Commented Translation of Part of

Claude-Louis Berthollet's Essai de statique chimique

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INTRODUCTION

Everyone who has studied high school chemistry has heard of Antoine Lavoisier. His name is automatically associated with chemical nomenclature, as John Dalton's is inextricably linked to the atomic theory. And yet Lavoisier was only one of many great French chemists who lived and worked in the years that spanned the French Revolution (Lavoisier was one of its victims). One of the greatest contributors to the progress of chemistry was an associate of Lavoisier, one Claude-Louis Berthollet. It is doubtful that many, even among those who have studied chemistry, have heard of him. This man s work was every bit as important and innovative as Lavoisier's. He was a distinguished man in his own time, who seemed to sail through all the upheavals and bounce back to the top after each one. He was, of course, very useful to the State in his capacity as industrial chemist. Lavoisier's downfall was largely due to the fact that he was a tax collector, a fatal occupation in such a time.

Although we associate chemical nomenclature with Lavoisier, the rational system of nomenclature was, in fact, devised by a group of four late eighteenth-century French chemists. Prior to the Revolution, France led the world in chemistry. In 1782, probably following a suggestion made by a Swedish chemist, Torbern Olof Bergman (1735-1784), the President of the Academy of Sciences, Guyton de Morveau, proposed a system of chemical nomenclature to

the Academy. Over the next five years the system was amended to bring it into line with the new theories of the Lavoisier school. In 1787, after Guyton had agreed to reconstruct his system, the Nomenclature Chimique was published jointly by Lavoisier, Berthollet, Fourcroy (an industrial chemist) and Guyton de Morveau. The system of rational nomenclature was later extended by another Swedish chemist, Baron Johan Jacob Berzelius (1779-1848). The system is noted for adaptability to new discoveries and to a broad variety of languages. It has of course been modified over the years to keep up with progress in the science. Nevertheless, it is still basically the same system it was nearly two hundred years ago.

It is our purpose to show that Berthollet's relative obscurity today is the result of poor communication on several levels in his lifetime. Communication of his ideas had four main obstacles to contend with. The first is related to the complexity and disordered state of chemical theory; the second (a direct result of the first) to the almost total lack of standard chemical terminology; the third to Berthollet's pompous, circuitous, long-winded writing style; and the fourth to the quality of the translation into English of his most important theoretical treatise, "Essai de statique chimique".

Claude-Louis Berthollet was born in Talloire, near Annecy in Savoy in 1748. At that time, the area was the home of a thriving textile industry, a fact that takes on importance as the story of

Berthollet s life unfolds. His early education was at Chambéry. During his formative years, Savoy was passed back and forth between France and Italy a number of times. It is more than likely that he grew up speaking both French and Italian, the former because his family was of French origin, the latter because of the environment. He studied medicine in Torino. In 1772 at the age of 24, he moved to Paris, where he became personal physician to the Duke of Orleans. He developed a great interest in chemistry and, in 1780, was admitted to the Academy of Sciences. In 1785 he formally announced his adherence to Lavoisier's new theories, rejecting the phlogiston theory of combustion to which he had previously adhered. Most of his practical experience was as an industrial chemist, which naturally led him to think in terms of huge quantities of reagents, and the effect of quantity on reactions. One of his special interests was the chemistry of dyeing. He introduced the use of chlorine as a bleaching agent at a plant in a small town called "Javel". Hence the terms "javel water" and "Javex".

Berthollet had a distinguished public career. As Holmes (1962: 139) points out, he is a precursor who does not fit the picture of the forgotten man. He was, at different times, Commissioner of the Mint, Commissioner of Agriculture and Arts, Professor at the Polytechnic and Normal Schools. During the early part of the French Revolution, he travelled throughout the country, giving instruction on smelting and the conversion of iron into steel. He was an adviser and long-time close friend of Napoleon Bonaparte, who made him a senator and later a count. He

nevertheless voted for the deposition of Napoleon in 1814. On the restoration of the Bourbons he was created a peer. A statue of Count Berthollet dominates the town square of the beautiful town of Annecy on Lake Geneva. He died at Arcueil (near Paris) on November 6 1822.

Problems related to subject matter

Chemistry in the late eighteenth and early nineteenth centuries was essentially a practical science. A chemist in search of a theory was generally after something that could be put to practical use. The purpose of theory was to validate existing practice, or justify changing it. Pharmacy, the textile industry, armaments, agriculture, all looked to chemistry for answers to specific problems. Berthollet made important contributions to all these fields; he was interested in them all. Theoretical chemistry was the new frontier; he was interested in that too. His work was more analagous to the R & D programs of modern drug companies than the speculative research done in university laboratories.

So much was still a matter of conjecture; there were so many conflicting theories, and everyone took sides. It took daring and insight to suggest any sort of general conclusion at all. The two main topics of study at the time were the composition of matter and the nature of reactions. Lavoisier made great strides in bringing simplicity and order to the chaos of knowledge on the

composition of matter when he defined an element as a substance that cannot be analyzed into or synthesized from simpler constituents. The definition paved the way for Dalton's atomic theory, published in 1808 in his New System of Chemical Philosophy, Part I.

It should be noted that the chemist and translator Thomas Thomson of Edinburgh was patently wrong when he said that the French Revolution and Napoleonic Wars cut off communication between Britain and the Continent. As Guerlac (1961: 549) points out, "Even in those troubled times, the scientists of each country had little difficulty in keeping abreast of what was going on in the other. A glance at any issue of Nicholson's Journal reveals that the latest discoveries of Guyton de Morveau, Vauquelin, Gay-Lussac, Proust and Berthollet and the rest were regularly summarized or translated from the Journal de physique and Annales de chimie. British discoveries were similarly reported in the French journals". Thomson was also one of Berthollet's most vigorous detractors. He considered his theories "subversive of all the laws of modern chemistry" (Holmes 1962: 113).

The theory of reactions was far more complex and more difficult to deal with, especially prior to 1808. For almost a century, chemists had been bogged down with affinity tables (originated by Etienne Francois Geoffroy, 1718). In the mid-eighteenth century, constructing affinity tables was one of the main occupations of chemists. When a new substance was discovered, a table of

affinity was constructed for it. The tables were based on the assumption that attraction between substances is an immutable constant. It was only very gradually that chemists came to realize that the position was too rigid. Lavoisier introduced the idea of affinity as a variable, dependent on a broad variety of properties.

It was Berthollet who first pointed out the intrinsic error of the tables. By suggesting that the effective action of a substance is related to its mass, he completely destroyed the significance of the affinity tables (Ladenburg 1906: 40). Berthollet's theoretical conclusions were basically correct. He made one fairly serious, if not surprising, error in that he classified solutions and alloys with compounds.

Following the death of Lavoisier (1794), Berthollet was the acknowledged leader of French chemistry for more than twenty years. His position was recognized outside France. Berthollet was a pioneer of modern chemical theory, especially the theory of chemical reactions. He embarked on a program aimed at in-depth study of the problem, backing it up by experiment. He built up an important research school at his country home in Arcueil, outside Paris. He came to the conclusion that the mechanics of reactions can be explained on the basis of a fixed affinity acting in concert with other, variable forces. He saw chemical reaction as a dynamic process, with the final result depending on the interplay of forces over a period of time, and greatly influenced by the quantities of reagents present.

Berthollet coined the expression "chemical mass" (masse chimique), which he defined as the product of the affinity of a substance with the weight present.

Significant discovery is so often not recognized as such by anyone but the innovator. This is precisely the case of Berthollet and his theory of chemical reactions. His ideas were away ahead of his time, to a great extent because they were beyond the capacities of the experimental methods available, a shortcoming he himself recognized (Ladenburg 1906: 42; Pattison-Muir 1907: 406). It was not until some sixty years later (1864-1867) that Guldberg and Waage formulated the Law of Mass Action.

Berthollet s experiments led him to the (erroneous) conclusion that variable composition is the norm. This involved him in a long and bitter dispute with Proust, a strong advocate of fixed composition. Berthollet did observe that varying reagent quantity and reaction time had great impact on the final result. His error was that he extrapolated too far. His conclusions were perfectly valid up to a point; his mistake was to confuse a <u>possible</u> explanation of a phenomenon with a <u>necessary</u> one (Kapoor 1965: note 48). The error was compounded by the fact that he "analyzed the crude product directly, and did not first try to satisfy himself that he was not dealing (as was generally the case) with a mixture" (Ladenburg 1906: 42). Ladenburg goes on to say (ibid.: 45) that "There are cases in which mixtures are, in

their whole behaviour, no longer distinguishable from compounds" and (p 46) that "In short, this distinction forms one of the most difficult and most important problems, and in point of fact it is often insufficiently attended to. In the study of chemical papers opportunity is often afforded of observing how errors have arisen through neglect of this very matter". Ladenburg made this statement a full century after Berthollet s publication of his Essai.

It is easy now to see how Berthollet made his mistake, and how, in a way, he and Proust were both right. A further point: Berthollet did admit constancy of composition (as an exception), whereas Proust denied the possibility of variable proportions. Ladenburg discusses the controversy at length, pointing out that it was largely based on a confusion between the conceptions of mixture and compound, a distinction which Berthollet repeatedly requested from Proust, in vain. Hindsight is a wonderful thing. However, at that time, the work of other chemists (led by John Dalton in Manchester) all seemed to indicate constancy of composition. At the end of eight years, the general opinion was that Berthollet had lost the battle. His other views suffered as a result of this apparent defeat.

Berthollet straddles the line that divides the old and the new chemistry. He was the last of the eighteenth century chemists, and the first of the modern, nineteenth century chemists. He was one of the team that developed the standard nomenclature, he foreshadowed most of the important aspects in which chemistry was

to develop during the nineteenth century, and his methodological treatment is one of the masterpieces of its kind in all chemical literature. He emphasized the need to find the causes underlying chemical phenomena, providing chemists with a most valuable clue as to their mode of procedure, i.e. construction of explanatory models. He pointed the way to the need for more accurate techniques of analysis and measurement through his understanding of the large variety of conditions that influence a chemical reaction.

Problems related to terminology

The terminology of this practical chemistry was, as we have mentioned, haphazard at best. As Pinchuck (1977: 175) points out, "...in specialized languages in the past, ... the standardization processes were left to the interplay of blind forces and individual efforts". Most of the lexical items that made up the specialized language used in the chemical laboratories (which were essentially workshops) at the turn of the nineteenth century were neither standardized nor defined. They formed what Pinchuck calls a "workshop language", i.e. a semi-specialized language characterized by spontaneity, disorder, and usefulness in communicating practical instructions. Workshop language is usually based on everyday language; it relies heavily on metaphor. As a science progresses and develops, there is an increasing need for isolating individual concepts from neighbouring ones. True terms usually lack the vividness and

pictorial qualities of the earlier workshop expression, which is necessarily lost in the search for an expression of conceptual exactness. Eventually the metaphor fades away altogether.

A lexical expression is a term only within the framework of a conceptual system in which it is defined as a term. A concept is defined, and then it is given a name. The progress of any science involves development of new concepts, followed by definition of new terms. The lexical units "terminology" and "nomenclature" are not synonyms. Pinchuck (1977: 183) makes the distinction very clear when he says that "Terminologies are associated with conceptual systems, whereas nomenclature consists of the labels given to various objects". A nomenclature may be a subdivision of a terminology. A terminology is never a subdivision of a nomenclature. Berthollet s definition of the expression "chemical mass" is a true definition of a term. The term may not mean the same today as it did then; nevertheless it was a valid term at the time he coined it.

