Three presidential addresses to the Chemical Section of the Philosophical Society of Glasgow : on the study of the history of chemistry, recent inquiries into the early history of chemistry, eleven centuries of chemistry / by John Ferguson.

THREE
PRESIDENTIAL ADDRESSES

TO THE

CHEMICAL SECTION

OF THE

Philosophical Society of Glasgow.

On the Study of the History of Chemistry.

Recent Inquiries into the Early History of Chemistry.

Eleven Centuries of Chemistry.

BY

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Introductory Address to the Chemical Section. By JOHN FERGUSON, Esq., M.A., Professor of Chemistry in the University of Glasgow.

[Read before the Philosophical Society of Glasgow, December 15, 1875.]

MY first duty to-night is to return thanks to the Section for the honour it has done me in electing me President.

It is the custom for those who are put in positions similar to my own, from time to time to leave the consideration of special topics, and to seek to direct attention to what may be doing by others in different fields, to endeavour to rise to wider views, to estimate the tendencies of the time, or to anticipate what may still remain concealed in the future. In complying with this custom, on the present occasion, I shall try to lay before you a few brief considerations on a topic which, whether it be of practical importance or not, has always appeared to me full of interest and highly suggestive.

There is no doubt that at the present time neither the history of science in general, nor of chemistry in particular, attracts many students. This is the more remarkable when it is considered that most other branches of history, as of philosophy, art, and literature—of individuals, peoples, and nations—of social, domestic, and political events—of civilisation as a great whole, are now cultivated to a higher pitch than at any previous time. It is also very curious, when we consider that this is the time when the facts and results of science have acquired their greatest extension by practical applications, and when the methods of scientific investigation are influencing other departments; when, therefore, the origin and development of those methods, and the ideas from which they sprung, or which they have attempted to realise, might be supposed to exercise as great an attraction on thoughtful minds as the origin and progress of language, or philosophy, or ethnology, or of some state or nation, and that therefore we might look for many histories of the inductive sciences. But, as we all know, there is a notable absence of such expositions, a notable indifference—amounting in some cases almost to horror—on the part of scientific men to the

history of their sciences, and to the lives and discoveries of their predecessors.

I cannot help comparing the interest felt by all classes of men for, say, Shakespeare, and for the minutest details of his life and works, with that felt (even by specialists) for, say, Sir Isaac Newton. I cannot help comparing the numbers of editions of Shakespeare's works with those of Newton's *Principia* and *Optics*. I think of the interest in Plato, as compared with that in Hippocrates; of the interest in Horace or Juvenal, as compared with that in Pliny's *Natural History*. Of the millions who have learned *Euclid* by rote, how many know or care whether Euclid is the name of a man or merely the title of a book on geometry? Would the civilised world take the interest in any new discovery connected with that famous Greek, which it has lately taken in the various investigations relating to Homer and the scene of the Trojan war? We might go through the literatures of ancient and modern times, and always with the same result. The poets, the philosophers, the historians live and appeal to all; those who have written of outer material nature are quite forgotten, or remembered but by a few.

One, indeed, might make shift to dispense with the interest of the multitude in these subjects, but that of scientific men themselves seems rarely enlisted by the history of their science. If this be so, is the conclusion unavoidable that this topic—the history of science—is so extensive that it is beyond the grasp of any one to deal with it? This can hardly be true. Or is it that the history of those branches of knowledge which themselves are most lauded at the present day for their precision, and especially for their use—that is, not for their own sakes, but as means to other, and of necessity more important ends, and which are to be taught sooner or later everywhere as among the most important educational agencies—that the history of those branches is quite deficient in interest?

To confine ourselves to our own science (though what I say is applicable more or less to others), do chemists at the present day feel that interest in the chemistry of, say, fifty or one hundred years ago, that a student of English, French, or German does in the literature of those languages during the same time? Is there any reason why he does not?

It will be urged that the studies are not comparable: the study of literature is of man's works, that of chemistry is of the works of Nature. It is more important, it will be said, to ask Nature than to read books. This, which is true, if properly explained,

would, if taken in its literal sense, make the study of natural science not a liberalising and humanising, but one of the most selfish and narrowing of pursuits. But as a matter of fact, even the greatest stickler for personal experiment cannot escape reading what has been done, and is doing. Indeed, for once we require to ask Nature, we consult books ten times. If books are not to be studied, what is the meaning of the haste to publish discoveries and discussions? Why should one not rest satisfied in one's own mind with having brought something new to light, instead of announcing it to the whole world? No one at the present day would venture to believe only what he had himself confirmed experimentally—that in his short life he could repeat and criticise everything that is doing by scores of workers in different departments—when it takes a large band of writers simply to reduce new investigations to a bulk in which they are available for perusal. Besides, all our theories are found only in books. Nature furnishes no theories. A science, however, is only a science in its theories, and to know these one must study them in succession in the books containing them. From what one sees, however, in current text-books, it is plain that the interest is supposed to lie in the matter of fact, and the historico-theoretical element is quite eliminated. Those who read even the larger works are left ignorant of the discovery of some all-important bodies. If such an epoch-making event as the discovery of sulphuric acid existed in the history of literature, philosophy, or art, how minutely would its history be examined and criticised!* suppose in a literary examination paper a review of the differences, say, between Pope and Tennyson was wanted, I imagine every one would be able to say something about the characteristics of these poets. But picture the modern chemical student asked to recapitulate Davy's arguments against the oxygen theory of acids, or the chief points in the long discussion between Berzelius and Gerhardt, or between Berthollet and Proust. And yet, I humbly conceive, the full comprehension of current views is unintelligible unless one has mastered preceding developments.

Assuming, then, the lack of interest in history as certain, the question arises, Why is it so?

So far as I am able to judge, it cannot be because the principles

* There is perhaps only one chemical question the history of which has been minutely discussed, and on which paper after paper has been written,—the discovery of the composition of water. The most recent contribution to this subject is by Dr. Kopp, in the third part of his *Beiträge*, 1875.

obtained from the history are of no importance, but rather from a latent feeling that there is a want of union between the science and its history. The facts and principles contained in the history of chemistry are not those of the science itself, or, if they are the same, they are considered from a very different point of view. The history of chemistry, in short, furnishes the chemist, as the investigator of certain properties of matter, with nothing which is of assistance to him in increasing his knowledge of these properties, and is therefore of no use to him in the pursuit of his calling. Naturally enough, then, he does not spend time on a subject—even the history of his own science—which has no more import for him than the history of grammar or of maritime discovery. But the penalty paid for this is severe, for there is no literature which sooner becomes antiquated, and even obsolete, than the scientific, which so soon ceases to have an intrinsic and acquires a purely historical value.

In perusing now the writings of Priestley or Scheele, Lavoisier or Davy, or even of more recent men, the interest, such as it is, felt in them is not derived solely from the number of new facts they contain—for they contain none, all the hard won facts of these men having long ago been swallowed up and assimilated in the general body of science—or the accuracy of the theories recorded, but the interest is mingled partly with curiosity to observe how far the author's knowledge was an advance upon that of his predecessors, how far that of the reader is an advance upon that of the most famous experimentalists and discoverers of their own or of any succeeding epoch ; partly with a personal interest in the men themselves, as possessed of genius, energy, and success in the discovery of chemical phenomena. But no chemist who wishes to be abreast of the facts of his time would think of studying Priestley's views on vital air, A.D. 1774, while last year's *Jahresbericht* is lying uncut. Following up this argument, it is plain that older writings will be perused still less frequently for the facts and ideas they furnish, so that when at last writings cease to have immediate connection with the present, they cease to attract the modern student.

Now, since only the modern cultivator of a branch of science—the student of chemistry, for instance—can intelligently read older books and correctly estimate the work of his predecessors, and yet does it not, it can hardly be expected that others will who have not the corresponding taste and knowledge. Thus, between those who will not and those who cannot record the events of the past, the profit, the ideas to be derived from the contemplation of the history of science, are

lost. Absorbed in the present, we think that it will remain as we have been taught, or have taught ourselves, to view it; when a change comes, and every foundation seems to be giving way, we are incapacitated by habit from estimating correctly the amount and the character or direction of the alteration. The corrective for the narrowness of such thinking is to be found in historical study—the best assistance in recognising and valuing the true worth of change is derived from historical ideas and laws.

The chemist, then, who, however devoted he may be to his special pursuit, and however completely he resigns himself in his actual work to the phenomena Nature compels him to accept, and to the inferences which he must necessarily draw from them, yet retains a consciousness of his own superiority to both facts and inferences, exhibits his true attitude to them when he reviews them as compared with the preceding phases of the science, and then reviews the whole science as co-ordinated with the rest of knowledge, and as an instrument of his own mental cultivation. At this stage, however, the chemist passes beyond the comparatively narrow sphere of his own science, and enters the wider domain of principles and general laws. Obviously in this transition the means made use of are necessarily historical. For if he bring his own science into connection with the rest of present knowledge, and abide there, he has only stated a fact; he has performed a synthesis, as he would say himself, but has not availed himself of the result. The only use of such a synthetic classification—beyond that of satisfying a desire of logical order—is to compare the whole circle of science thus obtained with similar generalisations of earlier times, to institute, in fact, historical comparisons for the eduction of historical laws and the rationalising of historical phenomena.

This, then, seems to indicate what is a chief cause of the want of interest in the history of chemistry. It is not so much that the facts of the history—or, as they may be called, chemical antiquities—are in themselves more or less interesting than any other mere facts, but that they have not always been dealt with in an interesting way; they have not been made to yield results which are of permanent interest in the science of laws, in the general development of thought. But to whatever cause we ascribe the deficiency of interest in the historical evolutions of the science—whether to the absorbing nature of facts and their experimental discovery, or to the still more devouring passion for practical applications of these facts to manufactures, which are to enable us to hold our own, as the phrase goes, against foreign competition, or to any other that

may be discovered—there can be no doubt as to the practical result, that no original work on the subject has appeared during the last five-and-forty years in this country. The want of historical interest, knowledge, and criticism was conspicuous when a recent occasion called for the exercise of all three, and when a feeble, half-spirited caveat was entered against a now famous utterance, as if the author of it were doubtful of the accuracy of his facts and the strength of his position. The treatment of history by the British writers is not of a kind to enable us to arrive at general ideas. As historians they have taken up what seems a perfectly barren position—they either apologise for, or petulantly complain of their facts. Their criticism, when there is any, consists in applying the historian's knowledge as a standard by which to judge that of a writer 50 or 100 or 1000 years earlier, without considering the manifold conditions and surroundings—some facilitating, others retarding—under which all knowledge is acquired at all times. So, instead of dealing with the chemistry of the Dark Ages, or of the time of Charles II., or of any other time as a fixed immutable phenomenon in the history of European thought, instead of searching for the causes from which these remarkable phases of science originated and prevailed to the extent they did, it has been too much the habit to find fault with the working of those epochs, to complain, for instance, that so much time was spent by the alchemists in trying to realise their belief that transmutation is possible, or to prepare the elixir of life. If any time could be spent to less purpose than that by the alchemists, it would be that spent by historians in complaining that the alchemists had so spent it.

And when we come to the minuter details of history, there is still a defect in the search for causes. There is much about what was discovered, but not about the why and how. The main question, however, ought to be, What is the idea which gave origin to a given course of investigation, or which dominated at a particular time? In how far was the idea confirmed, and thus became part of the established body of science, something which, being necessarily true, remains always available? Such methods of historical inquiry are those which attract the great bulk of mankind. It is the energising thought of the investigator which appeals direct to our own minds, and not the bare facts which he discovered. Contact with such a mind and with such thoughts is a far richer scientific training than the mere learning of secrets "wrung from Nature's close reserve;" and it is in history conceived in this spirit, not in

the dry calendar of dates and facts, that an ordinary human being finds rational interest and sympathy.

For the great bulk of mankind I have more hope of scientific culture being obtained by a study of the history of chemistry, or of some other branch of science, than by the little that can be got from lectures, and the less to be derived from current text-books. From the aridity of these last, no spring of human interest arises to quench the thirst of the student exhausted by the endless expanse of facts. And yet it was not always so; one has only to look back to some of the earlier treatises to find the discussions as well as the results. It would be curious to inquire into the origin of this change, but it is beside my present subject.

In what I have now said I speak, of course, of mental discipline by scientific methods, not of the training requisite for a man who is to make technical or professional use of chemistry. But just as any one, without knowing a syllable of Sanscrit or of Assyrian, can understand and value the deductions of modern philology, but, if he will become a linguistic investigator, must acquire different languages, so the majority of men who wish to have some acquaintance with the course of procedure and the results of chemistry, can learn from history what they never can master by personal experience. The educative value, in the wider sense, is one of the merits of the history of science, as has been pointed out by Dr. Whewell. "In the history of science," he says, "we see the infinite variety of Nature; of mental, no less than bodily nature; of the intellectual, as well as of the sensible world. The modes of generalisation of particulars—of ascent from the most actual things to the most abstract ideas—how different are they in botany, in chemistry, in geology, in physiology! Yet all most true and real; all most certain and solid; all of them genuine and indisputable lines of union and connection, by which the mind of man and the facts of the universe are bound together; by which the universe becomes a sphere with intellect for its centre; by which intellect becomes in no small degree able to bend to its purposes the powers of the universe." *

And, according to the same author, it thus becomes a corrective to ordinary abstract logic by the abundance of its matter and its inductive basis; in fact, it is only historically that a science can be

* *On the Influence of the History of Science upon Intellectual Education.* Lecture at the Royal Institution, p. 30.

taught inductively.* I should feel inclined, however, to ascribe higher than merely practical aims to the history; for, the recording of discovered facts being left to the science, the history should be concerned with the course of the discoveries, and the subjection of this course to the ideas of the epoch in which they were made.

