# INAUGURAL LECTURE

ON THE STUDY OF

# CHEMISTRY,

READ AT THE ASHMOLEAN MUSEUM,

NOVEMBER 2, 1822.

BY

CHARLES DAUBENY, M.D. F.R.S. M.G.S.

PROFESSOR OF CHEMISTRY, AND FELLOW OF MAGDALEN COLLEGE, OXFORD.

OXFORD,

AT THE UNIVERSITY PRESS.

SOLD BY J. PARKER, OXFORD; F. C. AND J. RIVINGTON, LONDON; J. UPHAM, BATH; AND BARRY AND SON, BRISTOL.

1823.

TO

SIR HUMPHREY DAVY, BART. P.R.S. &c.&c.

THIS HUMBLE ATTEMPT TO RECOMMEND

THE SCIENCE,

WHICH

DERIVES FROM HIS DISCOVERIES ITS STRONGEST INTEREST,

IS INSCRIBED,

AS A TRIBUTE OF RESPECT TO HIS GENIUS

AS A PHILOSOPHER,

AND ALSO TO THE RANK HE HOLDS

AS PRESIDENT OF THAT SOCIETY,

OF WHICH THE AUTHOR HAS SO LATELY HAD THE HONOUR

OF BEING ELECTED A MEMBER.

# PREFACE.

I HAVE been induced to commit this Lecture to print on two accounts: first, in the hope of recommending the study of Chemistry to the notice of those within the University, who were not able to be present when the Address was delivered; and, secondly, with the view of correcting some mistakes that have gone abroad with respect to the opportunities afforded at Oxford for cultivating this branch of science.

Although the details of Chemistry may be discussed in the excellent Lectures of Dr. Hope at Edinburgh, and probably in the present extended course delivered at the Royal Institution by Professor Brande, with a minuteness better suited to meet the views of the medical pupil; yet it may be safely asserted, that a series of between thirty and forty Lectures, generally exceeding an hour in length, ought, if the Lecturer makes a proper use of his time, to convey a sufficiently comprehensive view both of the principles of Chemistry, and of its more important applications, to satisfy the general student.

Whether more advantage might not be taken of the facilities which are afforded at Oxford for cultivating this and, I may with equal justice add, the other branches of modern science, by a slight addition to our system of academical study, is a question which I have ventured to discuss in a note at the close of this Lecture; the freedom of which will be excused within the University, as being dictated solely by a wish to extend its usefulness, and will serve at least to convince those of my readers who do not belong to it, that I have been far from attempting to throw any false colouring over such parts of the system as appear to me defective.

With respect to what I have said of cotemporary chemical writers, I need only remark, that although my respect for the distinguished names alluded to might possibly have induced me to avoid the course I have taken, had this been written originally with any further view than as an introduction to my Lectures; yet as the publication professes to give the substance of what was read before the University, I should esteem it almost a breach of good faith to make any material alteration at present in its contents.

As I have the honour to be known to scarcely any of the authors mentioned, my character of their works is less likely to be warped by that spirit of party, which has of late been too visible in the criticisms of scientific men upon each other, and has detracted considerably from the weight of their authority: nor can I imagine that any apology will be needed to men of candour and liberality, for having given my unbiassed opinion of their works, although in the execution of this task I may have been sometimes constrained to mingle censure with approbation.

*Oxford, Jan.* 10, 1823.

# INAUGURAL LECTURE.

In addressing you for the first time in consequence of my appointment to a Professorship in this distinguished seat of learning, I should consider myself wanting in gratitude to those whose good opinion has placed me in a situation so desirable, were I to enter upon the more immediate subject of this lecture, without briefly adverting to my own personal feelings on this occasion.

When I reflect indeed upon the talents and reputation of the other Professors with whom I have now the honour to be associated, and remember that my own pretensions to the chair of Chemistry rest rather on a fondness for the study, than on any adequate proofs I have given of my proficiency in it, I feel myself doubly called upon to express to the Members of Convocation generally, and to the Vice-Chancellor in particular, my best thanks for having unanimously conferred upon me an appointment, which almost from the period of my entering at the University I had looked up to, as one of the most desirable, with reference to my own peculiar pursuits, perhaps ever likely to fall within my reach.

Nor am I less bound to express in a public manner my acknowledgments to my predecessor in the situation I now occupy, to whose instructions in the early part of my chemical studies, and to whose friendly assistance and encouragement afterwards, I stand mainly indebted for whatever pretensions I may possess to succeed him; and it is no small satisfaction to me, even in a personal point of view, to reflect, that as his recent and well-earned advancement to the

Regius Professorship of Physic secures to us the continuance of his exertions in the general cause of science, although henceforth perhaps concentrated upon a different department of it, the University is spared the necessity of estimating my proficiency in comparison with his, and in this transfer of appointments, must at least expect to gain in one branch of knowledge, what it may have lost in another.

But gratifying as it is to my feelings to dwell on the obligations I am under to Dr. Kidd, his wishes will I am sure be most consulted by this brief mention of them; and it is the less necessary for me to be more particular, as most gentlemen here present have had opportunities of appreciating the zeal and liberality, with which he has at all times laboured to promote science in others, no less than the ability with which he has cultivated it himself.

I pass on therefore without further preface to the immediate subject of this discourse; in which it is my intention to lay before you the plan of the Lectures to which the present one is introductory, as well as to point out to you the respective merits and defects of those works on the subject of Chemistry, which, from the reputation they possess, or other causes, seem most likely to attract your attention.

As however it may be apprehended that there are some, even among the present audience, who might be disposed to move the previous question, as to the advantage which was likely to accrue to themselves from the study of this science, and who would therefore receive with indifference the offer of a guide through a country which they may never care to visit, it will not be amiss to begin by submitting to you the claims which Chemistry may advance to be considered as a branch of academical study,—as no unimportant part of that noble and extended superstructure, which the founders of our University establishments doubtless meant to erect upon the solid basis of classical education.

In considering the utility of any particular department of knowledge, we must regard it in two separate points of view; as it is subservient to the physical wants and conveniences of life, or as it is calculated to afford exercise to the understanding, and to satisfy that appetite for truth, which is the characteristic of an intellectual being: in other words, we may estimate its importance in the scale of acquirements, by contemplating it in the double light of an art and of a science.

Now though it is evident that the practical utility of any branch of knowledge, (using the term *utility* in its most narrow and confined acceptation,) far from being a ground for its exclusion from the circle of academical studies, ought rather to operate as a recommendation to it; yet an unfortunate prejudice seems to exist in certain minds, which renders them loth to believe, that what they are told is of such vital importance in the arts of life, can also be efficacious as a method of cultivating the understanding, of expanding the higher powers of the mind. They seem to consider, that philosophy itself may contract a soil by passing into vulgar hands, and that the higher branches at least in the tree of knowledge must of necessity be barren and unproductive.

To remove these unfounded prejudices, should any such exist in the minds of those I am addressing, to convince them that Chemistry has long ceased to be a mere empirical branch of knowledge, consisting of an assemblage of unconnected facts and obscure formulæ, an art, whose highest pretensions might be, that it constituted a subordinate department of medicine, I shall enter somewhat in detail into the claims it may advance to an high rank among the physical sciences, passing over as generally acknowledged its uses in the various manufactures, to which writers on this subject have in general rather injudiciously confined themselves.

If, in considering the different branches of physics with reference to the purposes of education, we were called upon to point out in them the conditions best calculated to develope the faculties of the human mind, and afford exercise for them all, I conceive the principal ones would be, that the study in question should have attained that precise point, at which, while its fundamental principles were fully established, much still remained to be done to complete the superstructure; at which the mass of ascertained facts, although sufficient to afford the materials for just and conclusive reasoning, was yet not so overwhelming from their number and intricacy, as to engross the whole attention, and thereby divert the mind from the task of discovery; where what had been *done* did not as yet bear so large a proportion to what was left *undone*, as to induce us to despair of adding any thing considerable to the existing stock of information.

Now it appears to me, that of the sciences with which I am acquainted, Chemistry is the one that approaches most nearly to the above description, and consequently, that it would be scarcely possible to fix on any other, adapted to afford the mind such constant excitement, or such various sources of occupation.

Whilst some branches of physics, from the full maturity they have attained, hold out to us little prospect, save that of following in the beaten track of our predecessors; others, more in their infancy, leave a feeling of dissatisfaction in the mind, from the doubts that continue to hang over many of their principal positions.

We enter upon the former with less alacrity, hopeless of attaining distinction in a field already so preoccupied; and we may be deterred from bestowing our attention on the latter, suspicious of the soundness of the foundations on which we should be obliged to build.

But from both these objections Chemistry appears free. If we look to its details, we cannot complain of any want of scope for inquiry in a science bounded only by the limits of the material world: if we examine its principles, we shall find that they are either established on too solid a basis to admit of scepticism, or capable of becoming so by an appeal to facts within our reach; like a fertile estate long since cleared of wood, but not yet exhausted by excessive tillage, it still holds out the prospect of a progressive and almost indefinite improvement; and the labour already expended upon it is calculated, in the present stage of its cultivation, to increase, rather than diminish, the future harvest of discovery.

It is also the peculiar beauty of Chemistry, that from its extent and variety it is adapted to afford occupation to minds of almost every order. Other studies exercise some particular faculty to the exclusion of the rest, and can only therefore be successfully prosecuted by men of one peculiar stamp: but those who consider the intellectual character of the individuals to whom Chemistry is most deeply indebted, will find, if I mistake not, so remarkable a difference between them, as would render their common success in the same pursuit unaccountable, were it not for the unequal degree in which the several faculties of the mind are called into action by the different branches of this science.

How opposite, for example, are the talents that we see displayed in the researches of a Priestley and a Cavendish; a Davy and a Wollaston; all highly distinguished in their respective capacities, all important contributors to the very same science: and what different powers of the mind are called forth in those, who, like Leslie, are engaged in investigating the chemical laws of heat, or, like Vauquelin, occupied in determining the chemical composition of mineral bodies.

