688 he went to Rome, where he practised medicine with considerable success. A few years after he returned to Paris, where his knowledge and discoveries gave him a very high reputation. In 1691 he became a member of the Academy of Sciences, and got the direction of the laboratory belonging to the academy: this enabled him to devote his undivided attention to chemical investigations. In 1702 he was taken into the service of the Duke of Orleans, who gave him a pension, and put him in possession of the most splendid and complete laboratory that had ever been seen. He was presented with the celebrated burning-glass of M. Tchirnhaus, by the Duke of Orleans, and was enabled by means of it to determine many points that had hitherto been only conjectural.

In 1704 he was made first physician to the Duke of Orleans, who honoured him with his particular esteem. This appointment obliging him to reside out of Paris, would have made it necessary for him to resign his seat in the academy, had not the king made a special exemption in his favour. In 1708 he married a daughter of the famous M. Dodart, to whom he had been long attached. Some years after he was attacked by a dysentery, which was cured, but returned from time to time. In 1715 it returned with great violence, and Homberg died on the 24th of September.

His knowledge was uncommonly great in almost every department of science. His chemical papers were very numerous; though there are few of them, in this advanced period of the science, that are likely to claim much attention from the chemical world. His pyrophorus, of which he has given a description in the Mémoires de l'Académie,[177] was made by mixing together human fæces and alum, and roasting the mixture till it was 242
reduced to a dry powder. It was then exposed in a matrass to a red heat, till every thing

combustible was driven off. Any combustible will do as a substitute for human fæces—gum, flour, sugar, charcoal, may be used. When a little of this phosphorus is poured upon paper, it speedily catches fire and kindles the paper. Davy first explained the nature of this phosphorus. The potash of the alum is converted into potassium, which, by its absorption of oxygen from the atmosphere, generates heat, and sets fire to the charcoal contained in the powder.

Homberg's papers printed in the Memoirs of the French Academy amount to thirty-one. They are to be found in the volumes for 1699 to 1714 inclusive.

M. Geoffroy, who was a member of the academy about the same time with Lemery and Homberg, though he outlived them both, and who was an active chemist for a considerable number of years, deserves also to be mentioned here.

Stephen Francis Geoffroy was born in Paris on the 13th of February, 1672, where his father was an apothecary. While a young man, regular meetings of the most eminent scientific men of Paris were held in his father's house, at which he was always present. This contributed very much to increase his taste for scientific pursuits. After this he studied botany, chemistry, and anatomy in Paris. In 1692 his father sent him to Montpelier, to study pharmacy in the house of a skilful apothecary, who at the same time sent his son to Paris, to acquire the same art in the house of M. Geoffroy, senior. Here he attended the different classes in the university, and his name began to be known as a chemist. After spending some time in Montpelier, he travelled round the coast to see the principal seaports, and was at St. Malo's in 1693, when it was bombarded by the British fleet.

In 1698 Count Tallard being appointed ambassador extraordinary to London, made 243
choice of M. Geoffroy as his physician, though he had not taken a medical degree. Here he made many valuable acquaintances, and was elected a fellow of the Royal Society. From London he went to Holland, and thence into Italy, in 1700, where he went in the capacity of physician to M. de Louvois. The great object of M. Geoffroy was always natural history, and materia medica. In 1693 he had subjected himself to an examination, and he had been declared qualified to act as an apothecary; but his own object was to be a physician, while that of his father was that he should succeed himself as an apothecary: this in some measure regulated his education. At last he declared his intentions, and his father agreed to them; he became bachelor of medicine in 1702, and doctor of medicine in 1704.

In 1709 he was made professor of medicine in the Royal College. In 1707 he began to lecture on chemistry, at the Jardin du Roi, in place of M. Fagan, and continued to teach this important class during the remainder of his life. In 1726 he was chosen dean of the faculty of medicine; and, after the two years for which he was elected was finished, he was again chosen to fill the same situation. There existed at that time a lawsuit between the physicians and surgeons in Paris; a kind of civil war very injurious to both; and the mildness and suavity of his manners fitted him particularly for being at the head of the body of physicians during its continuance. He became a member of the academy in 1699, and died on the 6th of January, 1731.

The most important of all his chemical labours, and for which he will always be remembered in the annals of the science, was the contrivance which he fell upon, in 1718, of exhibiting the order of chemical decompositions under the form of a table.[178] This
method was afterwards much enlarged and improved. Such tables are now usually known 244
by the name of *tables of affinity*; and, though they have been of late years somewhat neglected, there can be but one opinion of their importance when properly constructed.

M. Geoffroy first communicated to the French chemists the mode of making Prussian blue, as Dr. Woodward did to the English.

Claude Joseph Geoffroy, the younger brother of the preceding, was also a member of the Academy of Sciences, and a zealous cultivator of chemistry. Many of his chemical papers are to be found in the memoirs of the French Academy. He demonstrated the composition of sal ammoniac, which however was known to Glauber. He made many experiments upon the combustion of the volatile oils, by pouring nitric acid on them. He explained the pretended property which certain waters have of converting iron into copper, by showing that in such cases copper was held in solution in the water by an acid, and that the iron merely precipitated the copper, and was dissolved and combined with the acid in its place. He pointed out the constituents of the three vitriols, the green, the blue, and the white; showing that the two former were combinations of sulphuric acid with oxides of iron and copper, and the latter a solution of lapis calaminaris (*carbonate of zinc*) in the same acid. He has also a memoir on the emeticity of antimony, tartar emetic, and kermes mineral; but it is rather medical than chemical. He determined experimentally the nature of the salt of Seignette, or Rochelle salt, and showed that it was obtained by saturating cream of tartar with carbonate of soda, and crystallizing. It is curious that this discovery was made about the same time by M. Boulduc. I have noticed only a few of the papers of M. Geoffroy, junior; because, though they all do him credit, and contributed to the improvement of chemistry, yet none of them contain any of those great discoveries, which stand as 245
landmarks in the progress of science, and constitute an era in the history of mankind. For the same reason I omit several other names that, in a more minute history of chemistry, would deserve to be particularized. 246

CHAPTER VIII.

OF THE ATTEMPTS TO ESTABLISH A THEORY IN CHEMISTRY.

Bacon, Lord Verulam, as early as the commencement of the 17th century, had pointed out the importance of chemical investigations, and had predicted the immense advantages which would result from the science, when it came to be properly cultivated and extended; but he did not himself attempt either to construct a theory of chemistry, or even to extend it beyond the bounds which it had reached before he began to write. Neither did Boyle, notwithstanding the importance of his investigations, and his comparative freedom from the prejudices of the alchymists, attempt any thing like a theory of chemistry; though the observations which he made in his Sceptical Chemist, had considerable effect in overturning, or at least in hastening the downfall of the absurd chemical opinions which at that time prevailed, and the puerile hypotheses respecting the animal functions, and the pathology and treatment of diseases founded on these opinions. The first person who can with propriety be said to have attempted to construct a theory of chemistry, was Beccher.

John Joachim Beccher, one of the most extraordinary men of the age in which he lived,
was born at Spires, in Germany, in the year 1635. His father, as Beccher himself informs us, 247
was a very learned Lutheran preacher. As he lost his father when he was very young, and as that part of Germany where he lived had been ruined by the thirty years' war, his family was reduced to great poverty. However, his passion for information was so great, that he contrived to educate himself by studying what books he could procure, and in this way acquired a great deal of knowledge. Afterwards he travelled through the greatest part of Germany, Italy, Sweden, and Holland.

In the year 1666 he was appointed public professor of medicine in the University of Mentz, and soon after chief physician to the elector. In that capacity he took up his residence in Munich, where he was furnished by the elector with an excellent laboratory: but he soon fell into difficulties, the nature of which does not appear, and was obliged to leave the place. He took refuge in Vienna, where, from his knowledge of finance, he was appointed chamberlain to Count Zinzendorf, and through him acquired so much importance in the eyes of the court, that he was named a member of the newly-erected College of Commerce, and obtained the title of imperial commercial counsellor and chamberlain. But here also he speedily raised up so many enemies against himself, that he found it necessary to leave Vienna, and to carry with him his wife and children. He repaired to Holland, and settled at Haerlem in 1678. Here he was likely to have been successful; but his enemies from Vienna followed him, and obliged him to leave Holland. In 1680 we find him in Great Britain, where he examined the Scottish lead-mines, and smelting-works; and in 1681, and 1682, he traversed Cornwall, and studied the mines and smelting-works of that great mining county; here he suggested several improvements and ameliorations. Soon after this an advantageous proposal was made to him by the Duke of Mecklenburg Gustrow, by means of Count Zinzendorf; but all his projects were arrested by his death, which took place in the year 1682. It is said that he died in London, but I have not been able to find any evidence of this. 248

It would be a difficult task to particularize his various discoveries, which are scattered through a multiplicity of writings. He was undoubtedly the first discoverer of boracic acid, though the credit of the discovery has usually been given to Homberg.[179] But then he gives no account of boracic acid, nor does he seem to have attended to its qualities. The following is a list of Beccher's writings:

1. Metallurgia, or the Natural Science of Metals.

2. Institutiones Chymicæ.

3. Parnassus Medicinalis illustrata.

4. Œdipus Chymicus seu Institutiones Chymicæ.

5. Acta laboratorii Chymici Monacensis seu Physica Subterranea.—This, which is the most important of all his works, is usually known by the name of "Physica Subterranea." This is the sole title affixed to it in the edition published at Leipsic, in 1703, to which Stahl has prefixed a long introduction. It is divided into seven sections. In the first he treats of the creation of the world; in the second he gives a chemical account of the motions and changes which are constantly going on in the earth; in the third he treats of the three principles of all bodies, which he calls *earths*. The first of these principles of metals and stones is the *fusible* or *stony earth*; the second principle of minerals is the *fat earth*, improperly called *sulphur*; the third principle is the *fluid earth*, improperly called *mercury*; in the fourth section he treats of the action of subterraneous principles, or the formation of *mixts*; in the fifth he treats of the solution of the three classes of mixts, animals, vegetables, and metals; in the sixth he treats of *mixts*, in which he gives their chemical constituents. This section is very curious, because it gives Beccher's views of the constitution of compound bodies. It will be seen from it that he had much more correct notions of the real objects of chemistry, than any of his contemporaries. In the seventh and last section he treats of the accidents and physical affections of subterraneous bodies. 249

6. Experimentum Chymicum novum quo artificialis et instantanea metallorum generatio et transmutatio, ad oculum demonstratur.—This constitutes the first supplement to the Physica Subterranea.

7. Supplementum secundum in Physicam subterraneam, demonstratio philosophica seu Theses Chymicæ, veritatem et possibilitatem transmutationis metallorum in aurum evincentes.

8. Trifolium Beccherianum Hollandicum.

9. Experimentum novum et curiosum de Minera arenaria perpetua, sive prodromus historiæ seu propositionis Præp. D.D. Hollandiæ ordinibus ab authore factæ, circa auri extractionem mediante arena littorali per modum mineræ perpetuæ seu operationis magnæ fusoriæ cum emolumento. Loco supplementi tertii in Physicam suam subterraneam.

10. Chemical Luckpot, or great chemical agreement; in a collection of one thousand five hundred chemical processes.

11. Foolish Wisdom and wise Folly.

12. Magnalia Naturæ.

13. Tripus Hermeticus fatidicus pandens oracula chemica; seu I. Laboratorium portatile, cum methodo vere spagyricæ seu juxta exigentiam naturæ laborandi. Accessit pro praxi et exemplo; II. Centrum mundi concatenatum seu Duumviratus hermeticus s. magnorum duorum productorum nitri et salis textura et anatomia atque in omnium 250
præcedentium confirmationem adjunctum est; III. Alphabetum Minerale seu viginti quatuor theses de subterraneorum mineralium genesi, textura et analysi; his accessit concordantia mercurii lunæ et menstruorum.

14. Chemical Rose-garden.

15. Pantaleon delarvatus.

16. Beccheri, Lancelotti, etc. Epistolæ quatuor Chemicæ.

Beccher’s great merit was the contrivance of a chemical theory, by which all the known facts were connected together and deduced from one general principle. But as this theory was adopted and considerably modified by Stahl, it will be better to lay a sketch of it before the reader, after mentioning a few particulars of the life and labours of one of the most extraordinary men whom Germany has produced; a man who, in spite of the moroseness and haughtiness of his character, and in spite of the barbarity of his style, raised himself to the very first rank as a man of science; and had the rare or almost unique fortune of giving laws at the same time to two different and important sciences, which he cultivated together, without letting his opinions respecting the one influence him with regard to the other. These sciences were chemistry and medicine.

George Ernest Stahl was born at Anspach, in the year 1660. He studied medicine at Jena under George Wolfgang Wedel; and got his doctor’s degree at the age of twenty-three. Immediately after this he began his career as a public lecturer. In 1687 the Duke of Weimar gave him the title of physician to the court. In 1694 he was named, at the solicitation of Frederick Hoffmann, second professor of medicine in the University of Halle, which had just been established. Hoffmann and he were at that time great friends, though they afterwards quarrelled. Both of them were men of the very highest talents and both were the 251
founders of medical systems which, of course, each was anxious to support. Hoffmann had greatly the superiority in elegance and clearness of style, and in all the amenities of polite manners. But perhaps the moroseness of Stahl, and the obscurity, or rather mysticism of his style, contributed equally with the more amiable qualities of Hoffmann to excite the

attention and produce the veneration with which he was viewed by his pupils, and, indeed, by the world at large.

At Halle he continued as a teacher of medicine for twenty-two years. In 1716 he was appointed physician to the King of Prussia. In consequence of this appointment he left Halle, and resided in Berlin, where he died in the year 1734, in the seventy-fifth year of his age. Notwithstanding the great figure that Stahl made as a chemist, there is no evidence that he ever taught that science in any public school. The Berlin Academy had been founded under the superintendence of Leibnitz, who was its first president; and therefore existed when Stahl was in Berlin: but, till it was renovated in 1745 by Frederick the Great, this academy possessed but little activity, and could scarcely, therefore, have stimulated Stahl to attend to chemical science. However, his Chymia rationalis et experimentalis was published in 1720, while he resided in Berlin. The same date is appended to the preface of his Fundamenta Chymiæ; but, from some expressions in that preface, it must, I should think, have been written, not by Stahl, but by some other person.[180] I suspect that the book had been written by some of his pupils, from the lectures of the author while at Halle. If this was really the case, it is obvious that Stahl must have taught chemistry as well as medicine in the 252
University of Halle.

Stahl's medical theory is not less deserving of notice than his chemical. But it is not the object of this work to enter into medical speculations. Like Van Helmont, he resolved all diseases into the actions of the *soul*, which was not merely the former of the body, but its ruler and regulator. When any of the functions are deranged, the soul exerts itself to restore them again to their healthy state; and she accomplishes this by what in common language is called disease. The business of a medical man, then, is not to prevent diseases, or to stop them short when they appear; because they are the efforts of the soul, the *vis medicatrix naturæ*, to restore the deranged state of the functions: but he must watch these diseases, and prevent the symptoms from becoming too violent. He must assist nature to produce the intended effect, and check her exertions when they become abnormal. It was a kind of modification of this theory, or rather a mixture of the Stahlian and Hoffmannian theories, that Dr. Cullen afterwards taught in Edinburgh with so much eclat. And these opinions, so far as medical theories have any influence on practice, still continue in some measure prevalent. Indeed, much of the vulgar practice followed by medical men, chiefly in consequence of the education which they have received, is deduced from these two theories. But it would be too great a digression from the object of this work to enter into any details: suffice it to say, that the rival theories of Hoffmann and Stahl for many years divided the medical world in Germany, if not in the greater part of Europe. It was no small matter of exultation to so young a medical school as Halle, to have at once within its walls two such eminent teachers as Hoffmann and Stahl.

Let us turn our attention to the chemical writings of Stahl. Of these the most important
is his Fundamenta Chymiæ dogmaticæ et experimentalis. It is divided, like the chemistry of 253
Boerhaave, into a theoretical and practical part. The perusal of it is very disagreeable, as it is full of German words and phrases, and symbols are almost constantly substituted for words, as was at that time the custom.

His definition of chemistry is much more exact than Boerhaave's. It is, according to him, the art of resolving compound bodies into their constituents, and of again forming them by uniting these constituents together.

He is inclined to believe with Beccher, that the simple principles are four in number. The *mixts* are compounds of these principles; and he shows by the doctrine of permutations that if we suppose the simple principles four, then the number of mixts will be 40,340. He treats in the first place of *mixts*, *compounds*, and *aggregates*.

The first object of chemistry is *corruption*, the second *generation*. Of these he treats at considerable length, giving an account of the different chemical processes, and of the apparatus employed.

He next treats of *salts*, which he defines mixts composed of water and earth, both simple and pure, and intimately united. The salts are vitriol, alum, nitre, common salt, and sal ammoniac. He next treats of more compound salts. These are sugar, tartar, salts from the animal and salts from the mineral kingdom, and quicklime.

After this comes sulphur, cinnabar, antimony, the sulphur of vitriol, the sulphur of nitre, resins, and distilled oils. Then he treats of water, which he divides into aqua *humida* or common water, and aqua *sicca* or mercury. Next he treats of earths, which are of two kinds, viz., *friable earths*, such as *clay*, *loam*, sand, &c., and metallic earths constituting the bases of the metals.

He next treats of the metals; and, as a preliminary, we have a description of the method 254 of smelting, and operating upon the different metals. The metals are then described successively in the following order: Gold, silver, copper, iron, tin, lead, bismuth, zinc, antimony.

To this part of the system are added three sections. The first treats of mercuries, the second of the philosopher’s stone, and the third of the universal medicine. We must not suppose that Stahl was a believer in these ideal compositions; his object is merely to give a history of the different processes which had been recommended by the alchymists.

The second part of his work is divided into two *tracts*. The first tract contains three sections. The first of these treats of the nature of solids and fluids, of solutions and menstrua, of the effects of heat and fire, of effervescence and boiling, of volatilization, of fusion and liquefaction, of distillation, of precipitation, of calcination and incineration, of detonation, of amalgamation, of crystallization and inspissation, and of the fixity and firmness of bodies. In the second section we have an account of salts, and of their generation and transmutation, of sulphur and inflammability, of phosphorus, of colours, and of the nature of metals and minerals. In this article he gives short definitions of these bodies, and shows how they may be known. The bodies thus defined are gold, silver, iron, copper, lead, tin, mercury, antimony, sulphur, arsenic, vitriol, common salt, nitre, alum, sal ammoniac, alkalies, and salts; viz., muriatic acid, sulphuric, nitric, and sulphurous.

In the third section he treats of the method of reducing metallic calces, of the mode of separating metals from their scoriæ, of the mode of making artificial gems, and finally of the mode of giving copper a golden colour.

The second tract is divided into two parts. The first part is subdivided into four sections. In the first section he treats of the instruments of chemical motion, of fire, of air, of 255 water, of the most subtile earth or salt. In the second section he treats *de subjectis*, under the several heads of dissolving aggregates, of triturations and solutions, and of calcinations and combustions. In the third section he treats of the object of chemistry under the following heads: Of chemical corruption, consisting of compounds from liquids, of the separation of solids and fluids, of mixts, of the solution of compounds from solids. In the fourth section he treats of fermentation.

The second part of this second tract treats of chemical generation, and is divided into two sections. In the first section he treats of the aggregate collection of bodies into fluids and solids. The section treats of compositions under the heads of volatile and solid bodies. He gives in the last article an account of the combination of mixts.

The third and last part of this elaborate work discusses three subjects; viz. *zymotechnia* or *fermentation*, *halotechnia*, or the production and properties of salts, and *pyrotechnia*, in which the whole of the Stahlian doctrine of *phlogiston* is developed. This third part has all the appearance of having been notes written down by some person during the lectures of Stahl: for it consists of alternate sentences of Latin and German. It is not at all likely that Stahl himself would have produced such a piebald work; but if he lectured in Latin, as was at that time the universal custom, it was natural for a person occupied in taking down the lectures, to write as far as was possible in Latin, but when any of the Latin phrases were lost, or did not immediately occur to memory, it were equally natural to write down the meaning of what the professor stated in the language most familiar to the writer, which was undoubtedly the German.

Another of Stahl's works is entitled "Opusculum Chymico-physico-medicum," published at Halle in a thick quarto volume, in the year 1715. It contains a great number of 256
tracts, partly chemical and partly medical, which it is needless to specify. Perhaps the most curious of them all is his dissertation to show the way in which Moses ground the golden calf to powder, dissolved it in water, and obliged the children of Israel to drink it. He shows that a solution of hepar sulphuris (*sulphuret of potassium*), has the property of dissolving gold, and he draws as a conclusion from his experiments that this was the artifice employed by Moses. We have in the same volume a pretty detailed treatise on metallurgic pyrotechny and docimasy. This is the more curious, because Stahl never appears to have frequented the mines and smelting-houses of Germany. He must, therefore, have drawn his information from books and from experiment.

Another of his books is entitled "Experimenta, Observationes, Animadversiones, CCC. Numero." An octavo volume, printed at Berlin in 1731. Another of his books is entitled "Specimen Beccherianum." There are also two chemical books of Stahl, which I have seen only in a French translation, viz., *Traité de Soufre* and *Traité de Sels*. These are the only chemical writings of Stahl that I have seen. There are probably others; indeed I have seen the titles of several other chemical works ascribed to him. But as it is doubtful whether he really wrote them or not, I think it unnecessary to specify them here.

Stahl's writings evince the great progress which chemistry had made even since the time of Beccher. But it is difficult to say what particular new facts, which appear first in his writings were discovered by himself, and what by others. I shall not, therefore, attempt any enumeration of them. His reasoning is more subtile, and his views much more extensive and profound than those of his predecessors. The great improvement which he introduced into chemistry was the employment of *phlogiston*, to explain the phenomena of combustion and 257
calcination. This theory had been originally broached by Beccher, from whom Stahl evidently borrowed it, but he improved and simplified it so much that the whole credit of it was given to him. It was called the Stahlian theory, and raised him to the highest rank among chemists. The sole objects of chemists for thirty or forty years after his time was to illucidate and extend his theory. It applied so happily to all the known facts, and was supported by experiments, which appeared so decisive that nobody thought of calling it in question, or of interrogating nature in any other way than he had pointed out. It will be requisite, therefore, before proceeding further with this historical sketch, to lay the outlines of the phlogistic theory before the reader.