In speaking as I have done of historians, I am perhaps guilty of dealing to them the same kind of criticism as they bestowed upon their predecessors. I am perhaps not considering sufficiently that when they wrote they were not so far removed from what were deemed pestilent errors as we are now, and especially that the higher method of regarding history was unknown to them. This, however, is but saying in other words that if the science has progressed during the last fifty years, so has the treatment of its history; that if new facts and generalisations have been added to the general system, new facts and generalisations have been won in the domain of history; that if, as I said before, a chemist feels it his duty rather to study the annual survey for 1874 than Bishop Watson's or Bergman's *Essays*, so the historian would not engage in the perusal of Thomson's or Brande's *Sketches*, if he had the recent contributions to chemical history of Dr. Kopp still to read, or Andrieu's exposition of *Alchemy*.†

It is our regret that, for the most recent information and newest lights upon the subject, we must go to France and Germany, because, with all our endeavours, we seem as unable to hold our own, to quote the phrase once more, against foreign competition in this department of investigation as in others. For the second time the Germans are engaged in recording the history of the sciences. The older series appeared about the beginning of the century, and it contained works which, in spite of the progress of discovery, are still valuable. The newer series is appearing under the joint patronage of the King of Bavaria and the Academy of Sciences at Munich, and is executed by some of the most distinguished specialists in Germany. We turn to France, and we find there a series of histories, not on the same scale as the German, it is true, but perhaps better suited for popular reading. It differs also in being a private enterprise; but this shews

* It is a modern fancy that a science should be taught inductively—that is, as the facts were discovered. It is unnecessary to confute so unpractical a notion; but it is worth while remembering that Berzelius anticipated it long ago, and pointed out its deficiencies.

† In the *Encyclopædia Britannica*, I. 459–467. Edin., 1875. 9th Edition.

the interest felt for science among the French. Both countries, and especially Germany, can also produce several histories of chemistry of greater or less value, written in recent times. One may regret, also, that such a body as the Royal Society,* or the British Association, is not able to organise a scheme similar to that of the Munich Academy, and to issue a series on the history of science in Britain during the last 150 or 200 years.

Among the problems which the history of chemistry affords, that of tracing the origin of the science is one of the most interesting, and at the same time most recondite. In searching for this we must not start with a preconceived notion of the importance of this or that period of history; we must try to attain it, not by carrying back the modern concept to a definite starting point, and not by supposing that the progress of chemical ideas was solely an outgrowth from the mind being directed in one course of observation and thinking. On the contrary, since the progress of ideas in one line of thought sooner or later conditions and is conditioned by progress in other branches of inquiry, and even originates new topics for investigation and discussion, we may rather look for chemical notions appearing from time to time incidentally in the midst of other developments of thought. As the idea of history—whether of special or of universal and philosophical—is that of evolution, from simple to complex relations and manifestations, we may expect chemistry not only in itself, but also in its general relations, as a body of ascertained and partially reasoned facts, to agree with this idea. The time, therefore, at which we shall choose to recognise the commencement of any special phase will depend very much upon the weight we attach to the details of the manifestation at the time we examine it, the delicacy of our perception of cause and effect, the germs or antecedents of thought and their outgrowth. But on whatever period we finally settle, we shall always find that the phase of the period immediately preceding to some extent determines that which follows—that, in short, the difficulty of finding an absolute beginning which is experienced in pure thought reproduces itself in merely temporal events.

There seems to have been a reason, though not exactly what they supposed, in the older historians pushing back the origin of their

* It must not be forgotten, however, that the Royal Society has recently done good historical work in compiling an index to scientific periodical literature.

science to the earliest periods of recorded chronology. They thought, perhaps, that since it was so venerable and weighty by its age, which was undoubted, it must be still more reverenced if it could be shewn to have had an existence from the very beginning of time. But if we follow the example thus set us, and also carry back to a very early time the origin of the modern science, it would be necessary to explain the sense in which the word origin is used. I should employ it then to denote, not a commencement relative or absolute, but rather the causes and conditions of growth, and the emergence of a defined course of thought from among a set of stray observations and casual remarks. What these causes and conditions were could be considered only in the history itself.

From what has been said there seem to be various ways in which the history of chemistry, like other histories, may be treated. Influenced by the importance of the ideas of any epoch, we may seek to bring them into prominence, and pass over slightly the manner in which they developed. To some extent this mode of dealing with history is not without advantages. It happens, however, sometimes that the ideas are not presented in their entirety in a concrete example. More frequently they dominate in the general tone of thought or manner of regarding phenomena, and it would accordingly require several examples for every side to be exhibited. In the selection of these examples, however, and treatment of them, it is possible to investigate the history of chemistry from another side, and with rather different results. For if we choose, as we must do, the best instances of any period—the representative men whom it presents—we shall arrive at a knowledge, not of the abstract impersonal ideas of the time, but the influence of these agents in embodying them, in modifying and reducing them to practice. Thus, if by the former process we recognise in the ideas the highest historical abstractions, obtained by the adjustment of many opposing claims, of many conflicting facts and hypotheses—and by filling up from other sources and knowledge of what ought to be, the imperfect notions inductively obtained — the embodiment of these ideas are the authors of the discoveries which led to them, the men who changed the aspect of the science for their successors, until their own changes had to be changed, and whose names designate their whole epoch. History of ideas becomes history of their ideas; and in contemplating what they attempted, and wherein they succeeded and failed, we obtain one of the lessons which history supplies.

It is not possible for me to enter on further details, to search out causes, or even to sketch, on the wide plan referred to above, an

outline of chemical history. The most that one can do, even supposing anything more were interesting, is to direct attention to the most salient features. To avoid one-sidedness, and to bring out more clearly the conditions under which general ideas sprung up and grew, it would be requisite to give some account of the men who lived during the epochs, as it is from their writings that we arrive at knowledge of the dominant thought of their time.

What has been said of ideas prevalent during a series of years points to and renders a classification or distribution of the subject according to these necessary. Each period is distinguished by well-marked features—though within itself these sometimes present very considerable variations, which it is of real importance to remember, since they naturally prevent hasty application of ill-defined generalities, or the conferring of a general title, whether opprobrious or laudatory on any period as a whole. Of still greater use are they when the attempt is made to estimate the typical men in an epoch, especially in the ascription to them either of all the faults or all the merits of their time.

The nature of the subject fortunately saves us the trouble of searching for a classification. It is of such a kind, indeed, that it rather forces itself upon us, and the consequence is, that all the best historians are agreed about the divisions which are to be adopted. Accordingly, it runs as follows :—

Period I.

This coincides in general with ancient history. It extends from the earliest period to the first centuries of the present era, and may be divided into three sections.

1. The history of chemical knowledge among the nations of antiquity, down to the seventh century, B.C. It includes what little is known of the chemical arts of the Indians, Egyptians, Hebrews, and other nations of antiquity. We can only judge of these from their metals, glass, colours, and other antiquities.

2. From 640, B.C., down to the second or third century, A.D. It includes the arts of the Greeks and Romans, both as judged from their remains and from the allusions in their literature, and especially their speculations. The latter attract us by the names of Thales, Empedocles, Democritus, Leucippus, Aristotle, Lucretius, and a host of others. This is the epoch of the subjective evolution of natural laws.

3. This section coincides with the rise and progress of mysticism in the later Alexandrian schools. It is in this period that chemistry

first appears as a branch of occult learning; and the germs of the idea which burst into full flower in the following period can be plainly traced in this. To this time also point the great number of Greek MSS. found in the public libraries of Europe, which deal with chemistry under the name of "the sacred art," and which have recently attracted so much attention among chemical historians. As yet our knowledge of these remains is very imperfect; but we have reason to believe that by a careful examination of them some light may be thrown upon the origin of the idea of transmutation. One thing seems certain, that the idea can be traced back to the third, or perhaps even the second century of our era, and that the name chemistry is of very early origin.

Period II.

This corresponds to the Middle Ages of European history. Just as in the political events of this period the East and West were closely associated, a similar connection existed in science and literature. This, which is the period of alchemy, embraces the great names of Rhazes, Avicenna, Djaber in the East, and the equally famous names of Albertus Magnus, Roger Bacon, Lully, and Basil Valentine in the West. It includes no fewer than seven centuries—from the eighth or ninth down to the sixteenth.

Period III.

At this time begins a new epoch, inaugurated by the zeal of Paracelsus—the epoch of medical chemistry. The theories of this time were of comparatively short duration. They dominated for barely two centuries, corresponding with the first two of modern history, after the Reformation. The chemists of this period were energetic and successful, and have left their names stamped deeply on the science to this day. Besides Paracelsus were Libavius, Glauber, Van Helmont, Agricola, and many others of great ability.

Period IV.

This falls within the seventeenth and eighteenth centuries, and it is the first in which chemistry stands out as a definite subject, with a special field of investigation apart from applications, with a body of ascertained facts and methods, and with what may be called a general principle. It was inaugurated by Boyle, reached its highest theoretical position in Stahl, and was concluded amidst the brilliant discoveries of Black, Cavendish, Priestley, and Scheele.

Period V.

A single step with Lavoisier brings us to the last period, that of modern chemistry. At this point history should properly stop; but though chemists still reckon Lavoisier's theories as permanent, there are many other men whose discoveries and reasonings have, from the progress of events, inevitably fallen into neglect, and have been for the present forgotten. It would be quite possible, therefore, to treat these even now from the historical point of view.

We cannot help being struck with the very different knowledge we have of these periods.

Of the first section of the first we are almost in complete ignorance, both as to details and general views. But when we come to the second section, our relations to it are so numerous and close, the biographies of the great men who then flourished, the customs and language, the literature and philosophy, the art and architecture have been so minutely examined, that we can fraternise with Greek and Roman over a gap of twenty or thirty centuries far more readily than with our own ancestors, the Saxons, who lived in our own country at an interval of less than half that time.

As we descend in the chronology, we find that individuals stand out more and more clearly defined, and the ideas by which they were influenced become more numerous and complex, more difficult to harmonise and combine.

Thus we arrive at the present, when facts and hypotheses are well known, when the individual men at work with them are familiar to us by name or acquaintance; but when the dominating idea by which this age will be hereafter referred to by posterity is, from its magnitude, comparatively unknown, even by those who are helping to fix it. Thus we return to the point from which we started, having learned by actual though very brief inspection, that the historical view of a science is not the science itself, as it appears at any one time, but is a branch of the wider science of life and philosophy, which has therefore to be cultivated in this wider spirit, if for no other end than the completion of the round of human knowledge.

Recent Inquiries into the Early History of Chemistry: Introductory Address to the Chemical Section. By JOHN FERGUSON, Esq., M.A., Professor of Chemistry in the University of Glasgow.

[Read before the Philosophical Society of Glasgow, Nov. 22, 1876.]

IT seems to me that an apology is due the Society for addressing it to-night, for everything that was open for me to say on the progress of chemistry during the year has been said. A review of scientific advance was given by Dr. Andrews in his address as President of the British Association, and all the more important manufactures, which have an interest for Glasgow, were reported on in detail by specially qualified members of this Society. I hope that the impulse which has been given this autumn to recording progress in the chemical arts may cause the appearance in future years of continuations of these reports to be read to the Society.

Anticipated, as I have thus been, in describing the advance in general discovery and technical applications, I shall consider to-night some recent inquiries into early chemical history, a subject of which one hears less than of others.

At the conclusion of the remarks with which I opened last session,* I gave a rough classification of the periods into which the history of chemistry falls. The first includes what we know (α) of the arts of the ancients involving chemistry; (β) of the arts of the Greeks and Romans, with the theoretical views of the former —that is, the period of classical antiquity from 640 B.C. down to the second or third century A.D.; and (γ) of the era of neoplatonism, of scepticism, and of mysticism, which prevailed from the second to the fifth century. I also remarked that it was to this third era that the Greek MSS. treating of "the sacred art," found in several European libraries, pointed, and it is to these MSS. I purpose directing your attention for a little at the present time.

At the beginning of his *History of Chemistry*, Dr. Thomson refers

* *Proceedings of the Philosophical Society of Glasgow*, vol. x., pp. 37, 38.

to this subject. * He quotes the well known passages from the lexicon of Suidas, who flourished in the eleventh century, and who, in his explanation of the word χημεία as the preparation of silver and gold, tells how the Emperor Diocletian sought out and burned the books on the subject, to prevent the Egyptians becoming rich thereby and resisting the Romans. The other passage is under the word δέρας, skin, where Suidas explains that the golden fleece won by the Argonauts through the love of Medea for Jason, was not a fleece of gold at all, but a skin, on which was written the mode of preparing gold chemically. "From these two passages," he proceeds, "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." He mentions that "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. † 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.' 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." He thereupon quotes the passage which narrates how the angels rewarded women for their love, by teaching them the operations of nature, and then adds:—

"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.