It is this circumstance, indeed, in the character of Chemistry, that has occasioned a remark made use of by some with the view of recommending the study, and by others with the intent of depreciating it.

It has been said, that, unlike mechanical science, Chemistry requires no particular preparation; and that whilst in the former we are obliged previously to plod through the fatiguing and intricate avenues of mathematics, no such necessity exists in the latter, where so little depends on calculation, and so much upon experiment.

This, whilst it furnishes the advocates of the pursuit with a plea for recommending it as less abstruse and more generally accessible than other branches of physics, has lowered it in the estimation of others, who measure the dignity of a science in proportion to its difficulty, and the intellect which its prosecution consequently demands.

It should be recollected, however, by the latter class of persons, that the observation alluded to is only correct with reference to *certain* branches of chemical science: in the investigation of the laws of heat and of chemical combination, the progress made will in great measure depend upon the mathematical attainments of those who cultivate it; for though calculation can never be allowed to supersede experiment, it will be found to be its best and surest guide.

In other departments of Chemistry, a mind ready in invention, and fertile in resources, quick in discovering remote analogies, and ingenious in varying experiments, and contriving new methods of research, is perhaps best calculated to arrive at distinction; whilst, in a third class of chemical inquiries, extreme accuracy of observation, and a rigorous attention to minute circumstances, appear the most valuable qualifications.

It may therefore be fairly concluded, that Chemistry is capable of affording occupation to minds of the highest, as well as the most limited powers; and those who enter upon the pursuit, conscious of their inferiority to some of the great names with which they may find themselves associated, will nevertheless derive both satisfaction and encouragement from the reflection, that even if unequal to cope with these in investigating the higher departments of chemical philosophy, they may contribute in perhaps an equal degree to its advancement, by directing their attention to the minuter details.

Nor has Chemistry fewer claims to our attention, when viewed in connection with other branches of knowledge, than when considered with reference to its own intrinsic recommendations.

It is needless to remark, that a more than superficial acquaintance with this science is essential in every gradation of medical practice; and that the physician, who should pretend to enter upon his profession unprepared with this knowledge, would not only overlook many valuable medicines, but, by injudiciously combining those he employed, might destroy all their virtues, and even convert them into active poisons.

In physiology, the theory of respiration and animal heat, and many facts relating to the circulation of the blood, and the functions of digestion and secretion, are so dependent on chemical principles, that an ignorance of them would lead to constant embarrassment and endless mistakes.

The same may be said of the changes that occur in plants; many of which, like those in animals, may be considered in some sense chemical phenomena, since they consist in the production of new compounds, differing from the former in their intimate nature and constitution: and although the cause of these changes is for the most part different in living bodies, from that which operates on inert matter, yet as the latter force is *controlled* only, but not *extinguished* by the introduction of this new principle, and the two agents have each a share in the changes produced, it is impossible to understand either, without studying the nature of both.

Perhaps, too, a chemical examination of the products which result from the influence of the living principle on animal and vegetable matter, might lead us to determine more nearly the nature of this mysterious agent; or should it turn out, that the laws which govern its operation are too refined and intricate to be reduced to the same species of calculation as those of chemical attraction; if that play of affinities, by which we must suppose the various animal secretions to be elaborated out of the same material, should appear to the last to admit of no more particular explanation, than that they resulted from the agency of the living principle; we may still hope, by an accurate comparison of the changes that take place in the various circumstances of life and decay, to ascertain how far they are referable to vital, and how far to chemical actions.

If we turn to those branches of knowledge which explain to us the properties of inorganic matter, the importance of being prepared with a knowledge of Chemistry is equally obvious: thus the chemical characters of minerals often afford the best and readiest means of discriminating their species; and the great questions of geology can only be determined by an appeal to chemical principles, as the phenomena which it is intended to explain are in most cases chemical effects, and in many probably dependent on chemical actions.

In the extended field of mechanical philosophy, there are probably few branches that do not require an occasional appeal to its principles: thus the cause of those imperfections which had for nearly a century limited the application of steam to the purposes of machinery, and consequently the mode of remedying them, was suggested to Mr. Watt in great measure by an attentive study of Dr. Black's theory of latent heat; and if we were ignorant of the chemical composition of the atmosphere, we should be but little competent to undertake the investigation of its mechanical properties.

But the science of meteorology is so dependent on the changes which take place in the constitution of the atmosphere, that it must be considered rather as a branch of chemical than of mechanical science, and ought therefore to be mentioned, not as illustrating the assistance afforded to other sciences by chemistry, but as a proof of the vast field which it embraces within itself.

Chemical processes indeed, far from being confined to the workshop of the artisan or the laboratory of the philosopher, have a share in almost all the great changes that are taking place throughout the material world; and so long as there is any thing in the study of nature that has a tendency to enlarge and liberalize the mind, the pursuit of this science will possess an importance and interest, even without any reference to its numerous practical applications.

"It is also" (as an illustrious chemical philosopher of the present day has observed[a]) "a double source of interest in

[a] Sir H. Davy's Elements of Chem. Phil. p. 58.

"this science, that, while it is connected with the grand "operations of nature, it is likewise subservient to the common processes, as well as the most refined arts of life. "New laws cannot be discovered in it without increasing "our admiration of the beauty and order of the universe; "and no new substances can be made known, which are "not sooner or later subservient to some purpose of "utility."

Having endeavoured to remove the prejudices, which, though at present rarely avowed, still perhaps continue silently to obstruct the progress of Chemistry among certain classes of society, I intend to lay before you the plan of the Lectures which I am about to commence; and, in order the better to enable you to follow me through the detail, shall first explain my notion of the character of the science on which I propose to treat.

There is perhaps no one department of knowledge respecting the nature of which such confused notions have been entertained as of Chemistry, to judge at least from the diversity of definitions given of the subject by distinguished writers, all representing the science in a different point of view; and for the most part either obscure, imperfect, or unexplanatory.

One of the standard systems [b] gives as a definition of this science, that *it treats of those events or changes in natural bodies which are not accompanied by sensible motions;* a description, which, besides its being open to cavil, falls under the important objection, that it is as obscure as the thing defined. Ask an individual who had never heard of Chemistry, whether he can form any clearer conception of those phenomena which form the subject-matter of this science, by being told that they are unaccompanied by sensible motions, and I imagine he will reply in the negative.

Another definition, which has at least the merit of conciseness, states, that *Chemistry relates to those changes which result from heat and mixture;* but leaves us, like the pre-

[b] Thomson's Chemistry, vol. i. p. 2.

ceding one, equally in the dark with regard to the nature of the changes that take place from the above causes.

In order to have a clear and perhaps a sufficiently correct idea of the real nature of chemical phenomena [c], we must consider that there are certain properties inherent in all matter, and others, distinctive of particular kinds. Now as it is the province of mechanical philosophy to treat of the former, so is it that of Chemistry to explain to us the latter; and accordingly all changes in the material world, which appear to result from properties acknowledged to be universal, and differing only in degree, will be mechanical phenomena, whilst those dependent on properties which serve to distinguish one kind of matter from another, may in general be accounted chemical.

Thus when I merely reduce the bulk of a body without altering its properties, I act upon it mechanically; but when by the pressure I apply, some change takes place in its nature and constitution, (as in the experiment of producing water by the compression of oxygen and hydrogen gases,) the effect may be considered chemical. Chemistry therefore has for its object the investigation of those changes that take place in the intimate constitution of matter, which are caused by the agency of heat and mixture, and are productive either of new combinations, or of the resolution of existing compounds into the elements of which they consist.

In explaining therefore the principles of Chemistry, we have our choice of two methods; either that of beginning with the causes of chemical changes, and then proceeding to their effects; or of following the reverse order, and tracing up these effects to their causes: in other words, we may

[c] It cannot be expected that this or any other definition will be absolutely correct, when we recollect that the distinction between what is, and what is not the subject of Chemistry, was made before philosophers entertained clear notions of the nature and extent of the latter science, and therefore that it is in some measure arbitrary. Were our classification of the subjects of chemical and mechanical science to be regulated implicitly by the above definition, magnetism ought to belong to the former, since it is a property peculiar to iron in certain states of combination.

either commence with the general laws of chemical combination, and afterwards describe the details ; or after stating the peculiar properties of each simple substance, and of the compounds which it forms, conclude by an exposition of the general principles on which the whole depends.

Much may be said in favour of both these arrangements. The latter, or the inductive, as it may be called, is adopted by Dr. Thomson in his elaborate System of Chemistry, and has the advantage of following more nearly the order of discovery, and of not presupposing an acquaintance with the particular facts of the science, as we are obliged to do in the opposite scheme. It is liable however to an objection which more than counterbalances these advantages; namely, that from the want of that connecting link which a familiarity with the general laws of chemical composition supplies, the student is deprived of a large portion of that interest, which would be otherwise excited by referring each effect as he proceeded to its respective cause.

It is my intention therefore to follow the practice of the majority of chemists, who begin by laying down the causes of those phenomena which are accounted chemical, and afterwards proceed to state the particular effects dependent on the general laws first stated.

But as the effects of chemical agencies are of two kinds, consisting either in the production of new compounds, or the decomposition of those already existing, it becomes a question, whether it would be most proper to begin synthetically with the simplest principles, and then examine the combinations to which they give rise, or, singling out such compounds as are best known and most generally diffused, proceed analytically, by pointing out the elements of which they consist.

Although it will be admitted, that the former plan may be more philosophical, and perhaps better adapted for a treatise, yet I am inclined to think, that in a course of Lectures it will be convenient to begin with such substances as are most familiar to us, without regarding whether they are simple or compound; and I am the more disposed to do so in the present instance, as it is the plan adopted by Dr. Kidd in his Syllabus, to which many of you are no doubt habituated.

The method then which I propose to pursue, will be as follows:

After illustrating by a few familiar examples the nature of the phenomena we are about to consider, I shall proceed to lay down the general laws on which they depend, which may for the most part be traced to the operation of two distinct and often conflicting forces—chemical affinity, and heat.