Obstruction of communication within a given technology is not uncommon today. At the turn of the nineteenth century, a time of endless debate on the fundamentals of an emerging science, when underlying theory was in constant flux, obstruction must have been almost the norm. Chemical terminology was sheer chaos, leading to serious comprehension problems and endless argument among scientists who spoke the same language.

There comes a time in the development of any science when definition of terms is absolutely essential. A language in which great accuracy cannot be achieved is inadequate for the needs of science. In 1787, Lavoisier, Berthollet, Fourcroy and Guyton de Morveau jointly published the standard chemical nomenclature, a landmark in the progress of chemistry, and the culmination of many years of work. At this juncture, standardized nomenclature was absolutely essential to further progress of the science. This achievement of French chemists solved the problems of naming individual chemical substances. It did not address the problems associated with the terminology of chemical processes.

This crucial shortcoming remained. There was no standard terminology for chemistry as a science, for the simple reason that there was no general theory on which it could be based, in any country. For many decades chemists on the Continent and in Britain continued to flounder around in a sea of confusion because the terms they used in discussing the composition and reactions of the various substances had no precise, specific meanings. Chemists simply did not know the difference between an element and a substance, a compound and a mixture, reaction and solution, an atom and a molecule, a body and a substance, and so on ad infinitum. Of course the nomenclature was a giant step; but it was a step, not the whole marathon. The development of a standard chemical terminology was impossible until there was a body of well defined chemical theory on which to base it.

It begins to look as if we are dealing with a chicken-and-egg situation. In a sense we are. This was a time when everything was happening at once. Think of dumping a giant jigsaw puzzle out of its box on to a table. Now imagine there is no overall picture to help fit the pieces together. The only way to work is by trial and error. In the early 1800s working in chemistry was much like working on just such a puzzle. There were no guidelines, little agreement on matters of theory, and a vague, poorly defined terminology.

A scientific term is a member of a conceptual structure and an integral part of a discipline. A term is defined by the content it stands for, not by any peculiarities in its linguistic structure. At a time when there was little agreement on the nature of chemical reactions and on the very structure of matter, standard terminology was an utter impossibility. It takes very little reading of scientific works of the period to demonstrate that, in fact, terminology was anything but consistent. Indeed, there was no way it could have been.

A few examples might be in order. Berthollet first. The most obvious is the indiscriminate use of the expressions "atome", "molécule", "particule", and "partie élémentaire". He adds to the confusion by occasionally using the word "élément" in a non-technical sense. When talking of acids and bases, he is quite consistent in his use of the word "acide", but seems to alternate indiscriminately between "alkali", "base" and "base alcaline". He talks about a substance s "affection" or, again, its

"disposition". He defines the term "masse" as a true scientific term, and then proceeds to use it otherwise as well.

Three frequently recurring words make understanding especially difficult. These are "effet", "condition", and the abovementioned "affection". They often seem to have no place in the context in which Berthollet uses them. The most probable explanation for this rather puzzling terminology can be found in Berthollet's educational background. His training undoubtedly included scholastic philosophy, Cartesian philosophy, perhaps even both. In any case, he would certainly have been exposed to the Latin terms "effectus", "conditio" and "affectio", which were part of the standard terminology of both philosophical systems. Lewis and Short define the three terms as follows: effectus (II in particular with reference to the result of an action, an operation, effect, tendency, purpose...); conditio (IIB of things, a situation, condition, nature, mode or manner...); and affectio (B - of bodies, a change in the state or condition, mode or manner). The classical authority is valid because of the fact that medieval and classical usage of the terms are almost identical. Berthollet s use of the three analogous French terms often seems closer to the scholastic definitions of the corresponding Latin terms than to any scientific meaning. Confusion of scientific and philosophical terminology would certainly provide an added barrier to clarity of expression.

The works of John Dalton were (and are) generally easier to understand than those of Berthollet. Even Dalton was not immune

to ambiguity. Sometimes he uses the word "gas", at others the expression "elastic fluid", obviously in reference to the same reality. He speaks of "ultimate particles", "extremely small particles" and "atoms". He refers to a "parcel of liquid", "ponderable bodies", and often uses the word "bulk", apparently to mean something not clearly either weight or volume.

Berthollet's Writing Style

Unlike the majority of chemical works of the time, Berthollet's major work "Essai de statique chimique", was not an elementary chemistry text. It was in no way aimed at the average student. It was in fact an advanced treatise on physical chemistry - the physics of chemical reactions - one that was some sixty years before its time. Despite his errors, he came far closer to the truth than any of his colleagues. But his work was revolutionary, complex, over the students' heads, and written in a style that was anything but clear, concise or easy to understand. His sentences ramble on and on, his punctuation is bizarre even for his time, his terminology is absymally inconsistent. Furthermore, the subject matter is very complex.

We are not talking of translation. French chemists found it hard going. It soon gained a reputation as a book that was very difficult to understand. In his introduction to the Essai, Crosland (p. xx) refers to Jean-Baptiste Dumas, who was born in the south of France in 1800 and received an elementary scientific education in

Geneva. Dumas was a largely self-taught chemist. By his own admission, it took him four years of constant study to absorb the Essai de statique chimique, a work he describes as "rather obscure", mentioning his many difficulties in understanding certain passages. He even says there are many passages in the book that can only be understood by referring to the writings of his pupils. Despite these difficulties, he considered that he owed his knowledge of chemistry to Berthollet.

This was clearly not a simple textbook for the uninitiated, but an advanced treatise that could be understood only by those very familiar with the subject matter, and willing to put up with Berthollet s convoluted style. Another example of Berthollet s long-winded style can be seen in his introduction to Riffault's French translation of the "Système de chimie" by Thomas Thomson. The introduction, a full 170 pages long, is in reality a rambling commentary on the current work and theoretical views of a whole series of chemists.

For purposes of comparison, let us move to England for a moment, to Manchester and John Dalton. The first part of Dalton's New System of Chemical Philosophy was published (in 1808) five years after the publication of Berthollet s Essai. There is a marked difference between the writing styles of the two men. Unfortunately Berthollet forgot what Dalton so vividly realized, that "brevity is the soul of wit", and expanded his theories in a lengthy and not particularly interesting treatise (Pattison Muir, 1907: 399). Dalton, on the other hand, was a born teacher. He expressed his

ideas clearly and simply (Cardwell, 1968: intro xx; quoting Farrar - 159 et seq). Many chemists (led by Thomson) announced that Dalton's ideas contradicted Berthollet's. We now know that it is more likely that Dalton was influenced by Berthollet s work. It is known that the two chemists were friends and carried on a long correspondence, in French. Berthollet was an honorary member of the Royal Society in Manchester, of which Dalton was the leading light. It was not until much later that the compatibility of their two theories was generally recognized. By that time, Dalton s fame and Berthollet's obscurity were fairly well established.

Quality of Translation

Up until about 1750 Latin was the language of science. Publication in the vulgate began in England and soon spread to other European countries. Communication of ideas among scientists made translation essential. Most of the translation was done by the scientists themselves. The subject matter was at least somewhat familiar. The more complex the ideas expressed, the greater the requirement for the translator to have a scientific background. Occasionally, for reasons that are not always clear, a scientific work was translated by a person totally unfamiliar with the subject matter. This seems to have been the case with B. Lambert, the translator of Berthollet's "Essai de statique chimique".

Crosland, in his introduction to the 1972 re-issue of the

original French version of the Essai, admits that, "Berthollet s meaning is not always clear", but says that "The basic fault of the English translation is that the translator often obscures passages which are fairly clear in the original French and provides a clear but questionable meaning to passages where Berthollet is ambiguous" (1972: xii).

The British Museum General Catalogue lists Lambert, B. as a "miscellaneous writer". He is not mentioned in the Catalogue de la bibliothèque nationale de France. The British Museum catalogue credits him with a total of four translations, all published in 1805 and 1806: the Berthollet, Travels to the westward of the Alleghany Mountains (Michaux), An essay on the spirit and influence of the Reformation of Luther (Villers, C.F.D. de) and Characteristic anecdotes from the History of Russia (Clausen, H.F.C.). Lambert is credited with one original work, The History and Survey of London and its Environs, from the earliest period to the present time. This is a 4 volume work, published in London in 1806 for Hughes and Jones by Dewick and Clarke. The publisher of the Villers translation is given as M. Jones. Nothing else is known of Lambert, his name appears nowhere except with reference to this two-year period. Judging by the diversity of the works he translated, he was not a chemist. Besides, if he were, his name would surely appear somewhere.

Based on the two examples of his work examined, the Berthollet and the essay on Luther, he was not much of a translator either. The

Luther is a good example of a translation done by the sort of person who believes that anyone with a rudimentary knowledge of two languages is by definition a translator. The sort of person who translates "... au milieu de la France rendue au catholicisme..." (Villers, p. 2) by "...in the bosom of France, restored to the catholic worship..." (Lambert, 1805, p. 2); and "D'autres, qui portent la vue plus loin..." (Villers, p. 10) by "Others, who carry their views a little farther..." (Lambert, 1805, p. 8).

Despite his obvious shortcomings, Lambert does have my sympathy. The day he agreed to translate Berthollet s Essai, he took on a Herculean task. As I have attempted to show, some of the terminological problems involved are virtually insoluble. How does any translator, scientifically trained or not, deal with "...des masses placées à une distance où la figure des molécules, leurs intervalles et leurs affections particulières n'ont aucune influence..."? (Berthollet, Intro, p. 1). This is but one example of the host of problems Lambert was faced with, problems even more difficult to solve in 1803 than they are today. Over and above the particular problems related to individual words was the general problem caused by the absence of a conceptual structure covering chemical reactions. The Essai would have been a challenge to any of the British scientists who usually translated French and German scientific works into English at that time; infinitely more so for a "miscellaneous writer" untrained in chemistry and with no special talent for translation.

In the Introduction to the Essai, Crosland quotes The Literary

Journal of November, 1804. The article he cites describes Lambert as a person who "appears not to have been sufficiently conversant with the subject to be qualified for the undertaking. Even the idiom of our own language has been so completely neglected, as to make the work in many places absolutely unintelligible to the English reader. Besides all this, hardly a page occurs in which several awkward mistakes and mistranslations do not totally alter and pervert the meaning of the original" (1972, p. xi). It would be presumptuous of me to add anything further to this assessment of Lambert s translation skills.

ESSAI

DE

STATIQUE CHIMIQUE

PREMIERE PARTIE.

ESSAY ON CHEMICAL STATICS

INTRODUCTION

All forces that produce chemical phenomena are the result of mutual attraction between particles of substances. This attraction is called "affinity" to distinguish it from astronomical attraction.

There is probably little fundamental difference between the two types of attraction. Because astronomical attraction involves bodies separated by great distances, the shape, configuration and position of the constituent molecules are irrelevant. The effects of the attractive force are always proportional to the mass and to the inverse of the square of the distance; they can be accurately calculated. Affinity (chemical attraction), however, is greatly influenced by specific (often unrecognized) conditions. The effects of chemical attraction cannot be deduced from a general principle, but can only be observed in individual, successive cases. Very few of these effects can be separated from the totality of the phenomena produced to an extent sufficient to allow meaningful calculation.

ESSAI
DE
STATIQUE CHIMIQUE.

INTRODUCTION.

Les puissances qui produisent les phénomènes chimiques sont toutes dérivées de l'attraction mutuelle des molécules des corps à laquelle on a donné le nom d'affinité, pour la distinguer de l'attraction astronomique.