It was conceived by Beccher and Stahl that all *combustible* bodies are compounds. One of the constituents they supposed to be dissipated during the combustion, while the other constituent remained behind. Now when combustible bodies are subjected to combustion, some of them leave an acid behind them; while others leave a fixed powdery matter, possessing the properties of an *earth*, and called usually the *calx* of the combustible body. The metals are the substances which leave a calx behind them when burnt, and sulphur and phosphorus leave an acid. With respect to those bodies that would not burn, chemists did not speculate much at first; but afterwards they came to think that they consisted of the fixed substance that remained after combustion. Hence the conclusion was natural, that they had already undergone combustion. Thus quicklime possessed properties very similar to the calces of metals. It was natural, therefore, to consider it as a calx, and to believe that if the matter dissipated during combustion could be again restored, lime would be converted into a substance similar to the metals.

Combustibility then, according to this view of the subject, depends upon a principle or material substance, existing in every combustible body, and dissipated during the combustion. This substance was considered to be absolutely the same in all combustible bodies whatever; hence the difference between combustible bodies proceeded from the other principle or number of principles with which this common substance is combined. In consequence of this identity Stahl invented the term *phlogiston*, by which he denoted this common principle of combustible bodies. Inflammation, with the several phenomena that attend it, depended on the gradual separation of this principle, which being once separated, what remained of the body could no longer be an inflammable substance, but must be similar to the other kinds of matter. It was this opinion that combustibility is owing to the presence of phlogiston, and inflammation to its escape, that constituted the peculiar theory of Beccher, and which was afterwards illustrated by Stahl with so much clearness, and experiments to prove its truth were advanced by him of so much force, that it came to be distinguished by the name of the Stahlian theory. 258

The identity of phlogiston in all combustible bodies was founded upon observations and experiments of so decisive a nature, that after the existence of the principle itself was admitted, they could not fail to be satisfactory. When phosphorus is made to burn it gives out a strong flame, much heat is evolved, and the phosphorus is dissipated in a white smoke: but if the combustion be conducted within a glass vessel of a proper shape, this white smoke will be deposited on the inside of the glass; it quickly absorbs moisture from the atmosphere, and runs into an acid liquid, known by the name of phosphoric acid. If this liquid be put into a platinum crucible, and gradually heated to redness, the water is dissipated, and a substance remains which, on cooling, congeals into a transparent colourless body like glass: this is dry *phosphoric* acid. If now we mix phosphoric acid with a quantity of charcoal powder, and heat it sufficiently in a glass retort, taking care to exclude the external air, a *portion* or the *whole* of the charcoal will disappear, and phosphorus will be formed possessed of the same properties that it had before it was subjected to combustion. The conclusion deduced from this process appeared irresistible; the charcoal, or a portion of it, had combined with the phosphoric acid, and both together had constituted phosphorus. 259

Now, in changing phosphoric acid into phosphorus, we may employ almost any kind of combustible substance that we please, provided it be capable of bearing the requisite heat; they will all equally answer, and will all convert the acid into phosphorus. Instead of charcoal we may take lamp-black, or sugar, or resin, or even several of the metals. Hence it was concluded that all of these bodies contain a common principle which they communicate to the phosphoric acid; and since the new body formed is in all cases identical, the principle communicated must also be identical. Hence combustible bodies contain an identical principle, and this principle is phlogiston.

Sulphur by burning is converted into sulphuric acid; and if sulphuric acid be heated with charcoal, or phosphorus, or even sulphur, it is again converted into sulphur. Several of the metals produce the same effect. The reasoning here was the same as with regard to phosphoric acid, and the conclusion was similar.

When lead is kept nearly at a red heat in the open air for some time, being constantly stirred to expose new surfaces to the air, it is converted into the beautiful pigment called *red lead*; this is a calx of lead. To restore this calx again to the state of metallic lead, we have only to heat it in contact with almost any combustible matter whatever. Pit-coal, peat, charcoal, sugar, flour, iron, zinc, &c., all these bodies then must contain one common 260
principle, which they communicate to red lead, and by so doing convert it into lead. This common principle is phlogiston.

These examples are sufficient to show the reader the way in which Stahl proved the identity of phlogiston in all combustible bodies. And the demonstration was considered as so complete that the opinion was adopted by every chemist without exception.

When we inquire further, and endeavour to learn what qualities phlogiston was supposed to have in its separate state, we find this part of the subject very unsatisfactory, and the opinions very unsettled. Beccher and Stahl represented phlogiston as a dry substance, or of an earthy nature, the particles of which are exquisitely subtile, and very much disposed to be agitated and set in motion with inconceivable velocity. This was called by Stahl *motus verticillaris*. When the particles of any body are agitated with this kind of motion, the body exhibits the phenomena of heat or ignition, or inflammation, according to the violence and rapidity of the motion.

This very crude opinion of the earthy nature of phlogiston, appears to have been deduced from the insolubility of most combustible substances in water. If we except alcohol, and ether, and gums, very few of them are capable of being dissolved in that liquid. Thus the metals, sulphur, phosphorus, oils, resins, bitumens, charcoal, &c., are well known to be insoluble. Now, at the time that Beccher and Stahl lived, insolubility in water was considered as a character peculiar to earthy bodies; and as those bodies which contain a great deal of phlogiston are insoluble in water, though the other constituents be very soluble in that liquid, it was natural enough to conclude that phlogiston itself was of an earthy nature.

But though the opinions of chemists about the nature and properties of phlogiston in a
separate state were unsettled, no doubts were entertained respecting its existence, and 261
respecting its identity in all combustible bodies. Its presence or its absence produced almost all the changes which bodies undergo. Hence chemistry and combustion came to be in some measure identified, and a theory of combustion was considered as the same thing with a theory of chemistry.

Metals were compounds of *calces* and phlogiston. The different species of metals depend upon the different species of calx which each contains; for there are as many *calces* (each simple and peculiar) as there are metals. These calces are capable of uniting with phlogiston in indefinite proportions. The calx united to a little phlogiston still retains its earthy appearance—a certain additional portion restores the calx to the state of a metal. An enormous quantity of phlogiston with which some calces, as calx of manganese, are capable of combining, destroys the metallic appearance of the body, and renders it incapable of dissolving in acids.

The affinity between a metallic calx and phlogiston is strong; but the facility of union is greatly promoted when the calx still retains a little phlogiston. If we drive off the whole phlogiston we can scarcely unite the calx with phlogiston again, or bring it back to the state of a metal: hence the extreme difficulty of reducing the calx of zinc, and even the red calx of iron.

The various colours of bodies are owing to phlogiston, and these colours vary with every alteration in the proportion of phlogiston present.

It was observed very early that when a metal was converted into a calx its weight was increased. But this, though known to Beecher and Stahl, does not seem to have had any effect on their opinions. Boyle, who does not seem to have been aware of the phlogistic theory, though it had been broached before his death, relates an experiment on tin which he made. He put a given weight of it into an open glass vessel, and kept it melted on the fire till a certain portion of it was converted into a calx: it was now found to have increased 262
considerably in weight. This experiment he relates in order to prove the materiality of heat: in his opinion a certain quantity of heat had united to the tin and occasioned the increase of weight. This opinion of Boyle was incompatible with the Stahlian theory: for the tin had not only increased in weight, but had been converted into a calx. It was therefore the opinion of Boyle that calx of tin was a combination of *tin* and *heat*. It could not consequently be true that calx of tin was tin deprived of phlogiston.

When this difficulty struck the phlogistians, which was not till long after the time of Stahl, they endeavoured to evade it by assigning new properties to phlogiston. According to them it is not only destitute of weight, but endowed with a principle of levity. In consequence of this property, a body containing phlogiston is always lighter than it would otherwise be, and it becomes heavier when the phlogiston makes its escape: hence the reason why calx of tin is heavier than the same tin in the metallic state. The increase of weight is not owing, as Boyle believed, to the fixation of heat in the tin, but to the escape of phlogiston from it.

Those philosophic chemists, who thus refined upon the properties of phlogiston, did not perceive that by endowing it with a principle of levity, they destroyed all the other characters which they had assigned to it. What is gravity? Is it not an attraction by means of which bodies are drawn towards each other, and remain united? And is there any reason for supposing that chemical attraction differs in its nature from the other kinds of attraction which matter possesses? If, then, phlogiston be destitute of gravity, it cannot possess any attraction for other bodies; if it be endowed with a principle of levity, it must have the property of repelling other bodies, for that is the only meaning that can be attached to the term. But if phlogiston has the property of repelling all other substances, how comes it to be 263
fixed in combustible bodies? It must be united to the calces or the acids, which constitute the other principle of these bodies; and it could not be united, and remain united, unless a principle of attraction existed between it and these bases; that is to say, unless it possessed a principle the very opposite of levity.

Thus the fact, that calces are heavier than the metals from which they are formed, in reality overturned the whole doctrine of phlogiston; and the only reason why the doctrine continued to be admitted after the fact was known is, that in these early days of chemistry, the balance was scarcely ever employed in experimenting: hence alterations in weight were little attended to or entirely overlooked. We shall see afterwards, that when Lavoisier introduced a more accurate mode of experimenting, and rendered it necessary to compare the original weights of the substances employed, with the weights of the products, he made use of this very experiment of Boyle, and a similar one made with mercury, to overturn the whole doctrine of phlogiston.

The phlogistic school being thus founded by Stahl, in Berlin, a race of chemists succeeded him in that capital, who contributed in no ordinary degree to the improvement of the science. The most deservedly celebrated of these were Neumann, Pott, Margraaf, and Eller.

Caspar Neumann was born at Zullichau, in Germany, in 1682. He was early received into favour by the King of Prussia, and travelled at the expense of that monarch into Holland, England, France, and Italy. During these travels he had an opportunity of making a personal acquaintance with the most eminent men of science in all the different countries which he visited. On his return home, in 1724, he was appointed professor of chemistry in the Royal College of Physic and Surgery at Berlin, where he delivered a course of lectures 264 annually. During the remainder of his life he enjoyed the situation of superintendent of the Royal Laboratory, and apothecary to the King of Prussia. He died in 1737. He was a Fellow of the Royal Society, and several papers of his appeared in the Transactions of that learned body. The following is a list of these papers, all of which were written in Latin:

1. Disquisitio de camphora.

2. De experimento probandi spiritum vini Gallici, per quam usitato, sed revera falso et fallaci.

Some merchants in Holland, England, Hamburg, and Dantzic, were in possession of what they considered an infallible test to distinguish French brandy from every other kind of spirit. It was a dusky yellowish liquid. When one or two drops of it were let fall into a glass of French brandy, a beautiful blue colour appeared at the bottom of the glass, and when the brandy is stirred, the whole liquid becomes azure. But if the spirit tried be malt spirit, no such colour appears in the glass. Neumann ascertained that the test liquid was merely a solution of sulphate of iron in water, and that the blue colour was the consequence of the brandy having been kept in oak casks, and thus having dissolved a portion of tannin. Every spirit will exhibit the same colour, if it has been kept in oak casks.

3. De salibus alkalino-fixis.

4. De camphora thymi.

5. De ambragrysea.

His other papers, published in Germany, are the following:

In the Ephemerides.

1. De oleo distillato formicorum æthereo.

2. De albumine ovi succino simili.

In the Miscellania Berolinensia.

1. Meditationes in binas observationes de aqua per putrefactionem rubra, vulgo pro tali 265 in sanguinem versa habita.

2. Succincta relatio exactis Pomeraniis de prodigio sanguinis in palude viso.

3. De prodigio sanguinis ex Pomeranio nunciato.

4. Disquisitio de camphora.

5. De experimento probandi spiritum vini Gallicum.

6. De spiritu urinoso caustico.

7. Demonstratio syrupum violarum ad probanda liquida non sufficere.

8. Examen correctionis olei raparum.

9. De vi caustica et conversione salium alkalino-fixorum aëri expositorum in salia neutra.

He published separately,

1. De salibus alkalino-fixis et camphora.

2. De succino, opio, caryophyllis aromaticis et castoreo.

3. On saltpetre, sulphur, antimony, and iron.

4. On tea, coffee, beer, and wine.

5. Disquisitio de ambragrysea.

6. On common salt, tartar, sal ammoniac and ants.

After Neumann's death, two copies of his chemical lectures were published. The first consisting of notes taken by one of his pupils, intermixed with incoherent compilations from other authors, was printed at Berlin in 1740. The other was printed by the booksellers of the Orphan Hospital of Zullichau (the place of Neumann's birth), and is said to have been taken from the original papers in the author's handwriting. Of this last an excellent translation, with many additions and corrections, was published by Dr. Lewis, in London, in the year 1759; it was entitled, "The Chemical Works of Caspar Neumann, M.D., Professor of Chemistry at Berlin, F.R.S., &c. Abridged and methodized; with large additions, containing the later discoveries and improvements made in Chemistry, and the arts depending thereon. By William Lewis, M.B., F.R.S. London, 1759." This is an excellent book, and contains 266 many things that still retain their value, notwithstanding the improvements which have been made since in every department of chemistry.

I have reason to believe that the laborious part of this translation and compilation was made by Mr. Chicholm, whom Dr. Lewis employed as his assistant. Mr. Chicholm, when a young man, went to London from Aberdeen, where he had studied at the university, and acquired a competent knowledge of Greek and Latin, but no means of supporting himself. On his arrival in London, one of the first things that struck his attention was a Greek book, placed open against the pane of a bookseller's window. Chicholm went up to the window, at which he continued standing till he had perused the whole Greek page thus exposed to his view. Dr. Lewis happened to be in the shop: he had been looking out for a young man whom he could employ to take charge of his laboratory, and manage his processes, and who should possess sufficient intelligence to read chemical works for him, and collect out of each whatever deserved to be known, either from its novelty or ingenuity. The appearance and manners of Chicholm struck him, and made him think of him as a man likely to answer the purposes which he had in view. He called him into the shop, and after some conversation with him, took him home, and kept him all his life as his assistant and operator. Chicholm was a laborious and painstaking man, and by continually working in Lewis's laboratory, soon acquired a competent knowledge of chemistry. He compiled several manuscript volumes, partly consisting of his own experiments, and partly of collections from other authors. At Dr. Lewis's death, all his books were sold by auction, and these manuscript volumes among the rest. They were purchased by Mr. Wedgewood, senior, who at the same time took Mr. Chicholm into his service, and gave him the charge of his own laboratory. It was Mr. Chicholm that was the constructor of the well-known piece of apparatus known by the name of Wedgewood's pyrometer. After his death the instrument continued still to be constructed for some time; but so many complaints were made of the unequal contraction of the pieces, that Mr. Wedgewood, junior, who had succeeded to the pottery in consequence of the death of his father, put an end to the manufacture of them altogether. 267

John Henry Pott was born at Halberstadt, in the year 1692. He was a scholar of Hoffmann and Stahl, and from this last he seems to have imbibed his taste for chemistry. He settled at Berlin, where he became assessor of the Royal College of Medicine and Surgery, inspector of medicines, superintendent of the Royal Laboratory, and dean of the Academy of Sciences of Berlin. He was chosen professor of theoretical chemistry at Berlin; and on the death of Neumann, in 1737, he succeeded him as professor of practical chemistry. He was beyond question the most learned and laborious chemist of his day. His erudition, indeed, was very great; and his historical introductions to his dissertation displays the extent of his reading on every subject of which he had occasion to treat. It has often struck me that the historical introductions which Bergmann has prefixed to his papers, are several of them borrowed from Pott. The Lithogeognosia of Pott is one of the most extraordinary productions of the age in which he lived. It was the result of a request of the King of Prussia, to discover the ingredients of which Saxon porcelain was made. Mr. Pott, not being able to procure any satisfactory information relative to the nature of the substances employed at Dresden, resolved to undertake a chemical examination of all the substances that were likely to be employed in such a manufacture. He tried the effect of fire upon all the stones, earths, and minerals, that he could procure, both separately and mixed together in various proportions. He made at least thirty thousand experiments in six years, and laid 268 the foundation for a chemical knowledge of these bodies.[181] It is to this work of Pott that we are indebted for our knowledge of the effects of heat upon various earthy bodies, and upon mixtures of them. Thus he found that pure white clay, or mixtures of pure clay and quartz-sand, would not fuse at any temperature which he could produce; but clay, mixed with lime or with oxide of iron, enters speedily into fusion. Clay also fuses with its own weight of borax; it forms a compact mass with half its weight, and does not concrete into a hard body when mixed with a third of its weight of that salt. Clay fuses easily with fluor spar; it fuses, also, with twice its weight of protoxide of lead, and with its own weight of sulphate of lime, but with no other proportion tried. It was a knowledge of these mutual actions of bodies on each other, when exposed to heat, that gradually led to the methods of examining minerals by the blowpipe. These methods were brought to the present state of perfection by Assessor Gahn, of Fahlun, the result of whose labours has been published by Berzelius, in his treatise on the blowpipe. Pott died in 1777, in the eighty-fifth year of his age.

His different chemical works (his Lithogeognosia excepted) were collected and translated into French by M. Demachy, in the year 1759, and published in four small octavo volumes. The chemical papers contained in these volumes are thirty-two in number. Some of these papers cannot but appear somewhat extraordinary to a modern chemist: for example, M. Duhamel had published in the memoirs of the French Academy, in the year 269 1737, a set of experiments on common salt, from which he deduced that its basis was a fixed alkali, which possessed properties different from those of potash, and which of course required to be distinguished by a peculiar name. It is sufficiently known that the term *soda* was afterwards applied to this alkali; by which name it is known at present. Pott, in a very elaborate and long dissertation on the base of common salt, endeavours to refute these opinions of Duhamel. The subject was afterwards taken up by Margraaf, who demonstrated, by decisive experiments, that the base of common salt is *soda*; and that soda differs essentially in its properties from potash.

Pott's dissertation on *bismuth* is of considerable value. He collects in it the statements and opinions of all preceding writers on this metal, and describes its properties with considerable accuracy and minuteness. The same observations apply to his dissertation on zinc.

John Theodore Eller, of Brockuser, was born on the 29th of November, 1689, at Pletzkau, in the principality of Anhalt Bernburg. He was the fourth son of Jobst Hermann Eller, a man of a respectable family, whose ancestors were proprietors of considerable estates in Westphalia and the Netherlands. Young Eller received the rudiments of his education in his father's house, from which he went to the University of Quedlinburg; and from thence to the University of Jena, in 1709. He was sent thither to study law; but his passion was for natural philosophy, which led him to devote himself to the study of medicine. From Jena he went to Halle, and finally to Leyden, attracted by the reputation of the older Albinus, of Professor Sengerd and the celebrated Boerhaave, at that time in the height of his reputation. The only practical anatomist then in Leyden, was M. Bidloo, an old man of eighty, and of course unfit for teaching. This induced Eller to repair to Amsterdam, 270 to study under Rau, and to inspect the anatomical museum of Ruysch. Bidloo soon dying, Rau was appointed his successor at Leyden, whither Eller followed him, and dissected under him till the year 1716. After taking his degree at Leyden, Eller returned to Germany, and devoted a considerable time to the study and examination of the mines of Saxony and the Hartz, and of the metallurgic processes connected with these mines. From these mines he repaired to France, and resumed his anatomical studies under Du Verney and Winslow. Chemistry also attracted a good deal of his attention, and he frequented the laboratories of Grosse, Lemery, Bolduc, and Homberg, at that time the most eminent chemists in Paris.

From Paris he repaired to London, where he formed an acquaintance with the numerous medical men of eminence who at that time adorned this capital. On returning to Germany in 1721, he was appointed physician to Prince Victor Frederick of Anhalt Bernburg. From Bernburg he went to Magdeburg; and the King of Prussia called him to Berlin in 1724, to teach anatomy in the great anatomic theatre which had been just erected. Soon after he was appointed physician to the king, a counsellor and professor in the Royal Medico-Chirurgical College, which had been just founded in Berlin. He was also appointed dean of the Superior College of Medicine, and physician to the army and to the great Hospital of Frederick. In the year 1755 Frederick the Great made him a privy-counsellor, which is the highest rank that a medical man can attain in Prussia. The same year he was made director of the Royal Academy of Sciences of Berlin. He died in the year 1760, in the seventy-first year of his age. He was twice married, and his second wife survived him.

Many chemical papers of Eller are to be found in the memoirs of the Berlin Academy. 271 They were of sufficient importance, at the time when he published them, to add considerably to his reputation, though not sufficiently so to induce me to give a catalogue of them here. I am not aware of any chemical discovery for which we are indebted to him; but have been induced to give this brief notice of him, because he is usually associated with Pott and Margraaf, making with them the three celebrated chemists who adorned Berlin, during the splendid reign of Frederick the Great.

Andrew Sigismund Margraaf was born in Berlin, in the year 1709, and acquired the first principles of chemistry from his father, who was an apothecary in that city. He afterwards studied under Neumann, and travelling in quest of information to Frankfort, Strasburg, Halle, and Freyburg, he returned to Berlin enriched with all the knowledge of his favourite science which at that time existed. In 1760, on the death of Eller, he was made director of the physical class of the Berlin Academy of Sciences. He died in the year 1782, in the seventy-third year of his age. He gradually acquired a brilliant reputation in consequence of the numerous chemical papers which he successively published, each of

which usually contained a new chemical fact, of more or less importance, deduced from a set of experiments generally satisfactory and convincing. His papers have a greater resemblance to those of Scheele than of any other chemist to whom we can compare them. He may be considered as in some measure the beginner of chemical analysis; for, before his time, the chemical analysis of bodies had hardly been attempted. His methods, as might have been expected, were not very perfect; nor did he attempt numerical results. His experiments on phosphorus and on the method of extracting it from urine are valuable; they communicated the first accurate notions relative to this substance and to phosphoric acid. 272
He first determined the properties of the earth of alum, now known by the name of *alumina*; showed that it differed from every other, and that it existed in clay, and gave to that substance its peculiar properties. He demonstrated the peculiar nature of soda, the base of common salt, which Pott had called in question, and thus verified the conclusions of Duhamel. He gives an easy process for obtaining pure silver from the chloride of that metal: his method is to dissolve the pure chloride of silver in a solution of caustic ammonia, and to put into the liquid a sufficient quantity of pure mercury; the silver is speedily reduced and converted into an amalgam, and when this amalgam is exposed to a red heat the mercury is driven off and pure silver remains. The usual method of reducing the chloride of silver is to heat it in a crucible with a sufficient quantity of carbonate of potash, a process which was first recommended by Kunkel. But it is scarcely possible to prevent the loss of a portion of the silver when the chloride is reduced in this way. The modern process is undoubtedly the simplest and the best, to reduce it by means of hydrogen. If a few pieces of zinc be put into the bottom of a beer-glass and some dilute sulphuric acid be poured over it an effervescence takes place, and hydrogen gas is disengaged. Chloride of silver, placed above the zinc in the same glass, is speedily reduced by this hydrogen and converted into metallic silver.