Having thus gone through what may be regarded as the general principles of the science, I shall proceed to describe those bodies which are most generally diffused throughout nature: the chemical composition of the atmosphere will therefore occupy us first, and this will be followed by an explanation of the process of combustion, and other effects resulting from the union of one of the constituents of the atmosphere with various substances.

We shall then be prepared to examine the chemical properties of water; and whilst insisting on the proofs of its compound nature, I shall have an opportunity of introducing the subject of electricity, the chemical agencies of which are particularly evinced in the analysis and composition of this fluid, and could therefore be understood but imperfectly, if discussed before.

Being now masters of the chemical nature of air and water, we shall take a view of the general principles of meteorology, or the natural history of the atmosphere; the changes in which must in great measure arise out of the mutual action of the two former bodies.

Having shewn, whilst on the subject of electricity, that certain bodies are attracted to the positive, and others to the negative pole of the Voltaic battery, and that substances similarly circumstanced in this respect correspond to a certain degree in their other properties, I shall avail myself of this distinction in my subsequent Lectures, and begin by considering those which, like oxygen, are attracted to the positive extremity of the Galvanic pile.

The acids which consist of only one base united with oxygen, will first be noticed; and under the head of each I shall describe the nature of the simple combustible which it contains, together with the remaining compounds formed by the latter with oxygen, or other bodies before enumerated.

Acids which, though attracted to the positive pole, do not appear to contain oxygen, will form the next subject of consideration: and in pursuance of the analytical plan on which the Lectures will be conducted, I shall consider under the head of Muriatic Acid the peculiar substance, chlorine, to which it owes its acidity; and under that of Fluoric Acid, the more hypothetical principle, fluorine.

Iodine, and its compounds, will form the next subject of inquiry; being placed last in this class of substances, from the obscurity which still appears to hang over their real nature.

The next division of my Course will be occupied by the consideration of those primary compounds, which are attracted, like hydrogen, to the negative extremity of the Voltaic battery.

These, whether called by the name of alkalies, earths, or metallic oxides, are all compounds of oxygen, and some base attracted to the negative pole; it will therefore be proper to class the whole under one series, together with the analogous compounds formed by the union of chlorine and iodine with various substances.

Under the head of each Alkali, Earth, and Metal, I shall state the most important salts formed by their union with the acids before enumerated.

Acids consisting of more than one base united with oxygen, will occupy us next: and under the head of Acetic Acid, it will be my intention to explain the process of vinous fermentation, and the production of alcohol; from which we may proceed, by an easy transition, to the consideration of vegetable, and afterwards of animal chemistry.

In this part of the subject it will be necessary to keep in view the distinction between those processes which are the result of *chemical*, and those which depend on *vital* actions: in the latter class our object is limited to the consideration of the chemical nature of the effects produced, as, for instance, the differences of composition existing between the blood and the substances secreted from it; but in the former class of phenomena, we must likewise endeavour to explain the nature of the processes by which these changes have been effected.

It is probable that I may conclude by pointing out to you briefly, the methods pursued for analyzing mineral, vegetable, and animal bodies; which will give me an opportunity of recapitulating many of the leading facts detailed in the former parts of my Course, and presenting some of them under a new aspect.

It now only remains, that I should lay before you a brief digest of the principal writers, to whose works I can refer you for information on the subject of Chemistry. They may be divided for convenience sake into three classes; namely, those who have written on the history of the science; secondly, systematic authors, who have drawn up a general view of its principles; and, thirdly, such as have confined themselves to some particular branch or application of it to the arts.

Of the historical class, one of the earliest writers worth consulting is Borrichius, a learned Dane, who flourished in the seventeenth century.

In his work *De Ortu et Progressu Chimiæ*, (of which you may see a copy in the Radcliffe library,) he appears to take much pains in tracing the origin of the science to the remotest periods, even to that of Tubal-cain, for no other reason, than because the scriptures tell us, that he was the instructor of every artificer in brass and iron.

But if we are permitted to consider the knowledge of any art which is now found to be dependent on chemical principles an evidence of the existence of the science itself, I know not where we are to draw the line; and the first person who discovered the art of lighting a fire, or applied it to culinary purposes, may perhaps have as good a title to the name of chemist as Tubal-cain himself.

Chemistry indeed can only be said to have existed as a department of physics, from the time when men began to put together the facts before accumulated, and to generalize upon them: the practice of chemical operations when guided by no principle, like those of various artizans, or by one evidently absurd and visionary, like that which directed the labours of the alchemists, affords no evidence of the antiquity of the science.

The fanciful nature of much of Borrichius' reasoning is exposed by Conringius, in his learned work *De Hermetica Philosophia;* for which I may also refer the student to the Radcliffe library.

A more laborious history of the opinions of the most learned alchemists was published in the year 1702, at Geneva, by Mangetus, in 2 vol. folio; but the elegant little work by the Abbé du Fresnoy, in 3 vol. 12mo. will be sufficient for general readers.

The author, in a tone of serious irony[d], traces up the history of alchemy to the time of Hermes Trismegistus, an Egyptian king, remarkable for his universal acquirements, but unfortunately not mentioned as having applied himself to alchemy by any writer of antiquity. The first volume gives a biographical account of the principal alchemists down to the time at which he wrote; the second, an abstract of

[d] The following is one of the passages that lead me to give this character to the Abbé's work. Speaking of a celebrated alchemist, who afterwards turned Christian, and pursued his new vocation with all the zeal of a proselyte, he remarks, "He afterwards applied himself to the conversion of the "heathens, a problem of not less difficult solution, than the conversion of "the metals into gold."

some of their opinions; and the third, a catalogue of all the works that have been handed down to us on this study.

Those whose curiosity is satisfied with a more rapid glance of what should be termed rather the *mythology* than the *history* of the science, may consult Shaw's translation of Boerhave's Chemistry, especially of the last edition of that work, the date of which is 1741: he will there find a list of all the principal writers on alchemy and chemistry down to the date of the work; and a copy of the catalogue given by Borrichius, Du Fresnoy, and others, of the Greek manuscripts on alchemy, scattered through the various libraries of Europe.

In the midst of many high-sounding names which savour of the dark ages, we recognize, with no small astonishment, those of Democritus, Theophrastus, Plato, and Aristotle; but few will agree with Borrichius in supposing them genuine.

It seems indeed fully established, that no trace of alchemy is discoverable in any one of the writers of antiquity; and that the earliest work in which we can find the word *chemia* employed, is one on astrology, attributed to the fourth century[e].

Those who desire to see the arguments in favour of the transmutation of metals briefly and impartially stated, will do well to consult a note appended by Dr. Shaw to the first edition of his translation of Boerhave's Chemistry. One of the most remarkable stories related, is that told on the authority of Helvetius, Physician at the Hague to the Prince of Orange, who made it public in a separate pamphlet, translated into English, and to be seen among other works on the same subject in the Radcliffe library.

The pamphlet goes by the quaint title of *The Golden Calf;* and viewing its substance as a fabrication, affords a striking example of the propensity which exists in certain

[e] Jul. Fermi. Mater. Astronomicon, lib. iii. c. 15.

minds to mystify and deceive others, without any further motive than the pleasure which imposture affords. Helvetius, an eminent physician at the court of Holland, could hardly have expected to gain any additional credit or notoriety by the publication of a fictitious narrative: nor whilst he boldly asserts the efficacy of the powder of projection left him by the mysterious stranger, does he pretend to have any store of it in his possession to work fresh miracles, or to have been informed with respect to the mode of preparing it.

The anecdote is told in an abridged form in the entertaining History of Alchemy, by professor Brande, inserted in a late number of the Journal of Science, which is brought down to a period so late as the commencement of the present century, when the death of Peter Woulfe[f], a singular character, well known to many scientific men in London, who had devoted his life to the pursuit of this chimæra, may be presumed to have closed the list of English alchemists.

It is worth remarking, however, whilst we are on this subject of alchemy, how much nearer the discoveries of modern science have brought us to the solution of some of the problems on which the professors of that occult art were employed, than could have been anticipated half a century ago, from the progress which Chemistry had at that time made[g].

[f] This singular character lived in chambers at one of the Inns of Court in London. His rooms were a perfect chaos, from the piles of books, papers, and instruments accumulated in every part of them. His friends were occasionally admitted to his abode at his breakfast hour, which was generally at four in the morning. When offended with any one of them, he used to give him some present, which was understood as a hint that his presence was not agreeable. No account is given of the processes he pursued; but it appears, that he laid much stress on the efficacy of prayer. He had an heroic remedy for illness, which was, that of taking a place in the mail to Edinburgh, and returning immediately by the same conveyance. He died in 1805.

[g] Yet on the other hand the progress of chemical knowledge has explained away some of the facts, by which enlightened men in former days justified their belief in alchemy. Thus Mr. Boyle, alluding to the fact of the altera-

The exhibition of fluoric acid in its pure and concentrated form, seems to have made us acquainted with that to which the alchemist attached so high an importance, namely, an universal solvent. If you read Sir H. Davy's paper on this subject[h], you will be convinced that this body approaches, in its properties, very nearly to the above description; for a mass of horn-silver, hollowed out to admit it, seemed almost the only recipient which was not immediately acted upon.

With regard to the second object, although we certainly cannot boast of any method of effecting the transmutation of metals, yet recent discoveries seem calculated to impress us with a persuasion of its possibility, supposing that we had at our command that powerful agent, *time*, of which nature makes such important use in her laboratory.

We observe the catalogue of metallic bodies increasing upon us by yearly additions, and the properties of those most recently discovered graduating by such nice shades into those of the older ones[i], as to render the probability great, that they are not all simple substances, but composed of the same elements united in different proportions.

This probability is strengthened, now that we know the alkalies and earths to be metallic oxides, and have reason to suspect the former to be generated spontaneously out of the constituents of air and water.