Il est probable que l'une et l'autre ne sont qu'une même propriété; mais l'attraction astronomique ne s'excerçant qu'entre des masses placées à une distance où la figure des molécules, leurs intervalles et leurs affections particulières, n'ont aucune influence, ses effets toujours proportionnels à la masse et à la raison inverse du carré des distances, peuvent être rigoureusement soumis au calcul : les effets de l'attraction chimique ou de l'affinité, sont au contraire tellement altérés par les conditions particulières et souvent indéterminées, qu'on ne peut les déduire d'un principe général; mais qu'il faut les constater successivement. Il n'y

Observation is the only means of determining a body's chemical properties, and the interaction of affinities operating under specific conditions. If affinity is basically the same force as astronomical attraction, it adheres to the laws of mechanics that govern phenomena due to mass action. Chemical theory is slowly progressing toward statement of general principles. It is logical to assume that these principles, when they are finally formulated, will be analagous to the principles of mechanics. Until that time, the search for principles can only be based on observation.

The immediate effect of a substance's affinity is always combination. All the effects of chemical action are therefore direct results of the formation of a combination.

Every substance that has a tendency to combine does so in proportion to affinity and quantity. All chemical observation leads to this conclusion.

a que quelques-uns de ces effets qui puissent être assez dégagés de tous les autres phénomènes, pour se prêter à la précision du calcul.

C'est donc l'observation seule qui doit servir à constater les propriétés chimiques des corps, ou les affinités par lesquelles ils exercent une action réciproque dans une circonstance déterminée ; cependant, puisqu'il est très-vraisemblable que l'affinité ne diffère pas dans son origine de l'attraction générale, elle doit également être soumise aux lois que la mécanique a déterminées pour les phénomènes dus à l'action de la masse, et il est naturel de penser que plus les principes auxquels parviendra la théorie chimique auront de généralité, plus ils auront d'analogie avec ceux de la mécanique ; mais ce n'est que par la voie de l'observation qu'ils doivent atteindre à ce degré, que déjà l'on peut indiquer.

L'effet immédiat de l'affinité qu'une substance exerce, est toujours une combinaison ; en sorte que tous les effets qui sont produits par l'action chimique, sont une conséquence de la formation de quelque combinaison.

Toute substance qui tend à entrer en combinaison, agit en raison de son affinité et de sa quantité. Ces vérités sont le dernier terme de toutes les observations chimiques.

Mais, 1°. Les différentes tendances à la com-

1. The different tendencies to combine must be viewed as so many forces, forces that either reinforce each other, or cancel one another out to some degree. The only way to compare these forces, or to reach an understanding of the effects they produce, is to examine them one by one.

2. A substance's chemical action depends on more than the affinity specific to each component, and the quantity of each one. It also depends on the state of the components: an existing combination may suppress some of a component's affinity; reduction in volume or condensation may alter distances between components. I have labelled the conditions that alter the properties of a substance's elementary components the substance's "constitution". Analysis of any chemical action requires evaluation of each of these conditions and of all relevant circumstances.

The properties of a body that can alter its affinity have additional effects (unrelated to those that result in combination) that are dealt with by the various branches of physics. Furthermore a number of phenomena partially or wholly dependent on affinity are best studied from some other angle,

binaison doivent être considérées comme autant de forces qui concourrent à un résultat, ou qui se détruisent en partie par leur opposition; de sorte qu'il faut distinguer ces forces pour parvenir à l'explication des phénomènes qu'elles produisent, ou pour les comparer entr'eux.

2°. L'action chimique d'une substance ne dépend pas seulement de l'affinité qui est propre aux parties qui la composent, et de la quantité; elle depend encore de l'etat dans lequel ces parties se trouvent, soit par une combinaison actuelle qui fait disparaître une partie plus ou moins grande de leur affinité, soit par leur dilatation ou leur condensation qui fait varier leur distance réciproque : ce sont ces conditions qui, en modifiant les propriétés des parties élémentaires d'une substance, forment ce que j'appelle sa constitution : pour parvenir à l'analyse de l'action chimique, il faut apprécier non-seulement chacune de ces conditions, mais encore toutes les circonstances avec lesquelles elles ont quelque rapport.

Les propriétés des corps qui peuvent ainsi modifier l'affinité, ont encore d'autres effets qui sont indépendants de ceux que produit la combinaison, et qui sont l'objet des différentes parties de la physique. Il y a même plusieurs phénomènes qui, quoiqu'ils soient produits en tout

because the effect of affinity is minimal or has not yet been determined experimentally. Properties not directly related to affinity are called "physical properties". There is often a correlation between physical and chemical properties. A phenomenon caused by the joint action of both types of property can only be explained in terms of both. Closer ties among the physical sciences can only be beneficial to all concerned.
A general theory is a principle based on observations made from all points of view (i.e. physical sciences). A particular theory explains a chemical phenomenon on the basis of its relationship to all relevant properties.

Some sciences can progress appreciably without any theoretical basis. A science that deals mainly with natural facts has only to establish arbitrary order in observed facts. Chemistry is not one

ou en partie par l'affinité, doivent cependant être considérés sous un autre rapport, soit parce que l'affinité n'y contribue que pour une part trop faible, soit parce que l'expérience n'a pu conduire encore à déterminer les affinités particulières auxquelles ils sont dus. On désigne comme propriétés physiques toutes celles qui ne paraissent pas dépendre immédiatement de l'affinité.

Il suit de là qu'il doit souvent exister un rapport entre les propriétés physiques et les propriétés chimiques; qu'il faut souvent avoir recours aux unes et aux autres pour l'explication d'un phénomène auquel elles peuvent concourir, et qu'il convient d'établir une relation intime entre les différentes sciences dont la physique se compose, pour qu'elles puissent s'éclairer mutuellement.

Les principes établis sur les résultats de faits observés sous chaque point de vue, et l'explication des phénomènes chimiques fondée sur leurs rapports avec toutes les propriétés dont ils sont des conséquences, constituent la théorie qu'on doit distinguer en théorie générale et en théories particulières.

Il y a des sciences qui peuvent parvenir à un certain degré de perfection sans le secours d'aucune théorie, et seulement par le moyen d'un ordre arbitraire qu'on établit entre les

of these. Observation is generally based on experiment, and the results are influenced by the interaction of more or less accidental circumstances. Every experiment has a goal, is based on an hypothesis. For experimental observation to have any meaning, the facts observed must be compared from different angles, and at least some of the conditions necessary to each phenomenon observed must be established. Otherwise, it is impossible to reproduce observed phenomena. The most farfetched suppositions, ideas that today may seem positively ridiculous, had their uses in earlier times. Each hypothesis led to painstaking experimentation, essential to the early stages of chemistry as a science. The experiments produced a large body of facts. These in turn revealed a large number of properties and improved experimental methods.

However chemistry was simply an ever expanding volume of partial observations. The theories advanced were the antithesis of general laws, i.e. totally unrelated particular theories, their only limits those of human imagination. Chemists remained aloof, cut off from other branches of learning. As the facts accumulated, chemistry moved steadily further from being a true science.

observations des faits naturels dont elles s'occupent principalement ; mais il n'en est pas de même en chimie, où les observations doivent naître presque toujours de l'expérience même, et où les faits résultent de la reunion factice des circonstances qui doivent les produire. Pour tenter des expériences, il faut avoir un but, être guidé par une hypothèse ; et pour tirer quelque avantage de ses observations, il faut les comparer sous quelques rapports, et déterminer au moins quelques-unes des circonstances nécessaires auxquelles chaque phénomène observé doit son origine, afin qu'on puisse le reproduire. Ainsi des suppositions plus ou moins illusoires, et même des chimères qui sont aujourd'hui ridicules, mais qui ont engagé aux tentatives les plus laborieuses, ont été nécessaires au berceau de la chimie : par leur moyen les faits se sont multipliés, un grand nombre de propriétés a été constaté, et plusieurs arts se sont perfectionnes.

Toutefois la chimie ne fesait que se grossir d'observations incomplètes, et de theories particulieres qui n'avaient aucune liaison entre elles, qui se succédaient comme les caprices de l'imagination, et qui n'avaient aucun rapport avec les lois generales ; orgueilleuse et isolée de toutes les autres connaissances, plus elle fesait d'acquisitions, plus elle s'éloignait du caractere des veritables sciences.

It is only since affinity was recognized as the basis of all combination that chemistry can be regarded as a science tending toward establishment of general principles. Attempts have been made to classify the combinations possible for each element, and to establish the proportions required.

Bergman had a great influence on acceptance of affinity as a general principle. He identified most of the conditions that alter affinity or the effects it produces. He introduced chemical analysis methods based on affinity, and attained a degree of precision hitherto unknown.

Many phenomena, however, result from combinations involving oxygen, the substance which appears to have the most active affinities. Before the existence of this substance was known, observed fact had to be supplemented by hypothesis. No sooner did Priestley discover this all important substance than Lavoisier determined its combinations, thus attributing its numerous effects to their true cause. This great scientist's unforgettable discoveries elucidated not merely oxygen-related phenomena but

Ce n'est que depuis que l'on a reconnu l'affinité comme la cause de toutes les combinaisons, que la chimie a pu être regardée comme une science qui commençait à avoir des principes généraux : dès-lors on a cherché à soumettre à un ordre régulier la succession des combinaisons, que différents elements peuvent former, et à determiner les proportions qui entrent dans ces combinaisons.

Bergman donna beaucoup plus d'étendue à l'application de ce premier principe : il fit appercevoir la plupart des causes qui pouvaient en déguiser ou en faire varier les effets : il fonda sur lui les méthodes des différentes analyses chimiques, qu'il porta à un degré de précision inconnu jusqu'à lui.

Cependant un grand nombre de phénomènes dépendent de la combinaison de l'oxigène qui est la substance dont les affinités paraissent le plus actives; et son existence même n'était point connue : il fallait suppleer par des hypothèses à l'action qu'il exerce. Priestley n'eut pas plutôt fait connaître cette substance qui joue un rôle si important, que Lavoisier en determina les combinaisons, et rapporta à cette cause réelle les nombreux effets qu'elle produit. Le grand jour que ses decouvertes immortelles répandirent non-seulement sur les phénomènes qui en dependaient, mais encore sur l'action de

the action of a number of other gases discovered during the same period. The revolution in thinking that he produced makes his discoveries worthy of being considered a new, general theory.

Another prerequisite to correct interpretation of most phenomena is accurate understanding of the effect of heat on affinity and the results of affinity. After Black discovered the basic properties of heat, a number of physicists carried out more advanced experiments. Lavoisier and Laplace have published a technical paper that describes precise laws governing the basic properties of heat.

The chemistry of today is familiar with the properties that are the driving force that underlies all chemical action and is the source of all the phenomena it produces. Chemistry is currently based on principles that have led to rapid advances in all branches of the science.

Particular theories are limited to consideration of specific facts or a restricted category of phenomena. Many are no more than a rigorous application of observed properties, or a subjective description of an experiment. Until the science

plusieurs autres gaz découverts à la même époque, mérita à la révolution qu'il produisit l'honneur d'être regardée comme une théorie générale et nouvelle.

La considération précise d'une cause également puissante, par les modifications qu'elle introduit dans les résultats de l'affinité, celle de l'action de la chaleur était aussi nécessaire pour l'interprétation de la plupart des phénomènes : on devait à Black la découverte des propriétés fondamentales de la chaleur ; elles avaient occupé après lui plusieurs physiciens ; mais elles furent soumises à des lois bien déterminées, dans un savant mémoire qu'on doit à Laplace et à Lavoisier.