* *The History of Chemistry*, by Thomas Thomson, M.D., i. 3. London, 1830. The story about Diocletian has got into general history: it is referred to, for instance, by Gibbon, *Decline and Fall*, chap. xiii., who styles it "the first authentic event in the history of alchemy."

† *De Ortu et Progressu Chemiæ*, p. 12. [Hafniæ, 1668. Borrichius' words seem quite explicit: Verba *Zosimi*, quæ juxta mecum in Manuscriptis Biblioth. Reg. Parisinæ exstantia legit, adeoque in notis ad *Eusebii Chronica* jam ante expressit Scaliger, ita habent.]

Shaw has increased this list to eighty-nine.* But among these we find the names of Hermes, Isis, Horus, Democritus, Cleopatra, Porphyry, Plato, &c.—names which have undoubtedly 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;" . . . . after which the idea percolated by Spain into Western Europe.

In a following paragraph† Dr. Thomson, referring to the opinions respecting the origin of alchemy, again quotes the passage from Zosimus about the fallen angels or demons who revealed to the daughters of men the sublime art of chemistry, or the fabrication of gold and silver, and adds:—"It is quite unnecessary to refute this extravagant opinion, obviously founded on a misunderstanding of a passage in the sixth chapter of Genesis," in which "there is no mention whatever of angels, or of any information on science communicated by them to mankind."

This is practically all that is said on the subject by the chief British historian of chemistry, and it is eminently unsatisfactory. It is so, because the authors whom he mentions—Borrichius, Boerhaave, and especially Shaw—give a very large amount of information on the subject, which he might, at least, have quoted more at length, as he was professedly writing history; because the tone in which the above passages are written exhibits ignorance of the duties

* Shaw's *Translation of Boerhaave's Chemistry*, i. 20. [3rd Edit. London, 1753.]

† *History of Chemistry*, i. 8. London, 1830. The story as told by Zosimus is not taken from Genesis, but is similar to that given by Clemens Romanus, who flourished in the second or third century A.D. See *Homilies*, VIII., chap. xi–xiv. (English Translation in the Ante-Nicene Library, vol. xvii., pp. 142, 143), Edinburgh, 1870. And compare also the *Recognitions* of Clemens, Bk. I., chap. xxix. (Ante-Nicene Library, vol. iii., p. 163), Edinburgh, 1867.

of an historian, indicates that the author thought that historical conclusions could be arrived at by a different method from that by which conclusions—say, in chemistry—could be arrived at, and that assertions evidently unproved, at least by himself, could pass current in history, though they could not pass current in science; because he has applied no criticism to the statements of his authorities, but allowed them, full of curious matter as they are, to be forgotten; because, while admitting that the MSS. quoted by these authorities date back to the fifth century of our era, and that they are likely, therefore, to contain something, either positive or negative, about the state of chemistry in those days, he has not shewn any consciousness of this possibility—has not apparently put himself to the trouble of discovering if anything more was known about them. In short, the whole subject has been practically ignored by Thomson.

That there was a great deal to be ascertained recent investigation has shewn.

Since Thomson's history nothing has appeared on the subject in English, except by Mr. Rodwell, in some articles contributed to *Nature*, and afterwards reprinted in a single volume.* The author has said a little more about the Greek MSS. He has also described one in the National Library at Paris from personal inspection; but his decision respecting them all is adverse to their claims to antiquity, to their genuineness—that is, to their being really the work of the persons whose names they bear, and he seems to think that they are not so old as the fourth or fifth century, but were most probably written subsequent to the origin of alchemy, which he places in Arabia, not long prior to the eighth century.

The authority upon whom he seems chiefly to rely is the French chemical historian, Dr. Ferd. Hoefer.† Hoefer certainly has the merit of disentombing the Greek chemical MSS. of the Paris library, of describing them, and of giving extracts from them both in the original and in a French translation. He shewed, however, no evidence in the first edition of his history that he knew there were similar MSS. in existence elsewhere—that was excusable;

* *The Birth of Chemistry*, London, 1874. He does not specify which of the Paris MSS. he saw. His examination of the subject is quite brief; he mentions Borrichius and Juncker, in addition to Hoefer, but he does not seem to have noticed the extent and complexity of the questions involved, nor does he quote Kopp.

† *Histoire de la Chimie*, 2 vols. Paris, 1842-43. 2nd Edition, 2 vols., Paris, 1866-69.

but after twenty years, the new edition displayed no increase of knowledge, no proof of further research: the author had stopped short in his inquiry. As a critic and interpreter he is apt to be too easy and fanciful, and his inferences have sometimes to be toned down. It must be admitted, however, that the liberality of his interpretations arises from an enthusiasm in favour of the antiquity of knowledge of chemical facts, though these were interpreted very differently from what we do now. I can understand, therefore, Mr. Rodwell's distrust of the subject as given by Hoefer.

Three years subsequent to Hoefer's second edition, and four years, at least, prior to Mr. Rodwell's essay, appeared a work by Dr. Kopp of Heidelberg,* which has practically exhausted the subject up to the present time. In it he has given a review of the whole literature of the subject; and when I tell you that it occupies upwards of five hundred closely printed large octavo pages, you will be able to form a notion of how much has been written on it in past times, and how many points for discussion are opened up, and still have to be settled. Moreover, Dr. Kopp does not deal at all with what the MSS. contain, but principally with what is known of their origin and composition, the manner in which they came to Western Europe, their age, the number of tracts they severally contain, the nominal authors of these tracts, and their agreement and discrepancies, so far as can be gathered from tables of contents. He has also discussed some questions incidental to the main subject, such as the origin of the name chemistry, the earliest occurrence of it, the earliest occurrence of the idea of transmutation, or of the art of making gold and silver, and the early history of distillation. Into all these he has entered minutely and carefully, but has been very cautious in his inferences, because acquaintance with the present state of the inquiry only makes more apparent how much has still to be done before we are in a position to pronounce with any degree of confidence on these antiquarian matters. There is no doubt, however, that this work of Dr. Kopp's is the most important contribution to the literature of the history of chemistry made during many years. He has had the courage to take up a subject neglected by chemical historians, because despised; neglected by literary historians, because unintelligible and unattractive to them, and to examine it with the straightforward purpose of finding what it will yield, unbiassed by any feeling as to whether the product would prove

* *Beiträge zur Geschichte der Chemie*, Braunschweig, 1869. I published a short notice of this work in the *Academy*, September, 1870, I. 315.

valuable or not. This is, indeed, the only way in which such a topic could be approached; for to examine what one presupposes to be worthless is wasteful, and may lead to depreciation of what little merit it may chance to possess; whereas, to begin with great anticipations of valuable results, is likely, when these seem not to be forthcoming, to generate indifference to the whole matter. It is better, as Dr. Kopp has done, to start with the fact that this is a large subject, which has never been fairly examined, from which no one can tell what results may be obtained; let it be ascertained, therefore, whether it is a reality or an appearance, and then we shall be able to pronounce as to its value.

It is, of course, impossible for me to give in a short address a review of the whole subject; but I shall indicate some of the points, and may take another opportunity of entering more minutely into some of them.

The interest of the inquiry at present turns upon the existence of certain Greek manuscripts, which profess to deal with chemical or alchemical problems under various names. Among the questions that at once arise regarding them, there are the following:—How many MSS. are there? Are they on the whole the same, or are their contents essentially different? Are they all of the same age, or were they written by different persons, at different times, and at different places? Whence did they come to the Western libraries, where they are now preserved? What connection is there between them and contemporary or later chemical writings, and between them and earlier writings, if any exist? These and similar questions can be answered only by direct examination of the manuscripts; and as this has been done only partially for a few of the manuscripts, our information on some topics is an absolute blank, while on others what we have is defective and uncertain. Practically, indeed, the whole matter requires thorough investigation.

The Greek manuscripts which are known are preserved in the libraries enumerated in the following table.* The order followed is chronological, so far as dates could be got. Some libraries contain more than one MS. These are distinguished by numbers.

List of Greek Chemical or Alchemical MSS.

Where Preserved.	No. of Tracts.	Apparent Age.
Venice, St. Marks, . . .	43	Sæc. XI.–XII.
Paris, Radulphi, ...	12	
,, 2325, ...	8	End of Sæc. XIII.
,, 2329, ...	28	XV.

* The list is drawn up from Kopp's elaborate descriptions.

Where Preserved.	No. of Tracts.	Apparent Age.
Oxford, Bodleian, imperfect,	19 ?	Sæc. XV.
Leyden,	24	1440.
Paris, 2275,	14	1467.
,, 2327,	38	1486.
Wolfenbüttel, 2 copies,	8 & 4	
Florence,	53	End of Sæc. XV.
Paris, 2249,	11	XV.–XVI.
Montpellier,	32	
Turin,	12	XVI.
Munich,	29	XVI.
Middlehill,	6–7	XVI.
Paris, 2326,	4	XVI.
Escurial, A,	45	XVI.
,, B,	46	XVI.
Vienna, 2 copies,	32	1564.
Breslau,	15	1565.
Altenburg-Gotha,	34	1623.
Milan,	15	
Paris, 2250,	10	
,, 2252,	17	
Augsburg,		
Cologne,		
Cracow,		
Leipzig,		
Weimar,		
Wittenberg,		

This list which I have just read contains thirty MSS., supposing that there is no reduplication, and the age of them ranges from say the twelfth century down to the early years of the seventeenth, there being a number for which no dates are given. Manuscripts which stretch over a period of 500 years must necessarily contain a great number of variations. Every one who has compared even different printed editions of the same book is aware of variations, possibly minute, but still existing, and sometimes of great importance. Much greater differences, of course, exist in MSS., where the personal error of the transcriber comes much more into play than in printing; and every one who has had the curiosity to examine a critical edition, say of Horace or Virgil, or any other classical author, will soon be satisfied as to the variations in words, phrases, spelling, punctuation which the manuscripts display.

What the variations are in the present instance are unknown, for the text of any one of the manuscripts has never been printed at all; and, so far as I know, no two of the manuscripts have ever been compared. That considerable, perhaps important, divergences will be found when a collation is made, there can be little doubt.

The only comparison that has yet been made is that of their contents, by Dr. Kopp. The number of tracts in each thus determined, is given in the above table. It is impossible for me at present to give you all the names of the authors or the titles of the tracts, but the following is an enumeration of some of the more important :—

List of Authors.

Hermes.	Pelagios.	Salmanas.
Agathodæmon.	Olympiodoros.	Horus.
Isis.	Theophrastos.	Sophar.
Joannes.	Hierotheos.	Dioscoros.
Stephanos.	Archelaos.	Porphyrios.
Moses.	Anepigraphos.	Epibechios.
Maria.	Christianos.	Heraclius.
Democritos.	Plato.	Claudianus.
Synesios.	Aristoteles.	Sergius.
Zosimos.	Kosmas.	Nicephoros Blemmydas.
Kleopatra.	Pappos.	Isaac Monachus.
Komarios.	Psellos.	Iamblichos.
Heliodoros.	Ostanes.	

The following will give a notion of the kind of titles which seem to occur most frequently in these collections.

Zosimos,	Of the Virtue and Composition of Waters.
,,	Of the Divine Water.
,,	Of the Method of Confecting Gold.
,,	Of Chemical Instruments and Furnaces.
Heliodoros,	Of the Sacred Art of Chemists.
Theophrastos,	Of the Sacred and Divine Art.
Hierotheos, Archelaos, Pelagios, and Ostanes,	Of the Sacred Art.
Hierotheos,	Of the Stone of the Philosophers.
,,	Of Gold Making.
Anepigraphos,	Of the Divine Water; Of Dealbation, or Whitening.
Olympiodoros,	Of Gold Making.
,,	Of the Making of *Asēmos*, and Hydrarge, and Cinnabar.

The inference from a comparison of these lists is, that the manuscripts contain practically the same writings by the same authors—if we dare judge from mere titles—and that the chief difference is in the number of tracts the MSS. contain, and not in the tracts themselves.

The authors of the tracts obviously cannot be the writers of the MSS.; and if they were so in the oldest MS., that is, the Venetian,

the MSS. of subsequent centuries must have been copied from that or some other earlier MS. by others. In a few cases the MSS. bear the name of the copyist, the date, and place of writing; but this is the exception, and for most the date can be ascertained only by the tests applicable to MSS. in general, such as handwriting.

The fact of there being copies of different dates introduces another important factor. The value of a MS., from the historical or philological point of view—that is, as regards the purity and primitive form of the text—is not necessarily identical with that from the merely antiquarian one of age; or, the oldest MS. in point of time does not necessarily contain the oldest form of the text, except when the MS. is actually the original. This seems the case with these Greek MSS. The oldest of all is of the eleventh century, and it is preserved in the library of St. Mark's at Venice. It is of great importance, and it was described, its contents were enumerated, and a few extracts from it were printed in the year 1745.* But though the oldest and also one of the fullest, for it contains forty-three tracts, it does not appear to contain the oldest form of the text. This is approached more nearly by the Escurial MS. B, containing forty-six tracts, which is of much later date, having been written in the sixteenth century. This has been made probable from the following circumstance:—In both of these MSS., as in some others, there is contained a catalogue of Greek chemical writers which does not always correspond with the contents of the MSS., either in the order or actual number and description of the separate tracts. It so happens, however, that while the older Venetian MS., which contains this list, in its actual contents differs from it, the later Escurial MS. corresponds with it very closely. It would appear that there had been an original form, or at least an older one than any now known to exist, of which this catalogue is probably the index, and of which the best representative is the comparatively recent Escurial MS. B.†

You can well understand, however, that an elaborate comparison of these two MSS. would be required before it could be said what connection, if any, exists between them, and what clue there may be to the discovery of their true authorship and previous history.