Such is the explanation proposed by Daubuisson, to account for the periodical efflorescence of common salt (or muriate of soda) in the deserts of Africa, the steppes of

tion produced in the qualities of gold, by the addition of minute portions of other metals, (as is well known to be the case when it is exposed to the vapours of lead or arsenic,) argues, that if it be possible to debase a perfect metal, we ought by parity of reasoning to allow the possibility of exalting or ennobling a baser one. This reasoning, loose as it may appear at present, might have been thought plausible at the time, before the nature of metallic alloys had been investigated, and when the prejudices of the age lent almost as much weight to the arguments that might be advanced in favour of the transmutation of metals, as they now do to the contrary side of the question.

[h] Philosophical Transactions, 1813, 14.

[i] Compare, for instance, the properties of palladium with platinum, and of cadmium with tin.

Siberia, and the great table-land of North America, as related by Pallas, Humboldt, and others[k]; and this is more obviously the case with respect to saltpetre, (or nitrate of potass,) which results in many cases from a peculiar action of moisture and atmospheric air upon lime and other earths, assisted by the admixture of decomposing animal and vegetable matter, but not, as it should seem, altogether dependent on their presence.

I may refer you for further particulars to two papers relating to the production of nitre on the walls of this very laboratory; the first in the Manchester Memoirs, by Dr. Wall, the second in the Philosophical Transactions, by Dr. Kidd: at present it is sufficient to state, that in attempting to account for its existence under the above circumstances, we have only the alternative of supposing the metal calcium to be transmuted into potassium, or the latter to be in this instance generated out of the constituents of air and water.

We are equally at a loss to account for the quantity of alkaline matter present in the ashes of various plants, when nourished in soils that do not appear to afford a particle of that substance; or if they possessed any, to have derived it from the decomposition of other vegetable matter, thus removing the difficulty only one step farther.

If we admit the inferences deduced by Dr. Macculloch, in a late curious paper with respect to the metallic nature of carbon[l], the proof of the spontaneous generation of metallic matter is still more direct; for a plant nourished only by distilled water will increase in size, until the carbon it contains vastly exceeds its whole original bulk.

It would also seem, as though even earthy matter was generated in certain animal and vegetable processes; for although we may reject the absurd speculations of Lamarck and Demaillet on this subject, yet setting aside the apparent disproportion between the phosphate of lime present in the

[k] It must be confessed, however, that in turning to Pallas's account of the salt beds of Siberia and Crim Tartary, I find but little to countenance Daubuisson's theory.

[l] See Ed. Phil. Journ. for October 1822.

bones of animals, and that contained in their food[1]; from what source, I may ask, are we to suppose the animalcules, whose labours are building up whole islands, I might almost say whole continents, of coral reefs in the antarctic seas, to derive the lime which constitutes the principal material of their superstructure? If from the muriate of lime contained in the ocean, we must adopt one or other of the following suppositions; either that these animals have begun their labours at a period comparatively late to that from which we date the commencement of the existing order of things, an assumption quite gratuitous, and contrary to all analogy; or, what is still more improbable, that the calcareous matter contained in the sea has ever since been undergoing a gradual diminution, and that at no very remote period the quantity of muriate of lime present must have been so considerable, as to have rendered the properties of sea water different from what they are at present.

These suppositions, indeed, are both so irreconcileable with that system of compensation, which we observe throughout nature, and which tends to preserve so completely the permanency and consistency of the existing order of things, that I cannot help viewing it as more probable, that the calcareous matter, of which these coral reefs are principally composed, really owe their origin to a peculiar animal secretion.

The metallic substance which Berzelius appears to have produced from the volatile alkali through the agency of galvanism, affords an additional proof of the compound nature of this class of bodies; and the supposing them compounds, removes the great theoretical difficulty to the fact of their transmutation.

These considerations, coupled with the strong testimony adduced in favour of a few of the cases mentioned, which is such as to oblige the candid Bergman to confess, that it appeared to him impossible to reject it, without doing away

[1] I am pleased to find, that Dr. Prout, in his paper on the Incubation of the Egg, published in the last volume of the Philosophical Transactions, has arrived at the same conclusion with myself upon different grounds.

with historical evidence altogether, must be balanced against the imposture manifest on the face of some of these accounts, the credulity evinced in others, and the ignorance of chemical principles, which is the characteristic of almost all[m].

If the alchemists in any instance succeeded in converting the baser metals into gold, it is certain, at least, that their object was not attained by any known and established process, but that they stumbled upon it accidentally, by perpetually ringing the changes upon a vast series of unconnected chemical operations. Hence, being utterly in the dark with regard to the conditions on which their success depended, they were as little able to repeat the experiment at pleasure, as the calico-printer, who uses the kaleidoscope to assist him in the invention of new patterns, is to recover any combination of figures that has pleased his eye, when the glass has once been shifted, and a new arrangement of its objects presented itself.

[m] The most singular instance of alchemical pretensions that we read of in an enlightened age, is that afforded us in the case of Dr. Price, of Guildford, which occurred so recently as the year 1784. Although the anecdote is, no doubt, well known to many of my readers, yet I may just mention, that the individual alluded to was a physician long established in his profession, and of some eminence in it; that he was supposed to be in easy circumstances, and that his reputation as a chemist had procured him a degree at Oxford, long before he was known to have applied himself to alchemy. The pamphlet, in which he sets forth his discoveries on this subject, goes by the modest title of "Experiments on Mercury;" and its style and manner does not savour in the least of quackery or mysticism. The experiments in which mercury was, by the addition of a certain powder, to be converted into gold, are reported to have in some cases failed, and in others succeeded; but the successful as well as the unsuccessful trials are stated to have been witnessed by respectable persons then living, to contradict the fact, if incorrectly told, amongst whom we recognize the name of Mr. Gough, the antiquary. Dr. Price appeals with considerable force to the circumstance, that the mercury, (which had been taken at random by one of the party out of a large trough used for pneumatic experiments,) on being added to the powder by which its conversion into gold was effected, neither boiled nor passed off in vapour, though exposed to a red, and even a white heat. The apparent candour of his narrative having induced the Royal Society to pay some attention to the subject, a committee was appointed, before whom Dr. Price, after some demur, agreed to repeat his experiments; but before the time of trial arrived, he was found to have poisoned himself with laurel-water.

Let it not however be supposed, that even if the composition of metals were fully ascertained, it would follow that we should be able, by putting together the elements in their proper proportions, to form them anew at pleasure.

It is a rare accident, that those mineral bodies which have been analyzed with the greatest exactness, can be produced by artificial means; and until we have succeeded in forming specimens of mica, quartz, and felspar, the composition of which is fully ascertained; until we can crystallize the diamond, and compose the loadstone, we should deserve all the ridicule which has been cast upon the labours of the alchemists, if we were to attempt to apply our chemical knowledge to so visionary an object as that of the transmutation of metals.

A general history of the progress of chemistry, properly so called, up to the present day, is still a desideratum in science; but the student will find brief notices prefixed to most systematic works on the subject: that by the Bishop of Llandaff in the last century, and by Sir H. Davy in the present, are among the best.

Dr. Wall, who ought also to be mentioned as having revived the study of Chemistry in this University, (having delivered a course of lectures in this school after they had been long discontinued,) has inserted in his Inaugural Discourse, published in 1783, an interesting sketch of the progress of Chemistry up to that date.

Of systematic works on Chemistry, the earliest that deserves notice is that by Stahl; in which he attempts to connect the scattered observations made up to that time, by the aid of an hypothesis. He supposes the metals to be compounds of earths and a certain inflammable principle termed phlogiston, which is extricated from these bodies during combustion, leaving the calx, or caput mortuum, behind.

This very natural explanation was the universal creed for nearly a century; and though exploded, yet it is curious to remark, that even at the present day all the known phenomena of Chemistry may be reconciled to it, if we only adopt the modification of Stahl's theory proposed by Cavendish, and consider that phlogiston, which according to his view was what we now call hydrogen gas, instead of being extricated from the metal during combustion, remains attached to it in combination with the vital principle of the air [n]. But this is a clumsy and circuitous mode of accounting for a process, which the theory of Lavoisier explains in a much simpler manner, by confining itself to the expression of what has been proved, without supposing the existence of an hypothetical agent.

It is no bad exercise however for the chemical student, to prove his familiarity with the facts of the science, by attempting to explain the phenomena according to the phlogistic as well as the antiphlogistic system; and with this view it might not be amiss for those who have leisure to peruse the works of Stahl, which have shared the fate of all theoretical treatises, in being forgotten, when a new system has superseded that which they inculcate.

I am at a loss indeed to point out any work, which will be read with much interest on the subject of Chemistry, of an earlier date than Watson's Chemical Essays, which, from the ease and purity of their style, no less than from the luminous manner in which every subject is handled, will always be referred to as a classical work, in spite of any changes which the science may undergo.

But to acquire an insight into the state of Chemistry at the present day, we need not take up the subject earlier than the time of Lavoisier. In the elementary work of that philosopher, we shall find the fundamental principles of the antiphlogistic system stated with more precision, and with a fuller detail of facts, than probably in any subsequent work.

The author naturally dwells with greater complacency on this part of the science, which he had the principal merit of

[n] According to this view, metals would be compounds of an unknown base and hydrogen; and oxides compounds of the same base with hydrogen and oxygen, like the vegetable acids.

reducing to its present form; the other parts of his work, though less valuable in consequence of the changes since introduced, may yet be consulted with advantage.

I should scarcely recommend your undertaking the perusal of the laborious work of Fourcroy, published a few years after that of Lavoisier, as the facts it details may be better obtained from subsequent compilations.

It may be worth while to refer to Mayow's Experiments on Air in 1674; Rey's Essays on the Calcination of Metals, of which extracts are given in a late number of the Journal of Science, and Hooke's Micrographia, as affording proofs, that even at and before the commencement of the last century, many individuals caught a glimpse of the theory now so fully established, and were acquainted with many of the facts on which it rests.