Margraaf's chemical papers, down to the time of publication, were collected together, translated into French and published at Paris in the year 1762, in two very small octavo volumes, they consist of twenty-six different papers: some of the most curious and important of which are those that have been just particularized. Several other papers written by him appeared in the memoirs of the Berlin Academy, after this collection of his works 273
was published, particularly "A demonstration of the possibility of drawing fixed alkaline salts from tartar by means of acids, without employing the action of a violent fire." It was this paper, probably, that led Scheele, a few years after, to his well-known method of obtaining tartaric acid, a modification of which is still followed by manufacturers.

"Observations concerning a remarkable volatilization of a portion of a kind of stone known by the names of flosse, flusse, fluor spar, and likewise by that of hesperos: which volatilization was effectuated by means of acids." Pott had already shown the value of fluor spar as a flux. Three years after the appearance of Margraaf's paper, Scheele discovered the nature of fluor spar, and first drew the attention of chemists to the peculiar properties of fluoric acid.

In France, in consequence chiefly of the regulations established in the Academy of Sciences, in the year 1699, a race of chemists always existed, whose specific object was to cultivate chemistry, and extend and improve it. The most eminent of these chemical labourers, after the Stahlian theory was fully admitted in France till its credit began to be shaken, were Reaumur, Hellot, Duhamel, Rouelle, and Macquer. Besides these, who were the chief chemists in the academy, there were a few others to whom we are indebted for chemical discoveries that deserve to be recorded.

René Antoine Ferchault, Esq., Seigneur de Reaumur, certainly one of the most extraordinary men of his age, was born at Rochelle, in 1683. He went to the school of Rochelle, and afterwards studied philosophy under the Jesuits at Poitiers. Hence he went to Bourges, to which one of his uncles, canon of the holy chapel in that city, had invited him.

At this time he was only seventeen years of age, yet his parents ventured to intrust a younger brother to his care, and this care he discharged with all the fidelity and sagacity of a 274
much older man. Here he devoted himself to mathematics and physics, and he soon after went to Paris to improve the happy talents which he had received from nature. He was fortunate enough to meet with a friend and relation in the president, Henault, equally devoted to study with himself, equally eager for information, and possessed of equal honour and integrity, and equally promising talents.

He came to Paris in 1703. In 1708 he was admitted into the Academy of Sciences, in the situation of *élève* of M. Varignon, vacant by the promotion of M. Saurin to the rank of associate.

The first papers of his which were inserted in the Memoirs of the Academy were geometrical: he gave a general method of finding an infinity of curves, described by the extremity of a straight line, the other extremity of which, passing along the surface of a given curve, is always obliged to pass through the same point. Next year he gave a geometrical work on Developes; but this was the last of his mathematical tracts. He was charged by the academy with the task of giving a description of the arts, and his taste for natural history began to draw to that study the greatest part of his attention. His first work as a naturalist was his observations on the formation of shells. It was unknown whether shells increase by intussusception, like animal bodies, or by the exterior and successive addition of new parts. By a set of delicate observations he showed that shells are formed by the addition of new parts, and that this was the cause of the variety of colour, shape, and size which they usually affect. His observations on snails, with a view to the way in which their shells are formed, led him to the discovery of a singular insect, which not only lives on snails, but in the inside of their bodies, from which it never stirs till driven out by the snail. 275

During the same year, he wrote his curious paper on the silk of spiders. The experiments of M. Bohn had shown that spiders could spin a silk that might be usefully employed. But it remained to be seen whether these creatures could be fed with profit, and in sufficiently great numbers to produce a sufficient quantity of silk to be of use. Reaumur undertook this disagreeable task, and showed that spiders could not be fed together without attacking and destroying one another.

The next research which he undertook, was to discover in what way certain sea-animals are capable of attaching themselves to fixed bodies, and again disengaging themselves at pleasure. He discovered the various threads and pinnæ which some of them possess for this purpose, and the prodigious number of limbs by which the sea-star is enabled to attach itself to solid bodies. Other animals employ a kind of cement to glue themselves to those substances to which they are attached, while some fix themselves by forming a vacuum in the interval between themselves and the solid substances to which they are attached.

It was at this period that he found great quantities of the buccinum, which yielded the purple dye of the ancients, upon the coast of Poitou. He observed, also, that the stones and little sandy ridges round which the shellfish had collected were covered with a kind of oval grains, some of which were white, and others of a yellowish colour, and having collected and squeezed some of these upon the sleeve of his shirt, so as to wet it with the liquid which they contained, he was agreeably surprised in about half an hour to find the wetted spot assume a beautiful purple colour, which was not discharged by washing. He collected a number of these grains, and carrying them to his apartment, bruised and squeezed different parcels of them upon bits of linen; but to his great surprise, after two or three hours, no 276
colour appeared on the wetted part; but, at the same time, two or three spots of the plaster at the window, on which drops of the liquid had fallen, had become purple; though the day was cloudy. On carrying the pieces of linen to the window, and leaving them there, they also

acquired a purple colour. It was the action of light, then, on the liquor, that caused it to tinge the linen. He found, likewise, that when the colouring matter was put into a phial, which filled it completely, it remained unchanged; but when the phial was not full, and was badly corked, it acquired colour. From these facts it is evident, that the purple colour is owing to the joint action of the light and the oxygen of the atmosphere upon the liquor of the shellfish.

About this time, likewise, he made experiments upon a subject which attracted the attention of mechanicians—to determine whether the strength of a cord was greater, or less, or equal to the joint strength of all the fibres which compose it. The result of Reaumur's experiments was, that the strength of the cord is less than that of all the fibres of which it is composed. Hence it follows, that the less that a cord differs from an assemblage of straight fibres, the stronger it is. This, at that time considered as a singular mechanical paradox, was afterwards elucidated by M. Duhamel.

It was a popular opinion of all the inhabitants of the sea-shore, that when the claws of crabs, lobsters, &c., are lost by any means, they are gradually replaced by others, and the animal in a short time becomes as perfect as at first. This opinion was ridiculed by men of science as inconsistent with all our notions of true philosophy. Reaumur subjected it to the test of experiment, by removing the claws of these animals, and keeping them alone for the requisite time in sea-water: new claws soon sprang out, and perfectly replaced those that had been removed. Thus the common opinion was verified,and the contemptuous smile of 277 the half-learned man of science was shown to be the result of ignorance, not of knowledge.

Reaumur was not so fortunate in his attempts to explain the nature of the shock given by the torpedo; which we now know to be an electric shock produced by a peculiar apparatus within the animal. Reaumur endeavoured to prove, from dissection, that the shock was owing to the prodigious rapidity of the blow given by the animal in consequence of a peculiar structure of its muscles.

The turquoise was at that time, as it still is, considerably admired in consequence of the beauty of its colour. Persia was the country from which this precious stone came, and it was at that time considered as the only country in the universe where it occurred. Reaumur made a set of experiments on the subject and showed that the fossil bones found in Languedoc, when exposed to a certain heat, assume the same beautiful green colour, and become turquoises equally beautiful with the Persian. It is now known, that the true Persian turquoise, the *calamite* of mineralogists, is quite different from fossil bones coloured with copper. So far, therefore, Reaumur deceived himself by these experiments; but at that time chemical knowledge was too imperfect to enable him to subject Persian turquoise to an analysis, and determine its constitution.

About the same period, he undertook an investigation of the nature of imitation pearls, which resemble the true pearls so closely, that it is very difficult, from appearances, to distinguish the true from the false. He showed that the substance which gave the false pearls their colour and lustre, was taken from a small fish called by the French *able*, or *ablette*. He likewise undertook an investigation of the origin of true pearls, and showed that they were indebted for their production to a disease of the animal. It is now known, that the introduction of any solid body, as a grain of sand, within the shell of the living pearl- 278 shellfish, gives occasion to the formation of pearl. Linnæus boasted that he knew a method of forming artificial pearls; and doubtless his process was merely introducing some solid particle of matter into the living shell. Pearls consist of alternate layers of carbonate of lime and animal membrane; and the colour and lustre to which they owe their value depends upon the thinness of the alternate coats.

The next paper of Reaumur was an account of the rivers in France whose sand yielded gold-dust, and the method employed to extract the gold. This paper will well repay the labour of a perusal; it owes its interest in a great measure to the way in which the facts are laid before the reader.

His paper on the prodigious bank of fossil shells at Touraine, from which the inhabitants draw manure in such quantities for their fields, deserves attention in a geological point of view. But his paper on flints and stones is not so valuable; it consists in speculations, which, from the infant state of chemical analysis when he wrote, could not be expected to lead to correct conclusions.

I pass over many of the papers of this most indefatigable man, because they are not connected with chemistry; but his history of insects constitutes a charming book, and contains a prodigious number of facts of the most curious and important nature. This book alone, supposing Reaumur had done nothing else, would have been sufficient to have immortalized the author.

In the year 1722 he published his work on the *art of converting iron into steel, and of softening cast-iron*. At that time no steel whatever was made in France; the nation was supplied with that indispensable article from foreign countries, chiefly from Germany. The object of Reaumur's book was to teach his countrymen the art of making steel, and, if possible, to explain the nature of the process by which iron is changed into steel. Reaumur 279
concluded from his experiments, that steel is iron impregnated with *sulphureous* and *saline* matters. The word *sulphureous*, as at that time used, was nearly synonymous with our present term *combustible*. The process which he found to answer, and which he recommends to be followed, was to mix together

4 parts of soot
2 parts of charcoal-powder
2 parts of wood-ashes
1½ parts of common salt.

The iron bars to be converted into steel were surrounded with this mixture, and kept red-hot till converted into steel. Reaumur's notion of the difference between iron and steel was an approximation to the truth. The saline matters which he added do not enter into the composition of steel; and if they did, so far from improving, they would injure its qualities. But the charcoal and soot, which consist chiefly of carbon, really produce the desired effect; for steel is a combination of *iron* and *carbon*.

In consequence of these experiments of Reaumur, it came to be an opinion entertained by chemists, that steel differed from iron merely by containing a greater proportion of phlogiston; for the charcoal and soot with which the iron bars were surrounded was considered as consisting almost entirely of phlogiston; and the only useful purpose which they could serve, was supposed to be to furnish phlogiston. This opinion continued prevalent till it was overturned towards the end of the last century, first by the experiments of Bergmann, and afterwards by those of Berthollet, Vandermond, and Monge, published in the Memoirs of the French Academy for 1786 (page 132). In this elaborate memoir the authors take a view of all the different processes followed in bringing iron from the ore to the state of steel: they then give an account of the researches of Reaumur and of Bergmann; 280
and lastly relate their own experiments, from which they finally draw, as a conclusion, that steel is a compound of iron and carbon.

The regent Orleans, who at that time administered the affairs of France, thought that this work of Reaumur was deserving a reward, and accordingly offered him a pension of 12,000 livres. Reaumur requested of the regent that this pension should be given in the name of the academy, and that after his death it should continue, and be devoted to defray the necessary expenses towards bringing the arts into a state of perfection. The request was granted, and the letters patent made out on the 22d of December, 1722.

At that time tin-plate, as well as steel, was not made in France; but all the tin-plates wanted were brought from Germany, where the processes followed were kept profoundly secret. Reaumur undertook to discover a method of tinning iron sufficiently cheap to admit the article to be manufactured in France—and he succeeded. The difficulty consisted in removing the scales with which the iron plates, as prepared, were always covered. These scales consist of a vitrified oxide of iron, to which the tin will not unite. Reaumur found, that when these plates are steeped in water acidulated by means of bran, and then allowed to rust in stoves, the scales become loose, and are easily detached by rubbing the plates with sand. If after being thus cleansed they are plunged into melted tin, covered with a little tallow to prevent oxidizement, they are easily tinned. In consequence of this explanation of the process by Reaumur, tin-plate manufactories were speedily established in different parts of France. It was about the same time, or only a little before it, that tin-plate manufactories were first started in England. The English tin-plate was much more beautiful than the German, and therefore immediately preferred to it; because in Germany the iron was converted into plates by hammering, whereas in England it was rolled out. This made it 281
much smoother, and consequently more beautiful.

Another art, at that time unknown in France, and indeed in every part of Europe except Saxony, was the art of making porcelain, a name given to the beautiful translucent stoneware which is brought from China and Japan. Reaumur undertook to discover the process employed in making it. He procured specimens of porcelain from China and Japan, and also of the imitations of those vessels at that time made in various parts of France and other European countries. The true porcelain remained unaltered, though exposed to the most violent heat which he was capable of producing; but the imitations, in a furnace heated by no means violently, melted into a perfect glass. Hence he concluded, that the imitation-porcelains were merely glass, not heated sufficiently to be brought into fusion; but true porcelain he conceived to be composed of two different ingredients, one of which is capable of resisting the most violent heat which can be raised, but the other, when heated sufficiently, melts into a glass. It is this last ingredient that gives porcelain its translucency, while the other makes it refractory in the fire. This opinion of Reaumur was soon after confirmed by Father d'Entrecolles, a French missionary in China, who sent some time after a memoir to the academy, describing the mode followed by the Chinese in the manufactory of their porcelain. Two substances are employed by them, the one called *kaolin* and the other *petunse*. It is now known that *kaolin* is what we call porcelain-clay, and that *petunse* is a fine white felspar. Felspar is fusible in a violent heat, but porcelain-clay is refractory in the highest temperatures that we have it in our power to produce in furnaces.

Reaumur made another curious observation on glass, which has been, since his time,
employed very successfully to explain the appearances of many of our trap-rocks. If a glass 282
vessel, properly secured in sand, be raised to a red heat, and then allowed to cool very slowly, it puts off the appearance of glass and assumes that of stoneware, or porcelain. Vessels thus altered have received the name of *Reaumur's porcelain*. They are much more refractory than glass, and therefore may be exposed to a pretty strong red heat without any danger of softening or losing their shape. This change is occasioned by the glass being kept long in a soft state: the various substances of which it is composed are at liberty to exercise their affinities and to crystallize. This makes the vessel lose its glassy structure altogether. In like manner it was found by Sir James Hall and Mr. Gregory Watt, that when common greenstone was heated sufficiently, and then rapidly cooled, it melted and concreted into a glass; but if after having been melted it was allowed to cool exceedingly slowly, the constituents again crystallized and arranged themselves as at first—so that a true greenstone

was again formed. In the same way lavas from a volcano either assume the appearance of slag or of stone, according as they have cooled rapidly or slowly. Many of the lavas from Vesuvius cannot be distinguished from our *greenstones*.

Reaumur's labours upon the thermometer must not be omitted here; because he gave his name to a thermometer, which was long used in France and in other parts of Europe. The first person that brought thermometers into a state capable of being compared with each other was Sir Isaac Newton, in a paper published in the Philosophical Transactions for 1701. Fahrenheit, of Amsterdam, was the first person that put Newton's method in practice, by fixing two points on his scale, the freezing-water point and the boiling-water point, and dividing the interval between them into one hundred and eighty degrees.

But no fixed point existed in the thermometers employed in France, every one 283
graduating them according to his fancy; so that no two thermometers could be compared together. Reaumur graduated his thermometers by plunging them into freezing water or a mixture of snow and water. This point was marked zero, and was called the freezing-water point. The liquid used in his thermometers was spirit of wine: he took care that it should be always of the same strength, and the interval between the point of freezing and boiling water was divided into eighty degrees. Deluc afterwards rectified this thermometer, by substituting mercury for spirit of wine. This not only enabled the thermometer to be used to measure higher temperatures, but corrected an obvious error which existed in all the thermometers constructed upon Reaumur's principle: for spirit of wine cannot bear a temperature of eighty degrees Reaumur without being dissipated into vapour—absolute alcohol boiling at a hundred and sixty-two degrees two-thirds. It is obvious from this, that the boiling point in Reaumur's thermometer could not be accurate, and that it would vary, according to the quantity of empty space left above the alcohol.

Finally, he contrived a method of hatching chickens by means of artificial heat, as is practised in Egypt.

We are indebted to him also for a set of important observations on the organs of digestion in birds. He showed, that in birds of prey, which live wholly upon animal food, digestion is performed by solvents in the stomach, as is the case with digestion in man: while those birds that live upon vegetable food have a very powerful stomach or gizzard, capable of triturating the seeds which they swallow. To facilitate this triturating process, these fowls are in the habit of swallowing small pebbles.

The moral qualities of M. Reaumur seem not to have been inferior to the extent and
variety of his acquirements. He was kind and benevolent, and remarkably disinterested. He 284
performed the duties of intendant of the order of St. Louis from the year 1735 till his death, without accepting any of the emoluments of the office, all of which were most religiously given to the person to whom they belonged, had she been capable of performing the duties of the place. M. Reaumur died on the 17th of October, 1756, after having lived very nearly seventy-five years.

John Hellot was born in Paris in the year 1685, on the 20th of November. His father, Michael Hellot, was of a respectable family, and the early part of his son's education was at home: it seems to have been excellent, as young Hellot acquired the difficult art of writing on all manner of subjects in a precise, clear, and elegant style. His father intended him for the church; but his own taste led him decidedly to the study of chemistry. He had an uncle a physician, some of whose papers on chemical subjects fell into his hands. This circumstance kindled his natural taste into a flame: he formed an acquaintance with M. Geoffroy, whose reputation as a chemist was at that time high, and this friendship was afterwards cemented by Geoffroy marrying the niece of M. Hellot.

His circumstances being easy, he went over to England, to form a personal acquaintance with the many eminent philosophers who at that time adorned that country. His fortune was considerably deranged by Law's celebrated scheme during the regency of the Duke of Orleans. This obliged him to look out for some resource: he became editor of the Gazette de France, and continued in this employment from 1718 to 1732. During these fourteen years, however, he did not neglect chemistry, though his progress was not so rapid as it would have been, could he have devoted to that science his undivided attention. In 1732 he was put forward by his friends as a candidate for a place in the Academy of Sciences; and in the year 1735 he was chosen adjunct chemist, vacant by the promotion of 285 M. de la Condamine to the place of associate. Three years after he was declared a supernumerary pensioner, without passing through the step of associate. His reputation as a chemist was already considerable, and after he became a member of the academy, he devoted himself to the investigations connected with his favourite science.

His first labours were on zinc; in two successive papers he endeavoured to decompose this metal, and to ascertain the nature of its constituents. Though his labour was unsuccessful, yet he pointed out many new properties of this metal, and various new compounds into which it enters. Neither was he more successful in his attempt to account for the origin of the red vapours which are exhaled from nitre in certain circumstances. He ascribed them to the presence of ferruginous matters in the nitre; whereas they are owing to the expulsion and partial decomposition of the nitric acid of the nitre, in consequence of the action of some more powerful acid.

His paper on sympathetic ink is of more importance. A German chemist had shown him a saline solution of a red colour which became blue when heated: this led him to form a sympathetic ink, which was pale red, while the paper was moist, but became blue upon drying it by holding it to the fire. This sympathetic ink was a solution of cobalt in muriatic acid. It does not appear from Hellot's paper that he was exactly aware of the chemical constitution of the liquid which constituted his sympathetic ink; though it is clear he knew that cobalt constitutes an essential part of it.

Kunkel's phosphorus, though it had been originally discovered in Germany, could not be prepared by any of the processes which had been given to the public. Boyle had taught his operator, Godfrey Hankwitz, the method of making it. This man had, after Boyle's death, opened a chemist's shop in London, and it was he that supplied all Europe with this curious article: on that account it was usually distinguished by the name of *English* 286 *phosphorus*. But in the year 1737 a stranger appeared in Paris, who offered for a stipulated reward to communicate the method of manufacturing this substance to the Academy of Sciences. The offer was accepted by the French government, and a committee of the academy, at the head of which was Hellot, was appointed to witness the process, and ascertain all its steps. The process was repeated with success; and Hellot drew up a minute detail of the whole, which was inserted in the Memoirs of the Academy, for the year 1737. The publication of this paper constitutes an era in the preparation of phosphorus: it was henceforward in the power of every chemist to prepare it for himself. A few years after the process was much improved by Margraaf; and, within little more than twenty years after, the very convenient process still in use was suggested by Scheele. Hellot's experiments on the comparative merits of the salts of Peyrac, and of Pecais were of importance, because they decided a dispute—they may also perhaps be considered as curiosities in an historical point of view; because we see from them the methods which Hellot had recourse to at that early period in order to determine the purity of common salt. They are not entitled, however, to a more particular notice here.

In the year 1740 M. Hellot was charged with the general inspection of dyeing; a situation which M. du Foy had held till the time of his death in 1739. It was this appointment, doubtless, which turned his attention to the theory of dyeing, which he tried to explain in two memoirs read to the academy in 1740 and 1741. The subject was afterwards prosecuted by him in subsequent memoirs which were published by the academy.

In 1745 he was named to go to Lyons in order to examine with care the processes followed for refining gold and silver. Before his return he took care to give to these 287 processes the requisite precision and exactness. Immediately after his return to Paris he was appointed to examine the different mines and assay the different ores in France; this appointment led him to turn his thoughts to the subject. The result of this was the publication of an excellent work on assaying and metallurgy, entitled “De la Fonte des Mines, des Fonderies, &c. Traduit de l’Allemand de Christophe-André Schlutter.” The first volume of this book appeared in 1750, and the second in 1753. Though this book is called by Hellot a translation, it contains in fact a great deal of original matter; the arrangement is quite altered; many processes not noticed by Schlutter are given, and many essential articles are introduced, which had been totally omitted in the original work. He begins with an introduction, in which he gives a short sketch of all the mines existing in every part of France, together with some notice of the present state of each. The first volume treats entirely of docimasy, or the art of assaying the different metallic ores. Though this art has been much improved since Hellot’s time, yet the processes given in this volume are not without their value. The second volume treats of the various metallurgic processes followed in order to extract metals from their ores. This volume is furnished with no fewer than fifty-five plates, in which all the various furnaces, &c. used in these processes are exhibited to the eye.

While occupied in preparing this work for the press he was chosen to endeavour to bring the porcelain manufactory at Sevre to a greater state of perfection than it had yet reached. In this he was successful. He even discovered various new colours proper for painting upon porcelain; which contributed to give to this manufactory the celebrity which it acquired.

In the year 1763 a phenomenon at that time quite new to France took place in the coal-mine of Briançon. A quantity of carburetted hydrogen gas had collected in the bottom of the 288 mine, and being kindled by the lights employed by the miners, it exploded with great violence, and killed or wounded every person in the mine. This destructive gas, distinguished in this country by the name of *fire-damp*, had been long known in Great Britain and in the Low Countries, though it had not before been known in France. The Duke de Choiseul, informed of this event, had recourse to the academy for assistance, who appointed Messrs. de Montigny, Duhamel, and Hellot, a committee to endeavour to discover the remedies proper to prevent any such accident from happening for the future. The report of these gentlemen was published in the Memoirs of the Academy;[182] they give an account both of the fire-damp, and *choke-damp*, or *carbonic acid gas*, which sometimes also makes its appearance in coal-mines. They very justly observe that the proper way to obviate the inconveniency of these gases is to ventilate the mine properly; and they give various methods by which this ventilation may be promoted by means of fires lighted at the bottom of the shaft, &c.