On voit donc que la chimie a acquis de nos jours la connaissance de ces propriétés génératrices qui accompagnent toute action chimique, et qui sont la source de tous les phénomènes qu'elle produit : cette science a donc pu être fondée sur des principes dont l'application a fait faire des progrès rapides à toutes les connaissances qu'elle embrasse.

Comme les théories particulières bornent leurs considérations à certains faits ou à quelques classes de phénomènes, elles peuvent souvent se restreindre à l'application rigoureuse des propriétés bien constatées, et n'être, pour ainsi dire, que l'expression réservée de l'expérience,

progresses sufficiently to broaden their scope, they cannot be any more than this. Particular theories are based on knowledge acquired through the senses. This is especially true when it comes to determining the elements that make up a compound substance and the methods used to do so.

The above does not apply to a theory that involves consideration of all particular theories, that attempts to establish which chemical properties are common to all bodies, and which specific to individual bodies. The aims of such a theory are to shed light on all subjects, improve all methods, collect and compare results. It seeks out individual causes that contribute to a given phenomenon, and attempts to determine their relative weight. It goes beyond mere observation and comparison of phenomena whose causes are obvious. It suggests a possible relationship between knowledge already acquired and facts as yet unknown. It may abandon without explanation facts whose importance is not recognized - because of inaccurate or poorly

jusqu'à ce que les progrès de la science leur donnent une plus grande extension : elles peuvent donc être réduites à toute la certitude qui peut appartenir aux connaissances fondées sur le témoignage de nos sens; ce qui est sur-tout vrai pour la détermination des éléments des substances composées, et des méthodes par lesquelles on parvient à cette détermination.

Il n'en est pas de même de la théorie qui embrasse la considération de toutes les théories particulières, et qui cherche à démêler ce qu'il peut y avoir de commun entre les propriétés chimiques de tous les corps, et ce qui peut dépendre d'une disposition particulière à chacun : occupée de répandre la lumière sur tous les objets, de perfectionner toutes les méthodes, de recueillir les résultats pour les comparer, elle tâche de reconnaître toute la puissance de chaque cause, et toutes les causes qui peuvent concourir à chaque phénomène ; elle porte la vue par-delà les limites de l'observation ; elle ne compare pas seulement les phénomènes dont les causes peuvent être clairement assignées ; mais elle indique la liaison qui peut se trouver entre les connaissances acquises et celles auxquelles on doit aspirer : si elle abandonne sans explication un certain nombre de faits dont elle n'apperçoit encore aucune conséquence,

planned experiment, or because the facts are based on the complex interaction of a number of properties - only to re-examine them when relevant new facts come to light.

The theory must of course be based on accepted truths, and fairly well grounded conjecture. Application of the principles on which it is based will provide fairly complete, fairly accurate explanations of a variety of phenomena. The theory improves and grows in importance through further observation and interaction with other sciences.

Once the general properties that are the goal of all the effects of chemical action were recognized, the conditions of affinity that best comply with all explanations were soon set out as constant, established laws. The laws could then be used as the basis for further explanation. The progress of a science is measured mainly by its capacity to enlarge its scope in this way.

Because I am convinced that current chemical principles and, as a consequence, their corollaries cannot as yet properly be classified as fundamental, I have undertaken to re-examine them

soit parce qu'ils doivent être éclaircis par des expériences plus exactes ou mieux dirigées, soit parce qu'ils dépendent d'un conflit trop grand de différentes propriétés, elle les ressaisit dès quelle apperçoit une lueur qui peut la guider.

Cette théorie repose nécessairement sur des vérités bien établies, et sur des conjectures plus ou moins fondées; et, par l'application des principes auxquels elle s'élève, elle donne des explications plus ou moins complètes, plus ou moins certaines des phénomènes divers; elle se perfectionne et s'aggrandit par les progrès de l'observation, et par son commerce avec les autres sciences.

Dès que l'on a reconnu les propriétés générales auxquelles doivent aboutir tous les effets de l'action chimique, on s'est hâté d'établir, comme lois constantes et déterminées, les conditions de l'affinité qui ont paru satisfaire à toutes les explications; et réciproquement on déduit de ces lois toutes les explications, et c'est dans la superficie que la science acquiert par là, que l'on fait principalement consister ses progrès.

Persuadé que les principes adoptés en chimie, et les conséquences immédiates qu'on en tire pour qu'elles servent elles-mêmes de principes secondaires, ne devaient point encore être admis

exhaustively. The observations that led me to believe that we still know relatively little about the effects of affinity are contained in an earlier publication that deals with my research on the laws of affinity.

The present essay is an attempt to enlarge on my earlier reflections so as to include all the factors that may alter the results of chemical action (the product of affinity and quantity). It includes discussion of the interdependence of the chemical properties of an individual body, and of the properties of different substances. Every attempt has been made to establish the forces produced by this interaction through examination of their effects. In addition, an attempt has been made to distinguish between forces that reinforce the effects and forces that weaken them.

The essay is divided into two parts. The first part deals with all aspects of chemical action. The second part deals with the substances that have the most profound effect on chemical phenomena, and classification of these substances by property or interrelationship of affinities.

I begin by considering affinity and its influence on the coherence of the component parts of a body. I define "cohesion" as the combined effect of the individual affinities of the

comme des maximes fondamentales, je les ai rappelés à un nouvel examen, et j'ai déjà publié dans mes recherches sur les lois de l'affinité les observations qui m'ont porté à croire qu'on ne s'était pas encore fait une idée très-exacte des effets qu'elle produit.

Le but de cet essai est d'étendre mes premières réflexions à toutes les causes qui peuvent faire varier les résultats de l'action chimique, ou du produit de l'affinité et de la quantité. J'examinerai donc quelle est la dépendance mutuelle des propriétés chimiques des corps, comparées d'abord entr'elles, et considérées ensuite dans les différentes substances; quelles sont les forces qui naissent de leur action dans les effets qui en proviennent, et quelles sont celles de ces forces qui concourrent à ces effets ou qui leur sont opposées.

L'essai est divisé en deux parties : dans la première, je considère tous les éléments de l'action chimique, et dans la seconde, les substances qui l'exercent et qui contribuent le plus aux phénomènes chimiques, en les classant par leurs dispositions ou par les rapports qui existent entre leurs affinités.

Le premier effet de l'affinité sur lequel je fixe l'attention, est celui qui produit la cohérence des parties qui entrent dans la composition d'un corps; c'est l'effet de l'affinité réci-

components. Cohesion has the effect of holding components together. It is opposed to all the forces that influence them to form different combinations.

All affinities whose action tends to reduce the effects of cohesion must be considered as opposing forces that lead to dissolution. For example, a liquid can liquefy a solid if the liquid's force of dissolution is stronger than the solid's force of cohesion. Sometimes dissolution occurs immediately. Sometimes it cannot occur until cohesion has been weakened by the first stages of combination. Under some circumstances the liquid can do no more than moisten the surface of the solid. If the solid's affinity for the liquid produces an effect no greater than that produced by the mutual affinity of the liquid's constituents, the solid is not even moistened. Affinity and dissolution produce a variety of effects, depending on their relative strength. These effects must be distinguished one from the other. However we should not fall into the error of those physicists who attribute inconsistent results to the action of two affinities, one chemical, the other physical.

Chemists have not been able to ignore the effects of cohesion.

However, they have presumed cohesion to be a property that is exclusive to solid bodies and disappears when a body changes to another state. What actually happens is that the effects remain, even though they may no longer be apparent. The same thing occurs when any physical force is suppressed. One of the main disparities between my explanation and generally accepted theory is that the latter ignores this consideration.

The interaction between components of a substance that makes them tend to come together can be overcome by a force of dissolution. The extent to which the combining force is diminished depends on the quantity of solvent used and the amount of heat used to step up its action. Conversely, reduction in heat or solvent quantity increases the combining force and related effects. The various separations and precipitations that occur in liquids because of the formation of a solid are the result of such reductions.

Crystallization is one of the obvious effects of the force of cohesion. The parts that crystallize take on a symmetrical configuration determined by the interaction of small particles of solid material that separate out from a liquid as a result of their force of cohesion. Some properties of solids (e.g. ease of

proque de ces parties, que je distingue par le nom de force de cohesion, et qui devient une force opposée à toutes celles qui tendent à faire entrer dans une autre combinaison les parties qu'elle tend au contraire à réunir.

Toutes les affinites qui tendent par leur action à diminuer l'effet de la cohesion, doivent être considerées comme une force qui lui est opposée, et dont le résultat est la dissolution. Lors donc qu'un liquide agit sur un solide, sa force de dissolution peut produire la liquéfaction du solide, si elle l'emporte sur celle de cohesion; mais quelquefois cet effet a lieu immediatement; quelquefois il faut que la cohesion soit d'abord affaiblie par un commencement de combinaison; il est des circonstances où le liquide ne peut agir qu'a la surface du solide et le mouiller; enfin le solide ne peut pas même être mouillé, lorsque son affinité avec le liquide ne produit pas un effet plus grand que celui de l'affinite mutuelle des parties de ce dernier. Ces deux forces produisent donc, selon leur rapport, differents resultats qui doivent être distingues, mais qu'il ne faut pas attribuer, avec quelques physiciens, a deux affinites dont ils ont regarde l'une comme chimique, et l'autre comme derivee des lois physiques

Les effets de la force de cohesion n'ont pu echapper a l'attention des chimistes; mais ils

ne l'ont considérée que comme une qualité des corps actuellement solides, de sorte que la solidité n'existant plus, ils l'ont regardée comme détruite : au contraire, ses effets peuvent cesser d'être sensibles sans qu'elle cesse d'agir, ainsi que toutes les forces physiques qui sont comprimées : c'est ici l'une des principales causes de la différence que l'on trouvera entre les explications que je présente et celles qui sont adoptées, et dans lesquelles on a négligé de faire entrer cette considération.

L'action réciproque qui tend à réunir les parties d'une substance peut être surmontée par une force dissolvante, et son énergie diminue à mesure que la quantité du dissolvant augmente, ou que son action est accrue par la chaleur; au contraire, elle augmente si les circonstances précédentes s'affaiblissent, et elle reproduit enfin des effets qui sont dus à sa prépondérance : de là toutes les séparations et précipitations qui ont lieu dans un liquide, et qui sont dues à la formation d'un solide.

La cristallisation est un des effets remarquables de la force de cohésion ; les parties qui cristallisent prennent un arrangement symétrique qui est déterminé par l'action mutuelle des petits solides que leur force de cohésion sépare d'un liquide; et les conditions d'un solide qui se rompt plus facilement dans un sens que dans

breakage along a specific axis, fragility, elasticity, ductile strength) are factors of the configuration.

The solubility of any salt depends on the balance between the salt's cohesion and the dissolving power of the liquid involved. This explains why one salt will crystallize rather than another, and why salts can be separated by successive evaporation. The force of cohesion opposes both the effect of the solvent and interaction with other salts. Several salts in solution are all part of a liquid where individual action is in a state of equilibrium, until such time as the force of cohesion acquires sufficient energy to change the least soluble salts to the solid state.

The immediate effect of all chemical action is combination. Dissolution is simply combination considered in the light of its relationship to the force of cohesion. In all combinations substances have been observed to act in proportion to the quantity present within the sphere of activity. An obvious corollary is that the action of a substance slows down as saturation is approached.

Some substances have one predominant affinity that greatly influences its properties. These strong affinities are used to

un autre, qui est plus ou moins fragile, plus ou moins élastique, plus ou moins ductile, dépendent de cet arrangement.