The *Comparative View of the Phlogistic and Antiphlogistic Systems*, by Mr. Higgins, formerly of Pembroke college in this University, which was published in 1789, is interesting on two accounts; as affording one of the best refutations of the former hypothesis, and as furnishing the first hint of the doctrine of definite proportions.

It may be doubted however, whether the short and incidental notice taken by that author of the manner in which bodies unite, could ever have led to the general reception of the theory in question, had not the subject been taken up subsequently by Mr. Dalton of Manchester, at a time when a larger number of facts had been accumulated, capable of establishing its correctness. Even Mr. Higgins, indeed, appears in various parts of his book to have lost sight of his own theory, and to fall in with the generally received idea at the time he wrote; that the elements of bodies unite in every conceivable proportion up to the point of saturation.

Of the more systematic works on Chemistry, that of Dr. Thomson probably holds the first place: one of its principal defects consists in the nature of the arrangement, which is such as to oblige the student to learn a vast assemblage of particular facts, before he arrives at that part of the work which treats of the general principles on which they all depend. His division of the subject into the science of Chemistry, and a chemical examination of nature, gives an unnecessary complexity to the study.

He has taken much pains in assigning to each writer his respective discoveries; and the extensive reading displayed in his work gives a sort of authority to his decisions, provided their impartiality can be relied upon; nor, as far as I know, has this been impeached with regard to philosophers of the last age, although in speaking of cotemporary writers he has been accused of indulging occasionally in personal and local prejudices.

The inaccuracies, which his adversaries have been on the watch to detect, are after all not more numerous than might reasonably be expected in a field of such extent; and the mass of information conveyed, will cause his work to be consulted as a dictionary, even by those who disclaim it as a system.

The Chemical Dictionary of Dr. Ure is also a valuable compendium; and a comparison of this with the System of Dr. Thomson, will afford us the best chance of arriving at truth on those questions, which have supplied the editors of the Royal Institution Journal with an handle of attack against the rival work of the Glasgow Professor.

The Treatise of Dr. Murray, though less full and comprehensive than that of Thomson, is superior to it in point of arrangement and precision of language; two qualifications for which the former chemist was eminently distinguished, and which enabled him to appear with so much advantage, both as a systematic and a controversial writer. Owing however to the death of the author, which deprives us of the chance of seeing a new edition, we must depend on other sources for the most modern discoveries.

Professor Brande likewise has published an useful manual: but the author must excuse my objecting to the outline of geology he has introduced in the Appendix, as being a subject, which has assumed too great an importance to be treated as it deserves in the short space allotted to it, as a subordinate branch of a system of Chemistry°.

For practical chemists, I can recommend nothing more than the Elements and the Epitome of Dr. Henry; in which the details of experiments are more fully stated, than in the systematic treatises before alluded to.

In addition to the above, which may be considered the standard works in our language, I should recommend to the beginner the little unpretending duodecimo, entitled *Conversations on Chemistry;* which contains in a small space more important information, than can be gathered from many books of twice its dimensions.

The incomplete treatise by Sir H. Davy, called *Elements of Chemistry*, gives a masterly view of many parts of the science, but others are touched upon too slightly: as far as it has proceeded, it is valuable, as presenting the general views of so eminent a philosopher, on those very points on which he has laboured so successfully; but as this would not be the case in the subsequent volumes, we can hardly desire to see talents of so high an order diverted from their proper sphere, for the sake of completing an undertaking in which they would be less available than other qualities of mind of a more ordinary and homely character.

In France, since Fourcroy gave to the world in 1789 a complete view of the Lavoiserian Chemistry, no systematic work has appeared, excepting that of Monsr. Thenard. Of this, the most valuable and original part appears to have been translated by Messrs. Merrick and Children; being that which relates to chemical analysis, a subject there treated with greater fulness than in any work with which I am acquainted. The only fault, if it be one, which I have to find with this part of the work, is, that the combinations

° The same objection applies to that part of Dr. Thomson's treatise which is occupied by a description of rocks and minerals; a subject that can scarcely be said to belong to the subject of Chemistry, and for which most persons would choose rather to resort to the original sources from whence the information was derived.

supposed are often such as never probably occur in nature, so that the directions given for analyzing them can be considered at best in the light merely of chemical exercises.

In the German language the work of Professor Oersted, " on the identity of electrical and chemical forces," has been highly spoken of: and though, from the abstract given in the Annals of Philosophy, his theories strike one as obscure and metaphysical, yet his classification of simple substances and primary compounds seems judicious; and the soundness of his views in many respects is confirmed by the recent discoveries on the connection between magnetism and electricity, which claim the rare merit of having been deduced from theory, before they were ascertained by experiment.

I should far exceed the limits assigned to the present Lecture, if I were to consider with the same minuteness the works that may be consulted with advantage in any of the particular departments of Chemistry. I shall therefore simply state the more important detached publications, without entering into the wide field of the periodical journals, or the transactions of learned societies.

The most laborious investigators of the laws of chemical affinity are Bergman and Berthollet; the former of whom has established the general principles of combination, whilst the latter has pointed out the circumstances that limit their universality.

The work of Bergman need not be consulted in the present day, as all the important information has been extracted and commented upon by subsequent writers; but the chemical statics of Berthollet seem hardly to receive at present the attention they deserve, since the general reception of the opposite views of Dalton.

Yet until the general principle insisted upon by Berthollet (namely, that chemical combination depends partly on the mass, and partly on the strength of the affinity) has been overthrown by contradictory experiments, it would appear hardly philosophical to give a decided opinion on the mere ground of the difficulty that may exist in reconciling the facts of Berthollet with the atomic theory. Sir H. Davy, in his Elements, has ingeniously attempted to explain away these facts; and I may refer you to his work as containing the most pertinent remarks I have seen upon the subject: but his explanation does not I think comprehend all the cases brought forwards; and the fact that earths and metallic oxides, when precipitated from their combinations, often retain a trace of the acid with which they were united [p], can hardly, I think, be accounted for without recurring to Berthollet's views. Some experiments of my own, which are detailed in a paper on the separation of lime from magnesia, which I contributed to the Edinburgh Philosophical Journal [q], might be referred to with the same intent.

The subject of definite proportions first started by Mr. Higgins, has been developed at greater length in Mr. Dalton's System of Chemistry, which I did not include among the sytematic treatises, as it seems written with the express design of giving publicity to his own views on the subject of chemical proportions, and a few other points.

It is seldom that a mind of so original a cast as Mr. Dalton's will stoop to the drudgery of compilation; and hence it often happens that the productions of such men can hardly be recommended to the student so much as other systems of very inferior pretensions.

Those however, who are advanced in the study, will soon be sensible of the value of such a work as Mr. Dalton's, and will find the principles of the science in many respects handled in a more philosophical spirit, than in any other treatise with which I am acquainted.

On the laws of heat, the Lectures of Dr. Black may still be read with interest and improvement. His discovery of

[p] As it may be said that this has happened in the experiments of ordinary chemists from a want of care in washing the precipitate, I must beg the reader to refer to Berzelius' curious paper on compounds which result from weak affinities, which will at least convince him that I have some ground for the statement made in the text.

[q] See Ed. Phil. Journal, 8vo. for July and October, 1822.

the caloric absorbed or given out by bodies in passing from one condition to another, the first that can be said to have given to Chemistry the form and dignity of a science, may be studied perhaps with more advantage in his own luminous exposition, than in the subsequent compilations of others.

On the subject of radiant heat, and on the relation of the latter to moisture, the works of Professor Leslie supply us with the most important information.

The originality of his experiments, and the acuteness with which he avails himself of any new views that chance to open upon him in the course of his inquiries, place him in a very high rank among the philosophers of the age: but it must be confessed, that the vagueness of some of his speculations, and the fanciful nature of others, his fondness for digressions, and contempt of all arrangement, to say nothing of his frequent sins against good taste, which are too glaring to need any comment, are circumstances which, though they may not weaken our admiration of his genius, must detract considerably from the character of his works, regarded as standard treatises on the subjects to which they relate.

Count Rumford, though a philosopher of far inferior powers to Professor Leslie, has contributed many additional facts to this department of Chemistry; and, if himself a bad reasoner, has at least the merit of having collected the premises on which others may build legitimate conclusions.

Dr. Wells has presented us with a very ingenious explanation of the phenomena of dew, in a volume of essays, the style and arrangement of which affords an agreeable contrast to that of Professor Leslie's treatise.

Sir H. Davy's Essay on Flame may be referred to, not only for its intrinsic merit, as giving us the first satisfactory explanation of that phenomenon, but as affording the best example of that originality of thought, and readiness of invention, which in a science like that of Chemistry is perhaps the most valuable of qualifications.

The invention of a lamp, which should continue to burn isolated from the general mass of that fluid which continued to nourish it, would have appeared to us, before the particulars of it were made known, little less than a contradiction in terms; and if assured of its possibility, we should be equally surprised at the simplicity of a contrivance, where we should anticipate that the end could only be attained by a complicated and unwieldy apparatus.

The only work I shall mention which relates to the particular facts of Chemistry, is the *Recherches Physico-Chimiques* of Messrs. Gay-Lussac and Thenard, which detail a series of results only inferior in importance to those of Sir H. Davy on the decomposition of the alkalies.

On the analysis of minerals, the essays of Klaproth are invaluable; and it is to be wished that a translation into English of the later volumes were made by some competent person, as a companion to the former ones[r].

Professor John's *Laboratorium* seems conducted on a similar plan; but is a work, I believe, of less authority.

I have before alluded to the translation of that part of Monsieur Thenard's system which relates to analysis, and again recommend it to your notice. Dr. Thomson has also furnished the Supplement to the Encyclopedia Britannica with a valuable article on the same subject, which contains in particular some useful directions for examining the gases.

Berzelius' late treatise gives a most complete and valuable account of the indications afforded by the blowpipe, and contains a variety of incidental facts on Chemistry not generally known. We are indebted to Mr. Children for a translation of this work, as well as of that of Monsieur Thenard, enriched by some valuable notes of his own.