In 1763 M. Hellot was appointed, conjointly with M. Tillet, to examine the process followed for assaying gold and silver. They showed that the cupels always retained a small portion of the silver assayed, and that this loss, ascribed to the presence of a foreign metal, made the purity of the silver be always reckoned under the truth, which occasioned a loss to the proprietor.

His health continued tolerably good till he reached his eightieth year: he was then struck with palsy, but partially recovered from the first attack; but a second attack, on the

13th of February, 1765, refused to yield to every medical treatment, and he died on the 15th of that month, at an age a little beyond eighty. 289

Henry Louis Duhamel du Monceau was born at Paris in the year 1700. He was descended from Loth Duhamel, a Dutch gentleman, who came to France in the suite of the infamous Duke of Burgundy, about the year 1400. Young Duhamel was educated in the College of Harcourt; but the course of study did not suit his taste. He left it with only one fact engraven on his memory—that men, by observing nature, had created a science called *physics*; and he resolved to profit by his freedom from restraint and turn the whole of his attention to that subject. He lodged near the Jardin du Roi, where alone, at that time, physics were attended to in Paris. Dufoy, Geoffroy, Lemery, Jussieu, and Vaillant, were the friends with whom he associated on coming to Paris. His industry was stimulated solely by a love of study, and by the pleasure which he derived from the increase of knowledge; love of fame does not appear to have entered into his account.

In the year 1718 saffron, which is much cultivated in that part of France formerly distinguished by the name of Gâtinois, where Duhamel's property lay, was attacked by a malady which appeared contagious. Healthy bulbs, when placed in the neighbourhood of those that were diseased, soon became affected with the same malady. Government consulted the academy on the subject; and this learned body thought they could not do better than request M. Duhamel to investigate the cause of the disease; though he was only eighteen years of age, and not even a member of the academy. He ascertained that the malady was owing to a parasitical plant, which attached itself to the bulb of the saffron, and drew nourishment from it. This plant extended under the earth, from one bulb to another, and thus infected the whole saffron plantations.

M. Duhamel formed the resolution at the commencement of his scientific career to devote himself to public utility, and to prosecute those subjects which were likely to 290 contribute most effectually to the comfort of the lower ranks of men. Much of his time was spent in endeavouring to promote the culture of vegetables, and in rendering that culture more useful to society. This naturally led to a careful study of the physiology of trees. The fruit of this study he gave to the world in the year 1758, when his Physique des Arbres was published. This constitutes one of the most important works on the subject which has ever appeared. It contains a great number of new and original facts; and contributed very much indeed to advance this difficult, but most important branch of science: nor is it less remarkable for modesty than for value. The facts gathered from other sources, even those which make against his own opinions, are most carefully and accurately stated: the experiments that preceded his are repeated and verified with much care; and the reader is left to discover the new facts and new views of the author, without any attempt on his part to claim them as his own.

M. Duhamel had been attached to the department of the marine by M. de Maurepas, who had given him the title of *inspector-general*. This led him to turn his attention to naval science in general. The construction of vessels, the weaving of sailcloths, the construction of ropes and cables, the method of preserving the wood, occupied his attention successively, and gave birth to several treatises, which, like all his works, contain immense collections of facts and experiments. He endeavours always to discover which is the best practice, to reduce it to fixed rules, and to support it by philosophical principles; but abstains from all theory when it can be supported only by hypothesis.

From the year 1740, when he became an academician, till his death in 1781, he made a regular set of meteorological observations at Pithiviers, with details relative to the direction 291 of the needle, to agriculture, to the medical constitution of the year, and to the time of nest-building, and of the passage of birds.

Above sixty memoirs of his were published in the Transactions of the French Academy of Sciences. They are so multifarious in their nature, and embrace such a variety of subjects, that I shall not attempt even to give their titles, but satisfy myself with stating such only as bear more immediately upon the science of chemistry.

It will be proper in conducting this review to notice the result of his labours connected with the ossification of bones; because, though not strictly chemical, they throw light upon some branches of the animal economy, more closely connected with chemistry than with any other of the sciences. He examined, in the first place, whether the ossification of bones, and their formation and reparation, did not follow the same law that he had assigned to the increments of trees, and he established, by a set of experiments, that bones increase by the ossification of layers of the periosteum, as trees do by the hardening of their cortical layers. Bones in a soft state increase in every direction, like the young branches of plants; but after their induration they increase only like trees, by successive additions of successive layers. This organization was incompatible with the opinion of those who thought that bones increased by the addition of an earthy matter deposited in the meshes of the organized network which forms the texture of bones. M. Duhamel combated this opinion by an ingenious experiment. He had been informed by Sir Hans Sloane that the bones of young animals fed upon madder were tinged red. He conceived the plan of feeding them alternately with food mingled with madder, and with ordinary food. The bones of animals thus treated were found to present alternate concentric layers of red and white, corresponding to the different periods in which the animal had been fed with food 292 containing or not containing madder. When these bones are sawn longitudinally we see the thickness of the coloured layers, greater or less, according to the number of plates of the periosteum that have ossified. As for the portions still soft, or susceptible of extending themselves in every direction, such as the plates in the neighbourhood of the marrow, the reservoir of which increases during a part of the time that the animal continues to grow, the red colour marks equally the progress of their ossification by coloured points more or less extended.

This opinion was attacked by Haller, and defended by M. Fougeroux, nephew of M. Duhamel; but it is not our business here to inquire how far correct.

One of the most important of M. Duhamel's papers, which will secure his name a proud station in the annals of chemistry, is that which was inserted in the Memoirs of the Academy for 1737, in which he shows that the base of common salt is a true fixed alkali, different in some respects from the alkali extracted from land plants, and known by the name of *potash*, but similar to that obtained by the incineration of marine plants. We are surprised that a fact so simple and elementary was disputed by the French chemists, and rather indicated than proved by Stahl and his followers. The conclusions of Duhamel were disputed by Pott; but finally confirmed by Margraaf. M. Duhamel carried his researches further, he wished to know if the difference between potash and soda depends on the plants that produce them, or on the nature of the soil in which they grow. He sowed kali at Denainvilliers, and continued his experiments during a great number of years. M. Cadet, at his request, examined the salts contained in the ashes of the kali of Denainvilliers. He found that during the first year soda predominated in these ashes. During the successive years the potash increased rapidly, and at last the soda almost entirely disappeared. It was obvious from this, that the alkalies in plants are drawn at least chiefly from the soil in which they 293 vegetate.

The memoirs of M. Duhamel on ether, at that time almost unknown, on soluble tartars, and on lime, contain many facts both curious and accurately stated; though our present knowledge of these bodies is so much greater than his—the new facts ascertained respecting them are so numerous and important, that the contributions of this early experimenter, which probably had a considerable share in the success of subsequent investigations, are now almost forgotten. Nor would many readers bear patiently with an attempt to enumerate them.

There is a curious paper of his in the Memoirs of the Academy for 1757. In this he gives the details of a spontaneous combustion of large pieces of cloth soaked in oil and strongly pressed. Cloth thus prepared had often produced similar accidents. Those who were fortunate enough to prevent them, took care to conceal the facts, partly from ignorance of the real cause of the combustion, and partly from a fear that if they were to state what they saw, their testimony would not gain credit. If the combustion had not been prevented, then the public voice would have charged those who had the care of the cloths with culpable negligence, or even with criminal conduct. The observation of M. Duhamel, therefore, was useful, in order to prevent such unjust suspicions from hindering those concerned from taking the requisite precautions. Yet, twenty years after the publication of his paper, two accidental spontaneous combustions, in Russia, were ascribed to treason. The empress Catharine II. alone suspected that the combustion was spontaneous, and experiments made by her orders fully confirmed the evidence previously advanced by the French philosopher.

One man alone would have been insufficient for all the labours undertaken by M. Duhamel; but he had a brother who lived upon his estate at Denainvilliers (the name of which he bore), and divided his time between the performance of benevolent actions and studying the operations of nature. M. Denainvilliers prosecuted in his retreat the observations and experiments intrusted by his brother to his charge. Thus in fact the memoirs of Duhamel exhibit the assiduous labours of two individuals, one of whom contentedly remained unknown to the world, satisfied with the good which he did, and the favours which he conferred upon his country and the human race. 294

The works of M. Duhamel are very voluminous, and are all written with the utmost plainness. Every thing is elementary, no previous knowledge is taken for granted. His writings are not addressed to philosophers, but to all those who are in quest of practical knowledge. He has been accused of diffuseness of style, and of want of correctness; but his style is simple and clear; and as his object was to inform, not philosophers, but the common people, greater conciseness would have been highly injudicious.

Neither he nor his brother ever married, but thought it better to devote their undivided attention to study. Both were assiduous in no ordinary degree, but the ardour of Duhamel himself continued nearly undiminished till within a year of his death; when, though he still attended the meetings of the academy, he no longer took the same interest in its proceedings. On the 22d of July, 1781, just after leaving the academy, he was struck with apoplexy, and died after lingering twenty-two days in a state of coma.

He was without doubt one of the most eminent men of the age in which he lived; but his merits as a chemist will chiefly be remembered in consequence of his being the first person who demonstrated by satisfactory evidence the peculiar nature of soda, which had been previously confounded with potash. His merits as a vegetable physiologist and agriculturist were of a very high order. 295

Peter Joseph Macquer was born at Paris, in 1718. His father, Joseph Macquer, was descended from a noble Scottish family, which had sacrificed its property and its country, out of attachment to the family of the Stuarts.[183] Young Macquer made choice of medicine as a profession, and devoted himself chiefly to chemistry, for which he showed early a decided taste. He was admitted a member of the Academy of Sciences in the year 1745, when he was twenty-seven years of age. Original researches in chemistry, the composition of chemical elementary works, and the study of the arts connected with chemistry, occupied the whole remainder of his life.

His first paper treated of the effect produced by heating a mixture of saltpetre and white arsenic. It was previously known, that when such a mixture is distilled nitric acid comes over tinged with a blue colour; but nobody had thought of examining the residue of this distillation. Macquer found it soluble in water and capable of crystallizing into a neutral salt composed of potash (the base of saltpetre), and an acid into which the arsenic was changed by the nitric acid communicating oxygen to it.

Macquer found that a similar salt might be obtained with soda or ammonia for its base. Thus he was the first person who pointed out the existence of arsenic acid, and ascertained the properties of some of the salts which it forms. But he made no attempt to obtain arsenic acid in a separate state, or to determine its properties. That very important step was reserved for Scheele, for Macquer seems to have had no suspicion of the true nature of the salt which he had formed. 296

His next set of experiments was on Prussian blue. He made the first step towards the discovery of the nature of the principle to which that pigment owes its colour. Prussian blue had been accidentally discovered by Diesbach, an operative chemist of Berlin, in 1710, but the mode of producing it was kept secret till it was published in 1724, by Dr. Woodward in the Philosophical Transactions. It consisted in mixing potash and blood together, and heating the mixture in a covered crucible, having a small hole in the lid, till it ceased to give out smoke. The solution of this mixture in water, when mixed with a solution of sulphate of iron, threw down a green powder, which became blue when treated with muriatic acid: this blue matter was *Prussian blue*. Macquer ascertained that when Prussian blue is exposed to a red heat its blue colour disappears, and it is converted into common peroxide of iron. Hence he concluded that Prussian blue is a compound of oxide of iron, and of something which is destroyed or driven off by a red heat. He showed that this something possessed the characters of an acid; for when Prussian blue is boiled with caustic potash it loses its blue colour, and if the potash be boiled with successive portions of Prussian blue, as long as it is capable of discolouring them, it loses the characters of an acid and assumes those of a neutral salt, and at the same time acquires the property of precipitating iron from the solutions of the sulphate at once of a blue colour. Macquer ascribed the green colour thrown down, by mixing the blood-lie and sulphate of iron to the potash in the blood-lie, not being saturated with the colouring matter of Prussian blue. Hence a portion of the iron is thrown down in the state of Prussian blue, and another portion in that of yellow oxide of iron: these two being mixed form a green. The muriatic acid dissolves the yellow oxide and leaves the Prussian blue untouched. Macquer, however, did not succeed in determining the nature of 297 the colouring matter; a task reserved for Scheele, whose lot it was to take up the half-finished investigations of Macquer, and throw upon them a new and brilliant light. Macquer thought that this colouring matter was *phlogiston*. On that account the potash saturated with it, which was employed by chemists to detect the presence of iron by forming with it Prussian blue, was called *phlogisticated alkali*.

Macquer, conjointly with Baumé, subjected the grains of crude platinum, to which the attention of chemists had been newly drawn, to experiment. Their principle object was to examine its fusibility and ductility. They succeeded in fusing it imperfectly, by means of a burning mirror, and found that the grains thus treated were not destitute of ductility. But upon the whole the experiments of these chemists threw but little light upon the subject. Many years elapsed before chemists were able to work this refractory metal, and to make it into vessels fitted for the uses of the laboratory. For this important improvement, which constitutes an era in chemistry, the chemical world was chiefly indebted to Dr. Wollaston.

In the year 1750 M. Macquer was charged with a commission by the court. There existed at that time in Brittany a man, the Count de la Garaie, who, yielding to a passion for benevolence, had for forty years devoted himself to the service of suffering humanity. He had built an hospital by the side of a chemical laboratory: he took care of the patients in the hospital himself; and treated them with medicines prepared in his laboratory. Some of these were new, and, in his opinion, excellent medicines; and he offered to sell them to government for the service of his hospital. Macquer was charged by government with the examination of these medicines. The project of the Count de la Garaie was to extract the salutary parts of minerals, by a long maceration with neutral salts. Among other things he 298 had prepared a mercurial tincture, by a process which lasted several months: but this tincture was merely a solution of corrosive sublimate in spirit of wine. Such is the history of most of those boasted secrets; sometimes they are chimerical, and sometimes known to all the world, except to those who purchase them.

M. Macquer had the fortune to live at a time when chemistry began to be freed from the reveries of alchymists; but methodical arrangement was a merit still unknown to the elementary chemical books, especially in France, where a residue of Cartesianism added to the natural obscurity of the science, by surcharging it with pretended mechanical explanations. Macquer was the first French chemist who gave to an elementary treatise the same clearness, simplicity, and method, which is to be found in the other branches of science. This was no small merit, and undoubtedly contributed considerably to the rapid improvement of the science which so speedily followed. His elements of chemistry were translated into different languages, especially into English; and long constituted the textbook employed in the different European universities. Dr. Black recommended it for many years in the University of Edinburgh. Indeed, it was only superseded in consequence of the new views introduced into chemistry by Lavoisier, which, requiring a new language to render them intelligible, naturally superseded all the elementary chemical books which had preceded the introduction of that language.

Macquer, during a number of years, delivered regular courses of chemical lectures, conjointly with Baumé. In these courses he preferred that arrangement which appeared to him to require the least preliminary knowledge of chemistry. He described the experiments, stated the facts with clearness and precision, and explained them in the way which appeared to him most plausible, according to the opinions generally received; but without placing 299 much confidence in the accuracy of these explanations. He thought it necessary to theorize a little, to enable his pupils the better to connect the facts and to remember them; and to put an end to that painful state of uncertainty which always results from a collection of facts without any theoretical links to bind them together. When the discoveries of Lavoisier began to shake the foundation of the Stahlian theory, Macquer was old; and it appears from a letter of his, published by Delametherie in the Journal de Physique, that he was alarmed at the prophetic announcements of Lavoisier in the academy that the reign of Phlogiston was drawing towards an end. M. Condorcet assures us that his attachment to theory, by which he means phlogiston, was by no means strong;[184] but his own letter to Delametherie rather shows that this statement was not quite correct. How, indeed, could he fail to experience an attachment to opinions which it had been the business of his whole life to inculcate?

Macquer also published a dictionary of chemistry, which was very successful, and which was translated into most of the European languages. This mode of treating chemistry was well suited to a science still in its infancy, and which did not yet constitute a complete whole. It enabled him to discuss the different topics in succession, and independent of each other: and thus to introduce much important matter which could not easily have been introduced into a systematic work on chemistry. The second edition of this dictionary was published just at the time when the gases began to attract the attention of scientific men; when facts began to multiply with prodigious rapidity, and to shake the confidence of chemists in all received theories. He acquitted himself of the difficult task of collecting and 300 stating these new facts with considerable success; and doubtless communicated much new information to his countrymen: for the discoveries connected with the gases originated, and were chiefly made, in England, from which, on account of the revolutionary American war, there was some difficulty of obtaining early information.

M. Hellot, who was commissioner of the counsel for dyeing, and chemist to the porcelain manufacture, requested to have M. Macquer for an associate. This request did much honour to Hellot, as he was conscious that the reputation of Macquer as a chemist was superior to his own. Macquer endeavoured, in the first place, to lay down the true principles of the art of dyeing, as the best method of dissipating the obscurity which still hung over it. A great part of his treatise on the art of dyeing silk, published in the collection of the Academy of Sciences, has these principles for its object. He gave processes also for dyeing silk with Prussian blue, and for giving to silk, by means of cochineal, as brilliant a scarlet colour as can be given to woollen cloth by the same dye-stuff. He published nothing on the porcelain manufacture, though he attended particularly to the processes, and introduced several ameliorations. The beautiful porcelain earth at present used at Sevre, was discovered in consequence of a premium which he offered to any person who could point out a clay in every respect proper for making porcelain.

Macquer passed a great part of his life with a brother, whom he affectionately loved: after his death he devoted himself entirely to his wife and two children, whose education he superintended. He was rather averse to society, but conducted himself while in it with much sweetness and affability. He was fond of tranquillity and independence. Though his health had been injured a good many years before his death, the calmness and serenity of his temper prevented strangers from being aware that he was afflicted with any malady. He 301
himself was sensible that his strength was gradually sinking; he predicted his approaching end to his wife, whom he thanked for the happiness which she had spread over his life. He left orders that his body should be opened after his decease, that the cause of his death might be discovered. He died on the 15th of February, 1784. An ossification of the aorta, and several calculous concretions found in the cavities of the heart, had been the cause of the disease under which he had suffered for several years before his death.

These four chemists, of whose lives a sketch has just been given, were the most eminent that France ever produced belonging to the Stahlian school of chemistry. Baron, Malouin, Rouelle senior, Tillet, Cadet, Baumé, Sage, and several others whose names I purposely omit, likewise cultivated chemistry, during that period, with assiduity and success; and were each of them the authors of papers which deserve attention, but which it would be impossible to particularize without swelling this work into a size greatly beyond its proper limits.

Hilaire-Marin Rouelle, who was born at Caen in 1718, was, however, too eminent a chemist to be passed over in silence. His elder brother, William Francis, was a member of the Academy of Sciences, and demonstrator to Macquer, who gave lectures in the Jardin du Roi. At the death of Macquer, in 1770, Hilaire-Marin Rouelle succeeded him. He devoted the whole of his time and money to this situation, and quite altered the nature of the experimental course of chemistry given in the Jardin du Roi. He was in some measure the author of the chemistry of animal bodies, at least in France. When he published his experiments on the salts of urine, and of blood, he had scarcely any model; and though he committed some considerable mistakes, he ascertained several essential and important facts, 302
which have been since fully confirmed by more modern experimenters. He died on the 7th of April, 1779, aged sixty-one years. His temper was peculiar, and he was too honest and too open for the situation in which he was placed, and for a state of society in which every thing was carried by intrigue and finesse. This is the reason why, in France, his reputation was lower than it ought to have been. It accounts, too, for his never becoming a member of the Academy of Sciences, nor of any of the other numerous academies which at that time swarmed in France. Nothing is more common than to find these unjust decisions raise or

depress men of science far above or far below their true standard. Romé de Lisle, the first person who commenced the study of crystals, and placed that study in a proper point of view, was a man of the same stamp with the younger Rouelle, and never on that account, became a member of any academy, or acquired that reputation during his lifetime, to which his laborious career justly entitled him. It would be an easy, though an invidious task, to point out various individuals, especially in France, whose reputation, in consequence of accidental and adventitious circumstances, rose just as much above their deserts, as those of Rouelle, and Romé de Lisle were sunk below. 303

CHAPTER IX.

OF THE FOUNDATION AND PROGRESS OF SCIENTIFIC CHEMISTRY IN GREAT BRITAIN.

The spirit which Newton had infused for the mathematical science was so great, that during many years they drew within their vortex almost all the scientific men in Great Britain. Dr. Stephen Hales is almost the only remarkable exception, during the early part of the eighteenth century. His vegetable statics constituted a most ingenious and valuable contribution to vegetable physiology. His hæmastatics was a no less valuable contribution to iatro-mathematics, at that time the fashionable medical theory in Great Britain. While his *analysis of air*, and experiments on the animal calculus constituted, in all probability, the foundation-stone of the whole discoveries respecting the gases to which the great subsequent progress of chemistry is chiefly owing.

Dr. William Cullen, to whom medicine lies under deep obligations, and who afterwards raised the medical celebrity of the College of Edinburgh to so high a pitch, had the merit of first perceiving the importance of scientific chemistry, and the reputation which that man was likely to earn, who should devote himself to the cultivation of it. Hitherto chemistry in Great Britain, and on the continent also, was considered as a mere appendage to medicine, and useful only so far as it contributed to the formation of new and useful remedies. This 304
was the reason why it came to constitute an essential part of the education of every medical man, and why a physician was considered as unfit for practice unless he was also a chemist. But Dr. Cullen viewed the science as far more important; as capable of throwing light on the constitution of bodies, and of improving and amending of those arts and manufactures that are most useful to man. He resolved to devote himself to its cultivation and improvement; and he would undoubtedly have derived celebrity from this science, had not his fate led rather to the cultivation of medicine. But Dr. Cullen, as the true commencer of the study of scientific chemistry in Great Britain, claims a conspicuous place in this historical sketch.

William Cullen was born in Lanarkshire, in Scotland, in the year 1712, on the 11th of December. His father, though chief magistrate of Hamilton, was not in circumstances to lay out much money on his son. William, therefore, after serving an apprenticeship to a surgeon in Glasgow, went several voyages to the West Indies, as surgeon, in a trading-vessel from London; but tiring of this, he settled, when very young, in the parish of Shotts; and after residing for a short time among the farmers and country people, he went to Hamilton, with a view of practising as a physician.