La différente solubilité des sels qui provient du rapport de leur force de cohésion à l'action du liquide dissolvant, est non-seulement la cause de leur cristallisation, mais aussi de leur séparation successive par le moyen de l'évaporation; elle n'est pas seulement opposée à l'effet du dissolvant, mais à leur action mutuelle; car pendant que différents sels sont en dissolution, ils ne forment qu'un liquide où toutes les actions particulières se contrebalancent jusqu'à ce que la force de cohésion ait acquis assez d'énergie pour faire passer à l'état solide ceux qui sont moins solubles.

Puisque l'effet immédiat de toute action chimique est une combinaison, la dissolution n'est elle-même qu'une combinaison considérée sous son rapport avec la force de cohésion; or, dans toute combinaison on remarque que l'action d'une substance est toujours proportionnelle à la quantité qui peut se trouver dans la sphère d'activité : une conséquence immédiate de cette loi, c'est que l'action d'une substance diminue en raison de la saturation qu'elle éprouve.

Parmi les affinités d'une substance, il y en a quelquefois une qui est dominante, et qui imprime son caractère à ses propriétés distinc-

classify substances within a system of chemistry. Furthermore, they are the immediate cause of most chemical phenomena.

All properties derived from a dominant affinity are suppressed or reappear along with it. Combination produces new properties unrelated to those that disappeared on saturation; they are the result of changes brought about by condensation or expansion of the combining elements. The interaction of particles in a combination reflects the condensation or expansion that brings the particles closer together or pushes them further apart. This is why a salt in combination has a specific solubility, a specific crystallization.

When a substance enters into a combination incompatible with its dominant affinity, it carries over into the combination all the properties related to the affinity, modified by the new composition and the extent of saturation. This is why an alloy has the properties of a metal. Changes in properties related to the interaction of simple or complex particles of a substance (force of cohesion, fusibility, specific weight) are directly

tives : ce sont ces affinités énergiques qui servent à classer les substances dans un système de chimie, et qui donnent naissance à la plupart des phénomènes chimiques.

Toutes les propriétés qui sont dérivées de cette affinité dominante deviennent latentes ou reparaissent avec elles ; la combinaison en a de nouvelles qui n'ont plus aucun rapport avec celles qui ont disparu par la saturation, mais elles sont une conséquence des changements qui se sont opérés par la condensation ou par la dilatation des éléments de la combinaison ; car l'action réciproque des molécules d'une combinaison correspond à la condensation ou à la dilatation qui approche ou éloigne les molécules ; ainsi les sels qui sont dans l'état de combinaison ont une solubilité et une cristallisation particuliere.

Lorsque les substances qui jouissent d'une affinité dominante subissent une combinaison qui est étrangère à l'action de cette affinité, elles y portent toutes les propriétés qui en dépendent, et qui ne sont que modifiées par la constitution qu'elles ont acquise, et par le degré de saturation qu'elles ont éprouvé ; ainsi un alliage conserve les propriétés métalliques ; et celles qui proviennent de l'action réciproque des molécules, soit simples, soit composées, telles que la force de cohésion, la fusibilité, éprouvent,

attributable to the altered interparticulate distance in the new configuration.

Suppose a substance has a powerful dominant affinity. Suppose that substance is saturated by another and the properties of the first disappear. It follows that the second substance has an equally powerful, but contrary dominant affinity.

Acids and alkalis provide an excellent example of the contrary properties that are the main source of chemical phenomena. Their interaction merits further discussion.

First of all, I consider that the mutual tendency of acids and alkalis to saturate each other to be a general property, unrelated to the specific tendencies of individual acids or bases, or the properties related to their components.

Reciprocal saturation of an acid and an alkali is an immediate effect of reciprocal affinities. It can even be taken as a measure of those affinities, provided the quantity of each required to reach saturation is taken into account. It follows

ainsi que la pesanteur spécifique, un changement qui n'est produit que par celui de la distance mutuelle des molecules dans la constitution qu'elles ont acquise par la combinaison.

Une affinité dominante et énergique dans une substance suppose une disposition analogue dans une autre substance dont les propriétés caractéristiques doivent par là être regardees comme antagonistes des siennes, puisqu'elles les font disparaître par la saturation.

Les acides et les alcalis montrent au plus haut degre ces propriétés antagonistes qui sont la source principale des phenomenes chimiques; leur action reciproque mérite donc de fixer particulièrement l'attention.

Je considère d'abord comme un attribut général, cette propriété correlative des acides et des alcalis de se saturer mutuellement, indépendamment des affections particulières à chacun d'eux, et des proprietes qui dependent des elements dont ils sont composes.

Comme cette saturation réciproque des acides et des alcalis est un effet immediat de leur affinité reciproque, elle doit être regardée comme la mesure de leur affinite, si l'on prend en consideration les quantites respectives qui sont necessaires pour produire cet effet. D'où il suit que les affinites des acides pour les alcalis ou des alcalis pour les acides sont proportion-

that the affinities of acids for alkalis and vice versa are proportional to their capacity for saturation. From this I conclude that when several acids act on a single alkali, the result is not a single combination between one acid and the alkali. Each acid acts in proportion to its capacity for saturation and the quantity present. I have named this complex relationship "chemical mass". What I am saying is that when several acids compete for one alkali, the action of each is proportional to its mass. Mass is determined by comparing the saturation capacities of all acids with reference to a given alkali, or of all alkalis with reference to a given acid.

The concept of elective affinity was postulated to explain combinations involving two acids and one alkali, or two acids and two alkalis. It was presumed that, by elective affinity, one substance would replace another in a combination, and that the interaction of four substances would produce two separate combinations.

This supposition does not comply with the general law governing combinations. In my opinion, the effects of affinity must be considered separately. i.e. the effect that produces combinations

nelles à leur capacité de saturation. J'établis en conséquence que lorsque plusieurs acides agissent sur une base alcaline, l'action de l'un des acides ne l'emporte pas sur celle des autres, de manière à former une combinaison isolée, mais chacun des acides a dans l'action une part qui est déterminée par sa capacité de saturation et par sa quantité; je désigne ce rapport composé, par la dénomination de *masse chimique*; je dis donc que chacun des acides qui se trouvent en concurrence avec une base alcaline agit en raison de sa masse; et pour déterminer les masses, je compare les capacités de saturation, soit de tous les acides avec une base, soit de toutes les bases avec un acide.

Pour expliquer les combinaisons qui se forment dans le concours de deux acides avec une base, et celles qui se produisent par l'action de deux acides et de deux bases, on a supposé une affinité élective qui, par sa graduation, substitue une substance à une autre dans une combinaison, et qui dans l'action réciproque de quatre substances, détermine deux combinaisons qui s'isolent.

Cette supposition ne peut point se concilier avec la loi générale des combinaisons; mais la considération des deux effets distincts de l'affinité, en tant qu'elle produit les combinaisons et qu'elle est le principe de la force de cohesion,

must be distinguished from the effect that produces the force of cohesion. This would explain everything that has been attributed to elective affinity or to the action of double affinities.

The general rule that a substance's chemical action is proportional to its affinity and its quantity is affected by the force of cohesion. It is also influenced by the expansive action of caloric (i.e. that which produces heat), the principle of expansibility.

Caloric contributes to all chemical phenomena by influencing the action of all substances. It is thus extremely important that its general properties and effect in a variety of circumstances be determined accurately. This is the reason behind the apparent digression from my stated aim.

Whether a given substance is in the solid, liquid or elastic state depends on the balance between two opposing forces. The first of these (cohesion) draws the particles of a simple or complex substance together. The second (caloric) exerts an expansive force. In some cases the action of caloric contributes to the combination of one substance with another; in other cases

m'a paru suffire à l'explication de tous les faits qu'on attribue à l'affinité élective et à l'action des doubles affinités.

La loi générale à laquelle est assujettie l'action chimique que les substances exercent en raison de l'énergie de leur affinité et de leur quantité, n'est pas seulement modifiée dans les effets qui en dépendent par la force de cohésion ; elle l'est encore par l'action expansive du calorique ou de la cause de la chaleur, qui est le principe de l'expansibilité.

Comme toutes les substances éprouvent dans leur action l'influence du calorique, et qu'il contribue par conséquent à tous les phénomènes chimiques, il est important de déterminer avec précision ses propriétés générales et les effets qu'il peut produire dans différentes circonstances. J'entrerai à cet égard dans des détails élémentaires qui paraissent étrangers au but que je me suis proposé.

C'est du rapport de l'action réciproque par laquelle les molécules d'une substance simple ou composée tendent à se réunir, avec l'action expansive que le calorique exerce sur elles, que dépend la disposition de cette substance à la solidité, à l'état liquide ou à l'état élastique : l'effet du calorique peut concourir, selon les circonstances, à la combinaison de cette substance avec les autres, ou lui être

it opposes it. Whenever caloric produces the elastic state, the resultant gas must be considered a result of a combination with caloric, and elasticity as a force opposed to both the solid state and liquid combinations. The action of elasticity precedes its becoming effective, a characteristic previously referred to with regard to solidity.

Caloric tends to increase the distance between the particles of a substance. It would always be an obstacle to combination were it not for two facts. Caloric can promote combination by reducing solidity (another obstacle to combination); it can increase elasticity and contribute to the action of gases. It supports the combination of some substances and provides an obstacle to that of others, depending on their individual properties. These effects must not be confused with those of reciprocal affinity.

Elastic fluids have a smaller capacity for chemical action than all other types of substance. This is because no elastic fluid can have more than a very small quantity of matter within the sphere of activity.

When gases interact, the result depends on the relative strength of each one's affinity. When affinity is weak, the result is a

contraire. Lorsque le calorique produit l'état élastique, on doit considérer le gaz qui en provient comme dû à la combinaison qu'il forme, et l'élasticité comme une force opposée, soit à la solidité, soit aux combinaisons liquides ; mais il faut appliquer à l'élasticité ce que j'ai remarqué sur la solidité : son action précède l'instant où elle devient effective.

L'effort du calorique qui tend à accroître la distance des molécules serait toujours opposé aux combinaisons des substances entre elles, s'il ne produisait souvent un effet plus grand que ce premier, en diminuant la solidité qui est un autre obstacle à la combinaison, ou en augmentant l'élasticité qui seconde l'action des gaz : il favorise donc les combinaisons de quelques substances, et il est contraire à d'autres selon leurs dispositions. Il ne faut pas confondre ces effets avec ceux de l'affinité réciproque des substances.

Les fluides élastiques ont un grand désavantage relativement aux autres substances dans l'action qu'ils exercent sur elles, car ils ne peuvent porter dans la sphère d'activité qu'une très-petite masse.

Dans l'action réciproque des gaz, les résultats sont très-différents selon l'intensité de l'affinité ; lorsqu'elle est faible, elle se borne à une dissolution dans laquelle les dimensions respectives

solution that leaves volume and properties unchanged. When affinity if strong, volume is greatly reduced and different combinations, with different properties, are formed. We must be aware of the properties that distinguish constant gases from vapours (substances that adopt the gaseous state only under specific conditions).

These effects, far greater in gases than in either liquids or solids, are dependent on changes in volume, in turn caused by changes in temperature. The rules governing expansion of elastic fluids must be accurately established. The behaviour of constant gases may then be compared to that of substances that become gases only when acted upon by a constant gas or by an increase in temperature.

Combination may change a naturally elastic substance into a liquid or a solid. The condensation that occurs produces new properties. We must distinguish between the chemical action such substances can exert in the altered state, and the energy that they acquire, energy that is transferable to the combination. The affinity of a combination can be defined as a force resulting from the affinities of the components, affinities that reappear when the combination is destroyed, or are altered to produce

et les propriétés ne sont point altérées; si elle est énergique, ces dimensions éprouvent une grande diminution, et il se forme des combinaisons qui ont des propriétés nouvelles; mais il faut reconnaître les propriétés qui distinguent les gaz constants des vapeurs qui ne prennent l'état de gaz que dans certaines circonstances.