* *Palladii de Febribus Concisa Synopsis Græce et Latine cum Notis Jo. Steph. Bernard. Accedunt Glossæ Chemicæ et Excerpta ex Poetis Chemicis ex Codice MS. Biblioth. D. Marci.* Lugd. Bat., 1745. Some account of the Greek chemists is given, and reference made to the St. Mark's MS., *un bellissimo codice*, by Giovanni Andres. *Dell' origine, progressi e stato attuale di ogni Letteratura*, vol. v., p. 205–213, Roma, 1813.

† Kopp, *Beiträge*, pp. 325, 331, Braunschweig, 1869.

Experience has shewn me how unexpectedly information turns up in out-of-the-way quarters, which enables one to settle without hesitation important facts or dates, and to demolish a whole superstructure of hypotheses founded with apparent stability on an assumed fact, which no one is prepared to call in question. For my own part, I believe that very interesting information might be gained by a collation of these MSS., and until this be done, opinions about them are—opinions. What has been accomplished in this direction hitherto is but small, when one remembers the labour, talent, and genius which have been lavished for centuries upon the ancient classical authors, and which is lavishing as copiously as ever, and, though to a much smaller extent, upon many later and less interesting and important writers. It is singular, however, that of all the scholars of the past who have caused the printing of piles of unread Greek and Latin, not one has attempted to print even respectable extracts from one of the collections. Promises of editions were made,* and fervent wishes for such were expressed by older scholars, but the former were never fulfilled, and the latter never gratified, and at most passages of a few pages have been reproduced.

The oldest printed collection, by Pizimenti, appeared in 1573. It contained writings of Democritus, Synesius, Pelagius, Stephanus, and Michael Psellus, but they were not in the Greek, but in a Latin translation. Nothing more was done till Fabricius printed in his great work † not only a collection of literary and bibliographical notices of the MSS., but also the text of writings of Heliodoros and of Synesios. In 1745, as I have already mentioned, extracts from the St. Mark's MS. were given by Jo. Steph. Bernard. They consist of passages in verse by the authors Theophrastos, Hierotheos, Archelaos, Heliodoros, Christianos, treating of χρυσοποιΐα, but the chief article is a Λέξικον κατὰ στοιχεῖον τῆς χρυσοποιΐας—that is, an Alphabetical Catalogue of Goldmaking,—which occupies twenty-eight pages. In 1777, Gruner edited the first *Actio* of Stephanos, with a Latin translation, from the Gotha and Breslau MSS.; and in 1807, the chemical vow or oath—*Isidis, Christiani et Pappi philosophi jusjurandum chemicum*—from the same MSS. At the end of last and beginning of this century, a work on the Paris MSS. was begun by Ameilhon, and extracts from it were published

* Leo Allatius, the librarian of the Vatican, spoke in 1634 of an edition of the Greek alchemists, but it never appeared.

† Fabricius, *Bibliotheca Græca*, Hamburg, 1718-28, and edited by Harles, Hamburg, 1790–1809.

from time to time; but he died in 1811, and nothing more was done. Next in order of time comes Ideler, who, in his edition of *Minor Greek Physicians and Physicists*, Berlin, 1841-42, includes tracts by Stephanos, Theophrastos, Hierotheos, and Archelaos, but without indicating the MS. or MSS. he had consulted. Lastly, Hoefer, in 1842-43, gave a few passages from the Paris MSS. by Zosimos and Olympiodoros, and the Epistle of Isis, and to these he added, in 1866, Greek extracts "On the Alchemy of the Egyptians," "On Symbols," "On the Opinions of the Ancient Philosophers respecting the Principle of Things," and "Hermetic Verses" [by John of Damascus (?)]. These extracts, however, form a mere drop in the bucket, compared with the whole.

The manuscripts and the authors are mentioned by several writers besides those already quoted. The earliest allusion to them by a Western alchemist, according to Kopp,* is in a *Treatise on Gold* by Pico della Mirandola, the nephew, who died in 1553.† He merely quotes the following as chemical authors:—Hostanes, Hermes, Democritus, Psellus, Olympiodorus, Heliodorus, Stephanus, Synesius, Theophilus, and Zosimus—all of whom are more or less prominent in the manuscripts. The older Western alchemists, such as Albertus Magnus, Roger Bacon, Arnold of Villanova, and Raymond Lully (all of whom flourished in the thirteenth and fourteenth cen-

* *Beiträge*, p. 321.

† This tract is contained in Manget's *Bibliotheca Chemica Curiosa*, Geneva, 1702, vol. ii., p. 563. In the list of chemical writers given in Nazari's *Il Metamorfosi Metallico et Humano*, Brescia, 1564, fol. 25–27, the names resembling those of the Greek MSS. are—Hermes, Democritus medicus, Agadimon (? Agathodæmon), Astanus (? Ostanes), Michael Psellius, Joannes Damascenus, Archelaij Turba, Theophilus, Maria. The following remarks on the subject by Gratarolus, which, so far as I remember, are not given by Kopp, may be added here, as shewing that these MSS. were well known in the sixteenth century. He refers to the alchemic interpretation of the story of Jason, to the burning of the books by Diocletian, and the Greek derivations of the name. Among the writers on the subject he has the following:—Blemidas, περὶ χρυσοποιίας, liber Græcus, manuscriptus in regia Galliæ bibliotheca. Isaac monachus scripsit ἀργύρου μέθοδον . . . in regia Galliæ bibliotheca, manuscriptus, Græcè. Zosimus author Græcus asseruatur in bibliotheca Regia: scripsit de Sacra arte, de Compositione aquarum ad χρυσοποιίαν, de instrumentis & caminis. Sunt & alij huius artis præceptores, ut Christianus, Heliodorus, Theophrastus, Archelaus, Pelagius, Ostanes, Olympiodorus, Democritus, Dioscurus, Synesius, & Stephanus, cuius est liber de Magna & sacra scientia. Omnes hi Græci sub nominibus antiquis, mihi tamen recentes uidentur. *Veræ Alchemiæ . . . Doctrina*, Basileæ, 1561. Prolegomena per G. Gratarolum. His last remark is interesting.

turies), and others who gave lists partly scriptural, partly mythological, partly real, do not exhibit any knowledge of the Greek writers. This was to be expected. Roger Bacon and his contemporary, Robert Grossteste, were almost the only men of their time who knew Greek; indeed, till the capture of Constantinople in the fifteenth century by the Turks, when many Greeks fled to Italy and Germany and France, bringing their language and literature with them, both were practically unknown in the West.* The European alchemists had, as it appears, obtained the principles of their art from the Arabic schools in Spain; and thus, while they never mention the Greeks, they are constantly alluding to Geber, Avicenna, Rhazes, and other Arabians. But after the sixteenth century, notices of these MSS. appear in various works, as in literary histories, and especially in library catalogues. None of the great collections of alchemical writings—Manget's *Bibliotheca*, Zetzner's *Theatrum Chemicum*, the *Museum Hermeticum*, &c.—contain treatises which, so far as I know, have been identified with any of the Greek.

Among the descriptions may be mentioned that of Reinesius, who states very clearly his opinion that the treatises were composed in Alexandria, brought to Constantinople, where they took form, and then were carried to the West by the Christian exiles. Reinesius, however, deals only with the Altenburg-Gotha MS. A MS. collection was also known to Gesner, and one belonged to the famous Dr. John Dee, the physician of Queen Elizabeth. At a later date, Borrichius enumerates the MSS. in the Vatican, at Paris, Venice, Munich, and Cologne.† Morhof also devotes a good deal of space to the question, and quotes Reinesius, Gesner, Dee, and Borrichius.‡ Fabricius adds those of Milan, the Escurial, Venice, Breslau, Gotha, and Wolfenbüttel; and Reuvens § mentions some of these, and adds Leyden. When it is remembered that the works of all these authors (except Reuvens), and of many others besides, were printed long prior to Dr. Thomas Thomson's history, it will be seen that he ignored the matter entirely.‖

* According to Warton, Greek was well known to the Saxon scholars. *History of English Poetry*, vol. i., p. cvi., London, 1840.

† Borrichius, *Hermetis, Ægyptiorum et Chemicorum Sapientia*, p. 79, Hafniæ, 1674.

‡ Morhof, *Polyhistor*, pp. 100-112, Lubecæ, 1714.

§ C. J. C. Reuvens, *Lettres à M. Letronne . . . sur les Papyres bilingues et Grecs, . . . du Musée . . . de l'Université de Leide.* Leide, 1830. Troisième Lettre.

‖ Dr. Thomson has the following note to Suidas in his *History*, p. 3:—"The word χημεία is said to occur in several Greek manuscripts of a much earlier date

Nothing has yet been said of the previous history of these collections. By whom were they made, at what time, and where? These are naturally the last questions which can be answered. Unless some of the MSS. themselves contain distinct indications of their authorship and date, the answers will be got only by sustained critical examination and a comparison with other literature of their supposed time. The indication at present is, that we have none of the first MSS., but only copies of greater or less value, which point to previous collections, either now destroyed or hidden in libraries where their very existence is unknown. The only indication of a compiler is in certain verses found in the Venice and Escurial B. copies, which have been printed by Steph. Bernardus. It is there said that the "loftily endowed understanding and the renowned spiritual gifts of an inspired Theodoros combined and arranged in this book the strange collection of all wise thoughts." Who Theodoros was is entirely unknown; and no other compiler is mentioned. As to the time at which the collections were made, Fabricius was of opinion that they are subsequent to the reign of the Emperor Heraklius, who reigned between 610 and 641. The separate treatises may have been composed before that time, and the collections made at any time prior to the eleventh century. There is nothing but ignorance on these points at present.

It is different when we inquire as to the scribes of particular MSS. In some the names are given, for instance—the Paris Codex, 2275, was written in 1467, by Manuel Rosati; No. 3178 (a MS. apparently lost now, but described by Montfaucon), in Crete, in 1478, by Theodoros Pelecanos, who was apparently a professional scribe; and No. 2327 was copied apparently by the same. A Greek scribe, Cornelius of Nauplia, living in Venice between 1560 and

[than Suidas, who flourished in the eleventh century]. 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 alchemy, 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." In the first part of this note Thomson declines to judge of a matter of fact upon which he could have acquired more knowledge had he referred to the older authorities. The second part of the note has no connection with the first. That a word is found in writings of a particular date is quite distinct from the question whether or not these belong to their reputed authors. But, apparently, as a plea for not investigating the matter of fact, he advances what could be ascertained only after thorough examination of the whole subject, what has not yet been ascertained, what, therefore, he did not know positively, but was merely his opinion. Had he been reasonable enough to collect and weigh the evidence, it existed almost in as great measure in 1830 as at the present time.

1570,* wrote the two Vienna MSS., and that at Breslau. These are quite recent; and if, as is possible, they are merely transcriptions of some of the older existing MSS., they can be only of very slight critical value. Their value, of course, would be raised if they are obviously independent of any of the other copies. In any case, the possible distinction must never be forgotten between the actual author, whoever he may have been, whether the same as, or, as is most probable, different from the ancient Greek whose name he bore, the compiler of the collection, and the transcriber of a particular copy.

As was to be expected the worth of these MSS. has been very variously estimated. Reinesius threw doubt upon their age and authenticity—that is, he did not believe that the treatises were the production of the ancient more famous men whose names were attached to them.† While I do not mean to say that the treatises are not supposititious, it is also possible to believe that the authors of some of them, at any rate, may have had the misfortune to have lawfully borne the names they are known by. Olaus Borrichius, again, attached very great importance to them, because he saw in them distinct proofs of the great antiquity of the Hermetic art, and he went the length of lamenting that so much time and labour had been spent on Martial and Petronius, while these MSS. were left to decay without attention. He was as bitterly opposed by Conring, who attacked the supposed antiquity of Hermes and the Hermetic science. Both sides of this discussion seem to be beside the subject; for, as in most such, the debate has turned less on what *is*, than on *what* has been said, or *how* it has been said. It may turn out, after properly conducted inquiry, that Hermes Trismegistus was a real person, and the Emerald Table genuine, recondite, and rare, or that they are both trumpery inventions of the Middle Ages; but there is little use in discussing opinions so long as defined facts are wanting.

Among modern critics, Hoefer, as I have already said, is inclined to set considerable value upon them, and to ascribe to the authors knowledge of chemical phenomena. Kopp, again, confesses that he has found less chemistry in them than he anticipated; but he also admits that this may be due to the phraseology employed, which, he says, is often quite unintelligible to him.

* Shaw's *Boerhaave's New Method of Chemistry*, vol. i., p. 20, London, 1753.

† Morhof, *Polyhistor*, p. 101, Lubecæ, 1714.