While he resided near Shotts, it happened that Archibald, Duke of Argyle, who at that time bore the chief political sway in Scotland, paid a visit to a gentleman of rank in that neighbourhood. The duke was fond of science, and was at that time engaged in some chemical researches which required to be elucidated by experiment. Eager in these pursuits, while on his visit he found himself at a loss for some piece of chemical apparatus which his landlord could not furnish; but he mentioned young Cullen to the duke as a person fond of chemistry, and likely therefore to possess the required apparatus. He was accordingly 305
invited to dine, and introduced to his Grace. The duke was so pleased with his knowledge, politeness, and address, that an acquaintance commenced, which laid the foundation of all Cullen's future advancement.

His residence in Hamilton naturally made his name known to the Duke of Hamilton, whose palace is situated in the immediate vicinity of that town. His Grace being taken with a sudden illness, sent for Cullen, and was highly delighted with the sprightly character, and ingenious conversation of the young physician. He found no difficulty, especially as young Cullen was already known to the Duke of Argyle, in getting him appointed to a place in the University of Glasgow, where his singular talents as a teacher soon became very conspicuous.

It was while Dr. Cullen was a practitioner in Shotts that he formed a connexion with William, afterwards Doctor Hunter, the famous lecturer on anatomy in London, who was a native of the same part of the country as Cullen. These two young men, stimulated by genius, though thwarted by the narrowness of their circumstances, entered into a copartnery business, as surgeons and apothecaries, in the country. The chief object of their contract was to furnish the parties with the means of carrying on their medical studies, which they were not able to do separately. It was stipulated that one of them, alternately, should be allowed to study in whatever college he preferred, during the winter, while the other carried on the common business in his absence. In consequence of this agreement, Cullen was first allowed to study in the University of Edinburgh, for a winter. When it came to Hunter's turn next winter, he rather chose to go to London. There his singular neatness in dissecting, and uncommon dexterity in making anatomical preparations, his assiduity in study, his mild manners, and easy temper, drew upon him the attention of Dr. Douglas, who at that time 306
read lectures on anatomy and midwifery in the capital. He engaged him as his assistant, and he afterwards succeeded him in the same department with much honour to himself, and advantage to the public. Thus was dissolved a copartnership of perhaps as singular a kind as any that occurs in the annals of science. Cullen was not disposed to let any engagement with him prove a bar to his partner's advancement in the world. The articles were abandoned, and Cullen and Hunter kept up ever after a friendly correspondence; though there is reason to believe that they never afterwards met.

It was while a country practitioner that young Cullen married a Miss Johnston, daughter of a neighbouring clergyman. The connexion was fortunate and lasting. She brought her husband a numerous family, and continued his faithful companion through all the alterations of his fortune. She died in the summer of 1786.

In the year 1746 Cullen, who had now taken the degree of doctor of medicine, was appointed lecturer on chemistry in the University of Glasgow; and in the month of October began a course on that science. His singular talent for arrangement, his distinctness of enunciation, his vivacity of manner, and his knowledge of the science which he taught, rendered his lectures interesting to a degree which had been till then unknown in that university: he was adored by the students. The former professors were eclipsed by the brilliancy of his reputation, and he had to encounter all those little rubs and insults that disappointed envy naturally threw in his way. But he proceeded in his career regardless of these petty mortifications; and supported by the public, he was more than consoled for the contumely heaped upon him by the ill nature and pitiful malignity of his colleagues. His practice as a physician increased every day, and a vacancy occurring in the chair in 1751, he was appointed by the crown professor of medicine, which put him on a footing of equality 307 with his colleagues in the university. This new appointment called forth powers which he was not before known to possess, and thus served still further to increase his reputation.

At that time the patrons of the University of Edinburgh were eagerly bent on raising the reputation of their medical school, and were in consequence on the look out for men of abilities and reputation to fill their respective chairs. Their attention was soon drawn towards Cullen, and on the death of Dr. Plummer, in 1756, he was unanimously invited to fill the vacant *chemical chair*. He accepted the invitation, and began his academical career in the College of Edinburgh in October of that year, and here he continued during the remainder of his life.

The appearance of Dr. Cullen in the College of Edinburgh constitutes a memorable era in the progress of that celebrated school. Hitherto chemistry being reckoned of little importance, had been attended by very few students; when Cullen began to lecture it became a favourite study, almost all the students flocking to hear him, and the chemical class becoming immediately more numerous than any other in the college, anatomy alone excepted. The students in general spoke of the new professor with that rapturous ardour so natural to young men when highly pleased. These eulogiums were doubtless extravagant, and proved disgusting to his colleagues. A party was formed to oppose this new favourite of the public. His opinions were misrepresented, it was affirmed that he taught doctrines which excited the alarm of some of the most moderate and conscientious of his colleagues. Thus a violent ferment was excited, and some time elapsed before the malignant arts by which this flame had been blown up were discovered.

During this time of public ferment Cullen went steadily forward; he never gave an ear to the gossip brought him respecting the conduct of his colleagues, nor did he take any 308 notice of the doctrines which they taught. Some of their unguarded strictures on himself might occasionally have come to his ears; but if it was so, he took no notice of them whatever; they seemed to have made no impression on him.

This futile attempt to lower his character being thus baffled, his fame as a professor, and his reputation as a physician, increased daily: nor could it be otherwise; his professional knowledge was always great, and his manner of lecturing singularly clear and intelligible, lively, and entertaining. To his patients his conduct was so pleasing, his address so affable and engaging, and his manner so open, so kind, and so little regulated by pecuniary considerations, that those who once applied to him for medical assistance could never afterwards dispense with it: he became the friend and companion of every family he visited, and his future acquaintance could not be dispensed with.

His private conduct to his students was admirable, and deservedly endeared him to every one of them. He was so uniformly attentive to them, and took so much interest in the concerns of those who applied to him for advice; was so cordial and so warm, that it was impossible for any one, who had a heart susceptible of generous emotions, not to be delighted with a conduct so uncommon and so kind. It was this which served more than any thing else to extend his reputation over every civilized quarter of the globe. Among ingenuous youth gratitude easily degenerates into rapture; hence the popularity which he enjoyed, and which to those who do not well weigh the causes which operated on the students must appear excessive.

The general conduct of Cullen to his students was this: with all such as he observed to be attentive and diligent he formed an early acquaintance, by inviting them by twos, by threes, and by fours at a time to sup with him; conversing with them at such times with the 309 most engaging ease, entering freely with them into the subject of their studies, their amusements, their difficulties, their hopes and future prospects. In this way he usually invited the whole of his numerous class till he made himself acquainted with their private character, their abilities, and their objects of pursuit. Those of whom he formed the highest opinion were of course invited most frequently, till an intimacy was gradually formed which proved highly beneficial to them. To their doubts and difficulties he listened with the most obliging condescension, and he solved them to the utmost of his power. His library was at all times open for their accommodation: in short, he treated them as if they had been all his relatives and friends. Few men of distinction left the University of Edinburgh, in his time, with whom he did not keep up a correspondence till they were fairly established in business. This enabled him gradually to form an accurate knowledge of the state of medicine in every country, and the knowledge thus acquired put it in his power to direct students in the choice of places where they might have an opportunity of engaging in business with a reasonable prospect of success.

Nor was it in this way alone that he befriended the students in the University of Edinburgh. Remembering the difficulties with which he had himself to struggle in his younger days, he was at all times singularly attentive to the pecuniary wants of the students. From the general intimacy which he contracted with them he found no difficulty in discovering those whose circumstances were contracted, or who laboured under any pecuniary embarrassment, without being under the necessity of hurting their feelings by a direct inquiry. To such persons, when their habits of study admitted it, he was peculiarly attentive: they were more frequently invited to his house than others, they were treated with unusual kindness and familiarity, they were conducted to his library and encouraged by the 310
most delicate address to borrow from it freely whatever books he thought they had occasion for; and as persons under such circumstances are often extremely shy, books were sometimes pressed upon them as a sort of task, the doctor insisting upon knowing their opinion of such and such passages which they had not read, and desiring them to carry the book home for that purpose: in short, he behaved to them as if he had courted their company. He thus raised them in the opinion of their acquaintances, which, to persons in their circumstances, was of no little consequence. They were inspired at the same time with a secret sense of dignity, which elevated their minds, and excited an uncommon ardour, instead of that desponding inactivity so natural to depressed circumstances. Nor was he less delicate in the manner of supplying their wants: he often found out some polite excuse for refusing to take money for a first course, and never was at a loss for one to an after course. Sometimes (as his lectures were never written) he would request the favour of a sight of their notes, if he knew that they were taken with care, in order to refresh his memory. Sometimes he would express a wish to have their opinion of a particular part of his course, and presented them with a ticket for the purpose. By such delicate pieces of address, in which he greatly excelled, he took care to anticipate their wants. Thus he not only gave them the benefit of his own lectures, but by refusing to take money enabled them to attend such others as were necessary for completing their course of medical study.

He introduced another general rule into the university dictated by the same spirit of disinterested benevolence. Before he came to Edinburgh, it was the custom of the medical professors to accept of fees for their medical attendance when wanted, even from medical students themselves, though they were perhaps attending the professor's lectures at the time. But Dr. Cullen never would take a fee from any student of the university, though he 311
attended them, when called on as a physician, with the same assiduity and care as if they had been persons of the first rank who paid him most liberally. This gradually led others to follow his example; and it has now become a general rule for medical professors to decline taking any fees when their assistance is necessary to a student. For this useful reform, as well as for many others, the students in the University of Edinburgh are entirely indebted to Dr. Cullen.

The first lectures which Dr. Cullen delivered in Edinburgh were on chemistry; and for many years he also gave lectures on the cases that occurred in the infirmary. In the month of February, 1763, Dr. Alston died, after having begun his usual course of lectures on the materia medica. The magistrates of Edinburgh, who are the patrons of the university, appointed Dr. Cullen to that chair, requesting that he would finish the course of lectures that had been begun by his predecessor. This he agreed to do, and, though he had only a few days to prepare himself, he never once thought of reading the lectures of his predecessor, but resolved to deliver a new course, which should be entirely his own. Some idea may be formed of the popularity of Cullen, by the increase of students to a class nearly half finished: Dr. Alston had been lecturing to ten; as soon as Dr. Cullen began, a hundred new students enrolled themselves.

Some years after, on the death of Dr. Whytt, professor of the theory of medicine, Dr. Cullen was appointed to give lectures in his stead. It was then that he thought it requisite to resign the chemical chair in favour of Dr. Black, his former pupil, whose talents in that department of science were well known. Soon after, on the death of Dr. Rutherford, professor of the practice of medicine, Dr. John Gregory having become a candidate for this place, along with Dr. Cullen, a sort of compromise took place between them, by which they 312
agreed to give lectures alternately, on the theory and practice of medicine, during their joint lives, the longest survivor being allowed to hold either of the classes he should incline. Unluckily this arrangement was soon destroyed, by the sudden and unexpected death of Dr. Gregory, in the flower of his age. Dr. Cullen thenceforth continued to give lectures on the practice of medicine till within a few months of his death, which happened on the 5th of February, 1790, when he was in the seventy-seventh year of his age.

It is not our business to follow Dr. Cullen's medical career, nor to point out the great benefits which he conferred on nosology and the practice of medicine. He taught four different classes in the University of Edinburgh, which we are not aware to have happened to any other individual, except to professor Dugald Stewart.

Notwithstanding the important impulse which he gave to chemistry, he published nothing upon that science, except a short paper on the cold produced by the evaporation of ether, which made its appearance in one of the volumes of the Edinburgh Physical and Literary Essays. Dr. Cullen employed Dr. Dobson of Liverpool, at that time his pupil, to make experiments on the heat and cold produced by mixing liquids and solids with each other. Dr. Dobson, in making these experiments, observed that the thermometer, when lifted out of many of the liquids, and suspended a short time in the air beside them, fell to a lower degree than indicated by another thermometer which had undergone no such process. After varying his observations on this phenomenon, he found reason to conclude that it was occasioned by the evaporation of the last drop of liquid which adhered to the bulb of the thermometer; the sinking of the thermometer being always greatest when this instrument was taken out of the most volatile liquids. Dr. Cullen had the curiosity to try whether the 313
same phenomenon would appear on repeating these experiments under the exhausted receiver of an air-pump. To satisfy himself, he put on the plate of the air-pump a glass goblet containing water; and in the goblet he placed a wide-mouthed phial containing sulphuric ether. The whole was covered with an air-pump receiver, having at the upper end a collar of leathers in a brass socket, through which a thick smooth wire could be moved; and from the lower end of this wire, projecting into the receiver, was suspended a thermometer. By pushing down the wire, the thermometer could be dipped into the ether; by drawing it up it could be taken out, and suspended over the phial.

The apparatus being thus adjusted, the air-pump was worked to extract the air. An unexpected phenomenon immediately appeared, which prevented the experiment from being made in the way intended. The ether was thrown into a violent agitation, which Dr.

Cullen ascribed to the extrication of a great quantity of air: in reality, however, it was boiling violently. What was still more remarkable, the ether, by this boiling or rapid evaporation, became all of a sudden so cold, as to freeze the water in the goblet around it; though the temperature of the air and of all the materials were at the fifty-fourth degree of Fahrenheit at the beginning of the experiment.

I have been particular in giving an account of this curious phenomenon, as it was the only direct contribution to the science of chemistry which Dr. Cullen communicated to the public. The nature of the phenomenon was afterwards explained by Dr. Black; in addition to Dr. Cullen, a philosopher, whom the grand stimulus which his lectures gave to the cultivation of scientific chemistry in this country, had the important merit of bringing forward.

Joseph Black was born in France, on the banks of the Garonne, in the year 1728: his father, Mr. John Black, was a native of Belfast, but of a Scottish family which had been for 314
some time settled there. Mr. Black resided for the most part at Bordeaux, where he was engaged in the wine trade. He married a daughter of Mr. Robert Gordon, of the family of Hillhead, in Aberdeenshire, who was also engaged in the same trade at Bordeaux. Mr. Black was a gentleman of most amiable manners, candid and liberal in his sentiments, and of no common information. These qualities, together with the warmth of his heart, appear very conspicuous in a series of letters to his son, which that son preserved with the nicest care. His good qualities did not escape the discerning eye of the great Montesquieu, one of the presidents of the court of justice in that province. This illustrious and excellent man honoured Mr. Black with a friendship and intimacy altogether rare; of which his descendants were justly proud.

Long before Mr. Black retired from business, his son Joseph was sent home to Belfast, that he might have the education of a British subject. This was in the year 1740, when he was twelve years of age. After the ordinary instruction at the grammar-school, he was sent, in 1746, to continue his education in the University of Glasgow. Here he studied with much assiduity and success: physical science, however, chiefly engrossed his attention. He was a favourite pupil of Dr. Robert Dick, professor of natural philosophy, and the intimate companion of his son and successor. This young professor was of a character peculiarly suited to Dr. Black's taste, having the clearest conception, and soundest judgment, accompanied by a modesty that was very uncommon. When he succeeded his father, in 1751, he became the delight of the students. He was carried off by a fever in 1757.

Young Black being required by his father to make choice of a profession, he preferred that of medicine as the most suitable to the general habits of his studies. Fortunately Dr. 315
Cullen had just begun his great career in the College of Glasgow, and having made choice of the field of philosophical chemistry which lay as yet unoccupied before him. Hitherto chemistry had been treated as a curious and useful art; but Cullen saw in it a vast department of the science of nature, depending on principles as immutable as the laws of mechanism, and capable of being formed into a system as comprehensive and as complete as astronomy itself. He conceived the resolution of attempting himself to explore this magnificent field, and expected much reputation from accomplishing his object. Nor was he altogether disappointed. He quickly took the science out of the hands of artists, and exhibited it as a study fit for a gentleman. Dr. Black attended his chemical lectures, and, from the character which has already been given of him, it is needless to say that he soon discovered the uncommon value of his pupil, and attached him to himself, rather as a co-operator and a friend, than a pupil. He was considered as his assistant in all his operations, and his experiments were frequently adduced in the lecture as good authority.

Young Black laid down a very comprehensive and serious plan of study. This appears from a number of note-books found among his papers. There are some in which he seems to

have inserted every thing as it took his fancy, in medicine, chemistry, jurisprudence, or matters of taste. Into others, the same things are transferred, but distributed according to their scientific connexions. In short, he kept a journal and ledger of his studies, and has posted his books like a merchant. What particularly strikes one in looking over these books, is the steadiness with which he advanced in any path of knowledge. Things are inserted for the first time from some present impression of their singularity or importance, but without any allusion to their connexions. When a thing of the same kind is mentioned again, there is generally a reference back to its fellow; and thus the most isolated facts often acquired a 316
connexion which gave them importance.

He went to Edinburgh to finish his medical studies in 1750 or 1751, where he lived with his cousin german, Mr. James Russel, professor of natural philosophy in that university.

It was the good fortune of chemical science, that at this very time the opinions of professors were divided concerning the manner in which certain lithontriptic medicines, particularly lime-water, acted in alleviating the excruciating pains of the stone and gravel. The students usually partake of such differences of opinion: they are thereby animated to more serious study, and science gains by their emulation. This was a subject quite to the taste of young Mr. Black, one of Dr. Cullen's most zealous and intelligent chemical pupils. It was, indeed, a most interesting subject, both to the chemist and the physician.

All the medicines which were then in vogue as solvents of urinary calculi had a greater or less resemblance to caustic potash or soda; substances so acrid, when in a concentrated state, that in a short time they reduce the fleshy parts of the animal body to a mere pulp. Thus, though they might possess lithontriptic properties, their exhibition was dangerous, if in unskilful hands. They all seemed to derive their efficacy from quicklime, which again derives its power from the fire. It was therefore very natural for them to ascribe its power to igneous matter imbibed from the fire, retained by the lime, and communicated by it to alkalies, which it renders powerfully acrid. Hence, undoubtedly, the term *caustic* applied to the alkalies in that state, and hence also the *acidum pingue* of Mayer, which was a peculiar state of fire. It appears from Dr. Black's note-books, that he originally entertained the opinion, that caustic alkalies acquired igneous matter from quicklime. In one of them he 317
hints at some way of catching this matter as it escapes from lime, while it becomes mild by exposure to the air; but on the opposite blank page is written, "Nothing escapes—the cup rises considerably by absorbing air." A few pages further on, he compares the loss of weight sustained by an ounce of chalk when calcined, with its loss while dissolved in muriatic acid. Immediately after this, a medical case is mentioned, which occurred in November, 1752. Hence it would appear, that he had before that time suspected the real cause of the difference between limestone and burnt lime. He had prosecuted his inquiry with vigour; for the experiments with magnesia are soon after mentioned.

These experiments laid open the whole mystery, as appears by another memorandum. "When I precipitate lime by a common alkali there is no effervescence: the air quits the alkali for the lime; but it is lime no longer, but C. C. C.: it now effervesces, which good lime will not." What a multitude of important consequences naturally flowed from this discovery! He now knew to what the causticity of alkalies is owing, and how to induce it or remove it at pleasure. The common notion was entirely reversed. Lime imparts nothing to the alkalies; it only removes from them a peculiar kind of air (*carbonic acid gas*) with which they were combined, and which prevented their natural caustic properties from being developed. All the former mysteries disappear, and the greatest simplicity appears in those operations of nature which before appeared so intricate and obscure.

Dr. Black had fixed upon this subject for his inaugural dissertation, and was induced, in consequence, to defer applying for his degree till he had succeeded in establishing his

doctrine beyond the possibility of contradiction. The inaugural essay was delivered at a moment peculiarly favourable to the advancement of science. Dr. Cullen had been just removed to Edinburgh, and there was a vacancy in the chemical chair in Glasgow: it could 318
not be bestowed better than on such an *alumnus* of the university—on one who had distinguished himself both as a chemist and an excellent reasoner; for few finer models of inductive investigation exist than are displayed in Black's essay on quicklime and magnesia. He was appointed professor of anatomy and lecturer on chemistry in the University of Glasgow in 1756. It was a fortunate circumstance both for himself and for the public, that a situation thus presented itself, just at the time when he was under the necessity of settling in the world—a situation which allowed him to dedicate his talents chiefly to the cultivation of chemistry, his favourite science.

When Dr. Black took his degree in medicine, he sent some copies of his essay to his father at Bordeaux. A copy was given by the old gentleman to his friend, the President Montesquieu, who, after a few days called on Mr. Black, and said to him, "Mr. Black, my very good friend, I rejoice with you; your son will be the honour of your name and family." This anecdote was told Professor John Robison by the brother of Dr. Black.

Thus Dr. Black, while in Glasgow, taught at one and the same time two different classes. He did not consider himself very well qualified to teach anatomy, but determined to do his utmost; but he soon afterwards made arrangements with the professor of medicine, who, with the concurrence of the university, exchanged his own chair for that of Dr. Black.

Black's medical lectures constituted his chief task while in Glasgow. They gave the greatest satisfaction by their perspicuity and simplicity, and by the cautious moderation of all his general doctrines: and, indeed, all his perspicuity, and all his neatness of manner in exhibiting simple truths, were necessary to create a relish for moderation and caution, after the brilliant prospects of systematic knowledge to which the students had been accustomed 319
by Dr. Cullen, his celebrated predecessor. But Dr. Black had no wish to form a medical school, distinguished by some all-comprehending doctrine: he satisfied himself with a clear account of as much of physiology as he thought founded on good principles, and a short sketch of such general doctrines as were maintained by the most eminent authors, though perhaps on a less firm foundation. He then endeavoured to deduce a few canons of medical practice, and concluded with certain rules founded on successful practice only, but not deducible from the principles of physiology previously laid down. With his medical lectures he does not appear to have been himself entirely satisfied: he did not encourage conversation on the different topics, and no remains of these lectures were to be found among his papers. The preceding account of them was given to Professor Robison by a surgeon in Glasgow, who attended the two last medical courses which Dr. Black ever delivered.

Dr. Black's reception at Glasgow by the university was in the highest degree encouraging. His former conduct as a student had not only done him credit in his classes, but had conciliated the affection of the professors to a very high degree. He became immediately connected in the strictest friendship with the celebrated Dr. Adam Smith—a friendship which continued intimate and confidential through the whole of their lives. Both were remarkable for a certain simplicity of character and the most incorruptible integrity. Dr. Smith used to say, that no one had less nonsense in his head than Dr. Black; and he often acknowledged himself obliged to him for setting him right in his judgment of character, confessing that he himself was too apt to form his opinion from a single feature.

It was during his residence in Glasgow, between the years 1759 and 1763, that he brought to maturity those speculations concerning the combination of *heat* with *matter*, 320
which had frequently occupied a portion of his thoughts. It had long been known that ice has the property of continuing always at the temperature of 32° till it be melted. This

happens equally though it be placed in contact with the warm hand or surrounded with bodies many degrees hotter than itself. The hotter the bodies are that surround it, the sooner is it melted; but its temperature during the whole process of melting, continues uniformly the same. Yet, during the whole process of melting, it is constantly robbing the surrounding bodies of heat; for it makes them colder, without acquiring itself any sensible heat.