No systematic work on Vegetable Chemistry has hitherto appeared; but some information may be collected from Sir H. Davy's Lectures on Agricultural Chemistry.

The most important series of experiments however, con-

[r] Mr. Children has published in the Journal of Science a translation of parts of this work.

nected with this subject, is that on Respiration by Mr. Ellis, which has the merit of giving a connected view of the chemical changes produced by that process both in plants and animals, tracing a general analogy throughout the whole, and establishing the fact, that the increased temperature which results, is only an indirect consequence of this process, and not to be accounted for on chemical principles.

On the subject of Animal Chemistry we have the short essay by Professor Berzelius; but as many additions to our knowledge have been made since this was published, it were desirable, if Dr. Prout, or some other chemist, who has attended particularly to the subject, would publish upon it. At present I can only refer you to a work by Professor John of Moscow, which has been translated into French, and is entitled, *Tableaux de Chimique animale*[s]. These tables give a summary of the results afforded by the experiments of different individuals on the chemical nature of the various organs both in man and other animals. As far as I have had an opportunity of examining them, they seem very complete.

On the applications of Chemistry to the Arts, the dictionary of Dr. Aikin dwells at considerable length; and the French work of Monsieur Chaptal may likewise be consulted with advantage.

It is to be regretted however that we do not possess more detached treatises by scientific Chemists on particular arts and manufactures: at present the only ones I can refer to, are Parke's Chemical Essays, and Bancroft's Theory of Permanent Colours: the latter of which works I can particularly recommend to the manufacturer, as explaining in a very able manner the philosophical principles of dyeing; and to the man of science, as affording, in the mutual action of the mordant and the colouring matter, a curious illustration of the general influence of chemical affinity.

[s] I have since found that there are similar tables by the same author, of Vegetable Products.

It might seem almost a mockery to lay before the student so extensive a catalogue of books, in a place where access to them could only be obtained through the private funds of the individual; but in an University so rich in public libraries, and with one exclusively dedicated to works of science and natural history, the difficulty must consist rather in the selection, than in the opportunity of reference.

In order however to afford those who feel interested in the pursuit every possible facility for obtaining information, I have arranged such scientific and professional works as are in my possession in a room attached to this laboratory, which I intend to be open to my class daily from twelve until four in the afternoon during term time. I believe they will find in the shelves almost all the works on Chemistry enumerated in the preceding notice; and on the table they will have an opportunity of referring to the last numbers of the three most important periodical publications connected with science; some medical works of the same description; and the most recent parts of the transactions of those scientific societies which excite most general interest at present.

In addition to the conveniences thus offered to the chemical student, I have determined on appropriating an adjoining room in this building, furnished with the most necessary apparatus, for the express accommodation of those gentlemen who may wish to repeat for themselves any of the experiments which seem to illustrate my Lectures; a practice I would recommend to all those who are desirous of obtaining a thorough acquaintance with the science, as tending to imprint the facts more vividly on their memory, guarding against any misconception of the Lecturer's meaning, and calling forth a livelier interest in the study they are engaged in.

By the means above stated I am in hopes of diminishing materially the difficulties which deter many from the practical pursuit of this science, whether arising from the expense attendant on the establishing a regular laboratory, or from the objections which may exist in the minds of some against the general prosecution of experimental Chemistry within a college by the junior members of the society.

With regard to a supply of the materials for experiment, I am happy to inform you, that a druggist in this city has at my request consented to keep in hand a constant stock of chemical re-agents, together with such apparatus as is most commonly wanted for experiments; so that I hope in these respects we shall in future be as well supplied, as we could be in the metropolis.

Should these arrangements have the desired effect in rendering Chemistry a popular pursuit in this University, I may anticipate with no small degree of confidence the advantages that are likely to accrue, not only to the individuals in thus obtaining a new source of intellectual enjoyment, but also to the science itself.

Until of late years, Chemistry, it must be confessed, has been too little cultivated by persons whose minds had been expanded by a previous course of liberal education[t], and was in great measure confined either to the artisan, who considered it simply with reference to his own occupation, or to the smatterer in learning, whose imperfect acquirements would render him only a readier dupe to the delusions of alchemy.

Even at present, perhaps, a certain deficiency in the higher order of chemists may be suspected from the disproportionate labour bestowed on the minuter details of the science, and from the difficulty which I have met with of pointing out among the many elaborate publications above enume-

[t] If we look back to the writings on Chemistry published a century ago, we shall soon be convinced that they were the productions of quite a different class of men from those who cultivate this science at present. Mr. Boyle appears to have been the first person, who, from the rank he held in society, rendered Chemistry at all fashionable among men of fortune and education; and thereby, probably, advanced the science, even more than by the discoveries with which he enriched it. Nevertheless, it appears to have won its way but slowly among the higher classes in this country, for it cannot be said to have been much cultivated here by men of liberal education, until the close of the last century.

rated, any, that in all respects comes up to my idea of what a treatise on chemical philosophy ought to comprehend.

From the introduction of Chemistry among the favourite studies of this place, I should anticipate more philosophical views on many of its higher branches; and I look forwards to this result with more confidence, from the rapid advances which the kindred science of Geology has made within the last few years, under the auspices of its present Professor.

On this latter subject I fully agree with the author of the excellent work on the *Geology of England* [u], himself a bright example of the union of scientific with classical attainments, who remarks, that in the Oxford school of Geology, a satisfactory proof has been afforded, in opposition to the misrepresentations of shallow sciolists, that the institutions of academical education are far from unfavourable to the cultivation of the physical sciences, but on the contrary might become, under proper management, the most suitable preparation for them.

To point out the causes which have nevertheless obstructed of late years the pursuit of other branches of modern knowledge in an University, to whose members the first philosophical society, in point of date, and one of the first in reputation throughout Europe, principally owes its establishment, would far exceed my present limits; but it must be a matter of congratulation to those who are interested either in the advancement of science, or in the fame of this University, to reflect, that these obstacles (whatever they may have been) seem gradually dying away, and that the same reform in academical education, which by giving a stronger impulse to the particular studies of the place, may seem at first sight to oppose an additional impediment to the pursuits of physical science, will eventually serve its cause [x],

[u] See the Introduction to Conybeare and Phillips' Geology of England and Wales, p. 48.

[x] In making these remarks, I of course proceed upon the assumption, that the spirit which every day manifests itself more and more within our University, strengthened by the feeling which prevails out of it, will lead

by inculcating juster views of the real object and use of classical education, and by impressing upon the mind a con-

eventually to some extension of our plan of academical education ; for at present, when I consider the little encouragement afforded to modern science, and the engrossing nature of the studies to which the attention of the student is necessarily directed, I am more disposed to wonder at the zeal for the former pursuits actually displayed, than at their being limited to comparatively few.

I cannot help, however, feeling sanguine, that the same spirit of improvement, which may be considered both as the cause and the effect of the late changes in our system of education, will soon acquire a momentum sufficient to overpower the remaining obstacles to its further extension, not indeed by subverting the principle, which is justly the boast of our University, that of rendering classical literature the basis of all other knowledge, but by holding out some encouragement for the student to proceed beyond that, which is on all hands admitted to derive its principal value from its preparing the mind for the reception of other kinds of information.

It might be easy to shew, that this would rather be a return to the original system of the place, than a deviation from it; for the fact, that each successive degree was formerly preceded by residence for a certain number of terms, and by a distinct examination, affords a sufficient proof, that the former were looked upon as testimonials of further proficiency, and not merely as certificates of the standing which the candidate for it may possess, coupled with the negative praise of his having not misconducted himself in the interval since his last degree.

The late Professor of Anglo-Saxon has pointed out in his Lecture, just published, how injuriously the custom of granting degrees without exacting residence, or enforcing some test of further attainments, is calculated to operate both upon the professors and the students; upon the former in weakening that spirit of exertion which they would feel, if the studies confided to their care were considered as integral parts of academical education ; on the students, in inducing them to rank some of the most important branches of modern knowledge, as objects scarcely deserving attention, except to indulge an ephemeral curiosity, or gratify some strong peculiar bent.

The danger, indeed, of rendering our establishments mere schools of classical literature, instead of seminaries of universal knowledge, begins to be felt so sensibly, that some alteration of the kind suggested would perhaps have taken place already, had it not been for the increased expense which the enforcement of residence for another year would entail upon the student. But those who urge this objection should recollect, that a Master of Arts degree is only imperative on the dependent members of colleges, on whom the injunction would press most lightly ; and that if the conferring it ceased to be a mere form, no loss of respectability could be incurred by omitting it ; whilst the obtaining it under such circumstances would confer, as it originally was meant to do, some kind of distinction.

It

viction, that such studies ought to be considered for the most part only preparatory to further attainments, as the best means of acquiring that correct taste, and those just habits of thought, which enable the possessor to engage with equal advantage in the investigation of moral or of physical truth.

It would be presumptuous, however, in me to dictate the specific alterations which would either be desirable in themselves, or could be adopted consistently with the existing feeling in the University; but if I am right in asserting, that the complaint above alluded to is made by many, who cannot be suspected of any undue bias in favour of the modern sciences; and if the defect be really of such a description, as in great measure to neutralize the advantages, which the solidity of the English system might otherwise command over the more superficial plan adopted in those Universities, where the whole of education is made to depend on public lectures, we ought not to be deterred, by any partial or temporary inconveniences, from applying a suitable remedy to so crying an evil.

Whether that remedy could be best obtained by lengthening the period of actual residence, or by setting apart one year, out of that at present enjoined, to the attending public lectures; or thirdly, whether, without rendering the modern sciences a necessary part of education, sufficient encouragement might not be held forth to their study, by placing them on the same footing with the mathematics, and conferring similar distinctions on those who had successfully prosecuted them, are questions which I freely leave to persons more experienced in the character of our institutions; only hoping, that the success that has attended the reforms lately introduced, instead of being appealed to as an argument against the practicability of further improvements in our system, will be viewed as the strongest encouragement to their being undertaken.