Tous ces effets varient par les changements de dimensions que produisent les changements de température, et qui sont beaucoup plus considérables que dans les liquides et les solides. Il importe donc de déterminer avec soin les lois que suit la dilatation des fluides élastiques, et de comparer sous ce rapport ceux qui sont permanents et ceux qui ne prennent cet état que par l'action des premiers ou par des élévations de température.

Les substances naturellement élastiques peuvent être ramenées par la combinaison à l'état liquide ou solide; alors elles acquierent des propriétés nouvelles par leur condensation. On doit distinguer l'action chimique qu'elles peuvent exercer dans cet état, et l'energie qu'elles ont acquise et qu'elles peuvent communiquer à leur combinaison en regardant l'affinité de celle-ci comme une force resultante des affinités élémentaires qui lui succedent lorsque la combinaison cesse, ou qui donnent naissance à

different affinities when the state of the combination is altered.

All natural phenomena occur in the atmosphere. Because atmospheric pressure and temperature, and combinations involving atmospheric components, greatly influence these phenomena, all three contributing factors must be accurately established.

The combined effect of the various sources of chemical action can produce a combination with constant proportions, or a combination whose proportions vary according to conditions. Altering the proportions of a combination with fixed proportions requires considerable force, more specifically a force equal to that holding the combination together. If that obstacle is overcome, the chemical action continues to produce an effect based on the strength of the affinities and the quantity of each substance involved. I have attempted to determine, for a number of combinations, the conditions that set limits on proportions, and appear to halt the progress of chemical action.

The time required for a chemical action to be completed is another important factor. It varies widely with the substances

d'autres affinités résultantes, lorsque l'état de combinaison vient à changer.

Tous les phénomènes de la nature se passent dans l'atmosphère qui concourt souvent à les produire par sa compression, sa température ou la combinaison des parties qui la composent; il faut donc avoir une connaissance exacte des qualités de l'atmosphère sous ces trois rapports.

Le résultat des différentes causes qui interviennent dans l'action chimique est quelquefois une combinaison dont les proportions sont constantes ; quelquefois au contraire les proportions des combinaisons qui se forment ne sont pas fixes et varient selon les circonstances dans lesquelles elles sont produites : dans le premier cas il faut une accumulation de forces pour changer les proportions, qui soit égale à celles qui tendent à maintenir leur état de combinaison : cet obstacle vaincu, l'action chimique continue à produire son effet en raison de l'énergie des affinités et de la quantité des substances qui l'exercent. J'ai tâché de déterminer les conditions qui limitent ainsi les proportions dans quelques combinaisons, et qui paraissent mettre une interruption dans la progression de l'action chimique.

Il y a encore dans l'action chimique une condition qui doit être prise en considération, et qui sert à expliquer plusieurs de ses effets; c'est

involved and prevailing conditions, and provides an explanation for a number of the action's effects. I have also examined the progress of chemical action from this angle.

The first part of the essay covers all the known aspects of chemical action. The second goes on to discuss the propensities of the substances that have the most striking chemical properties, those noted for a peculiar quality or a dominant affinity. In these properties I hope to find an explanation of the properties of the combinations the substances form, depending on their state, and an explanation of the phenomena they produce.

The second part includes discussion of the properties of inflammable substances and their combinations with one another; compound acids and the combinations they form depending on the ratio of their component parts; alkalis, earths, and metallic substances.

Vegetable and animal substances are extremely complex, not in the number of their constituent elements, but in the variety of substances formed, each of which is itself capable of action as a result of the force produced. These substances are so changeable, so variable that it is very difficult to formulate an accurate

l'intervalle de tems qui est nécessaire pour qu'elle s'exécute, et qui est très-variable selon les substances et selon les circonstances. J'examine sous ce rapport la propagation de l'action chimique.

Après avoir ainsi parcouru tous les éléments connus de l'action chimique, je passe à la seconde partie qui est destinée à considérer les dispositions des substances qui sont les plus remarquables par leurs propriétés chimiques, et classées par leur caractère distinctif ou par leur affinité dominante. Je tâche de trouver dans leurs propriétés l'origine de celles des combinaisons qu'elles forment, selon l'état dans lequel elles s'y trouvent et la raison des phénomènes auxquels elles concourrent.

J'examine sous cet aspect les propriétés des substances inflammables, celles de leurs combinaisons mutuelles, celles des acides composés et des differentes combinaisons qui en sont dérivées selon les proportions de leurs élements, celles des alcalis, des terres, et enfin des substances métalliques.

Les substances végétales et les substances animales sont très-complexes, moins par le nombre des elements qui entrent dans leur composition, que par les substances qui en proviennent, et qui agissent chacune par une force resultante; elles sont si mobiles et si variables qu'il est bien difficile de parvenir à une con-

explanation of the phenomena they produce. Their study requires extreme caution. This is why the discussion is limited to facts that appear well substantiated and, failing that, to the most logical explanations chemistry has provided for related phenomena.

The discussions that follow may seem to place undue stress on some subjects at the expense of others. A number of subjects are treated perfunctorily, not because they are unimportant, but because they are common knowledge among chemists. Far more time is devoted to other, perhaps less interesting, subjects on which I believe further light needs to be shed.

naissance exacte des causes des phénomènes qui leur doivent leur origine ; c'est dans leur considération qu'on doit porter la plus grande circonspection : je me bornerai à indiquer ce qui me paraît le mieux constaté, ou ce qu'on peut conjecturer de plus raisonnable sur les phénomènes de ce genre que la chimie a pu atteindre.

On trouvera une grande inégalité dans les discussions dans lesquelles j'entrerai : je passerai rapidement sur quelques objets qui sont importants, mais qui ne présentent rien d'incertain aux chimistes, et je m'arrêterai avec beaucoup de détails à d'autres qui sont moins intéressants, mais qui me paraîtront exiger de nouveaux éclaircissements

AN

ESSAY

ON

CHEMICAL STATICS;

WITH

COPIOUS EXPLANATORY NOTES,

AND AN

APPENDIX

ON

VEGETABLE AND ANIMAL SUBSTANCES.

FAITHFULLY TRANSLATED FROM THE ORIGINAL FRENCH OF

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MEMBER OF THE CONSERVATIVE SENATE, OF THE INSTITUTE, &c.

BY B. LAMBERT.

IN TWO VOLUMES.

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ADVERTISEMENT.

THE known abilities of the illustrious Author of this Essay render any eulogium on its merits unnecessary; and the object of the Work is so ably set forth in his own Introduction, that the Translator can add nothing to it. It will be sufficient for him to observe that he has endeavoured to adhere closely to the Original, that the Author's meaning might be thoroughly comprehended; and that he has been induced to alter the arrangement of the Notes from a belief that they are more convenient for reference in their present situation, than when dispersed through the body of the work.

INTRODUCTION.

THE powers which produce chemical phenomena are all derived from the mutual attraction of the moleculæ of bodies, to which the name of affinity is given, to distinguish it from astronomical attraction.

It is probable that they are the same property, but astronomical attraction being only exerted between masses placed at a distance, in which the figure of the moleculæ, their internal, and peculiar habitudes, have no influence, its effects, in all cases proportionate to the mass, and in the inverse ratio of the square of the distances, may be the object of accurate calculation: the effects of chemical attraction or affinity are, on the contrary, so changed by particular and frequently indeterminate conditions, that they cannot be deduced

deduced from any general principle; but must be considered in succession. There are but few of these effects which can be sufficiently disengaged from all the other phenomena to be rendered capable of precise calculation.

It is, therefore, by observation alone that the chemical properties of bodies, or those affinities by means of which they exert a reciprocal action in a determinate situation, can be estimated; nevertheless, since it is very probable that affinity differs only in its origin from the general attraction, it ought to be also submitted to those laws which mechanics has established for the phenomena arising from the action of the mass, and it is natural to suppose that the more of generality there is in the principles from which the chemical theory is derived, the greater must be their analogy with those of mechanics; but it is only by means of observation that they can attain to that degree which may be already foreseen.

The immediate effect of the affinity which a body exerts is always a combination; hence all the effects produced by chemical action are

are the consequence of the formation of some combination.

Every substance which has a tendency to enter into combination, acts in the ratio of its affinity and of its quantity. These facts are the ultimate end of every chemical observation.

But, 1st. The different tendencies to combination may be considered as so many forces which contribute to a result, or which partly destroy it by their opposition; these forces must, therefore, be distinguished in order to obtain an explanation of the phenomena which they produce, or to compare them together.

2d. The chemical action of a body does not depend solely upon the affinity peculiar to its component parts and upon the quantity; it also depends upon the state in which those parts are found, whether it be that of actual combination, which causes a larger or smaller portion of their affinity to disappear, or that, by their dilatation or condensation, their reciprocal distances are varied; it is these conditions which, by modifying the properties of the elementary parts of a substance,

stance, form that which I call its constitution: to obtain the analysis of chemical action, not only each of these conditions must be appreciated, but also every circumstance with which they have any connection.

The properties of bodies which can thus modify affinity have also other effects, independent of those which produce the combination, and which are the subjects of the different parts of physics. There are even many phenomena which, although they may be produced, wholly or in part, by affinity, ought nevertheless to be considered in another view, either because affinity contributes too slightly to their production, or because experiment has not hitherto been able to determine the particular affinities from which they arise. All those are called physical properties which do not seem to depend immediately on affinity.

Hence it follows, that a connection frequently exists between the physical properties and the chemical properties; that in many cases recourse must be had to both of them for the explanation of a phenomenon to which they may each contribute, and that it

is necessary to establish an intimate relation between the different sciences of physics, that they may mutually elucidate each other.

The principles established on the results of facts observed under every point of view, and the explanation of chemical phenomena, founded on their relations to all the properties of which they are the consequences, constitute Theory, which should be distinguished into general theory and partial theories.

Some sciences may reach a certain degree of perfection without the aid of any theory, solely by means of an arbitrary order, established from the observations of those natural facts which are principally the subject of them; but this is not the case with chemistry, in which the observations ought, in almost every case, to arise from experiment alone, and in which the facts result from the factitious union of the circumstances from which they must be produced. In making an experiment it is necessary to have some object in view, and to be guided by an hypothesis; and to obtain any advantage from the observations, they must be compared under

certain

certain conditions, and, at least, some of the circumstances necessary to the production of every phenomenon observed, must be ascertained, to the end that they may be reproduced. Thus, suppositions more or less illusory, and even those chimeras which at present appear ridiculous, but which have employed the most laborious investigations, were necessary to the infancy of chemistry: by their means facts were multiplied: a great number of properties were ascertained, and many arts were brought to perfection.

Still Chemistry was only enlarged with incomplete remarks and partial theories, unconnected with each other, which arose in succession like the caprices of the imagination, and had no relation to any general law: arrogant and insulated from every other species of knowledge, the greater the number of acquisitions made to it, the further was it removed from the character of true science.

It is only since the period that affinity has been recognized as the cause of all combinations, that Chemistry could be regarded as a science which began to have general principles: from that time its object has been to bring

bring the succession of combinations, which different elements are capable of forming, into a regular system, and to ascertain the proportions which enter into these combinations.

Bergman extended the application of this first principle very considerably: he pointed out the greatest number of the causes which might disguise or produce variations in its effects: on it he founded the processes of different chemical analysis, which brought it to a degree of precision unknown before his time.