Dr. Black had some vague notion that the heat so received by the ice, during its conversion into water, was not lost, but was contained in the water. This opinion was founded chiefly on a curious observation of Fahrenheit, recorded by Boerhaave; namely, that water might in some cases be made considerably colder than melting snow, without freezing. In such cases, when disturbed it would freeze in a moment, and in the act of freezing always gave out a quantity of heat. This opinion was confirmed by observing the slowness with which water is converted into ice, and ice into water. A fine winter-day of sunshine is never sufficient to clear the hills of snow; nor is one frosty night capable of covering the ponds with a thick coating of ice. The phenomena satisfied him that much heat was absorbed and fixed in the water which trickles from wreaths of snow, and that much heat emerged from it while water was slowly converted into ice; for during a thaw the melting snow is always colder than the air, and must, therefore, be always receiving heat from it; while, during a frost, the air is always colder than the freezing water, and must therefore be always receiving heat from it. These observations, and many others which it is needless to state, satisfied Dr. Black that when ice is converted into water it unites with a 321
quantity of heat, without increasing in temperature; and that when water is frozen into ice it gives out a quantity of heat without diminishing in temperature. The heat thus combined is the cause of the fluidity of the water. As it is not sensible to the thermometer, Dr. Black called it *latent heat*. He made an experiment to determine the quantity of heat necessary to convert ice into water. This he estimated by the length of time necessary to melt a given weight of ice, measuring how much heat entered into the same weight of water, reduced as nearly to the temperature of ice as possible during the first half-hour that the experiment lasted. As the ice continued during the whole of its melting at the same temperature as at first, he concluded that it would absorb, every half-hour that the process lasted, as much heat as the water did during the first half hour. The result of this experiment was, that the latent heat of water amounts to 140°; or, in other words, that this heat, if thrown into a quantity of water, equal in weight to that of the ice melted, would raise its temperature 140°.

Dr. Black, having established this discovery in the most incontrovertible manner by simple and decisive experiments, drew up an account of the whole investigation, and the doctrine which he founded upon it, and read it to a literary society which met every Friday in the faculty-room of the college, consisting of the members of the university and several gentlemen of the city, who had a relish for science and literature. This paper was read on the 23d of April, as appears by the registers of the society.

Dr. Black quickly perceived the vast importance of this discovery, and took a pleasure in laying before his students a view of the beneficial effects of this habitude of heat in the economy of nature. During the summer season a vast magazine of heat was accumulated in the water, which, by gradually emerging during congelation, serves to temper the cold of 322
winter. Were it not for this accumulation of heat in water and other bodies, the sun would no sooner go a few degrees to the south of the equator, than we should feel all the horrors of winter. He did not confine his views to the congelation of water alone, but extended them to every case of congelation and liquefaction which he has ascribed equally to the evolution or fixation of latent heat. Even those bodies which change from solid to fluid, not all at once, but by slow degrees, as butter, tallow, resins, owe, he found, their gradual softening to the same absorption of heat, and the same combination of it with the substance undergoing liquefaction.

Another subject that engaged his attention at this time, was an examination of the scale of the thermometer, to learn whether equal differences of expansion corresponded to equal additions or abstractions of heat. His mode was to mix together equal weights of water of different temperatures, and to measure the temperature of the mixture by a thermometer. It is obvious that the temperature must be the exact mean of that of the two portions of water; and that if the expansion or contraction of the mercury in the thermometer be an exact measure of the difference of temperature, a thermometer, so placed, will indicate the exact mean. Suppose one pound of water at 100° to be mixed with one pound of water at 200°, and the whole heat still to remain in the mixture, it is obvious that it would divide itself equally between the two portions of water. The water of 100° would become hotter, and the water of 200° would become colder: and the increase of temperature in the colder portion would be just as much as the diminution of temperature in the hotter portion. The colder portion would become hotter by 50°, while the hotter portion would become colder by 50°. Hence the real temperature, after mixture, would be 150°; and a thermometer plunged into 323 such a mixture, if a true measurer of heat, would indicate 150°. The result of his experiments was, that as high up as he could try by mixing water of different temperatures, the mercurial thermometer is an accurate measurer of the alterations of temperature.

An account of his experiments on this subject was drawn up by him, and read to the literary society of the College of Glasgow, on the 28th of March, 1760. Dr. Black, at the time he made these experiments, did not know that he had been already anticipated in them by Dr. Brooke Taylor, the celebrated mathematician, who had obtained similar results, and had consigned his experiments to the Royal Society, in whose Transactions for 1723 they were published. It has been since found by Coulomb and Petit, that at higher temperatures than 212° the rate of the expansion of mercury begins to increase. Hence it happens that at high temperatures the expansion of mercury is no longer an accurate measurer of temperature. Fortunately, the expansion of glass very nearly equals the increment of that of mercury. The consequence is, that in a common glass-thermometer mercury measures the true increments of temperature very nearly up to its boiling point; for the boiling point of mercury measured by an air-thermometer is 662°: and if a glass mercurial thermometer be plunged into boiling mercury, it will indicate 660°, a difference of only 2° from the true point.

There is such an analogy between the cessation of thermometric expansion during the liquefaction of ice, and during the conversion of water into steam, that there could be no hesitation about explaining both in the same way. Dr. Black immediately concluded that as water is ice united to a certain quantity of *latent heat*, so steam is water united to a still greater quantity. The slow conversion of water into steam, notwithstanding the great quantity of heat constantly flowing into it from the fire, left no reasonable doubt about the 324 accuracy of this conclusion. In short, all the phenomena are precisely similar to those of the conversion of ice into water; and so, of course, must the explanation be. So much was he convinced of this, that he taught the doctrine in his lectures in 1761, before he had made a single experiment on the subject; and he explained, with great felicity of argument, many phenomena of nature, which result from this vaporific combination of heat. From notes taken in his class during this session, it appears that nothing more was wanting to complete his views on this subject, than a set of experiments to determine the exact quantity of heat which was combined in steam in a state not indicated by the thermometer, and therefore *latent*, in the same sense that the heat of liquefaction in water is *latent*.

The requisite experiments were first attempted by Dr. Black, in 1764. They consisted merely in measuring the time requisite to convert a certain weight of water of a given temperature into steam. The water was put into a tin-plate wide-mouthed vessel, and laid upon a red-hot plate of iron, the initial temperature of the water was marked, and the time necessary to heat it from that point to the boiling point noted, and then the time requisite to boil the whole to dryness. It was taken for granted that as much heat would enter into the water during every minute that the experiment lasted, as did during the first minute. From this it was concluded that the latent heat of steam is not less than 810 degrees.

Mr. James Watt afterwards repeated these experiments with a better apparatus and very great care, and calculated from his results that the latent heat of steam is not under 950 degrees. Lavoisier and Laplace afterwards made experiments in a different way, and deduced 1000° as the result of their experiments. The subsequent experiments of Count Rumford, made in a very ingenious manner, so as to obviate most of the sources of error, to 325
which such researches are liable, come very nearly to those of Lavoisier. 1000° therefore, is usually now-a-days adopted as the number which denotes the true latent heat of steam.

Dr. Black continued in the University of Glasgow from 1756 to 1766, much esteemed as an eminent professor, much employed as an able and attentive physician, and much beloved as an amiable and accomplished man, happy in the enjoyment of a small but select society of friends. Meanwhile his reputation as a chemical philosopher was every day increasing, and pupils from foreign countries carried home with them the peculiar doctrines of his courses—so that *fixed air* and *latent heat* began to be spoken of among the naturalists of the continent. In 1766 Dr. Cullen, at that time professor of chemistry in Edinburgh, was appointed professor of medicine, and thus a vacancy was made in the chemical chair of that university. There was but one wish with regard to a successor. Indeed, when the vacancy happened in 1756, on the death of Dr. Plummer, the reputation of Dr. Black, who had just taken his degree, was so high, both as a chemist and an accurate thinker and reasoner, that, had the choice depended on the university, he would have been the new professor of chemistry. He had now, in 1766, greatly added to his claim of merit by his important discovery of latent heat; and he had acquired the esteem of all by the singular moderation and scrupulous caution which marked all his researches.

Dr. Black was appointed to the chemical chair in Edinburgh in 1766, to the general satisfaction of the public, but the University of Glasgow suffered an irreparable loss. In this new situation his talents were more conspicuous and more extensively useful. He saw that the case was so, and while he could not but be gratified by the number of students whom the high reputation of Edinburgh, as a medical school, brought together, his mind was forcibly 326
struck by the importance of his duties as a teacher. This led him to form the resolution of devoting the whole of his study to the improvement of his pupils in the elementary knowledge of chemistry. Many of them came to his class with a very scanty stock of previous knowledge. Many from the workshop of the manufacturer had little or none. He was conscious that the number of this kind of pupils must increase with the increasing activity and prosperity of the country; and they appeared to him by no means the least important part of his auditory. To engage the attention of such pupils, and to be perfectly understood by the most illiterate of his audience, Dr. Black considered as a sacred duty: he resolved, therefore, that plain doctrines taught in the plainest manner, should henceforth employ his chief study. To render his lectures perfectly intelligible they were illustrated by suitable experiments, by the exhibition of specimens, and by the repetition of chemical processes.

To this method of lecturing Dr. Black rigidly adhered, endeavouring every year to make his courses more plain and familiar, and illustrating them by a greater variety of examples in the way of experiment. No man could perform these more neatly or successfully; they were always ingeniously and judiciously contrived, clearly establishing the point in view, and were never more complicated than was sufficient for the purpose. Nothing that had the least appearance of quackery; nothing calculated to surprise and astonish his audience; nothing savouring of a showman or sleight-of-hand man was ever permitted in his lecture-room. Every thing was simple, neat, and elegant, calculated equally

to please and to inform: indeed simplicity and neatness stamped his character. It was this that constituted the charm of his lectures, and rendered them so delightful to his pupils. I can speak of them from experience, for I was fortunate enough to hear the last course of 327
lectures which he ever delivered. I can say with perfect truth that I never listened to any lectures with so much pleasure as to his: and it was the elegant simplicity of his manner, the perfect clearness of his statements, and the vast quantity of information which he contrived in this way to communicate, that delighted me. I was all at once transported into a new world—my views were suddenly enlarged, and I looked down from a height which I had never before reached; and all this knowledge was communicated without any apparent effort either on the part of the professor or his pupils. His illustrations were just sufficient to answer completely the object in view, and nothing more. No quackery, no trickery, no love of mere dazzle and glitter, ever had the least influence upon his conduct. He constituted the most complete model of a perfect chemical lecturer that I have ever had an opportunity of witnessing.

The discovery which Dr. Black had made that marble is a combination of lime and a peculiar substance, to which he gave the name of *fixed air*, began gradually to attract the attention of chemists in other parts of the world. It was natural in the first place to examine the nature and properties of this fixed air, and the circumstances under which it is generated. It may seem strange and unaccountable that Dr. Black did not enter with ardour into this new career which he had himself opened, and that he allowed others to reap the corn after having himself sown the grain. Yet he did take some steps towards ascertaining the properties of *fixed air*; though I am not certain what progress he made. He knew that a candle would not burn in it, and that it is destructive to life, when any living animal attempts to breathe it. He knew that it was formed in the lungs during the breathing of animals, and that it is generated during the fermentation of wine and beer. Whether he was aware that it possesses the properties of an acid I do not know; though with the knowledge 328
which he possessed that it combines with alkalies and alkaline earths, and neutralizes them, or at least blunts and diminishes their alkaline properties, the conclusion that it partook of alkaline properties was scarcely avoidable. All these, and probably some other properties of *fixed air* he was in the constant habit of stating in his lectures from the very commencement of his academical career; though, as he never published anything on the subject himself, it is not possible to know exactly how far his knowledge of the properties of *fixed air* extended. The oldest manuscript copy of his lectures that I have seen was taken down in writing in the year 1773; and before that time Mr. Cavendish had published his paper on *fixed air* and *hydrogen gas*, and had detailed the properties of each. It was impossible from the manuscript of Dr. Black's lectures to know which of the properties of *fixed air* stated by him were discovered by himself, and which were taken from Mr. Cavendish.

This languor and listlessness, on the part of Dr. Black, is chiefly to be ascribed to the delicate state of his health, which precluded much exertion, and was particularly inconsistent with any attempt at putting his thoughts down upon paper. Hence, probably, that carelessness about posthumous fame, and that regardlessness of reputation, which, however it may be accounted for from bodily ailment, must still be considered as a blemish. How differently did Paschal act in a similar state of health! With what energy did he exert himself in spite of bodily ailment! But the tone of his mind was quite different from that of Dr. Black. Gentleness, diffidence, and perhaps even slowness of apprehension, were the characteristic features by which the latter was distinguished.

There is an anecdote of Black which I was told by the late Mr. Benjamin Bell, of Edinburgh, author of a well-known system of surgery, and he assured me that he had it from the late Sir George Clarke, of Pennicuik, who was a witness of the circumstance related. 329
Soon after the appearance of Mr. Cavendish's paper on hydrogen gas, in which he made an approximation to the specific gravity of that body, showing that it was at least ten times

lighter than common air, Dr. Black invited a party of his friends to supper, informing them that he had a curiosity to show them. Dr. Hutton, Mr. Clarke of Elden, and Sir George Clarke of Pennicuik, were of the number. When the company invited had assembled, he took them into a room. He had the allentois of a calf filled with hydrogen gas, and upon setting it at liberty, it immediately ascended, and adhered to the ceiling. The phenomenon was easily accounted for: it was taken for granted that a small black thread had been attached to the allentois, that this thread passed through the ceiling, and that some one in the apartment above, by pulling the thread, elevated it to the ceiling, and kept it in this position. This explanation was so probable, that it was acceded to by the whole company; though, like many other plausible theories, it turned out wholly unfounded; for when the allentois was brought down no thread whatever was found attached to it. Dr. Black explained the cause of the ascent to his admiring friends; but such was his carelessness of his own reputation, and of the information of the public, that he never gave the least account of this curious experiment even to his class; and more than twelve years elapsed before this obvious property of hydrogen gas was applied to the elevation of air-balloons, by M. Charles, in Paris.

The constitution of Dr. Black had always been exceedingly delicate. The slightest cold, the most trifling approach to repletion, immediately affected his chest, occasioned feverishness, and if the disorder continued for two or three days, brought on a spitting of blood. In this situation, nothing restored him to ease, but relaxation of thought, and gentle exercise. The sedentary life to which study confined him, was manifestly hurtful; and he 330
never allowed himself to indulge in any investigation that required intense thought, without finding these complaints increased.

Thus situated, Dr. Black was obliged to be a contented spectator of the rapid progress which chemistry was making, without venturing himself to engage in any of the numerous investigations which presented themselves on every side. Such indeed was the eagerness with which chemistry was at that time prosecuted, and such the passion for discovery, that there was some risk that his undoubted claim to originality and priority in his own great discoveries, might be called in question, and even rendered doubtful. His friends at least were afraid of this, and often urged him to do justice to himself, by publishing an account of his own discoveries. He more than once began the task; but was so nice in his notions of the manner in which it should be executed, that the pains he took in forming a plan of the work never failed to affect his health, and oblige him to desist. It is known that he felt hurt at the publication of several of Lavoisier’s papers, in the Mémoires de l’Académie, without any allusion whatever to what he himself had previously done on the same subject. How far Lavoisier was really culpable, and whether he did not intend to do full justice to all the claims of his predecessors, cannot now be known; as he was cut off in the midst of his career, while so many of his scientific projects remained unexecuted. From the posthumous works of Lavoisier, there is some reason for believing that if he had lived, he would have done justice to all parties; but there is no doubt that Dr. Black, in the mean time, thought himself aggrieved, and that he formed the intention of doing himself justice, by publishing an account of his own discoveries; however this intention was thwarted and prevented by bad health.

No one contributed more largely to establish, to support, and to increase, the high 331
character of the medical school in the University of Edinburgh than Dr. Black. His talent for communicating knowledge was not less eminent than his faculty of observation. He soon became one of the principal ornaments of the university; and his lectures were attended by an audience which continued increasing from year to year for more than thirty years. His personal appearance and manners were those of a gentleman, and peculiarly pleasing: his voice, in lecturing, was low, but fine; and his articulation so distinct, that he was perfectly well heard by an audience consisting of several hundreds. While in Glasgow, he had

practised extensively as a physician; but in Edinburgh he declined general practice, and confined his attendance to a few families of intimate and respected friends. He was, however, a physician of good repute in a place where the character of a physician implied no common degree of liberality, propriety, and dignity of manners, as well as of learning and skill.

Such was Dr. Black as a public man. While young, his countenance was comely and interesting; and as he advanced in years, it continued to preserve that pleasing expression of inward satisfaction which, by giving ease to the beholder, never fails to please. His manners were simple, unaffected, and graceful; he was of the most easy approach, affable, and readily entered into conversation, whether serious or trivial: for he was not merely a man of science, but was well acquainted with the elegant accomplishments. He had an accurate musical ear, and a voice which would obey it in the most perfect manner; he sang and performed on the flute with great taste and feeling; and could sing a plain air at sight, which many instrumental performers cannot do. Music was his amusement in Glasgow; after his removal to Edinburgh he gave it up entirely. Without having studied drawing he had acquired a considerable power of expression with his pencil, both in figures and in 332
landscape. He was peculiarly happy in expressing the passions, and seemed in this respect to have the talents of a historical painter. Figure indeed, of every kind, attracted his attention; in architecture, furniture, ornament of every sort, it was never a matter of indifference to him. Even a retort, or a crucible, was to his eye an example of beauty, or deformity. These are not indifferent things; they are features of an elegant mind, and they account for some part of that satisfaction and pleasure which persons of different habits and pursuits felt in Dr. Black's company and conversation.

Those circumstances of form, and in which Dr. Black perceived or sought for beauty, were suitableness or propriety: something that rendered them well adapted for the purposes for which they were intended. This love of propriety constituted the leading feature in Dr. Black's mind; it was the standard to which he constantly appealed, and which he endeavoured to make the directing principle of his conduct.

Dr. Black was fond of society, and felt himself beloved in it. His chief companions, in the earlier part of his residence in Edinburgh, were Dr. Adam Smith, Mr. David Hume, Dr. Adam Ferguson, Mr. John Home, Dr. Alexander Carlisle, and a few others. Mr. Clarke of Elden, and his brother Sir George, Dr. Roebuck, and Dr. James Hutton, particularly the latter, were affectionately attached to him, and in their society he could indulge in his professional studies. Dr. Hutton was the only person near him to whom Dr. Black imparted every speculation in chemical science, and who knew all his literary labours: seldom were the two friends asunder for two days together.

Towards the close of the eighteenth century, the infirmities of advanced life began to bear more heavily on his feeble constitution. Those hours of walking and gentle exercise, which had hitherto been necessary for his ease, were gradually curtailed. Company and conversation began to fatigue: he went less abroad, and was visited only by his intimate 333
friends. His duty at college became too heavy for him, and he got an assistant, who took a share of the lectures, and relieved him from the fatigue of the experiments. The last course of lectures which he delivered was in the winter of 1796-7. After this, even lecturing was too much for his diminished strength, and he was obliged to absent himself from the class altogether; but he still retained his usual affability of temper, and his habitual cheerfulness, and even to the very last was accustomed to walk out and take occasional exercise. As his strength declined, his constitution became more and more delicate. Every cold he caught occasioned some degree of spitting of blood; yet he seemed to have this unfortunate disposition of body almost under command, so that he never allowed it to proceed far, or to occasion any distressing illness. He spun his thread of life to the very last fibre. He guarded

against illness by restricting himself to an abstemious diet; and he met his increasing infirmities with a proportional increase of attention and care, regulating his food and exercise by the measure of his strength. Thus he made the most of a feeble constitution, by preventing the access of disease from abroad. And enjoyed a state of health which was feeble, indeed, but scarcely interrupted; as well as a mind undisturbed in the calm and cheerful use of its faculties. His only apprehension was that of a long-continued sick-bed—from the humane consideration of the trouble and distress that he might thus occasion to attending friends; and never was such generous wish more completely gratified than in his case.

On the 10th of November, 1799, in the seventy-first year of his age, he expired without any convulsion, shock, or stupor, to announce or retard the approach of death. Being at table with his usual fare, some bread, a few prunes, and a measured quantity of milk, diluted with 334
water, and having the cup in his hand when the last stroke of his pulse was to be given, he set it down on his knees, which were joined together, and kept it steady with his hand in the manner of a person perfectly at ease; and in this attitude expired without spilling a drop, and without a writhe in his countenance; as if an experiment had been required to show to his friends the facility with which he departed. His servant opened the door to tell him that some one had left his name; but getting no answer, stepped about halfway to him; and seeing him sitting in that easy posture, supporting his basin of milk with one hand, he thought that he had dropped asleep, which was sometimes wont to happen after meals. He went back and shut the door; but before he got down stairs some anxiety, which he could not account for, made him return and look again at his master. Even then he was satisfied, after coming pretty near him, and turned to go away; but he again returned, and coming close up to him, he found him without life. His very near neighbour, Mr. Benjamin Bell, the surgeon, was immediately sent for; but nothing whatever could be done.[185]

Dr. Black’s writings are exceedingly few, consisting altogether of no more than three papers. The first, entitled “Experiments upon Magnesia alba, Quicklime, and other Alkaline Substances,” constituted the subject of his inaugural dissertation. It afterwards appeared in an English dress in one of the volumes of The Edinburgh Physical and Literary Essays, in the year 1755. Mr. Creech, the bookseller, published it in a separate pamphlet, together with Dr. Cullen’s little essay on the “cold produced by evaporating fluids,” in the year 1796. This 335
essay exhibits one of the very finest examples of inductive reasoning to be found in the English language. The author shows that magnesia is a peculiar earthy body, possessed of properties very different from lime. He gives the properties of lime in a pure state, and proves that it differs from limestone merely by the absence of the carbonic acid, which is a constituent of limestone. Limestone is a *carbonate of lime*; quicklime is the pure uncombined earth. He shows that magnesia has also the property of combining with carbonic acid; that caustic potash, or soda, is merely these bodies in a pure or isolated state; while the mild alkalies are combinations of these bodies with carbonic acid. The reason why quicklime converts mild into caustic alkali is, that the lime has a stronger affinity for the carbonic acid than the alkali; hence the lime is converted into carbonate of lime, and the alkali, deprived of its carbonic acid, becomes caustic. Mild potash is a carbonate of potash; caustic potash, is potash freed from carbonic acid.—The publication of this essay occasioned a controversy in Germany, which was finally settled by Jacquin and Lavoisier, who repeated Dr. Black’s experiments and showed them to be correct.