Mr. Rodwell also sets small value upon them, and sums up his views as follows * :—

"We have endeavoured to prove (α) that no reliable date can be assigned to existing Greek MSS. on alchemy, and (β) that the accepted date is too early. Even if we could prove that a man named Zosimus, living in the fourth century, wrote treatises on alchemy, we could not use the existing MSS. for any exact purpose connected with the history of science with safety; for since we have no such MS. earlier than the tenth or eleventh century, it would be quite impossible to determine whether additions had been made during transcription.† The facts are simply these:—there exist in various parts of the world Greek MSS. on alchemy, none of which are older than the tenth century.‡ Many of these bear the names of mythical personages of Egyptian mythology, some of ancient Greek philosophers, some of people who are supposed to have lived in the fourth or fifth century A.D. When we remember that no ancient writer makes mention of alchemy or chemistry, that the word χημεία is first used in the eleventh century,§ and when we further bear in mind the condition of the intellecual world in the fourth and fifth centuries, we think we may well admit that further evidence is necessary before we can assert that alchemy arose in the fourth century. Indeed, we are of opinion that, in spite of all that has been written on the subject, there is no good evidence to prove that alchemy and chemistry did not originate in Arabia not long prior to the eighth century A.D."

Fully to consider all the positions in this quotation, and merely to propose the doubts and questions which occur, would carry me beyond the limits of this address, and would, I fear, prove uninteresting to you. It would, in fact, involve the repetition in detail of

* *Birth of Chemistry*, p. 72. London, 1874.

† The author, I think, has gone rather too far here. The criticism which has been employed to such good purpose on the ancient classic authors, Horace, Virgil, Sophocles, &c., &c., the oldest MSS. of whose works are long subsequent to the dates at which they each lived, would be equally successful if applied to the text of the writings ascribed to Zosimus and the rest. Whether they would be worth *so much* attention is a different question. But see postscript.

‡ Eleventh century. See list of MSS. above, p. 6.

§ The word *chemia*, whatever it means, is met with in the "Mathesis" of Jul. Maternus Firmicus, who flourished in the fourth century. With respect to the date of the origin of the Greek MSS., the following remark of Kopp, which is almost stated as a thesis, may be quoted:—"It seems probable to me . . . that they (the MSS.), in part at least, owe their origin to the first centuries of our epoch" (*Beiträge*, p. 103–105). This is an opinion, or inference merely, it is true, but no one has shewn greater claims to have an opinion than Kopp.

much of Kopp's criticism, to which the author just quoted has not made any reference.

Allowing, however, that alchemy began in Arabia about the eighth century, there would still have to be considered the origin of these Greek writings. No similarity, so far as I know, has yet been traced between them. Whence, then, did the Greeks derive their notions? Supposing a similarity were to be traced, the question would be, which borrowed from the other, or did both borrow from a common source, say Egyptian, or Indian, or, as was recently re-advanced by Dr. Gladstone,* from China? In reply to the first, we know that in all other cases the Arabs borrowed from the Greeks—philosophy, especially mechanical and physical, and medicine. It would certainly be most unexpected if the Greeks borrowed their alchemy from the Arabs.† If, on the other hand, both borrowed from a common source, alchemy cannot be said to have originated in Arabia. In any case, the eighth century seems too modern. The works of Geber, if what we have are the genuine productions of a man who flourished in the eighth century, shew too great knowledge—a too confirmed and condensed reasoning for the subject treated of to have been of recent growth; and the author speaks of the *ancients*, a term he would hardly have applied to those who had cultivated an art which had begun fifty or even one hundred years before his time. We are not in the habit of calling Priestley and Lavoisier, or even Boyle or Lord Bacon, ancients.

In any case the connection between the Greek and Arabic writings would have to be made out—if there be any. Kopp seems to have no doubt that alchemy, if ever pursued in Egypt, was brought to Europe not by the Byzantine Greeks, but by way of Spain through the Arabs; and this certainly agrees with all we know of the events of the Saracen invasions and conquests.‡

* "The Birth of Alchemy." *Argonaut*, No. 25 for January, 1876, pp. 1–6. I say re-advanced, for the Chinese have been credited with a knowledge of chemistry for a very long time. Borrichius was of opinion that it was carried to them by the expeditions of Sesostris, or prior to these, and adds: "Unde & Chinenses plurimis ante Constantinum Magnum seculis arte Chemicâ inclaruere, ut ex *Martinii Histor. Chin.* liqvidum est. *Hoangtius*, inqvit, *in magna urbe Pukiang in Chemicis laboravit MMD. annis ante Christum*, qvanqvam & hoc paulò liberaliùs." *Hermetis...Sapientia*, p. 90, Hafniæ, 1674.

† See on the indebtedness of the Arabs to the Greeks for their learning, Warton's *History of English Poetry*, vol. i., p. xci., London 1840. In a note to this passage reference is made to Reinesius' "very curious account of the *Manuscript Collection of Greek Chemists* in the library of Saxe-Gotha," one of the few allusions in English to the MSS. known to me.

‡ *Beiträge*, p. 316.

Altogether, I think we are very far off at present from a settlement of most of these questions, and it is correct to suspend our opinion until some precise data are before us. The work to be done is laborious and unremunerative. The oldest and best MSS. should be ascertained and compared, and as complete a text as possible obtained, the date settled, and the contents, scientific and historical, sifted. These results have next to be compared with known Latin and Arabic authors—for whom a similar previous criticism would probably be indispensable—to detect similarities and differences. Then we might be able to speak to the value of the treatises.

The practical outcome would be to ascertain the origin, the progress and significance of that singular idea of transmutation which dominated for, say, ten or twelve centuries over all Europe, and compelled men to make for it the strangest sacrifices, even of life, to run great risks, and undergo the endless labour of ever frustrated hopes to realise it. I do not think we have yet got at the true meaning of the idea. It has been the habit to view it as the outgrowth of a superficial physical observation; this may have been the barest rudimentary form of the idea, but it soon became interwoven with astrology and astronomy, with symbols and mysticism, possibly with some forms of religion. But though we failed in getting at the origin of the idea, we might gain incidentally knowledge of physical and chemical facts and theories then observed and treasured. "The subject," says a writer in the *Quarterly Review* for 1821, "is curious in itself, even if it should not tend to the explanation of the kindred signs of the Egyptians; and no attempt to illustrate the wrecks of the physical knowledge of antiquity can be without utility." * Kopp, too, says that however foolish the contents of the MSS. may be, it is absurd to pass them by without something being done to ascertain their historical significance.† I would say that if the history of alchemy, as the predecessor of chemistry, has to be examined, so long as these MSS. are unemployed the history must be incomplete. Reuvens is probably correct when he affirms, that after all that has been done the history of early chemistry is still to be written.‡ We do not know how the idea originated, we do not know what aspect it presented to those who cultivated it, we do not know who strenuously adhered to it, and who merely talked about it and wrote about it. The

* *Quarterly Review*, vol. xxvi., p. 195. London, 1822.

† *Beiträge*, p. 255.

‡ Reuvens' *Lettres à M. Letronne*, . . . Leide, 1830, Troisième Lettre, p. 69.

language employed by the writers is exceedingly obscure; but it has seemed to me that if we could get at the central point—unless there be several, if you will excuse such a statement—the interpretation of the obscure language would be simple. The difficulty now is to get at the idea through the language. At the centre we should be able to trace the ramifications of the idea to the remote outskirts; but at the outskirts as we are, we are away from the centre, and can trace hardly any connection with other parts of the circle of old chemical views.

From what has been done within the last year or two, there are indications that the physical and medical knowledge of the early periods of our era are attracting attention, and are worthy of it. This last year extracts from Arabic authors on physical questions have been printed. From these it is obvious that the Arabs in the twelfth century were able to determine the specific gravity of different bodies with equal accuracy with ourselves, and there are indications of chemical knowledge in these extracts also.*

In his edition of the Arabic work *Fihrist*, Flügel alludes to the connection between the Greek MSS. and the Arabians, and says that Egypt is confessedly the home of alchemy—the black art—whose name *Kem* is of the same descent as chemistry, and points out coincidences in the names of the Greek authors with those in Oriental writings. †

These are indications of interest being taken by philologers in the early history of physical and chemical science. The most interesting notice of all, however, is that of a papyrus in the library at Leyden, which was described by M. Reuvens in the work already quoted above.‡ As this subject has not been mentioned in any English work, so far as I know, I shall abstract M. Reuvens' account.

The papyrus is 0·3 metre long by 0·18 metre broad—that is, a small folio. It contains ten sheets folded in two and stitched, thus forming twenty leaves, eight of which are written upon. These sixteen pages contain forty-five lines each, in a beautiful and legible

* *Quarterly Journal of Science*, No. LII., October, 1876, pp. 494–517.

† *Kitab-al-Fihrist*, Leipzig, 1872, 2er Band, pp. 186–196. This connection of the name of the science with that of the country was stated by J. Chartier in his work, *La Science du Plomb Sacré des Sages, ou de l'Antimoine*, . . . Paris, 1651, p. 5. See Kopp, *Beiträge*, p. 70, who has given various opinions as to this derivation, but has not quoted any allusion to it so early as this of Chartier's.

‡ Reuvens' *Lettres à M. Letronne*, . . . Leide, 1830, Troisième Lettre, Art. xi., Papyrus 66, p. 69, sqq.

uncial character. From the shape of the characters, it belongs to the time of the Constantines, or a little later (third or fourth century A.D.). It contains no contractions, except some for weights and measures. This curious book came from Thebes. It is not bound, but it is protected by the two outer leaves, which are left blank. M. Reuvens gives the contents, from which it seems to be occupied to a great extent with metallurgic chemistry and other technical matters. We meet with such phrases as *χρυσου δοκιμασια* (assay of gold), *αργυρου δοκιμασια* (assay of silver), *αργυρυυ καθαρσις* (purification of silver), *κασσιτερου καθαρσις* (purification of tin), *νιτρων* (nitre?), *κινναβαρει* (cinnabar), *καδμια* (calamine), *υδραργυρος* (quicksilver), &c., &c., words and phrases met with in the Greek MSS. already spoken of. Reuvens adds, "So far as I am able to judge, I believe that the history of alchemy, starting from the birth of this art, which goes back to the first century of our era, and drawn from original sources, is a study entirely to be done. It would exhibit the picture of one of the most curious aberrations of the human mind, and would doubtless furnish useful data for philology and the study of antiquity. It is known that all antiquity from the first authors who have mentioned chemistry, have regarded Egypt as the cradle of all knowledge referring to this art. One might even affirm, with M. Champollion,* that the primitive name of the country Chem, preserved by the Arabs, who have also retained a crowd of the original names of Egyptian towns, is the true etymology of the word chemistry, about which scholars have at all times been at variance. I presume that these small treatises on alchemy never have been published, because of the mystery with which the alchemists have always surrounded their science. There are, indeed, supposititious writings under the name of Hermes Trismegistus, Aristotle, and other personages famous in history, or quite fictitious; but these are in Latin, and are probably translations from the Greek or Arabic; for the Arabs were not less occupied with this vain science than the Greeks of the Lower Empire. But the great mass of ancient Greek writings of this kind were made into a collection, and imported into Europe, so far as one knows, at the fall of the Eastern Empire. They have not been edited." He then enumerates some of the libraries in which these MSS. are contained, and refers to previous use he had made of some passages when attempting to elucidate certain papyri on magic rites. "As to the papyrus

* *L'Egypte sous les Pharaons*, vol. i., p. 110, not. 2.

No. 66," he continues, "the chemical processes it contains seem to have related to certain arts and manufactures. But it is very likely that it also contains the first attempts of the adepts in the great work. The word *χρυσοποια* (gold making), is not in it, but the phrase *ασημου ποιησις* * [the making of the unmarked—*χρυσος ασημος*, uncoined gold] does occur, and is one of the formulæ frequently met with in the later Greek MSS. It means the *confection* of *silver*, which alchemically should precede gold. Perhaps they viewed gold as the quintessence of silver. The word *λευκωσις*, bleaching or whitening, is probably also connected with the same idea." Reuvens judges—but admits that he has no chemical knowledge—from comparison, that this word whitening is the same as calcination or oxidation: the alchemists detected a mystic relation between the colours white and red of the different metals (*rubeus* or yellow, *ξανθος*, *ξανθωσις*) and the formation of gold and silver.†

This papyrus has been designated by Kopp the oldest chemical MS., its date being not later than 400 A.D., and possibly as early as 200 A.D. From Reuvens, Kopp gives a pretty full description of it, points out the possibility of its titles, such as *χαλκου λευκωσις*, *χαλκου χρυσοφανους ποιησις*, &c., denoting that these changes are viewed from the alchemical and not from the technical side, and the similarity of the titles to those in the later MSS. In this papyrus there seems to be rather a collection of short receipts or extracts from various sources, than a consecutive treatise, so that even in it, old as it is, the primitive form may not be given. As yet no edition of this most important MS. for the history of chemistry has appeared. The papyri of the Leyden library are gradually publishing, so that this one also may appear in due time. It would be very interesting, however, to have a transcription now, and then we could better afford to wait for what is of course the most valuable thing—a fac-simile.

Though apparently the oldest known writing on chemistry at present, it is not impossible that others of greater antiquity may still be found. The discovery by Dr. Ebers of a papyrus of the sixteenth century B.C., which had been taken from a mummy case, raises the hope that something similar, bearing on chemistry, may also yet be found. This papyrus deals with medicine, and is entitled "The Hermetic Book of Medicines of the Ancient Egyp-

* "Ασημος is *silver*. Ducange, *Gloss. Gr.* v. *ἄσημιν*, etc. (Reuvens).