# APPENDIX.

## OUTLINE

OF

## A COURSE OF LECTURES

ON

## CHEMISTRY,

TO BE DELIVERED AT THE MUSEUM, OXFORD, IN THE WINTER OF 1822, 23.

N. B. THE following is a reprint of the Syllabus drawn up for the use of my class, during the continuance of the Lectures I am at present delivering. Although it is my intention to render it more complete against my next course, I have chosen to insert it in its present state, as it may tend to illustrate the principles of arrangement which I have endeavoured to explain in the course of the preceding Lecture.

On the general principles of Chemistry:

1. Attraction.
2. Heat.

On the Atmosphere and its constituents.

On Water and its base.

On the agency of Electricity in the production of chemical changes.

On Meteorology, or Atmospheric Phenomena.

On primary compounds attracted to the positive pole of the Voltaic battery.

1. Acids containing oxygen.

   Carbonic acid, Nitric acid, Sulphuric acid, Phosphoric acid, Boracic acid, } and their respective bases.

2. Acids not containing oxygen.

   Muriatic acid, and its acidifying principle, chlorine.
   Other compounds containing chlorine.
   Fluoric acid, and its acidifying principle.
   On iodine, and its compounds.

On primary compounds attracted to the negative pole of the Voltaic battery.

1. Alkalies, and their bases,
2. Earths, and their bases,
3. Ores, and the metals they contain,

} with the principal salts formed by their union with the preceding acids.

On compounds consisting of oxygen and two simple combustibles.

1. Prussic acid, and its base, cyanogen,
2. Oxalic acid,
3. Gallic acid,
4. Acetic acid, with the history of vinous fermentation, alcohol, &c.

} with the principal salts which they contribute to form.

On vegetable Chemistry.

1. The chemical phenomena of vegetation.
2. The proximate principles of vegetables.

On animal Chemistry.

1. On the influence of chemical agencies upon the functions of animals.
2. On the proximate principles of animal matter.

On the methods to be pursued in analyzing,

1. The gases.
2. Mineral waters.
3. Minerals.
4. Vegetable substances.
5. Animal substances.

## LIST OF BOOKS

### REFERRED TO ON THE SUBJECT OF CHEMISTRY.


### I. *On the History of Chemistry.*

Borrichius de Ortu et Progressu Chemiæ.
Conringius de Hermetica Philosophia.
Mangetus, Bibliotheca Chemiæ.
Abbé Langret de Fresnoy Philosophie Hermétique.
Boerhave's Chemistry translated by Shaw.
Helvetius de Vitulo aureo.
Brande's History of Alchemy.—Journal of Science.
Davy's Elements of Chemistry—Introduction.
Wall's Inaugural Lecture on Chemistry.

### II. *Systematic Chemical Works.*

Stahl.
Watson's Chemical Essays.
Fourcroy's System.
Thomson's System.
Ure's Dictionary.
Murray's Elements.
Brande's Manual.
Henry's Elements.
Conversations on Chemistry.
Davy's Elements.
Thenard Traité de Chimie.
Oersted, sur l'Identité des Forces electriques et chimiques.

III. *Works on particular Branches of Chemistry.*

Bergman on Chemical Attraction.

Berthollet Statique Chimique.

Higgins' Comparative View of the Phlogistic and Antiphlogistic Systems.

Dalton's System of Chemistry.

Black's Lectures.

Leslie on Heat.

Leslie on the Relations of Heat and Moisture.

Rumford's Essays.

Wells's Essay on Dew.

Davy's Essay on Flame.

Gay-Lussac, Recherches physico-chimiques.

*On Chemical Analysis.*

Klaproth, Essays.

John's Laboratorium.

Thenard on Chemical Analysis, translated by Children.

Thomson, article *Decomposition Chemical*, in the Supplement to the Encyclop. Britannica.

Berzelius on the Blowpipe, translated by Children.

*Vegetable Chemistry.*

Davy's Lectures on Agricultural Chemistry.

Ellis on Respiration.

*Animal Chemistry.*

Berzelius' Essay.

John, Tableaux de Chimique animale.

*Applications of Chemistry to the Arts.*

Aikin's Dictionary.

Parke's Essays.

Bancroft's Theory of Permanent Colours.

ON THE

# APPLICATION OF CHEMISTRY

TO

# THE ARTS.

SINCE the preceding pages were sent to the press, I have been persuaded to deliver an opening Address at the new Literary and Philosophical Institution established at Bristol, in the course of which I adverted more in detail on the application of chemical science to the different branches of manufacture, than I had thought it necessary to do on the former occasion, when addressing an academical audience.

As the purport of what I said on this subject more particularly, has been strangely misapprehended by the individual who undertook to give a report of my Lecture in one of the Bristol newspapers, I feel it incumbent upon myself to publish this portion just as delivered; and for the rest may refer to an abstract given in Felix Farley's Bristol Journal for Saturday, January 11; in which the heads of my discourse are correctly set down.

*Extract from the Lecture delivered at the Bristol Institution, Jan.* 6, 1823.

IN considering the arts that owe their improvement to Chemistry, or on which the application of its principles may be expected to throw new light, I am compelled, from the vastness of the field, to confine myself chiefly to such as are connected with the commerce of this city, even though at the risk of omitting some of the most interesting and illustrative cases.

The remarks, however, that I have to make on the application of Chemistry to the manufactures of Bristol, will derive a sort of authority from the access I have had to several of the most important establishments; the principals of which, with a liberality that does them honour, have in several instances explained to me the details of the processes they adopt, and thereby enabled me to avail myself, in some measure, of their own practical experience.

With regard to the method of obtaining malleable iron, it may be sufficient to observe, that the examination of the ore to determine its richness and the impurities with which it may be mixed, the converting it by fusion with carbon into cast iron, and the expulsion, finally, of the latter ingredient, in order to render it malleable, are all processes dependent on chemical changes, and therefore must, *ceteris paribus*, be most successfully prosecuted by such as are acquainted with the principles of this science.

If it be objected, that the making of iron may be traced back to an age in which no theoretical knowledge of the kind existed, I may appeal to the rudeness and inconvenience of the methods first practised, and to the improvements since introduced in them by the aid of science, as proofs that speculative information and practical ingenuity ought ever to go hand in hand. Iron founderies have indeed been established ever since the time of the Romans; but so imperfectly was the ore reduced in those unenlightened periods, that many manufactories are now supplied with the very material which our forefathers had thrown away as dross, after extracting all the metal which they had imagined it to contain.

I need only refer to the extensive works of Messrs. Hill and Co. at Merthyr Tydvil, in proof of the correctness of this statement.

The process of making steel was also conducted originally without any reference to theory; but if we consider that its quality, which varies so remarkably, is known to depend upon the due proportion between the carbon and iron being preserved, it is fair to conclude, that an investigation of the subject, conducted on chemical principles, would suggest many improvements, and render the process a more certain one. A remarkable instance of this is derived from a paper lately published in the Philosophical Transactions by Mr. Stodart, a cutler in the Strand, assisted by Mr. Faraday, of the Royal Institution, a professed chemist. These researches, conducted entirely on scientific principles, appear to have led to the discovery of a mode of imitating that superior description of steel, of which the sabres of Damascus are fabricated: they have also considerably improved the quality of steel by alloying it with other metals, the very existence of which would have been unknown, had it not been for the sagacity of two scientific chemists—Dr. Wollaston and the late Mr. Tennant.

I would recommend, indeed, to those who are sceptical as to the advantages of theoretical knowledge in the arts, a perusal of the memoir drawn up conjointly by these two experimentalists, as a specimen of the true manner in which experience and speculation ought to be conjoined.

The manufacture of brass, I may venture to say, is not less improveable on chemical principles than that of iron. All manufacturers are aware of the uncertain composition of this alloy, and how much its quality depends on the proportion of zinc present. Were our manufacturers better chemists, they would probably devise some more precise method of producing that union, than the uncertain one of cementation. Le Sage, for instance, a scientific chemist, has shewn, that very fine brass may be manufactured by mixing together the oxyds of the two metals, and reducing them by a carbonaceous flux. This idea seems to deserve to be followed up.

The production of zinc is, I understand, rendered much more economical since the employment of a portion of blende. Now the discovery that blende is an ore of zinc, is due entirely to scientific Chemistry; for it is not long since this mineral, considered as a refuse material, was applied to no other purpose than to mend the roads; such at least was the case in Derbyshire.

The method of rendering zinc malleable, which employs a number of hands in this city, was the discovery of a French chemist, Monsr. Sage.

It is almost needless to remark, that the whole of soap-making is a series of chemical processes; but if we reflect upon the means pursued at present to gain the proposed end, we shall be convinced, that much might be gained in point of economy, as well as in the perfection of the manufacture, by a series of well-conducted experiments. How is it, for instance, that the mineral alkali alone can be employed for making hard soap; and whence does the utility of common salt, or muriate of soda, as a partial substitute for soda, arise? Is it decomposed by the potass, thus supplying the deficiency of barilla? If so, why might not the process be completed simply by employing common salt, together with a quantity of potass sufficient to decompose it? These questions, one would think, might be answered by a very few simple experiments; and the solution of them would amply repay the manufacturer for the trouble of obtaining the scientific knowledge necessary to lead him to these results. At all events, a familiar acquaintance with Chemistry would be desirable, were it only to enable him to determine the quantity of alkali present in the samples submitted to him for sale; for I think it may fairly be asserted, that any empirical method of ascertaining this must be fallacious, and that the only satisfactory one would be that of a chemical examination of the substance.

In the manufacture of verdigris an improvement has also been suggested, purely on theoretical principles. In the common way of preparing it, much waste of vinegar occurs; because the first portions of the acid go to oxydize the copper, which we know must necessarily take place before it can combine with any acid. An individual, whose knowledge of the process was entirely theoretical, reflecting on this fact, suggested, that the metal should be previously oxydized, by first heating it red hot, and afterwards plunging it into water: a method which, according to his statement, is found to have lessened considerably the consumption of acetic acid, the whole of which is now rendered subservient to the formation of the salt.