Dr. Black’s second paper was published in the Philosophical Transactions for 1775. It is entitled “The supposed Effect of boiling on Water, in disposing it to freeze more readily, ascertained by Experiments.” He shows, that when water that has been recently boiled is exposed to cold air, it begins to freeze as soon as it reaches the freezing point; while water that has not been boiled may be cooled some degrees below the freezing point before it begins to congeal. But if the unboiled water be constantly stirred during the whole time of

its exposure, it begins to freeze when cooled down to the freezing point as well as the other. He shows that the difference between the two waters consists in this, that the boiled water is 336
constantly absorbing air, which disturbs it, whereas the other water remains in a state of rest.

His last paper was "An Analysis of the Water of some boiling Springs in Iceland," published in the Transactions of the Royal Society of Edinburgh. This was the water of the Geyser spring, brought from Iceland by Sir J. Stanley. Dr. Black found it to contain a great deal of silica, held in solution in the water by caustic soda.

The tempting career which Dr. Black opened, and which he was unable to prosecute for want of health, soon attracted the attention of one of the ablest men that Great Britain has produced—I mean Mr. Cavendish.

The Honourable Henry Cavendish was born in London on the 10th of October, 1731: his father was Lord Charles Cavendish, a cadet of the house of Devonshire, one of the oldest families in England. During his father's lifetime he was kept in rather narrow circumstances, being allowed an annuity of £500 only; while his apartments were a set of stables, fitted up for his accommodation. It was during this period that he acquired those habits of economy, and those singular oddities of character, which he exhibited ever after in so striking a manner. At his father's death he was left a very considerable fortune; and an aunt who died at a later period bequeathed him a very handsome addition to it; but, in consequence of the habits of economy which he had acquired, it was not in his power to spend the greater part of his annual income. This occasioned a yearly increase to his capital, till at last it accumulated so much, without any care on his part, that at the period of his death he left behind him nearly £1,300,000; and he was at that time the greatest proprietor of stock in the Bank of England.

On one occasion, the money in the hands of his bankers had accumulated to the 337
amount of £70,000. These gentlemen thinking it improper to keep so large a sum in their hands, sent one of the partners to wait upon him, in order to learn how he desired it disposed of. This gentleman was admitted; and, after employing the necessary precautions to a man of Mr. Cavendish's peculiar disposition, stated the circumstance, and begged to know whether it would not be proper to lay out the money at interest. Mr. Cavendish dryly answered, "You may lay it out if you please," and left the room.

He hardly ever went into any other society than that of his scientific friends: he never was absent from the weekly dinner of the Royal Society club at the Crown and Anchor Tavern in the Strand. At these dinners, when he happened to be seated near those that he liked, he often conversed a great deal; though at other times he was very silent. He was likewise a constant attendant at Sir Joseph Banks's Sunday evening meetings. He had a house in London, which he only visited once or twice a-week at stated times, and without ever speaking to the servants: it contained an excellent library, to which he gave all literary men the freest and most unrestrained access. But he lived in a house on Clapham Common, where he scarcely ever received any visitors. His relation, Lord George Cavendish, to whom he left by will the greatest part of his fortune, visited him only once a-year, and the visit hardly ever exceeded ten or twelve minutes.

He was shy and bashful to a degree bordering on disease; he could not bear to have any person introduced to him, or to be pointed out in any way as a remarkable man. One Sunday evening he was standing at Sir Joseph Banks's in a crowded room, conversing with Mr. Hatchett, when Dr. Ingenhousz, who had a good deal of pomposity of manner, came up with an Austrian gentleman in his hand, and introduced him formally to Mr. Cavendish. He mentioned the titles and qualifications of his friend at great length, and said that he had been 338
peculiarly anxious to be introduced to a philosopher so profound and so universally known

and celebrated as Mr. Cavendish. As soon as Dr. Ingenhousz had finished, the Austrian gentleman began, and assured Mr. Cavendish that his principal reason for coming to London was to see and converse with one of the greatest ornaments of the age, and one of the most illustrious philosophers that ever existed. To all these high-flown speeches Mr. Cavendish answered not a word, but stood with his eyes cast down quite abashed and confounded. At last, spying an opening in the crowd, he darted through it with all the speed of which he was master; nor did he stop till he reached his carriage, which drove him directly home.

Of a man, whose habits were so retired, and whose intercourse with society was so small, there is nothing else to relate except his scientific labours: the current of his life passed on with the utmost regularity; the description of a single day would convey a correct idea of his whole existence. At one time he was in the habit of keeping an individual to assist him in his experiments. This place was for some time filled by Sir Charles Blagden; but they did not agree well together, and after some time Sir Charles left him. Mr. Cavendish died on the 4th of February, 1810, aged seventy-eight years, four months, and six days. When he found himself dying, he gave directions to his servant to leave him alone, and not to return till a certain time which he specified, and by which period he expected to be no longer alive. The servant, however, who was aware of the state of his master, and was anxious about him, opened the door of the room before the time specified, and approached the bed to take a look at the dying man. Mr. Cavendish, who was still sensible, was offended at the intrusion, and ordered him out of the room with a voice of displeasure, commanding him not by any means to return till the time specified. When he did come back 339
at that time, he found his master dead. What a contrast between the characters of Mr. Cavendish and Dr. Black!

The appearance of Mr. Cavendish did not much prepossess strangers in his favour; he was somewhat above the middle size, his body rather thick, and his neck rather short. He stuttered a little in his speech, which gave him an air of awkwardness: his countenance was not strongly marked, so as to indicate the profound abilities which he possessed. This was probably owing to the total absence of all the violent passions. His education seems to have been very complete; he was an excellent mathematician, a profound electrician, and a most acute and ingenious chemist. He never ventured to give an opinion on any subject, unless he had studied it to the bottom. He appeared before the world first as a chemist, and afterwards as an electrician. The whole of his literary labours consist of eighteen papers, published in the Philosophical Transactions, which, though they occupy only a few pages, are full of the most important discoveries and the most profound investigations. Of these papers, there are ten which treat of chemical subjects, two treat of electricity, two of meteorology, three are connected with astronomy, and there is one, the last which he wrote, which gives his method of dividing astronomical instruments. Of the papers in question, those alone which treat of Chemistry can be analyzed in a work like this.

1. His first paper, entitled, "Experiments on fictitious Air," was published in the year 1766, when Mr. Cavendish was thirty-five years of age. Dr. Hales had demonstrated (as had previously been done by Van Helmont and Glauber) that *air* is given out by a vast number of bodies in peculiar circumstances. But he never suspected that any of the *airs* which he obtained differed from common air. Indeed common air had always been considered as an elementary substance to which every elastic fluid was referred. Dr. Black had shown that 340
the mild alkalies and limestone, and carbonate of magnesia, were combinations of these bodies with a gaseous substance, to which he had given the name of *fixed air*; and he had pointed out various methods of collecting this fixed air; though he himself had not made much progress in investigating its properties. This paper of Mr. Cavendish may be considered as a continuation of the investigations begun by Dr. Black. He shows that there

exist two species of air quite different in their properties from common air: and he calls them *inflammable air* and *fixed air*.

Inflammable air (hydrogen gas) is evolved when iron, zinc, or tin, are dissolved in dilute sulphuric or muriatic acid. Iron yielded about 1-22d part of its weight, of inflammable air, zinc about 1-23d or 1-24th of its weight, and tin about 1-44th of its weight. The properties of the inflammable air were the same, whichever of the three metals was used to procure it, and whether they were dissolved in sulphuric or muriatic acids. When the sulphuric acid was concentrated, iron and zinc dissolved in it with difficulty and only by the assistance of heat. The air given out was not inflammable, but consisted of sulphurous acid. These facts induced Mr. Cavendish to conclude that the inflammable air evolved in the first case was the unaltered *phlogiston* of the metals, while the sulphurous acid evolved in the second case, was a compound of the same phlogiston and a portion of the acid, which deprived it of its inflammability. This opinion was very different from that of Stahl, who considered combustible bodies as compounds of phlogiston with acids or calces.

Cavendish found the specific gravity of his inflammable air about eleven times less than that of common air. This determination is under the truth; but the error is, at least in part, owing to the quantity of water held in solution by the air, and which, as Mr. Cavendish showed, amounted to about 1-9th of the weight of the air. He tried the combustibility of the 341
inflammable air, when mixed with various proportions of common air, and found that it exploded with the greatest violence when mixed with rather more than its bulk of common air.

Copper he found, when dissolved in muriatic acid by the assistance of heat, yielded no inflammable air, but an air which lost its elasticity when it came in contact with water. This *air*, the nature of which Mr. Cavendish did not examine, was *muriatic acid gas*, the properties of which were afterwards investigated by Dr. Priestley.

The *fixed air* (*carbonic acid gas*) on which Mr. Cavendish made his experiments was obtained by dissolving marble in muriatic acid. He found that it might be kept over mercury for any length of time without undergoing any alteration; that it was gradually absorbed by cold water; and that 100 measures of water of the temperature 55° absorbed 103·8 measures of fixed air. The whole of the air thus absorbed was separated again by exposing the water to a boiling heat, or by leaving it for sometime in an open vessel. Alcohol (the specific gravity not mentioned) absorbed 2¼ times its bulk of this air, and olive-oil about 1-3d of its bulk.

The specific gravity of fixed air he found 1·57, that of common air being 1.[186] Fixed air is incapable of supporting combustion, and common air, when mixed with it, supports combustion a much shorter time than when pure. A small wax taper burnt eighty seconds in a receiver which held 180 ounce measures, when filled with common air only. The same taper burnt fifty-one seconds in the same receiver when filled with a mixture of one volume fixed air, and nineteen volumes of common air. When the fixed air was 3-40ths of the whole 342
volume the taper burnt twenty-three seconds. When the fixed air was 1-10th, the taper burnt eleven seconds. When it was 6-55ths or 1-9·16 of the whole mixture, the taper would not burn at all.

Mr. Cavendish was of opinion that more than one kind of fixed air was given out by marble; in other words, that the elastic fluid emitted, consisted of two different airs, one more absorbable by water than the other. He drew his conclusion from the circumstance that after a solution of potash had been exposed to a quantity of fixed air for some time, it ceased to absorb any more; yet, if the residual portion of air were thrown away and new fixed air substituted in its place, it began to absorb again; but Mr. Dalton has since given a satisfactory explanation of this seeming anomaly by showing that the absorbability of fixed air in water is proportional to its purity, and that when mixed with a great quantity of common air or any other gas not soluble in water, it ceases to be sensibly absorbed.

Mr. Cavendish ascertained the quantity of fixed air contained in marble, carbonate of ammonia, common pearlashes, and carbonate of potash: but notwithstanding the care with which these experiments were made they are of little value; because the proper precautions could not be taken, in that infant state of chemical science, to have these salts in a state of purity. The following were the results obtained by Mr. Cavendish:

1000	grains	of marble contained	408	grs. fixed air.
1000	—	carb. of ammonia	533	—
1000	—	pearlashes	284	—
1000	—	carb. of potash	423	—

Supposing the marble, carbonate of ammonia, and carbonate of potash, to have been pure anhydrous simple salts, their composition would be

1000	grains	of marble contain	440	grs. fixed air.
1000	—	carb. of ammonia	709·6	—
1000	—	carb. of potash	314·2	—

Bicarbonate of potash was first obtained by Dr. Black. Mr. Cavendish formed the salt 343
by dissolving pearlashes in water, and passing a current of carbonic acid gas through the solution till it deposited crystals. These crystals were not altered by exposure to the air, did not deliquesce, and were soluble in about four times their weight of cold water.

Dr. M'Bride had already ascertained that vegetable and animal substances yield fixed air by putrefaction and fermentation. Mr. Cavendish found by experiment that sugar when dissolved in water and fermented, gives out 57-100ths of its weight of fixed air, possessing exactly the properties of fixed air from marble. During the fermentation no air was absorbed, nor was any change induced on the common air, at the surface of the fermenting liquor. Apple-juice fermented much faster than sugar; but the phenomena were the same, and the fixed air emitted amounted to 381/1000 of the weight of the solid extract of apples. Gravy and raw meat yielded inflammable air during their putrefaction, the former in much greater quantity than the latter. This air, as far as Mr. Cavendish's experiments went, he found the same as the inflammable air from zinc by dilute sulphuric acid; but its specific gravity was a little higher.

This paper of Mr. Cavendish was the first attempt by chemists to collect the different kinds of air, and endeavour to ascertain their nature. Hence all his processes were in some measure new: they served as a model to future experimenters, and were gradually brought to their present state of simplicity and perfection. He was the first person who attempted to determine the specific gravity of airs, by comparing their weight with that of the same bulk of common air; and though his apparatus was defective, yet the principle was good, and is the very same which is still employed to accomplish the same object. Mr. Cavendish then
first began the true investigation of gases, and in his first paper he determined the peculiar 344
nature of two very remarkable gases, *carbonic* and *hydrogen*.

2. Mineral waters have at all times attracted the attention of the faculty in consequence of their peculiar properties and medical virtues. Some faint steps towards their investigation were taken by Boyle. Du Clos attempted a chemical analysis of the mineral waters in France; and Hierne made a similar investigation of the mineral waters of Sweden. Though these experiments were rude and inaccurate, they led to the knowledge of several facts respecting mineral waters which chemists were unable to explain. One of these was the existence of a considerable quantity of *calcareous earth* in some mineral waters, which was

precipitated by boiling. Nobody could conceive in what way this insoluble substance (*carbonate of lime*) was held in solution, nor why it was thrown down when the water was raised to a boiling heat. It was to determine this point that Mr. Cavendish made his experiments on Rathbone-place water, which were published in the year 1767, and which may be considered as the first analysis of a mineral water that possessed tolerable accuracy. Rathbone-place water was raised by a pump, and supplied the portion of London in its immediate neighbourhood. Mr. Cavendish found that when boiled, it deposited a quantity of earthy matter, consisting chiefly of lime, but containing also a little magnesia. This he showed was held in solution by fixed air; and he proved experimentally, that when an excess of this gas is present, it has the property of holding lime and magnesia in solution.[187] Besides these earthy carbonates, the water was found to contain a little ammonia, some sulphate of lime, and some common salt. Mr. Cavendish examined, likewise, some other 345 pump-water in London, and showed that it contained lime, held in solution by carbonic acid.

3. Dr. Priestley, at a pretty early period of his chemical career, had discovered that when nitrous gas is mixed with common air over water, a diminution of bulk takes place; that there is a still greater diminution of bulk when oxygen gas is employed instead of common air; and that the diminution is always proportional to the quantity of oxygen gas present in the gas mixed with the nitrous gas. This discovery induced him to employ nitrous gas as a test of the quantity of oxygen present in common air; and various instruments were contrived to facilitate the mixture of the gases, and the measurement of the diminution of volume which took place. As the goodness of air, or its fitness to support combustion, and maintain animal life, was conceived to depend upon the proportion of oxygen gas which it contained, these instruments were distinguished by the name of *eudiometers*; the simplest of them was contrived by Fontana, and is usually distinguished by the name of the *eudiometer of Fontana*. Philosophers, in examining air by means of this instrument, at various seasons, and in various places, had found considerable differences in the diminution of bulk: hence they inferred that the proportion of oxygen varies in different places; and to this variation they ascribed the healthiness or noxiousness of particular situations. For example, Dr. Ingenhousz had found a greater proportion of oxygen in the air above the sea, and on the sea-coast; and to this he ascribed the healthiness of maritime situations. Mr. Cavendish examined this important point with his usual patient industry and acute discernment, and published the result in the Philosophical Transactions for 1783. He ascertained that the apparent variations were owing to inaccuracies in making the experiment; and that when the requisite precautions are taken, the proportion of oxygen in air is found constant in all 346 places, and at all seasons. This conclusion has since been confirmed by numerous observations in every part of the globe. Mr. Cavendish also analyzed common air, and found it to consist of

79·16	volumes azotic gas,
20·84	volumes oxygen gas.
100·00	

4. For many years it was the opinion of chemists that mercury is essentially liquid, and that no degree of cold is capable of congealing it. Professor Braun's accidental discovery that it may be frozen by cold, like other liquids, was at first doubted; and when it was finally established by the most conclusive experiments, it was inferred from the observations of Braun that the freezing point of mercury is several hundred degrees below zero on Fahrenheit's scale. It became an object of great importance to determine the exact point of the congelation of this metal by accurate experiments. This was done at Hudson's Bay, by Mr. Hutchins, who followed a set of directions given him by Mr. Cavendish, and from his experiments Mr. Cavendish, in a paper inserted in the Philosophical Transactions for 1783,

deduced that the freezing point of mercury is 38·66 degrees below the zero of Fahrenheit's thermometer.

5. These experiments naturally drew the attention of Mr. Cavendish to the phenomena of freezing, to the action of freezing mixtures, and the congelation of acids. He employed Mr. M'Nab, who was settled in the neighbourhood of Hudson's Bay, to make the requisite experiments; and he published two very curious and important papers on these subjects in the Philosophical Transactions for 1786 and 1788. He explained the phenomena of congelation exactly according to the theory of Dr. Black, but rejecting the hypothesis that heat is a *substance* sui generis, and thinking it more probable, with Sir Isaac Newton, that it 347 is owing to the rapid internal motion of the particles of the hot body. The latent heat of water, he found to be 150°. The observations on the congelation of nitric and sulphuric acids are highly interesting: he showed that their freezing points vary considerably, according to the strength of each; and drew up tables indicating the freezing points of acids, of various degrees of strength.

6. But the most splendid and valuable of Mr. Cavendish's chemical experiments were published in two papers, entitled, "Experiments on Air," in the Transactions of the Royal Society for 1784 and 1785. The object of these experiments was to determine what happened during the *phlogistication of air*, as it was at that time termed; that is, the change which air underwent when metals were calcined in contact with it, when sulphur or phosphorus was burnt in it, and in several similar processes. He showed, in the first place, that there was no reason for supposing that carbonic acid was formed, except when some animal or vegetable substance was present; that when *hydrogen gas* was burnt in contact with air or oxygen gas, it *combined* with that gas, and formed *water*; that *nitrous gas*, by combining with the oxygen of the atmosphere, formed *nitrous acid*; and that when *oxygen* and *azotic* gas are mixed in the requisite proportions, and electric sparks passed through the mixture, they *combine*, and form *nitric* acid.

The first of these opinions occasioned a controversy between Mr. Cavendish, and Mr. Kirwan, who maintained that carbonic acid is always produced when air is phlogisticated. Two papers on this subject by Kirwan, and one by Cavendish, are inserted in the Philosophical Transactions for 1784, each remarkable examples of the peculiar manner of the respective writers. All the arguments of Kirwan are founded on the experiments of others. He displays great reading, and a strong memory; but does not discriminate between 348 the merits of the chemists on whose authority he founds his opinions. Mr. Cavendish, on the other hand, never advances a single opinion, which he has not put to the test of experiment; and never suffers himself to go any further than his experiment will warrant. Whatever is not accurately determined by unexceptionable trials, is merely stated as a conjecture on which little stress is laid.

In the first of these celebrated papers, Mr. Cavendish has drawn a comparison between the phlogistic and antiphlogistic theories of chemistry; he has shown that each of them is capable of explaining the phenomena in a satisfactory manner; though it is impossible to demonstrate the truth of either; and he has given the reasons which induced him to prefer the phlogistic theory—reasons which the French chemists were unable to refute, and which they were wise enough not to notice. There cannot be a more striking proof of the influence of fashion, even in science, and of the unwarrantable precipitation with which opinions are rejected or embraced by philosophers, than the total inattention paid by the chemical world to this admirable dissertation. Had Mr. Kirwan adopted the opinions of Mr. Cavendish, when he undertook the defence of phlogiston, instead of trusting to the vague experiments of inaccurate chemists, he would not have been obliged to yield to his French antagonists, and the antiphlogistic theory would not so speedily have gained ground.

Such is an epitome of the chemical papers of Mr. Cavendish. They contain five notable discoveries; namely, 1. The nature and properties of hydrogen gas. 2. The solubility of bicarbonates of lime and magnesia in water. 3. The exact proportion of the constituents of common air. 4. The composition of water. 5. The composition of nitric acid. It is to him also that we are indebted for our knowledge of the freezing point of mercury; and he was 349
likewise the first person who showed that potash has a stronger affinity for acids than soda has. His experiments on the subject are to be found in a paper on Mineral Waters, published in the Philosophical Transactions, by Dr. Donald Monro.

END OF VOL. I.

C. WHITING, BEAUFORT HOUSE, STRAND.

xxiii

No. III.—XENOPHON, Vol. I. (translated by E. Spelman, Esq.), comprising a Biographical Sketch of the Historian; and his Anabasis, or Expedition of Cyrus into Persia, and retreat of the 10,000 Greeks. xiv

No. IV.—XENOPHON, vol. II. (translated by the Hon. Maurice Ashley Cooper), comprising the Cyropædia, or the Education, Life and Manners, Government, Wars, and Achievements of Cyrus, King of Persia.

No. V.—HERODOTUS, vol. I. (translated by the Rev. W. Beloe), comprising a Biographical Sketch of the Historian; and the first two Books of his History, containing a Narrative of the Acquisition of the Kingdom of Lydia by Crœsus, and the subsequent overthrow of the Lydian Empire by Cyrus; the early History of the Republics of Athens and Lacedæmon; with an account of Egypt, its Customs, Manners, and Governments.

No. VI.—HERODOTUS, vol II., comprising, in the 3d, 4th, and 5th Books, the Exploits of Cambyses, with the subjugation of the whole of Egypt; the elevation of Darius Hystaspes to the Persian throne; the disastrous Expeditions of the Persians against the Scythians during his reign; the progress of the Republics of Athens, Lacedæmon and Corinth, and their state during the time of the Persian Emperor Darius.

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No. VIII.—VIRGIL, vol. I., comprising a Biographical Sketch of the Poet; his *Eclogues*, or Pastoral Poems, translated by Archdeacon Wrangham; the *Georgics*, or Poems on Husbandry, translated by William Sotheby, Esq.; and the first two Books of the *Æneid*, translated by Dryden, and prefaced with his celebrated Dedication.

No. IX.—VIRGIL, vol. II., comprising the remainder of Dryden's translation of the *Æneid*, namely, from the third to the twelfth Book.

No. X.—PINDAR (translated by the Rev. C. A. Wheelwright, Prebendary of Lincoln); and ANACREON, by Mr. Thomas Bourne.