† Some of Reuvens' explanations I do not altogether agree with.

tians." It was printed in fac-simile, and was published in two volumes folio, in 1875, at Leipzig. The age of it seems undoubted; and if this be correct, it was written prior to the exodus of the Israelites. It appears to be one of the Hermetic books on medicine mentioned by Clemens Alexandrinus (200 A.D.), as the god Thuti or Thoth, who is the same as the Hermes Trismegistus of the Greeks, is mentioned in it. Of course, this Hermes was the person who instructed the Egyptians in the arts and sciences, in law and religion, and is the Hermes to whom all the alchemists looked as the oracle of their science.

If in this treatise we really have a Hermetic work, it is one of those hypotheses-demolishing facts to the existence of which I alluded above. There is no use in arguing against the antiquity of Hermes and the extent of his knowledge, if this be a veritable production, as old as Moses, in which Hermes is mentioned. These are points on which Egyptologists alone are entitled to speak. We may only hope that, from this and other similar writings, if such exist, some definite settlement may be arrived at of the long disputed date of the origin of alchemy, and to that extent of chemistry.

What I have now said is a very meagre sketch of the present state of the question. I regret that in the meantime I have not been able to give you the results of my own examination, either of the Leyden papyrus or of one of the MSS. But it may not have been uninteresting to see the directions in which modern scholarship is working its way into an antiquity which was only the vision of a dream to men like Borrichius, whose faith in their ideas was stronger than the proofs they could then bring in support of them; and the results shew how unsafe and unscientific it is to dogmatise on a subject, so very little examined as this has been, when we do not know what may be announced in to-morrow's newspaper or next week's journal.

Postscript.—With regard to the age of Zosimus, the following remark by Kopp (*Beiträge*, p. 55) may be quoted: "In an Egyptian writer on the art of transmuting metals, who perhaps, also, is to be placed in the fourth century (if not in a still earlier period): in Zosimos we find the word Chema," &c.

As to the value of the writings of Zosimos, no less a person than Beckmann has written as follows in his chapter on Indigo: "It is especially noteworthy that Zosimus, the chemist, declares the colour of the hyacinth of the ancients, that of woad, and of *μέλαν ἰνδικὸν*, to be the same or similar." And in the note to this passage

he adds: "As to the manuscripts of Zosimus, who is commonly called Panapolita, see *Fabricii Bibl. Græca*, vol. vi., pp. 612, 613; and vol. xii., pp. 748, 761. May I live to see the publication of them! They will certainly throw much light on the history of the arts. . . . It is remarkable that Zosimus calls indigo-dyers λαχωταὶ and ἰνδικοβάφοι, in order, perhaps, to distinguish them from the dyers with woad. The distinction, therefore, between indigo-dyers and those who dyed with woad must be very old." He further says, in reference to the confusion between *Indicum* and *Indicum nigrum*, indigo and Indian ink: "I should consider of far greater importance the opinion of the chemist Zosimus; but unfortunately his writings have not yet been printed. The period in which he lived is still uncertain, and it is still less known whether all the chemical manuscripts which bear that name were written by the same author." *Beyträge zur Geschichte der Erfindungen*, Bd. iv., pp. 504–506. Leipzig, 1799. *History of Inventions*, vol. ii., p. 269 (English Translation, 4th Ed.), Lond, 1846; in which, however, portions of the original have been omitted, a not unusual thing in this translation.

11 Centuries of Chemistry
see after next Track.

Eleven Centuries of Chemistry. Address on resigning the Presidency of the Chemical Section of the Philosophical Society. By JOHN FERGUSON, Esq., M.A., Professor of Chemistry in the University of Glasgow.

[Read before the Chemical Section, 11th November, 1878.]

IN accordance with a promise I made at the close of last Session, and seeing that I shall not have again an opportunity of addressing the Section officially, I am now desirous of presenting to your notice a few reflections on the science more especially cultivated here, in continuation and conclusion of those which I have already brought before you.*

I have been reminded by a look cast on chronological tables that this year, 1878, is the centenary of the birth of two of the most eminent discoverers of modern times, as well as that the year '78 has been more or less notable in the byegone annals of Chemistry. The title or idea of my present Address is, therefore, "Eleven Centuries of Chemistry."

Eleven hundred from eighteen hundred and seventy-eight leaves us with 778. I begin with that date, and ask what was known of Chemistry, and who were the chemists?

778. If chronology is to be depended on, a couple of years earlier, that is, in 776-7, the first and greatest of the mediæval chemists had died. He was the first—because, although he himself speaks of the ancients, meaning thereby his forerunners, nothing is known of those older chemists. He was the greatest—because his works have completely eclipsed or superseded those of his predecessors; because he had the greatest reputation among his contemporaries; because his works were numerous and important, his knowledge extensive and accurate, his theoretical views far-reaching, his practice, based on his facts and theories, logical and successful. His renown has come to us at the present unabated, he is quoted in every period until now, and he is referred to in the most recent text-books on pure and applied Chemistry. His science is safe to be known to all future genera-

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* *Proceedings of the Philosophical Society of Glasgow*, vol. x., p. 27 and p. 368.

tions. This chemist then, whom, though dead by 777, we may yet regard as the representative of 778, or of Chemistry in the eighth century, and the starting-point of our reflections, was called Dschabir, or more commonly Geber.

Hardly anything is known of his life. He was an Arab, born at Tarsus according to one account, was a pupil of Dschaafer ess-Sadik, whose works he edited, and was himself the reputed author of a vast number of works on almost every department of learning. He is best known, however, by his writings on Chemistry, which have descended to us in Latin translations made probably during the Middle Ages from the Arabic. These translations were published at the beginning of the sixteenth and during the seventeenth centuries, and, from the Latin, versions were made into English, French, and German. It was in 1678, just two hundred years ago, that the English translation appeared, to which I shall refer in due course.

From my having called Geber the greatest of mediæval chemists, I may have led you to expect something very wonderful, but it is possible you may be disappointed when the extent of his knowledge and scope of his science are put before you. Let me give you a short summary of both.

In his writings, then, Geber describes gold, silver, copper, tin, lead, and iron, and mercury. The first six were recognized as metals; their alloys were known, and their amalgams. That some of these metals could be converted into earthy powders by burning in the air, as well as by other processes, was also known. The oxides best known were of copper, iron, and mercury, and the yellow and red oxides of lead. White arsenic was a familiar substance, and its power of whitening copper is referred to in support of the author's general theory.

Sulphur was a substance regarded as of great value and importance. The native and purified sulphurs were made use of, but precipitated sulphur is described as well. The element was dissolved in an alkaline menstruum, and this was decomposed with acetic acid. Curiously, however, Geber does not remark the strong fetid odour which is produced in this decomposition. The effect of acting on copper and mercury with sulphur is specially referred to.

The alkaline carbonates are mentioned. Carbonate of potassium was obtained from cream of tartar by ignition, solution, and crystallization—sodic carbonate, or salt-alkali, from sea-shore plants. Caustic alkali was got by acting on the carbonate with caustic

lime. But no real distinction was made between the carbonates themselves, and between the alkalies in the mild and caustic states.

The mineral acids were employed. Sulphuric acid in an impure state was got by distilling alum. This water, as it is called, seems to have been used for acting on the metals, and on salts and other compounds. Nitric acid, called dissolving or solutive water, was prepared by distilling 1 lb. green vitriol, $\frac{1}{2}$ lb. nitre, $\frac{1}{4}$ lb. jameni alum. The red fumes which make their appearance in this operation seem to be noticed. By mixing sal ammoniac, or common salt, with the solutive water, a fluid was obtained which Geber says will dissolve gold, sulphur, and silver. He is right about two of these, but he is partially in error with regard to silver.

Acetic acid or vinegar is repeatedly mentioned, and it was got strong and pure by repeated distillation.

Geber's knowledge of saline substances was very considerable. He describes three varieties of alum, green vitriol, sal ammoniac, borax, saltpetre, common salt, nitrate of silver, corrosive sublimate, and terchloride of gold in solution.

Besides these he must have known a number of other salts produced by the mutual reactions of the strong acids with the metals, but as he does not describe them distinctly, it is hardly fair to enumerate them as part of his material. He describes, however, one or two acids of organic origin, and their solvent effects on certain substances.

Such is a brief catalogue of the substances or chemicals with which Geber worked. What were the operations to which he subjected them? They can be readily enumerated—solution, filtration, and crystallization. He employed these for the preparation and purification of salts of various kinds. Digestion at various degrees of heat was, of course, indispensable, as, for example, in the sun, in hot ashes, in the water bath—which he is one of the first chemists to describe—and in furnaces of different kinds. The construction of furnaces was to the old chemists a matter of the very greatest importance. At a time when there were no thermometers,* no gas, no spirit-lamps, it is easy to under-

* The thermometer was invented early in the 17th century, but no exact date is given. The earliest allusion to it for measuring differences of temperature for chemical purposes which I have seen, is in Lefebure's *Compleat Body of Chymistry*, London, 1664, 4to, part i., p. 95. There is a drawing of the instrument given besides.

stand that the chemists must have had to content themselves with very broad differences of temperature, and in fact they could do little else than distinguish between, *e.g.*, the temperature of boiling water and say a visible low red heat, between that and a red heat, between that and a fire urged to its utmost by vents and draught-holes placed in a particular way in the furnace. So important, however, was this subject of heat and its regulation felt, that Geber has written a separate treatise entitled, "Of Furnaces."

He was also quite familiar with the operations of cementation, *i.e.*, of purifying gold by means of a mixture of an alkaline carbonate and pounded bricks, and of cupellation, *i.e.*, of assaying or purifying gold by heating it with lead in a porous crucible called a *cupel*, made of pounded bone ash. The account he gives of this operation—apparently one of the oldest in metallurgical chemistry—is one of the most complete in the whole of his writings, and is so exact that it might be followed almost at the present day. Indeed, it bears a singular resemblance to the account of the same process given by the late Professor W. A. Miller, in his "Elements of Chemistry," part ii.

Another important operation was distillation, the separation of a more volatile from a less volatile fluid. It was employed for the preparation of nitric acid, the purification of acetic acid, and such like purposes. This has always been one of the most important of chemical processes, as it is undoubtedly one of the oldest. It was in use long before Geber's time, for, so far as one can gather, it was employed by the chemists at the beginning of our era—say 500 years before Geber. Indeed, there is every likelihood that so obvious and efficient a process must have been invented almost as soon as attention was directed to the ebullition and evaporation of fluids. The distillation described is of three kinds—ordinary distillation by ascent, distillation by descent, and what is called distillation by a filter—a species of filtration in which a bunch of fibres, or a piece of porous paper or cloth, is hung over the edge of a vessel with one end immersed in the fluid requiring filtration. Then, by capillary attraction, the fluid drains through the fibres and drops into a vessel placed beneath the projecting end.

And now, what was the theory which Geber maintained and tried to apply practically, besides defending it against the assaults of those persons who decried it? It was this:—The metals (then known) are bodies composed of two funda-

mental elements, one called mercury, the other sulphur. When these elements are in their purest possible state, most intimately mixed and digested with each other for a very long time in the earth, so as to form a perfectly equal and homogeneous body, the result is gold; and when the elemental sulphur is white, silver. The other metals are compounded of these same elemental substances, but they are in themselves less pure, being mingled with various earthy feculencies, and are not so thoroughly incorporated with each other. Hence, while gold and silver will stand to be heated in the air without change of substance, while they are dense and fulgent, highly extensible under the hammer, sonorous, and so on, and most difficult of attack by ordinary spirits and bodies, and will bear the trial of cementation and cupellation, all the other metals are acted on by fire and various agents. They have some of the properties of the nobler and more perfect metals, but they are quite deficient in others. It seems certain, however, from the changes observed in mines—for instance, iron tools in copper mines being gradually converted into copper; copper waters evaporated and digested in the sand by the heat of the sun yielding scales of most pure and perfect gold—that it is the intention of nature gradually to perfect these inferior metals, and by slow concoction to convert them into gold. By artificial processes, also, it is seen that these less perfect metals can be changed into one another. Geber asserts that he has seen lead converted by calcination into tin and *vice versa*. Now, since by a process of ripening, nature perfects the inferior metals, if there could be discovered any method of hastening this process, there should be nothing to prevent this conversion or transmutation being effected by human agency. According to the author, there is a way of effecting this, and a large part of his writings is devoted to the method. The transmutation is effected by the use of certain substances, which he calls *medicines;* and by a very clear course of argument he shows that there must be two for each imperfect metal—one medicine for the white, *i.e.* silver, and another for the red, *i.e.* gold. But he asserts that after an immense deal of labour he had discovered one medicine that would be efficacious when applied to any of the metals to ensure the transmutation of it to gold, and another, to silver. The idea he certainly works out very clearly; but the chief difficulty one has now, is in trying to understand what could have made such a clear thinker and observer as Geber suppose that he had in any particular case transmuted one metal into another. The only explanation

I can offer is, that there was the preconceived idea of the possibility, or, rather, natural necessity of progression towards perfection among the metals, that the *eduction* of one metal from another by a chemical process was interpreted, from ignorance of the permanence of bodies, to be *production* of the one metal from the other, and that he failed to verify by actual tests the results of his operations, and was thus untrue to his own principles. That Geber believed in transmutation, in a transmuting substance or substances, and in his having succeeded, is apparent in his writings.