A great number of phenomena, however, are dependent on the combination of oxigen, which, of all substances, is that whose affinities appear to be the most active, and its existence was not even known: hypotheses were, therefore, substituted for the action which it exercises. Priestley had no sooner made known this substance, which performs so important a part, than Lavoisier ascertained its combinations, and ascribed the numerous effects produced by it to the true cause. The great light spread by his immortal discoveries, not only over those phenomena

mena dependent on them, but also over the action of many other gases discovered at the same period, obtained, for the revolution which it produced, the honour of being regarded as a new and general theory.

The accurate investigation of a cause, equally powerful from the modifications produced by it in the results of affinity, that of the action of heat, was also necessary to explain the greater number of phenomena: it is to Black that the discovery of the fundamental properties of heat are due; since his time they have engaged the attention of many philosophers; but they were reduced to well-defined laws in an intelligent Memoir, for which we are indebted to Laplace and Lavoisier.

It is therefore evident that Chemistry has acquired, in our time, the knowledge of those generative properties which accompany all chemical action, and which are the source of all the phenomena produced by it: this science has therefore been founded upon principles which have been rapidly applied to every branch of knowledge within its compass.

As

As the partial theories are limited in their researches to certain facts, or to some classes of phenomena, they may frequently be restricted to the rigorous application of some well ascertained properties, and may be said to be the cautious language of experience, until the progress of the science gives them a more enlarged extent: they may then be reduced to that certainty which belongs to knowledge founded on the testimony of our senses: this is particularly true with respect to the determination of the elements of a compound substance, and the means by which that determination is obtained.

This is not the case with a theory which comprehends the consideration of all the partial theories, and which aims at disentangling that which may belong in common to the chemical properties of all bodies, from that which depends on the particular qualities of each: employed in elucidating all the objects; in bringing to perfection all the processes; in collecting and comparing all the results, it endeavours to discover every power of each cause, and every cause which contributes to each phenomenon; it carries the

mind

mind beyond the limits of observation; it not only compares the phenomena whose causes can be clearly manifested, but it also points out the connection which may exist between knowledge already obtained, and that which may be hoped for: if it omits the explanation of a certain number of facts from which it cannot yet deduce any consequence, either because it requires to be enlightened by more accurate or better directed experiments, or because they depend on a too extensive action between the different properties, it resumes them whenever any light is perceived by which it can be directed.

This theory necessarily rests on well established truths, and on conjectures whose foundations are more or less sure; and, by the application of the principles to which it is directed, it gives explanations of the various phenomena more or less complete, and more or less certain: it is brought to perfection and extended by the progress of observation, and by its intercourse with other sciences.

As soon as the general properties, to which all the effects of chemical action tend, are discovered, those conditions of the affinity which

which appeared to accord with all the explanations were established as constant and decided laws; and from these laws all the explanations were reciprocally deduced; and it is in the knowledge thus acquired by the science, that its progress was principally made to consist.

Persuaded that the principles adopted in Chemistry, and the immediate inferences derived from them, with a view to their being made use of as secondary principles, ought not yet to be admitted as fundamental maxims, I have undertaken a new examination of them, and I have already published, in my Researches into the Laws of Affinity, the observations which have led me to believe that a correct idea of the effects produced by it has not yet been formed.

The intention of this Essay is to extend my first reflections to all the causes which can produce a variation in the results of chemical action, or of the product of the affinity and the quantity. I shall therefore examine what is the mutual dependence of the chemical properties of bodies, compared, at first, with each other, and afterwards considered in the

different substances? what are the forces which arise from their action in the effects produced by them? and, what are the properties of the forces which contribute to these effects, or which are in opposition to them?

The Essay is divided into two parts: in the first, I consider all the elements of chemical action; and, in the second, the substances which exercise it, and which contribute the most to chemical phenomena, classing them according to their habitudes, or the relations existing between their affinities.

The first effect of affinity, to which I call the attention, is that produced by the coherence of the particles which enter into the composition of a body; it is the effect of the reciprocal affinity of these particles, which I distinguish by the name of the force of cohesion, and which becomes a force opposed to all those tending to cause them to enter into another combination, while it, on the contrary, tends to re-unite them.

Every affinity which tends by its action to diminish the effect of cohesion ought to be regarded as a force opposed to it, and of which the result is solution. When, therefore,

fore, a liquid acts on a solid, the force of solution can produce the liquefaction of the solid, if it is superior to that of cohesion; but this effect sometimes takes place immediately, and sometimes it requires that the cohesion should be first weakened by a commencement of combination; there are circumstances in which the liquid can only act on the surface of the solid and wet it; finally, the solid cannot even be wetted when its affinity with the liquid does not produce an effect greater than that of the mutual affinity of the parts of this latter. These two forces, therefore, according to their relations, produce different results, which must be distinguished, but which are not to be attributed, in conformity to the opinion of some philosophers, to two affinities, one of which they have considered as chemical, and the other as derived from the laws of physics.

The effects of the force of cohesion could not escape the attention of Chemists; but they have only considered it as a quality of bodies actually solid, so that when the solidity ceased they thought it was destroyed: on the contrary, its effects may cease to be

sensible without ceasing to act, which is also the case with all the physical powers comprehended in it: this is one of the principal causes of the difference to be found between the explanations I offer and those which have been adopted, and into which this consideration has not been admitted.

The reciprocal action which tends to unite the parts of a substance may be overcome by a dissolving power, and its energy diminishes in proportion as the quantity of the solvent increases, or as its action is assisted by heat; on the contrary it augments if the preceding circumstances are weakened, and finally reproduces the effects which are due to its preponderance: from this proceed all the separations and precipitations which take place in a liquid, and which arise from the formation of a solid.

Crystallization is one of the remarkable effects of the force of cohesion; the parts which crystallize assume a symmetrical arrangement which is determined by the mutual action of the small solids separated by their force of cohesion from a liquid: and the qualities of a solid which is more easily broken in one way than

than in another; which is more or less brittle, more or less elastic, more or less ductile, depend on this arrangement.

The different degrees of solubility of salts which arise from the relation of their force of cohesion to the action of the dissolving liquid, is not only the cause of their crystallization, but also of their successive separation by evaporation; it is not only opposed to the effect of the solvent, but also to their mutual action; because while the different salts are in solution, they form but one liquid, in which each peculiar action is counterbalanced until the force of cohesion of those which are least soluble has acquired sufficient energy to cause them to pass into the solid state.

Since the immediate effect of every chemical action is a combination, dissolution itself is only a combination considered with respect to the force of cohesion; because in every combination it will be observed that the action of any substance is always in proportion to the quantity contained within the sphere of its activity: an immediate consequence of this law is that the action of a substance

stance diminishes in proportion to the saturation it experiences.

Among the affinities of a substance, there is frequently one which is predominant, and which gives the character to its distinctive properties: these are the energetic affinities which are useful in the classification of bodies in a system of chemistry, and which give birth to the greatest part of the chemical phenomena.

All the properties derived from this governing affinity become latent and re-appear with it; combination communicates new ones which have no longer any relation with those that the saturation has caused to disappear, but are the consequence of the changes produced by the condensation or by the dilatation of the elements of the combination; for the reciprocal action of the moleculæ of a combination is proportionate to the condensation or dilatation which brings them together or removes them from each other; thus, salts, in a state of combination, possess a peculiar solubility and crystallization.

Whenever those substances, in which a predominating

dominating affinity exists, undergo a combination foreign to the action of this affinity, they carry with them all the properties dependent on it, which are only modified by the constitution they have acquired and by the degree of saturation they have experienced; thus an alloy retains the metallic properties, and those which arise from the reciprocal action of the moleculæ, whether they are simple or compound, such as the force of cohesion, fusibility, as well as specific gravity, undergo a change which is only produced by that of the mutual distances of the moleculæ in that constitution which they have acquired by the combination.

A predominant and energetic affinity in one body, supposes an analogous disposition in some other substance, whose characteristic properties ought, from thence, to be considered as opposed to those of the first, since they cause them to disappear by saturation.

The acids and alkalis offer the most striking examples of these adverse properties which are the principal source of chemical phenomena; their reciprocal action, therefore, is deserving of the most particular attention.

In

In the first place I consider this co-relative property of the mutual saturation of acids and alkalis, as a general attribute, independent of the particular affections of each of them, and of the properties arising from the elements of which they are composed.

As this reciprocal saturation of the acids and alkalis is an immediate effect of their reciprocal affinity, it ought to be regarded as the measure of their affinity, if the respective quantities which are necessary to produce this effect are taken into consideration. From whence it follows that the affinities of the acids for the alkalis, or of the alkalis for the acids, are proportionate to their capacity for saturation. In consequence I maintain that whenever several acids act upon one alkaline base, the action of one of the acids does not overpower that of the others, so as to form an insulated combination, but each of the acids has a share in the action proportionate to its capacity for saturation and to its quantity: I call this compound result by the denomination of a *chemical mass*: hence I affirm that each of the acids which is found in combination with an alkaline base acts in the ratio of its

its mass; and to ascertain the masses I compare the capacities for saturation, either of all the acids with a base, or of all the bases with an acid.

To explain the combinations which are formed by the operation of two acids on one base, and of those produced by the action of two acids and two bases, an elective attraction has been supposed, which, by its graduation, substitutes one substance for another in a combination, and which, in the reciprocal action of four substances, determines two combinations insulated from each other.

This supposition does not coincide with the general law of combinations; but the consideration of the two distinct effects of affinity, in so far as it produces combinations, and is the principle of the force of cohesion, appears to me sufficient for the explanation of all the facts which are attributed to elective affinity and the action of the double affinities.

That general law to which chemical action is subjected, that substances act in the ratio of the energy of their affinity and their quantity, is not modified by the effects arising from the force

force of cohesion alone, but also by the expansive power of caloric, or the cause of heat, which is the principle of expansibility.

Since the action of every body is influenced by caloric, which consequently contributes to every chemical phenomenon, it is of importance to ascertain its general properties with precision, and the effects it produces under different conditions. On this subject, I shall enter into elementary details which may appear foreign to the end I have proposed.

The tendency of every substance to the solid, liquid, or elastic state, depends on the relation of the reciprocal action, by which the moleculæ of a simple or compound body are disposed to unite, with the expansive action which caloric exercises upon them: the effect of caloric may, according to the circumstances, contribute to the combination of that substance with others, or it may be an obstacle to it. When caloric produces a state of elasticity, the gas arising from it must be considered as owing to the combination it forms, and the elasticity as an opposing power, either to solidity or to liquid combinations; but the observation

vation I have made on solidity must also be applied to elasticity, its action precedes the instant in which it becomes effective.

The power of caloric which tends to increase the distance of the moleculæ would be always opposed to the combination of substances with each other, if it did not frequently produce an effect superior to the first, by diminishing the solidity, which is another obstacle to combination; or by augmenting the elasticity which promotes the action of the gases: it therefore favours the combination of some substances and obstructs that of others according to their habitudes. These effects must not be confounded with those of the reciprocal affinity of bodies.

In comparison with other bodies, the elastic fluids are under great disadvantage in the action which they exert upon them, because the quantity of their mass within the sphere of activity is necessarily very small.

In the reciprocal action of the gases, the results are very different according to the intensity of the affinity; when that is weak, it is limited to a solution, in which the respective

spective capacities and properties are not changed; if it is powerful, these capacities experience a great diminution, and combinations are formed having new properties; but the properties which distinguish the permanent gases from vapours, which only assume the gazeous state under certain circumstances, must not be overlooked.