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FOOTNOTES:

1 The word χημεια is said to occur in several Greek manuscripts of a much earlier date. But of this, as I have never had an opportunity of seeing them, I cannot pretend to judge. So much fiction has been introduced into the history of Alchymy, and so many ancient names have been treacherously dragged into the service, that we may be allowed to hesitate when no evidence is presented sufficient to satisfy a reasonable man.

2 Χημεια, ἡ του αργυρου και χρυσου κατασκευη· ἡς τα βιβλια διερευνησαμενος ὁ Διοκλητιανος εκαυσε, δια τα νεωτερισθεντα αιγυπτιοις Διοκλητιανω· τουτοις ανημερως και φονικως εχρησατο ὁτεδη και τα περι χημειας χρυσου και αργυρου τοις παλαιοις γεγραμμενα βιβλια διερευνησαμενος εκαυσε, προς το μηκετι πλουτον αιγυπτιοις εκ της τοιαυτης προσγινεσθαι τεχνης, μηδε χρηματων αυτοις θαῤῥονιτας περιουσια του λοιπου ῥωμαιοις ανταιρειν.

3 Δερας, το χρυσομαλλον δερας, ὁπερ ὁ Ιασων δια της ποντικης θαλασσης συν τοις αργοναυταις εις την κολχιδα παραγενομενοι ελαβον, και την Μηδειαν την Αιητου του βασιλεως θυγατερα. Τουτο δε ουκ ὡς ποιητικως φερεται· αλλα βιβλιον ην εν δερμασι γεγραμενον περισχον ὁπως δειγινεσθαι δια χημειας χρυσον· εικοτως ουν ὁι τοτε χρουσουν ωνομαζον αυτο δερας δια την ενεργειαν την εξ αυτου.

4 De Ortu et Progressu Chemiæ, p. 12.

5 Σωσιμου του πανατολιτου γνησια γραφη, περι της ἱερας, και θειας τεχνης του χρυσου και αργυριου ποιησιος. Πανατολις was a city in Egypt.

6 Shaw’s Translation of Boerhaave’s Chemistry, i. 20.

7 Genesis iv. 22.

8 De Iside and Osiride, c. 5.

9 There are two Latin translations of these tables (unless we are rather to consider them as originals, for no Phœnician nor Greek original exists). I shall insert them both here.

I.—Verba secretorum Hermetis Trismegisti.

1. Verum sine mendacio certum et verissimum.

2. Quod est inferius, est sicut quod est superius, et quod est superius est sicut quod est inferius ad perpetranda miracula rei unius.

3. Et sicut omnes res fuerant ab uno meditatione unius: sic omnes res natæ fuerunt ab hac una re adaptatione.

4. Pater ejus est Sol, mater ejus Luna, portavit illud ventus in ventre suo, nutrix ejus terra est.

5. Pater omnis thelesmi totius mundi est hic.

6. Vis ejus integra est, si versa fuerit in terram.

7. Separabis terram ab igne, subtile a spisso suaviter cum magno ingenio.

8. Ascendit a terra in cœlum, iterumque descendit in terram, et recipit vim superiorum et inferiorum, sic habebis gloriam totius mundi. Ideo fugiat a te omnis obscuritas.

9. Hic est totius fortitudinis fortitudo fortis; quia vincit omnem rem subtilem, omnemque solidam penetrabit.

10. Sic mundus creatus est.

11. Hinc adaptationes erunt mirabiles, quarum modus est hic.

12. Itaque vocatus sum Hermes Trismegistus, habens tres partes philosophiæ totius mundi.

13. Completum est quod dixi de operatione solis.

II.—Descriptio Arcanorum Hermetis Trismegisti.

1. Vere non ficte, certo verissime aio.

2. Inferiora hæc cum superioribus illis, istaque cum iis vicissim vires sociant, ut producant rem unam omnium mirificissimam.

3. Ac quemadmodum cuncta educta ex uno fuere verbo Dei unius: sic omnes quoque res perpetuo ex hac una re generantur dispositione Naturæ.

4. Patrem ea habet Solem, matrem Lunam: ab aëre in utero quasi gestatur, nutritur a terra.

5. Causa omnis perfectionis rerum ea est per univerum hoc.

6. Ad summam ipsa perfectionem virium pervenit si redierit in humum.

7. In partes tribuite humum ignem passam, attenuans densitatem ejus re omnium suavissima.

8. Summa ascende ingenii sagacitate a terra in cœlum, indeque rursum in terram descende, ac vires superiorum inferiorumque coge in unum: sic potiere gloria totius mundi atque ita abjectæ sortis homo amplius non habere.

9. Isthæc jam res ipsa fortitudine fortior existet; corpora quippe tam tenuia quam solida penetrando subige.

10. Atque sic quidem quæcunque mundus continet creata fuere.

11. Hinc admiranda evadunt opera, quæ ad eundum modum instituantur.

12. Mihi vero ideo nomen Hermetis Trismegisti impositum fuit, quod trium mundi sapientiæ partium doctor deprehensus sum.

13. Hæc sunt quæ de chemicæ artis prestantissimo opere consignanda esse duxi.

10 "Accipe de humore unciam unam et mediam, et de rubore meridionali, id est anima solis, quartam partem, id est, unciam mediam, et de Seyre citrino, similiter unciam mediam, et de auripigmenti dimidium, quæ sunt octo, id est unciæ tres. Scitote quod vitis sapientum in tribus extrahitur, ejusque vinum in fine triginta peragitur."

11 Preface to Mangetus's Bibliotheca Chemica Curiosa.

12 Ibid.

13 Bergmann, Opusc. iv. 121.

14 I allude to his *Manuale sive de Lapide Philosophico Medicinali*. Opera Paracelsi, ii. 133. Folio edition. Geneva, 1658.

15 Wilson's Chemistry, p. 375.

16 Ibid., p. 379.

17 Probably corrosive sublimate.

18 Probably calomel.

19 Mangeti Bibliothecæ Chemicæ Præfatio.

20 Whoever wishes to enter more particularly into the processes for making the philosopher's stone contrived by the alchymists, will find a good deal of information on the subject in Stahl's Fundamenta Chemiæ, vol. i. p. 219, in his chapter *De lapide philosophorum*: and Junker's Conspectus Chemiæ, vol. i. p. 604, in his tabula 28, *De transmutatione metallorum universali*: and tabula 29, *De transmutatione metallorum particulari*.

21 Kircher, in his Mundus Subterraneus, has an article on the philosopher's stone, in which he examines the processes of the alchymists, points out their absurdity, and proves by irrefragable arguments that no such substance had ever been obtained. Those who are curious about alchymistical processes may consult that work.

22 Mem. Paris, 1722, p. 61.

23 The original author, whom all who have given any account of the alchymists have followed, is Olaus Borrichius, in his Conspectus Scriptorum Chemicorum Celebriorum. He does not inform us from what sources his information was derived.

24 Sprengel's History of Medicine, iv. 368.

25 It is curious that Olaus Borrichius omits Albertus Magnus in the list of alchymistical writers that he has given.

26 This tract and the next, which is of considerable length, will be found in Mangetus's Bibliotheca Chemica Curiosa, i. 613.

27 Gmelin's Geschitte der Chemie, i. 74.

28 Exodus xi. 2—xxv. 11, 12, 13, 17, 18, 24, 25, 26—xxviii. 8—xxxii. 2, &c.

29 Genesis xlvii. 14.

30 For example, Exodus xi. 2—xxvi. 19, 21—xxvii. 10, 11, 17, &c.

31 Genesis iv. 22.

32 For example, Exodus xxvii. 2, 3, 4, 6, 10, 11, 17, 18, 19—xxx. 18, &c. Numbers xxi. 9.

33 Deut. viii. 9.

34 Beitrage, vi. 81.

35 Plinii Hist. Nat. xxxiv. 1.

36 Plinii Hist. Nat. xxxiv. 2.

37 Pliny's phrase is *plumbum argentorium*. But that the addition was tin, and consequently that plumbum argentorium meant tin, we have the evidence of Klaproth, who analyzed several of these bronze statues, and found them composed of copper, lead, and tin.

38 Beitrage, vi. 89.

39 Beitrage, vi. 118. The statue in question was known by the name of "The Statue of Püstrichs," at Sondershausen.

40 Ibid., p. 127.

41 Ibid., p. 132.

42 Ibid., p. 134.

43 Plinii Hist. Nat. xxxiv. 11.

44 Lib. v. c. 117.

45 See Plinii Hist. Nat. xxxiv. 13.

46 Genesis iv. 22.

47 Deut. iv. 20.

48 Deut. viii. 9.

49 Numbers xxxv. 16.

50 Levit. i. 17.

51 Deut. xviii. 5.

52 Deut. xxvii. 5.

53 Iliad, lib. xxiii. l. 826.

54 Xenophon’s Anabasis, v. 5.

55 Plinii Hist. Nat. xxxiv. 14.

56 Numbers xxxi. 22.

57 Iliad xi. 25.

58 Lib. xxxiv. c. 17.

59 Numbers xxxi. 22.

60 Dioscorides, lib. v. c. 110.

61 Lib. v. c. 110.

62 The ancients were in the habit of extracting mercury from cinnabar, by a kind of imperfect distillation. The native mercury they called *argentum vivum*, that from cinnabar *hydrargyrus*. See Plinii Hist. Nat. xxxiii. 8.

63 Lib. v. c. 99.

64 Lib. xxxiii. c. 6.

65 2 Kings ix. 30.

66 Chap. 23. v. 40, the Vulgate has it εστιβιζω τους οφθαλμους σουο.

67 Hartmanni Praxis Chemiatrica, p. 598.

68 Plinii Hist. Nat. xxxiii. 6.

69 Περι των λιθων, c. 71.

70 Bucol. iv. 1. 45.

71 Plinii Hist. Nat. xxxv. 6.

72 Phil. Trans. 1814, p. 97.

73 Job xxviii. 17.

74 Plinii Hist. Nat. xxxvi. 26.

75 Beitrage, vi. 140.

76 Ibid., p. 142.

77 Beitrage, p. 144.

78 Phil. Trans. 1815, p. 108.

79 Plinii Hist. Nat. xxxvii. 2.

80 Plinii Hist. Nat. xxxvii. 2.

81 This opinion was first formed by Baron Born, and stated in his Catalogue of Minerals in M. E. Raab's collection, i. 356. But the evidences in favour of it have been brought forward with great clearness and force by M. Roziere. See Jour. de Min. xxxvi. 193.

82 Plinii Hist. Nat. ix. 38.

83 Ibid., ix. 36.

84 Plinii Hist. Nat. ix. c. 38.

85 Exodus xxv. 4.

86 See Bancroft on Permanent Colours, i. 79.

87 Plinii Hist. Nat. xxxv. 11.

88 Plinii Hist. Nat. xxviii. 12. The passage of Pliny is as follows: "Prodest et sapo; Gallorum hoc inventum rutilandis capillis ex sevo et cinere. Optimus fagino et caprino, duobus modis, spissus et liquidus: uterque apud Germanos majore in usu viris quam feminis."

89 Hist. of Inventions, iii. 239.

90 Genesis ix. 20.

91 "Oinô d' ek kritheôn pepoiêmenô diachreontai; ou gar sphi eisi en tê chôrê ampeloi." Euterpe chap. 77.

92 De Moribus Germanorum, c. 23. "Potui humor ex hordeo aut frumento in quandam similitudinem vini corruptus."

93 Plinii Hist. Nat. xxxv. 12.

94 The word topazo is said by Pliny to signify, in the language of the Troglodytes, *to seek*.

95 Plinii Hist. Nat. ii. 63.

96 Beitrage, iii. 104.

97 "Quoniam inficiendis claro colore lanis candidum liquidumque utilissimum est, contraque fuscis et obscuris nigrum."—*Plinii*, xxxv. 15.

98 See Dioscorides, lib. v. c. 123. Plinii Hist. Nat. xxxv. 18.

99 Matthew v. 13.—"Ὑμεις εστε το ἁλας της γης· εαν δε το ἁλας μωρανθη, εν τινι ἁλισθησεται· εις ουδεν ισχωει ετι ει μη βληθηναι εξω, και καταπατεισθαι ὑπο των ανθρωπων."

100 Proverbs xxv. 20.

101 "Cujus asperitas visque in tabem margeritas resolvit."

102 Plinii Hist. Nat. ix. 35.

103 For a fuller account of the progress of science among the Arabians than would be consistent with this work, the reader is referred to Mortucla's Hist. des Mathématiques, i. 351; Sprengel's Hist. de la Médecine, ii. 246.

104 Boerhaave's Chemistry (Shaw's translation), i. 26. *Note.*

105 Golius was not, however, the first translator of Geber. A translation of the longest and most important of his tracts into Latin appeared in Strasburg, in 1529. There was another translation published in Italy, from a manuscript in the Vatican. There probably might be other translations. I have compared four different copies of Geber's works, and found some differences, though not very material. I have followed Russel's English translation most commonly, as upon the whole the most accurate that I have seen.

106 Of course I exclude the writings of the Greek ecclesiastics mentioned in a previous part of this work, which still continue in manuscript; because, I am ignorant of what they contain.

107 Sum of Perfection, book ii. part i. chap. 5.

108 Ibid.

109 Ibid., chap. 6.

110 Sum of Perfection, book ii. part i. chap. 7.

111 Ibid.

112 Ibid., chap. 8.

113 Ibid.

114 Ibid., chap. 9.

115 Sum of Perfection, book ii. part i. chap. 9.

116 Ibid.

117 Ibid., chap. 10.

118 Investigation and Search of Perfection, chap. 3.

119 Invention of Verity, chap. 4.

120 Search of Perfection, chap. 3.

121 De Investigatione Perfect. chap. 4.

122 Invention of Verity, chap. 23.

123 Ibid., chap. 21.

124 Ibid., chap. 23.

125 Invention of Verity, chap. 8.

126 Sum of Perfection, book i. part iii. chap. 4.

127 Ibid., chap. 6.

128 Ibid.

129 Sum of Perfection, book i. part iv. chap. 16.

130 Invention of Verity, chap. 10.

131 Sum of Perfection, book i. part iii. chap. 4.

132 Ibid.

133 Invention of Verity, chap. 6.

134 Invention of Verity, chap. 7.

135 Sum of Perfection, book ii. part. ii. chap. 11.

136 Invention of Verity, chap. 14.

137 Ibid., chap. 4 and 12.

138 Sum of Perfection, book ii. part iii. chap. 10.

139 Invention of Verity, chap. 4.

140 Sum of Perfection, book i. part iii. chap. 8.

141 Ibid., book i. part iii. chap. 8.

142 Investigation of Perfections, chap. 11.

143 See Testamentum Paracelsi, passim.

144 "Hispania, Portugallia, Anglia, Borussia, Lithuania, Polonia, Pannonia, Valachia, Transylvania, Croatia, Illyrico, immo omnibus totius Europæ nationibus peragratis, undeque non solum apud medicos, sed et chirurgos, tonsores, aniculas, magos, chymistas, nobiles ac ignobiles, optima, selectiora ac secretiora, quæ uspiam extarent remedia, inquisivi acriter."—*Præfatio Chirurgiæ Magnæ.* Opera Paracelsi, tom. iii.

145 See the dedication to his treatise *De Gradibus et Compositionibus Receptorum et Naturalium*. Opera Paracelsi, vol. ii. p. 144. I always refer to the folio edition of Paracelsus's works, in three volumes, published at Geneva in 1658, by M. de Tournes, which is the edition in my possession.

146 Opera Paracelsi, i. 485.

147 There were two laudanums of Paracelsus; one was *red oxide of mercury*, the other consisted of the following substances: Chloride of antimony, 1 ounce; hepatic aloes, 1 ounce; rose-water, ½ ounce; saffron, 3 ounces; ambergris, 2 drams. All these well mixed.

148 Opera Paracelsi, iii, 101.

149 Opera Paracelsi, i. 243.

150 Ibid., ii. 84.

151 Opera Paracelsi, i. 328.

152 "Qui elegantiorem optat, ille eum condat."—*Ibid.*

153 Archidoxorum, lib. i. Opera Paracelsi, ii. 4.

154 De longa Vita. Opera Paracelsi, ii. 46.

155 Archidoxorum, lib. viii. Opera Paracelsi, ii. 29. In this book he gives the method of preparing the elixir of life. It seems to have been nothing else than a solution of *common salt* in water; for the quintessence of gold, with which this solution was to be mixed, was doubtless an imaginary substance.

156 Modus Pharmacandi. Opera Paracelsi, i. 811.

157 Liber de Nymphis, Sylphis, Pygmæis, et Salamandris, et de ceteris Spiritibus. Opera Paracelsi, ii. 388. If the reader can understand this singular book, his sagacity will be greater than mine.

158 Paragrani Alterius, tract. ii. Opera Paracelsi, i. 235. The reader who has the curiosity to consult this tract, will find abundance of similar stuff, which I did not think worth translating.

159 Philosophiæ, tract. iv. De Mineralibus. Opera Paracelsi, ii. 282. "Quando ergo hoc modo metalla fiunt et producuntur, dum scilicet verus metallicus fluxus et ductilitas aufertur et in septem metalla distribuitur; residentia quædam manet in Ares, instar fœtûm trium primorum. Ex hac nescitur zinetum, quod et metallum est et non est. Sic et bisemutum et huic similia alia partim fluida, partim ductilia sunt—Zinetum maxima ex parte spuria soboles est ex cupro et bisemutum de stanno. Ex hisce duobus omnium plurimæ fæces et remanentiæ in Ares fiunt."

160 It was as follows: "Collegium medicorum in Academia Parisiensi legitime congregatum, audita renunciatione sensorum, quibus demandata erat provincia examinandi apologiam sub nomine Mayerni Turqueti editam, ipsam unanimi consensu damnat, tanquam famosum libellum, mendacibus conviciis et impudentibus calumniis refertum, quæ nonnisi ab homine imperito, impudenti, temulento et furioso profiteri potuerunt. Ipsum Turquetum indignum judicat, qui usquam medicinam faciat, propter temeritatem, impudentiam et veræ medicinæ ignorantiam. Omnes vero medicos, qui ubique gentium et locorum medicinam exercent, hortatur ut ipsum Turquetum similiaque hominum et opinionum portenta, a se suisque finibus arceant et in Hippocratis ac Galeni doctrina constantes permaneant: et prohibuit ne quis ex hoc medicorum Parisiensium ordine cum Turqueto eique similibus medica consilia ineat. Qui secus fecerit, scholæ ornamentis et academiæ privilegiis privabitur, et de regentium numero expungetur.—Datum Lutetiæ in scholis superioribus, die 5 Decembris, anno salutis, 1603."

161 J. B. Van Helmont, Opera Omnia, p. 100. The edition which I quote from was printed at Frankfort, in 1682, at the expense of John Justus Erythropilus, in a very thick quarto volume.

162 Van Helmont, Opera Omnia, p. 104.

163 Ibid., p. 105.

164 De Flatibus, sect. 49. Opera Van Helmont, p. 405.

165 Ibid., p. 408.

166 Ibid., p. 409.

167 In his Magnum Oportet, sect. 39, p. 151, he gives an account of the origin of metals in the earth, and in that section there is a description of *bur*, which those who are anxious to understand the ideas of the author on this subject may consult.

168 As an example of the prescriptions of Sylvius, we give the following for malignant fever:

R. Theriac. veter. ʒij
Antim. diaphor. ʒj
Syrup. Card. Benedic. ℥ij
Aq. prophylact. ℥j
— Cinnam. ℥ss
— Scabios. ℥ij
M. D.

169 Shaw's Boyle, iii, 424.

170 De Ortu et Progressu Chemiæ. *Hafniæ*, 1674.

171 While travelling in a tract-boat, one of his fellow-travellers more orthodox than well informed, attacked the system of Spinoza with so little spirit, that Boerhaave was tempted to ask him if he had ever read Spinoza. The polemic was obliged to confess that he had not; but he was so much provoked at this public exposure of his ignorance, that he propagated the report of Boerhaave's attachment to Spinozism, and thus blasted his intention of becoming a clergyman.

172 Mem. Paris, 1734, p. 539.

173 Phil. Trans. 1733. No. 430, p. 145.

174 It is entitled, "El Arte de los Metales, en que se ensena el verdadero beneficio de los de oro y plata por azoque," &c.

175 Born's New Process of Amalgamation, translated by Raspe, p. 11.

176 I have never seen a copy of this last work; it must have been valuable, as it was the book from which Scheele derived the first rudiments of his knowledge.

177 For 1711, p. 238.

178 Mem. Paris, 1718, p. 202; and 1720, p. 20.

179 In the sixth chemical thesis, in the second supplement to the Physica Subterranea (page 791, Stahl's Edition. Lipsiæ, 1703), he says, "ubi etiam, continuato igne, ipsum sal volatile acquires, quod eadem methodo cum vitriolo seu spiritu aut oleo vitrioli, et oleo tartari, vel *borace* succedit."

180 "Primus in his facem prætulit Beccherus; eumque magno cum artis progressu sequentem videmus in ostendenda corporum analysi et synthesi chymica versatissimum et acutissimum—*Stahlium*."

181 There is a French translation of this work, entitled "Litheognosie, ou Examen Chymique des Pierres et des Terres en général, et du Talc de la Topaz, et de la Steatite en particulier; avec une Dissertation sur le Feu et sur la Lumière." Paris, 1753. With a continuation, constituting a second volume, in which all the experiments in the first volume are exhibited in the form of tables.

182 1763, p. 235.

183 I do not know what the true name was of which Macquer is a corruption. Ker is a Scottish name belonging to two noble families, the Duke of Roxburgh and the Marquis of Lothian; but I am not aware of M'Ker being a Scottish name: besides, neither of these families was attached to the house of Stuart.

184 Hist. de l'Acad. R. des Sciences, 1784, p. 24.

185 The preceding character of Dr. Black is from Professor Robison, who knew him intimately; and from Dr. Adam Ferguson, who was his next relation. See the preface to Dr. Black's lectures. The portrait of Dr. Black prefixed to these lectures is an excellent likeness.

186 This I apprehend to be a little above the truth, the true specific gravity of carbonic acid gas being 1·5277, that of air being unity.

187 The salts held in solution are in the state of bicarbonates of lime and magnesia. Boiling drives off half the carbonic acid, and the simple carbonates being insoluble are precipitated.

Transcriber's Note:

Inconsistent spelling and hyphenation are as in the original.

Page 51: "zeb" changed to read "zahav".

Page 53: "kemep" changed to read "keseph".

Page 54: "necheshet" changed to read "nechooshat".

Page 63: "berezel" changed to read "barzel".

Page 63: "ber" changed to read "bar".

Page 63: “nezel” changed to read “nazal”.

Page 76: “arrenichon” changed to read “arrhenichon”.

Page 81: “chuanos” changed to read “kyanos”.