The above, the composition of the metals, is the great principle which pervades his works; but one sees incidentally remarks of a general kind, which show that the author attempted to assign reasons for the phenomena he observed, or that these phenomena were merely illustrations of certain general principles. For example, the notion of affinity makes its appearance in its original form, viz., that of relationship. One substance acts upon another, because there is some kind of communion between them. Mercury amalgamates, therefore, rapidly with gold, and lead, and tin, but less readily with silver and copper, and not at all with iron, because it has so little mercury in its composition. From this he draws very cleverly a conclusion which I give in the original words (Russell's translation, p. 160):—

"Study in all your works that argentvive may excel in the commixtion. And if you can perfect by argentvive only, you will be the searcher out of a most precious perfection; and of the perfection of that, which overcomes the work of nature. For you may cleanse it most inwardly, to which mundification Nature cannot reach. But the probation of this, viz. that those bodies which contain a greater quantity of argentvive, are of greater perfection, is their easie reception of argentvive. For we see bodies of perfection amicably to embrace argentvive."

In the preceding I have culled just a few of the leading points of interest which are to be met with in the books of this father of modern chemistry, as he is not inappropriately termed. Were this a suitable opportunity, and if there were time enough it would be easy by giving quotations and descriptions to show how far the writer had advanced in the knowledge of certain classes of substances and reactions, and how sound his view was of the relations of man and nature. But as this would occupy a succession of hours I cannot undertake the task now. My object at present is rather to show the sum of his knowledge, and we find it comprised

in this very short statement: There are six metals and mercury, sulphur, and arsenic. There are two or three acids—solvents—and there is a variety of middle minerals and salts, some soluble and some insoluble. The substances, when subjected to certain operations, can be altered, decomposed, combined in a variety of ways. The agents, and processes, and apparatus are all of use for the great object of the whole science and art of Chemistry, viz., to transmute the imperfect or inferior metals into the superior perfect metals, gold and silver.

I have spent some time upon this author, partly because of his own very great merit, and partly because no theory ever broached in Chemistry has endured for such a length of time as his, has had so romantic a history, and has had such an influence. So far as the mere question of duration is concerned, no single author and no theory have survived as these have done. Not only were the opinions and ideas of Geber quoted by most of his successors, but his works have been often printed, and an edition appeared in German, with a commentary, so late as 1792. Nay, more, there was printed and published in London in the year 1850 a very singular work entitled *A Suggestive Enquiry into the Hermetic Mystery*, in which, among many others, Geber's works and views about transmutation are referred to, and apparently in perfectly good faith. I should not be surprised, indeed, to hear of some one at the present moment studying Geber's books, trusting implicitly in his views, and endeavouring to perfect the impure and imperfect metals by working on the lines indicated by him.

Quite distinct, however, from this particular persistence of Geber's doctrines to the present, the consideration of which would lead me into a totally different route from that which I have proposed to myself to follow in this address, there is the legitimate historical continuation of these same views in a different direction, and leading to quite different results. It is this continuation I propose to follow up, and, according to the title of my address, I should take the time by centuries.

978. For two of these centuries, from 777, the date of Geber's death, to 978, I have found hardly any name in chemistry at which I could halt. It is true that in 978 Avicenna was born, but though Avicenna was distinguished as a physician, or at all events as the great systematizer of medicine for the middle ages, and though he seems to have believed in the general principle of transmutation, he made no advances, and rather employed Chemistry as

an aid to medicine and pharmacy. It must not be forgotten, however, that the influence he exercised as a physician was literally unbounded down to the sixteenth century. Just as the church held men's minds enthralled on theology, and philosophy, and every-day life, so Avicenna's word was final in medicine, and was worth any number of other men's reasons. This lasted until the sixteenth century, when the influence of the church was attacked by Luther, and that of Avicenna was demolished by Paracelsus.

From 978, the birth year of Avicenna, down to 1278, there is again hardly a name to be quoted in the History of Chemistry. The only exceptions, perhaps, are Albertus Magnus, who was born in 1193, and died about 1280; Roger Bacon, born about 1214, died 1274; Michael the Scot, born about 1200, died about 1270-80. These are names better known in the history of philosophy, and physics, and Aristotelian learning, than in Chemistry. All three are credited with chemical writings; but these contain little more than a recapitulation of Geber's doctrines: the theory of composition and transmutation is the same, and as for the positive knowledge of substances there is nothing to add.

1278. Perhaps the true representative of Chemistry in 1278 is Raymund Lully, who was born in the island of Majorca in 1235, and died in 1315.* About this time, therefore, he was in his forty-third year, and he had already spent an adventurous life. He had travelled in Spain, and Italy, and France, and Africa, studying Arabic, and trying to convert the infidels. In Milan he took to alchemy, and, long after, he succeeded in preparing the philosopher's stone, with which in England he effected several historical transmutations. These appear in all the histories by the partisans and defenders of alchemy as among the best authenticated cases. Apart from this, however, there is his actual Chemistry, which remains in his very numerous writings. His general theoretical views, like those of Bacon, Albertus Magnus, and Arnold of Villanova, are still Geber's. He believed in the composition of the metals, and of necessity in their relationship and mutual transformation. He was, besides, quite familiar with all the facts of the science that had been discovered in the 500 years which had elapsed from the days of Geber. For example, he could prepare alcohol by distilling red wine, and he could make it

* Some say 1335. There is a good deal of confusion about the events of Lully's life.

stronger and more volatile by distilling it over carbonate of potassium. He also knew that it was inflammable. He is the first to mention carbonate of ammonia (sal volatile), and to show that it is precipitated by addition of alcohol to its aqueous solution. He was, besides, a clever manipulator, and describes various plans he adopted to effect his aims. He made use of lutes in distillation, to prevent the escape of the volatile portions, and he coated his glass vessels with clay, to prevent them cracking by exposure to heat.

There is no doubt, however, that in Raymund Lully there was a good deal of the charlatan, and, in fact, his life is that of a busy adventurer, who rather looked to transmutation as a means of getting money for his ideas about waging war against and converting Turks and infidels, than for love of science and the solution of a great problem. He complains bitterly, indeed, of the time he had spent over the works of Geber, and the futility of his exertions, and said that it was never by reading these, or any other books, that the great mystery could be attained.

1278-1478. It had been found, at last, by slow experience, that while certain actions and products were easy to obtain, the thing for which all the trouble was taken always slipped through the grasp of the experimenter, while the belief in its possibility took stronger hold on men's minds than ever. Hence, in the century, or rather the two centuries, succeeding Lully, from 1278 down to 1478, should be placed the period of alchemy pure and simple, during which the attempt to realise in practice the problem which we have seen stated originally and clearly by Geber, had, in the 700 years which had elapsed since his death, very much altered its character. It had become less definite, less precise in men's minds. Investigation and experiment, even with a quite mistaken aim, had increased the knowledge of different bodies, had brought new properties to light, and had thereby complicated the question. And on the other hand, men with deficient insight into the practical side of the subject, had begun to surround it with enigmatical and mystical views, which partook rather of an attempt to construct a physical cosmogony, than to solve a definite chemical problem. Those, again, who still trusted in their operations, left the purely alchemical question, and took up incidental points which would subserve the main end, but themselves first required examination.

Accordingly, in this interval we meet with the famous adept Nicolas Flamel, whose story is such an extraordinary one that some writers assert, and not without plausibility, that it is

nothing but an allegorical account of the preparation of the philosopher's stone; and whose writings, or at least those ascribed to him, are full of what appears at first sight to be a set of conundrums, couched in very obscure language.

Just 400 years ago, also, lived George Ripley, Canon of Bridlington, Yorkshire, who worked at the Hermetic art, travelled on the Continent and lived long in Rome, and finally returned to his native country in 1478 in possession of the secret. He entered the Carmelite Order, lived a very retired life, was suspected of magic, wrote several books, one of the chief of which is the "*Book of the 12 Gates*," spent enormous sums in the defence of Europe, especially of the Island of Rhodes, against the Turks, and died about 1490. Through the mist of language one can see that he held the Geberian view of the composition of the metals, but added nothing to what was known of chemical facts. He seems, however, to have thought that the philosopher's stone, if it could be got, would be the best of all medicines for human ailments.

But while in the 15th century alchemy was flourishing in the highest degree, there was a Benedictine monk at Erfurt, who was investigating a substance which had been known for long, but which does not play any prominent part in the previous history of Chemistry. This monk was called Basil Valentine, and the substance he examined was antimony.

As in previous cases, however, there is considerable doubt as to the existence of a real person of this name at the date mentioned, and very considerable doubt as to the manner in which his writings (which were concealed in a hole in a wall) were disclosed, long after his death, by the place being opened by a thunderbolt. It seems that in the list of the friars at Erfurt, Basil Valentine's name does not occur, so that all the rest of the story is probably an invention, but there is no doubt about the existence of the books, whatever may be said of their true date and authorship.

The chief work of this author is entitled the *Triumphant Chariot of Antimony*, and though the author, both in it and in other works, shows that he was quite imbued with alchemical notions, he must have amassed an immense amount of knowledge about bodies in general, and antimony in particular, either by his own exertions, or by reading what others had done. If the latter, the authors that he consulted are no longer in existence; but on all accounts, it seems more correct to believe that the most of what he describes was his own discovery.

This work, which, with Kerkringius' Commentary, forms a small 8vo volume, was repeatedly published in Latin, English, and German. It is very difficult to say, in these old treatises, what is original and what has been added; but it would take a long time, in either case, to recapitulate the facts with which this work abounds. In one word, it contains almost every preparation of antimony that was known up to the beginning of this century. The sulphide, oxide, chloride, oxychloride, tartar emetic, and other compounds, can all be identified, and incidentally a great number of other bodies and reactions. Thus, for instance, spirit of salt is mentioned, and the extraction of metals in the wet way—for example, copper from pyrites, by allowing it to turn into vitriol by the humidity of the air, dissolving the vitriol in water, and adding to the solution a plate of iron. Were I to enter into the details given by this author, and show you not only his facts, but his erroneous and often inverted views, I should occupy more than the time at my disposal.

Basil Valentine is one of the most important of the names belonging to the alchemical period. He himself claims to have been possessed of the philosopher's stone, but his writings, as repositories of facts, and more definite scientific insight into reactions and into the permanency of matter, are among the most valuable remains of the older chemical literature, and will repay perusal by any one who is interested in seeing how the science gradually developed. He is not only ahead of Geber in the number of his facts, but he advanced also in his theory of composition; for, in addition to sulphur and mercury, he considered salt as an element, and maintained that these three were contained, not only in the metals, but in other substances as well. He agreed, however, with Geber in this, that the differences among the metals turned upon the different proportions and different degrees of purity of their constituents. But, on the other hand, he proposed views about relations between the metals and the planets in a small tractate, to which, as one writer has said, there are few parallels in its madness, even among the writings of this period. In practical chemistry, however, he was wonderfully skilled for his time; for not only are we indebted to him for a knowledge of antimony, as I have already said, but he seems to have had some idea about qualitative analysis. At any rate, he was able to detect several metals when mixed in small traces with others; and points out that a good deal of the apparent transmutation, which was used by the cheating alchemists of the

time to impose upon those ignorant of metals, was the effect of mixing metals in different proportions; and he showed that these mixtures contained no gold or silver.

Thus, at the end of the 15th century, during 800 years, chemists had made distinct progress in the knowledge of different substances. But two things remained unchanged—1st, the aim, to transmute inferior metals into gold and silver; 2nd, the general theory of composition of the metals. The only advance was to include under Chemistry other substances, and to ascribe to them the same composition. Parallel, too, with this purely scientific side of the subject, had undoubtedly run an applied or practical side. Medical men, alive to the importance of getting new medicines, had not been slow to avail themselves of the newly-discovered compounds; and hence the *Triumphant Chariot of Antimony* contains allusions to the medicinal effects of the antimonial compounds.

1578. I ask you, therefore, now to pass to the next centennial period, to 1578, and observe the changes.

In the interval a man had lived, who, deficient in learning and training, deficient in every grace of manner, of a common, some have said of a vicious and debased, life, had altered almost the whole face of an important branch of science. This was Paracelsus, who lived from 1493 to 1541. He it was who attacked and overthrew the Galenic and Arabic medicine, who freed men from the influence of an authority which had become an incubus, rather than a rational help, who gave a fresh impulse to inquiry without dread of the consequences. He it was who did away with the terrible prescriptions of the then physicians, and introduced what were distinctly called chemical medicines. But he did not confine himself to this alone. He attempted to give a rational explanation of disease by founding on chemical actions in the body. It is needless to say how vain this attempt was in the sixteenth, when physicians and physiologists are not yet ready for it in the nineteenth, century; but Paracelsus gave an impulse to the study of medical Chemistry, as distinct from alchemy, which lasted down to the beginning of the present century, and is well seen in the fact of Chemistry having been almost always pursued until then by medical men, and forming an essential part of a medical training. But Paracelsus' views had not carried conviction universally. He was keenly opposed by upholders of the older system, and as Paracelsus was far from being perfect or logical in his doctrines, it was not difficult to refute many of his positions. Still, his influence was felt in the

impulse he gave less prejudiced physicians to examine many bodies chemically, with the hope of discovering new and active remedies, and if possible to explain the actions in the human economy.