The economical production of the mineral acids is so dependent on the due proportion being preserved between the respective ingredients, that the process must always be defective, unless conducted on chemical principles.

Thus, it has been justly remarked[a], the principles of the formation of oil of vitriol depend on the solution of a problem of four conditions, or where four conflicting affinities are concerned; namely, those betwixt sulphurous acid, nitrous acid, oxygen gas, and water. Now these affinities are modified in a very essential manner, by the quantity of nitrogen present, and the degree of its temperature. It is therefore obvious, that if a problem of such intricacy be left to a rude operative hand to execute, the result must fall far short of that precision which might be attainable, if it were conducted on scientific principles.

Even the manufacture of gunpowder, though one of the arts that long preceded the cultivation of Chemistry, is understood to have received from a philosopher of the present day a further improvement: and in the last century, the chemical knowledge of another suggested a method of recovering from the damaged gunpowder its most valuable ingredient, the saltpetre; and thus proved the means of saving a great annual expense to government. But with reference to this subject, the most splendid instance of the utility of this science was afforded by the chemists of France, in the provision they made for the exigencies of their nation at the period immediately succeeding the revolution, when, surrounded by foreign enemies, and shut out from the sea,

[a] See Journal of Science, vol. xii. where it is stated, that the French undersell us in this article, though the raw material is dearer.

they were obliged to depend altogether upon the resources of science, for procuring the nitre required to supply their extraordinary demand for gunpowder.

The process of distillation, although strictly chemical, was, like many other arts, invented in a barbarous age, and is frequently carried on even at present without much attention to its scientific principles. Yet even in this case we have a proof that the application of speculative knowledge may contribute both to the improvement and the economy of the process, in the new method of distilling *in vacuo*, which was originally suggested to Mr. Watt, in consequence of his experiments on the lower temperature at which liquids boil, when atmospheric pressure is removed. By thus employing a more moderate heat, we are enabled to preserve from destruction a larger portion of the essential oil which gives to each spirit its peculiar flavour.

The researches of Chaptal have also shewn, that the taste of spirits depends much upon the malic acid they may contain, which, unless separated prior to distillation, is decomposed by the heat, and thus communicates to the spirit an empyreumatic flavour.

Dr. Macculloch has also shewn in his interesting little work on made-wines, that even this homely art admits of improvement on chemical principles.

The mode of producing sal ammoniac is entirely a chemical discovery. Until the last century, the whole supply of this article was furnished by the ports of Egypt, to which it was brought in the first instance from the Oasis of Jupiter Ammon.

As chemical knowledge extended, it was found that the basis of this salt was a constant product of the distillation of most animal matters, and might therefore be obtained at home at an expense incalculably less than that attending its importation from so great a distance. The process, as at present conducted, exhibits a curious series of chemical decompositions, which, it is presumed, can neither be understood nor successfully prosecuted without scientific knowledge. Even lately a still more economical method of obtaining this article has been adopted in Scotland, by employing the mother-water of the sea salt-works, which consists of muriate of magnesia, together with animal substances of various kinds. Now this invention was suggested by a paper in the *Annales de Chimie;* and was founded on the fact, which no manufacturer was likely to have stumbled upon in the course of his operations, that muriate of magnesia disengages its acid when exposed to a red heat.

The preparation of alum is, in all its steps, so completely a chemical process, that it would seem impossible to conduct it with any success, without some attention to its chemical principles. The French indeed, impressed with this feeling, employed long ago the science of professed chemists, such as Chaptal and Curandau, upon the subject; and in consequence contrived to surpass the English in the purity of their manufactured article. Their success appears to have stimulated our countrymen to corresponding exertions; for the alum manufactured here and at Glasgow is said at present fully to compete with any that can be produced abroad.

And although the secrecy that is preserved in some of the establishments in order to maintain their existing superiority, prevents my stating from authority how far they are indebted to Chemistry for it, yet I have no hesitation in expressing my opinion, that many of the improvements would on inquiry be found to have originated either directly or indirectly from men of science; and that even in the humble task of following their instructions, difficulties will sometimes arise which can only be removed by an appeal to the principles of the science from which the processes were derived.

When indeed we consider the attention necessary for securing the purity of the clay employed, for preventing the presence of any sulphate of iron, and for regulating the proportion of potass or ammonia, we cannot wonder that something more than mere practical experience should be required, to ascertain the most proper methods of attaining the desired object. The manufacturer too may thank the chemist for informing him, that the substance which remains after the distillation of aqua fortis contains two ingredients of his alum, viz. the sulphuric acid which unites with the clay, and the potass necessary for causing it to crystallize.

Although every process of sugar-refining necessarily consists in a series of chemical operations, yet that to which I would wish particularly to direct your attention, is the new method of making the patent sugar, introduced by Mr. Howard, a man of rank and science.

I need hardly inform the present audience, that its peculiarities consist in the more equal distribution of the heat by means of steam, in the use of a very ingenious system of filtration, and in enabling the sugar to boil at a lower temperature, by removing from the interior of the boiler the pressure of the atmosphere, and condensing the vapour which rises from the ebullition of the syrup.

If I am rightly informed with regard to the advantages of this new arrangement, I may in this instance claim from the manufacturer an acknowledgment of his obligations to scientific chemistry, as well as of the necessity of himself acquiring some knowledge of it, in order to regulate a process of such nicety.

The tanning of leather is so exclusively a chemical process, that every encouragement is held out to the manufacturer to make himself acquainted with its principles. Seguin, himself a tanner of considerable business in France, as well as a chemist of eminence, introduced an important change in the art, by ascertaining that it consisted in effecting a chemical union between the hide and a peculiar vegetable principle contained in the bark of the oak and other trees.

Hence he immediately inferred, that instead of immersing the animal substance in a tub containing oak bark, in which tannin constituted only one of many ingredients, it would be better to separate the tannin from the rest, and thus apply it in a more concentrated form. This method, first adopted by Seguin, soon became general on the continent; and though in this country the old process may still in some places be adhered to, yet I am told that the advantages of Seguin's more scientific method are generally felt, and that the effect is thereby produced in nine or ten days, instead of five weeks, which was the period formerly required.

Other important inferences may be deduced from the theoretical knowledge thus acquired.

Since tannin is found to exist in the bark of various trees, might not a cheaper substitute be found for the oak bark, at present principally employed by the manufacturer[b]? Might not the experiments of Mr. Hatchett, in the production of artificial tannin, be applied to practical results? Or if that of the oak should after all be found to retain its superiority, would it not be more economical to procure an extract of this principle from abroad, instead of importing the bark itself?

These suggestions I merely throw out for those who unite practical experience to theoretical knowledge: without the former, indeed, it would be presuming too far to hazard any opinion as to the specific improvements that might be introduced in this or any other of the manufactures; but the experience of what has been done already by the aid of science, gives us a rational confidence, that the same may again be applied with effect to similar results.

The process of gas illumination, now so extensively adopted in our streets, is another striking example of the utility of chemical knowledge in suggesting improvements, and the difficulty of availing ourselves of them when suggested, without some acquaintance with science.

How little the individual, who first collected and examined the gas emitted by coal under the influence of heat,

[b] I am indebted to my friend the Rev. R. Whately, of Oriel college, Oxford, for having pointed out to me the existence of a large quantity of tannin in the leaves and stalks of the rumex aquaticus, or great water dock, found abundantly in the meadows round Oxford.

was guided by any views of practical utility, may be readily inferred from the ridicule cast, even by men of science, upon the projector, who long afterwards, and in a much more advanced stage of our knowledge, first proposed the lighting a street with this material. Yet we have seen within a few years the success of the experiment so completely established, that at present the only struggle is between opposite companies contending to reap the acknowledged benefits of the invention, or endeavouring to establish the superiority of the gas from one kind of material over that from another.

We have thus before our eyes a striking proof of the futility of those prejudices, which exist in certain minds against the use of knowledge not immediately directed to practical purposes.

Nor are the processes in this new art as yet so complete, as to relieve the manufacturer from the necessity of appealing to Chemistry for instruction, or to allow of his competing with rival establishments, if he contents himself with following implicitly any prescribed routine of operations.

The purification of the carburetted hydrogen from its foreign ingredients, the method of obtaining the largest proportion of olefiant gas, on which the illuminating power depends, and the conversion of the coal tar itself into the same elastic fluid, are all problems that require the most refined researches of the scientific chemist to resolve.

The difference in the purity of the gas made by different companies is in itself a proof, that the manufacture depends for its success on a due attention to chemical principles.

But the most striking instance of scientific knowledge applied to purposes of the greatest practical utility, is afforded in Sir H. Davy's safety lamp, an invention which may justly be regarded as of vital importance to the future interests of this place; as the only circumstance that prevents the necessity of having recourse to this safeguard against subterraneous explosion, is the comparatively small extent and inferior depth of the coal mines of this neighbourhood;

a source of security which every year's consumption of fuel must have a tendency to diminish. I am also the more disposed to call your attention to this, because it cannot here be said, that any degree of natural shrewdness, or practical experience, could have supplied the want of scientific acquirements; for the danger to which the miner was exposed, from explosions that were continually occurring, had so long been felt, that all the ingenuity of those employed in the service had for a long period been fruitlessly directed to the discovery of a remedy. Indeed, if we peruse the detail of Sir H. Davy's researches, and consider the steps by which he was finally led to this most useful invention, we shall be persuaded, that it could only have been made by one, who to the most original powers of mind united a thorough acquaintance with the principles on which its success depended.

Let those then who undervalue the importance of speculative knowledge in the arts of life reflect, that but for the researches of a theoretical chemist, some of the most important coal mines in this country, which supply the metropolis with fuel, would probably at no very remote period have been rendered unworkable by the gradual accumulation of the coal-damp, which appears to increase with the depth: or that at best they could only have been pursued with a consumption of lives at which humanity shudders; such indeed as might render it questionable, whether even so useful a commodity ought to be purchased at such a price.