The most important contributions to Chemistry under these conditions were made by Libavius, who was born in 1560 and died in 1616. His work was done a little later than 1578, but he is the best representative of the time. He is distinguished by his firmness and moderation, by his learning and indomitable labour as a writer and controversialist, and also by his success as a discoverer. In 1597 he published a treatise on Chemistry, and in 1606 a collection of his works appeared at Francfort in three volumes folio. These volumes contain pretty nearly all the chemical knowledge of the time; and as they are furnished with very good drawings of apparatus, and also of a laboratory, the arrangements of which are fully described, we may regard them as forming perhaps the first text-book or manual on general Chemistry which had appeared.

The author still upheld the doctrine of composition from salt, sulphur, and mercury, but the importance of such vague elemental principles was not very much insisted upon. At any rate they were employed rather to express certain qualities or properties of bodies than anything about their ultimate composition. But in knowledge of the habits of bodies, and in the analytical discrimination of bodies, the author was far advanced. Thus, one of his treatises is devoted to the examination and analysis of mineral water, and for the period—300 years ago—is remarkably well done. To one of his discoveries the author has given his name: the *fuming liquor of Libavius.* This salt, the perchloride of tin, he prepared by distilling tin with corrosive sublimate, a method largely used by the older chemists for getting anhydrous chlorides.

In Libavius' time experiments were made upon dogs and cats and other animals. Libavius remarks that these are not altogether worthy of confidence, because animals are differently affected from men, and even among men there are not two temperaments which exactly resemble one another; and it is therefore impossible that the results should be absolute and applicable to every case. He was very shrewd in his ideas, and he showed himself a skilled observer in being able to recognize the identity of a substance prepared in two different ways. Thus, he saw that sulphuric acid got by distillation was the same as that which is formed when

what he called the acid spirit of sulphur, dissolved in water, is converted into the stronger and less volatile acid liquor.

You will remember that in the general course of history the sixteenth century is one of the most notable. The spread of the Reformation, the discovery of America, inventions and discoveries in astronomy and other branches of physics, and the extraordinary burst of literary genius—all these showed that some enormous clog had been removed from the human spirit, and that it was revelling in its newly acquired liberty. It was not to be expected, of course, that all would share in this progress alike, but one can see an immense advance and insight in general. The idea of science, as distinguished from ecclesiastical and scholastic dogmatism and authority, had struck root; and it was formulated and worked out by Lord Bacon at the beginning of the seventeenth century, and dominated in the work of that century.

1678. Of all byegone periods in the history of Chemistry the seventeenth century is one of the most remarkable. It was prolific in the highest degree in chemical writings of every kind of merit —from the clearest statements of facts by Glauber and Glaser and Lemery, and the most trenchant criticism by Boyle, down to the vaguest and most unintelligible allegories by those who still cherished the dream of a mystical philosopher's stone.

In fact, the cultivators of the subject are divisible into several groups, and if I just mention a few of the works which were published about 1678—200 years ago—you will understand what very different kinds of chemists there must have been.

Well, there were published in London in 1678 :—

The Works of Geber, the Arabian Prince and Philosopher. By Richard Russell.

Basil Valentine: his triumphant Chariot of Antimony; with Annotations of Theodore Kirkringius, M.D. Also by Richard Russell.

Ripley Revived; or, an Exposition upon Sir George Ripley's Hermetico-Poetical Works; written by Eirenæus Philalethes.

I have already spoken about Geber and Basil Valentine; but this third work is in the usual style of alchemical allegory, though it contains some plain chemical processes.* Alongside of these

* Besides these there is a swarm of alchemical works bearing date from 1660 to 1680.

there appeared quite a different set of chemical treatises. I need mention only those of Glaser and Lemery, and the corresponding little manuals of Bolnest, Thibaut, and others.* All these works are clear, and undisfigured by alchemical notions. Their aim is to describe the preparation of mineral and other substances for use in medicine, and they bear the same family resemblance to one another that the smaller text-books of the present day do among themselves.

But the authors still believed in the composition of metals from salt, sulphur and mercury, and worked away upon this theory with tolerable success. It requires an effort for us to believe that in the early years of the Royal Society such should have been the prevalent theory, and that one of the founders of that Society, the Hon. Robert Boyle, should have thought it necessary to argue against these principles. This, however, he did, and so wide-spread were these opinions that the work in which his arguments were contained, and which was published in 1680, bears as its title *The Sceptical Chymist.* In this work he refutes both the Aristotelian elements and the chemical triad, and gives as the true definition of an element that which is maintained at present.

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* *The Compleat Chymist: or, a New Treatise of Chymistry.... Written in French by Christopher Glaser. Faithfully Englished by a Fellow of the Royal Society. Illustrated with copper plates.* London, 1677. 12mo. [I read a notice of Glaser's Life and Works to the Chemical Section, January 27, 1873.]

A Course of Chymistry.... Writ in French by Monsieur Nicholas Lemery. Translated by Walter Harris, Doctor of Physick. London, 1677. 12mo.

The Art of Chymistry: as it is now practised. Written in French by P. Thibaut...and now translated into English by a Fellow of the Royal Society. London, 1675. 12mo.

Aurora Chymica: or, a rational way of preparing Animals, Vegetables, and Minerals for a Physical Use...Authore Edwardo Bolnest." London, 1672. 12mo.

The Curious Distillatory: or, the Art of Distilling Coloured Liquors, Spirits, Oyls, &c., from Vegitables, Animals, Minerals, and Metals. Written by Jo. Sigis. Esholt. Put into English by T. S. London, 1677. 12mo.

Such works are very numerous. Nor should it be forgotten that in 1675 the first bibliography of chemical books, including the first attempt to catalogue the chemical papers in the Royal Society's Transactions, was published at London by Will. Cooper, an indefatigable labourer in the cause of chemical literature.

But it took very long before Boyle's idea was adopted—in fact, I question whether in the popular mind it has been adopted yet. It exercised little or no influence on the chemical work of the following century, and the arguments drawn from experiment had to be put in force again for so important a substance as chlorine.

1778. The interval between 1678-1778 was a very eventful one. A whole theoretical epoch is included—the epoch of Phlogiston. Erroneous that theory may have been, but under it Chemistry became a science, and the new substances and reactions, and general principles and methods discovered were more than equal to those of the preceding ten centuries. To say nothing of the discovery of the gases, and of new metals, analytical Chemistry and technical and manufacturing Chemistry came into existence, and the ball which had been slowly rolling, but was gradually acquiring increased velocity, was now bounding along without a stop. Prior to 1778—in 1772—had begun the attack by Lavoisier on the Phlogistic system. It was concluded for himself by 1778, or shortly after, but it was some years before it had asserted its supremacy among the chemists of Europe.

The last quarter of the eighteenth century was distinguished not only by Lavoisier's great reform in the manner of regarding combustion, but by a succession of chemists whose lives overlap, and who one and all have left deep marks on the science.

Beginning with	Black,	Born 1728—1799
We have	Cavendish,	1731—1810
	Priestley,	1733—1804
	Bergman,	1735—1784
	James Watt,	1736—1819
	Watson,	1737—1816
	Scheele,	1742—1786
	Lavoisier,	1743—1794
	Berthollet,	1748—1822
	Fourcroy,	1755—1809
	Richter,	1762—1807
	Vauquelin,	1763—1829
	Wollaston,	1766—1828
	Dalton,	1766—1844
	Thomas Thomson,	1773—1852
	Thénard,	1777—1857
	Labarraque,	1777—1850
	Courtois,	1777—1838

And then in 1778 we have the illustrious names of Gay-Lussac

and Davy—the former born on the 6th of December, the latter on the 17th.

Berzelius, ... 1779—1848

And the last great name of the century—

Faraday, ... 1791—1867

A century ago, therefore, there were the beginnings of modern Chemical Science, and it has been impressed on me over and over again, when looking at history, chronology and biography, that there are epochs in which human genius displays itself resplendently at once, and that there is a similarity in this respect between the close of the sixteenth and eighteenth centuries. Remember that it was not in Chemistry alone that there was an array of talent, but in poetry and literature, in exploration at home and abroad, in war—Nelson and Picton were born in 1758, Napoleon was born in 1768, Wellington, Soult, and Ney in 1769—in politics and oratory, in philosophy and history, there was the same unstinted production.

But our attention is more especially called to the fact that we are on the eve of the centenary of the birth of Gay-Lussac and Davy—two of the greatest discoverers in Chemical Science the world has produced.

I need only remind you of Davy's great researches: nitrous oxide; electric conduction and decomposition—resulting, on the one hand, in the separation of potassium and sodium, the decomposition of the earths following as a necessary consequence, and on the other in the electro-chemical theory; iodine and chlorine—resulting in the extension and confirmation of the word element, the discovery of the so-called hydrogen acids, and the important modification of the French theory of the constitution of acids; the investigation of gaseous explosion and of flame, and the invention of the safety lamp. These are the contributions to science which stand out more prominently in connection with Davy. But over and above all this is the peculiar manner of his discoveries. He was no patient plodder. He did not elaborate his work in minute detail. He dashed it off in broad masses; but just on that account there has never been anyone to follow up his investigations. Davy's mantle fell on no one, not even on Faraday.

Gay-Lussac's work is of a different kind. Less broad and striking, it is of the most thorough and comprehensive kind. Though he did not discover potassium, he invented a mode of preparing it in

practical quantity. He did not at once grasp the significance of the elemental characters of iodine and chlorine, and was not at once prepared to accept the hydrogen acid theory, but he did at last give in his adherence, and his monograph on iodine and its compounds is a classical research, and exhausted the subject. Gay-Lussac's name is indissolubly connected with the discovery of cyanogen, the first compound and separable radical. He was one of the first to make balloon ascents for scientific purposes. But his greatest contribution to Chemical Science is the enunciation of the law of volume combination, which has certainly proved the resting place of modern theory. This law is the complement of that of combination by weight, and it had escaped Lavoisier and all the other chemists who had investigated the composition of water. Gay-Lussac's researches are very numerous, and extend to every department of the science. In especial he improved the method of making combustions of organic substances, and introduced the wet assay of silver by a standard solution of common salt, the volumetric estimation of bleaching solutions by arsenious acid, and alkalimetry by standard sulphuric acid. These are only some of the discoveries and inventions with which he enriched the science, and whether we consider his insight and calm power of working out his results, his wide views, his dexterity as a manipulator, and the persistence of his inventions, we can quite appreciate and agree with Sir Humphry Davy's observation that of all the French chemists of that time Gay-Lussac was the most distinguished.

It is too soon, and it is hardly the place, to celebrate the centenary of these two men of world-wide fame, but it is well to recall the memory of those to whom the human race is indebted for its progress, for its enlightenment, and for its well-being. From the days of Geber until now there never have been wanting willing and able hands to carry on the work. Some, like Davy, with everything in their favour, with almost everything successful, loaded with honours and gifts, and rewarded with the expressed thanks and gratitude of those he benefited. Others, like Glauber, who toiled and laboured and made his discoveries, but received no good of them, was neglected and died in abject poverty and misery. It is not for us to say what verdict will be passed a century hence on 1878. Before that time there will be a great sifting of knowledge. I cannot help thinking that at the present moment we have come to a period of stagnation in almost every department of human

effort—notably so in Chemistry. There is a good deal of working up of detail, and efforts are making to strike out new paths in theory, but the whole chemical world is in a state of back water. It may not be in our time, but I have little doubt that long before the year 1978 chemical action will be regarded in a very different way from what it is now. One can see almost already that the formulæ of statical chemistry are doomed. As expressions of final results they may still survive for a while, but, as all chemists know, the chemistry is not in the final balanced result but in the transition from one state of balanced rest to another. Dynamical formulæ must come sooner or later, and under the influence which they will have our present symbolic system, as an expression of certain effects, will probably undergo a radical alteration.

Prophecy is at all times a dangerous thing to indulge in; but there are too many important phenomena waiting explanation from present theory, which it seems unable satisfactorily to supply, and when once the demand for explanation becomes more clamant, it is easy to foresee that the present atomic views will be put on their trial. They have done good service in the past, and have guided chemists to important discoveries. My reading of past history and attempt to put it before you will have been to little purpose, if you are not prepared for the overthrow of this theory by facts which it has itself been the means of discovering.

And now, gentlemen, in conclusion, I feel it is impossible for me to resign this chair without thanking you for the forbearance which you have extended to my occupation of it. I have felt on many an occasion, that to conduct properly the business of a Society like this required more care and attention than it was in my power to bestow. It is my earnest hope, that this Society will ultimately take the position to which it is entitled as the instrument through which the great chemical industries located in Glasgow can appeal to the scientific and learned public. But it requires a long struggle in a period of obscurity before such a Society can emerge to the full light of publicity, and it requires an amount of energy and self-denial in its members which have not yet been fully brought into play.

With this hope, I beg to reconsign to your hands the onerous and honourable post of President, and to wish the Society all success.

Postscript, April 14, 1879.—The limits of the preceding address prevented the subjects being treated of in detail. I have tried,

however, to commemorate the centenary of Sir H. Davy in a series of articles in *Good Words* for February and March, and in the proximate number for May, 1879; and that of Gay-Lussac in a short article upon that chemist in the forthcoming volume of the *Encyclopædia Britannica.* The same volume will also contain what have proved to be centenary articles on Geber and Glaser. To these, which are contemporaneous, and in some respects more fully developed parts of this address, I would beg to refer such of my readers as take interest in the History of Chemical Science.

J. F.