All these effects are varied by the changes of capacity produced by the alteration of temperature, which are much more considerable than in liquids and solids. It is therefore of importance to determine carefully what are the laws to which the dilatation of elastic fluids is subject, and in this point of view, to compare those which are permanent with those which only assume that state by the action of the first, or by an elevation of temperature.

Those substances which are naturally elastic may be brought to the liquid or solid state by combination; they then acquire new properties by their condensation. It is necessary to distinguish the chemical action which they can exercise in this state, and the energy they have

have acquired and can communicate to their combination, regarding the affinity of this latter, as a power resulting from the elementary affinities which succeed it when the combination is at an end, or which give rise to other resulting affinities, when the state of the combination is changed.

All the phenomena of nature take place in the atmosphere, which frequently contributes to produce them by its compression, its temperature, or the combination of the parts which compose it; an exact knowledge of the qualities of the atmosphere under these three relations, is therefore necessary.

The result of the different causes, which interpose during chemical action, is sometimes a combination whose proportions are constant; sometimes, on the contrary, the proportions of the combinations which are formed, are not fixed, and vary according to the circumstances under which they are produced: in the first case, it requires an accumulation of powers to change the proportions equal to those which tend to maintain their state of combination; this obstacle overcome, chemical

cal action continues to produce its effects in the ratio of the energy of the affinities and the quantity of the bodies which exercise it. I have endeavoured to ascertain the conditions which thus limit the proportions, in some combinations, and which appear to place an obstacle to the progress of chemical action.

There is still a condition in chemical action which must be taken into consideration and which affords an explanation of many of its effects; it is the interval of time which is necessary for its being performed, and which is very variable according to the substances, and according to the circumstances. I examine under this head the propagation of chemical action.

Having thus gone through all the known elements of chemical action, I proceed to the second part which is appropriated to the consideration of the nature of those substances which are most remarkable for their chemical properties, and are classed by their distinctive character or by the predominating affinity. I endeavour to find in their properties the origin of those of the combinations which they form,

form, according to the state in which they are found, and the explanation of the phenomena to which they contribute.

In this manner I examine the properties of inflammable substances; those of their mutual combinations; those of compound acids and of the different combinations derived from them, according to the proportions of their elements; those of the alkalis, the earths, and, finally, metallic substances.

Vegetable substances and animal substances are very complex, not so much by the number of the elements which enter into their composition, as by the substances which arise from them, and which all act by a resulting force; they are so unsettled and so variable that it is very difficult to obtain an exact knowledge of the causes of the phenomena arising from them; the greatest circumspection is necessary in considering them: I shall confine myself to indicating what appears to me to be best ascertained, or what may be most reasonably conjectured respecting the phenomena of this description, which chemistry has been able to attain.

Great

Great inequality will be found in the discussions into which I enter: I pass rapidly over some subjects of importance, but which offer no incertitude to chemists, and I dwell with much minuteness on others which appear to me to require new elucidations.

AN

ESSAY

ON THE

SPIRIT AND INFLUENCE

OF

THE REFORMATION

By Luther.

THE WORK WHICH OBTAINED THE PRIZE
ON THIS QUESTION,

(Proposed by the National Institute of France, in the public Sitting of the 15th Germinal, in the Year X.)

"WHAT HAS BEEN THE INFLUENCE OF THE REFORMATION BY LUTHER ON THE POLITICAL SITUATION OF THE DIFFERENT STATES OF EUROPE, AND ON THE PROGRESS OF KNOWLEDGE?"

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ESSAY

ON THE

SPIRIT AND INFLUENCE

OF

THE REFORMATION BY LUTHER.

PART I.

GENERAL CONSIDERATIONS.

SECT. I.

On the State of the Question.

IF, during any of the centuries which preceded the ſixteenth, and while no oppoſition had been raiſed againſt the ſupremacy of the Roman pontiffs, a learned aſſembly had been deſirous of calculating the reſults of a ſchiſm, of a contrary opinion to that of Rome, the queſtion would doubtleſs have been framed thus: "what are the evils and the ſcandal, with which the church has been afflicted, on account of ſuch an impious and pernicious doctrine?" At this time, when ſeveral reſpectable nations have ſeparated from the Romiſh church; when the intimate connection by which all Europe is united has con-

vinced christians of that perſuaſion, that others are as virtuous, as well regulated, as enlightened as themſelves, the queſtion muſt neceſſarily aſſume another form. An Aſſembly of philoſophers, in the boſom of France, reſtored to the catholic worſhip, propoſes to aſcertain the influence of Luther's reformation on the ſtate of European ſociety, on the progreſs of knowledge. This change in language implies a great one in opinion; and, in this point of view, the queſtion may be ſaid to anſwer itſelf.

As the Inſtitute have not added any explanatory outline to the queſtion, the following conſiderations, the intention of which is to determine the object and the latitude of the anſwer, will not appear miſplaced.

By a ſuperficial obſerver, it may be thought that a religious revolution ſhould only exerciſe its influence on matters connected with religion; on the worſhip and the diſcipline of the church: but long before Luther's reformation, the church and the ſtate were ſo aſſimilated in every political body in Europe; their rights and their conſtitutions were ſo blended, that one of them could not be convulſed without the other experiencing the ſhock. The church, which had univerſally formed a ſtate within a ſtate, had carried its uſurpations over the latter ſo far, that it threatened to ſwallow it up. All Europe was for a length of time in danger of yielding to the dominion of an abſolute theocracy. The em-

perors of the new empire of the weſt, who ſaved it from that deſtiny, afterwards menaced it with the project of an univerſal monarchy. The Kings of France, England, Sweden, and Denmark, the princes and free cities of Germany and Italy offered only a partial and alternate oppoſition to the pretenſions of either of the competitors.—A new impulſe; a new and powerful tie, which united the oppreſſed againſt both the oppreſſors at the ſame time; an event which awakened every paſſion; the love of liberty; a religious and political fanaticiſm, which augmented the power of princes in a tenfold degree, by exalting the people, which, in ſhort, offered to the leaders, both independence and the rich prey of the ſpoils of the clergy; ſuch an event, I ſay, muſt, in ſuch a period, have produced an univerſal agitation in Europe. The ſyſtems of the modern ſtates were ſhook by it to their foundations. During the long and grievous ſtruggle which followed, every thing acquired a different form, and a different eſtabliſhment. A new political order aroſe from the ferment and general confuſion: the different elements of which it was compoſed, long agitated by contending forces, yielding, at length, to the laws of gravitation of the moral world, took the places in it aſſigned to them by their reſpective weights, but which, in moſt inſtances, were not thoſe they had formerly occupied. A new ſeries of ideas alſo aroſe from this conflict of

opinions: men dared to think, to reaſon, to examine thoſe things which, before, required only a blind ſubmiſſion. Thus a ſimple attack on eccleſiaſtical diſcipline produced a conſiderable change in the political ſituation of the ſtates of Europe, and in the morals of its inhabitants. The Inſtitute was therefore inſpired with the true ſpirit of hiſtory in encouraging the ſolution of the problem which it has ſo ably propoſed. It is honourable to a writer to be called upon to treat of religion and politics, the two cardinal points of human life, before ſuch an aſſembly. One of the firſt fruits of true liberty is the power of diſcuſſing theſe important objects without reſtraint, and the country where this privilege is exerciſed muſt incontrovertibly be free.

In inquiring what *has been* the influence of the reformation of Luther, the Inſtitute ſhows clearly that it does not conſider this influence as exiſting, at this time, in an active manner. In fact, near three centuries have elapſed ſince the firſt exploſion. The agitation occaſioned by it became gradually calmed; the power which originally gave the impulſe, and which produced ſo many new events, has ceaſed to act as a moving force, as a productive principle. The greater part of the inſtitutions which it created, and of thoſe which it modified, have been preſerved; ſome are extinct: but thoſe which remain are now guided by the univerſal courſe of events, and the re-

formation is no longer the immediate cauſe which directs their progreſs. It has nearly accompliſhed every thing of which it is capable; its influence is now perceived only mediately, without convulſions, and by the courſe of the inſtitutions originating from it. The time is therefore arrived when the advantages or diſadvantages which have reſulted to the human race from it, may be inquired into, enumerated, and diſcuſſed. It will doubtleſs be conformable to the views of the Inſtitute to confine myſelf to an exact ſpecification of all the proximate conſequences of the reformation, and to be ſatisfied with a ſlight notice of the remote ones. To engage in the details of theſe laſt, it would be neceſſary to draw the immenſe picture of the hiſtory of Europe ſubſequent to that period, ſince there is ſcarcely any great event, in which ſome reſult of the reformation, ſuch as the preſent conſtitution of the Germanic body, for example, or the republic of the United Provinces, has not, in its turn, exerciſed a greater or leſs degree of influence. We ſhould never get freed from this labyrinth of *mediate* conſequences; for, in this point of view, the influence of every political or religious commotion extends to infinity. To this day, we are more or leſs affected by what paſſed in India, Arabia, Greece, and Italy, in very remote times; we ſtill live very perceptibly under the influence of the irruption of the northern tribes, of the

cruſades, and of other political movements which have become the principles of action to the people. The line of deviation, often crooked, ſometimes retrograde, in the improvement of nations, is produced by the complicated action of many different forces: to mark its eſcapes, its aberrations, by putting a juſt value on the powers which have contributed to it, is the province of the philoſophy of hiſtory. The author of the preſent eſſay will eſteem himſelf fortunate, if his judges are of opinion that he has performed this taſk, with reſpect to that period of modern hiſtory in which the reformation was the predominant power.

Nevertheleſs it is not poſſible to engage in an inquiry into the effects of the reformation, without being, in ſome degree, obliged to give way to this reflection: "Is not the great event which I conſider as a cauſe, in itſelf ſo much a ſimple reſult of other cauſes, which have preceded it, that the true origin of all that has followed it muſt be referred to them, and not to it, which has only been an intermedium?"—Without doubt ſuch is the ſituation of the mind in theſe reſearches. While it looks forward, its point of departure ſeems to be the fixed baſe from whence all the ſucceſſive ſteps proceed. If its looks are turned back, the firſt point appears to it only the neceſſary conſequence of thoſe which have preceded it, and as a paſſage to arrive at thoſe which follow. To the mental

eye, every cauſe, in aſcending, becomes a ſimple effect: each effect becomes, in its turn, a cauſe, in deſcending. The inclination which we feel to attribute every thing which follows an event to the event itſelf, as though it was the cauſe of it, is the clew which guides us in the arrangement of hiſtorical facts: it is the law of coheſion by which the preſent is united to the paſt. To proceed in this manner from the effect to the cauſe, until we reach a firſt cauſe, ſubſiſting by itſelf, and which cannot be the effect of any other cauſe, is a neceſſary conſequence of our knowledge, which ſeeks an abſolute principle to build its ſpeculations on—It is on this ſlippery path that metaphyſics is loſt—A man who, without knowing the nature of the courſe of a river, ſhould arrive on its banks, ſeeing it here gliding through an extenſive plain, there confined within narrow vallies, in another place foaming beneath the precipice of a cataract; this man would take the firſt turning where it might be concealed by a projection, for the origin of the river; aſcending higher, a new turn, the cataract, will occaſion the ſame illuſion; at length, he reaches its ſource, he takes the mountain from which it iſſues for the firſt cauſe of the river: but he will ſoon think that the ſides of the mountain would be exhauſted by ſo continual a torrent; he will ſee clouds collected, the rains, without which the dried mountain could not ſupply a ſpring. Then the clouds

become the firſt cauſe; but it was the winds which brought theſe here, by paſſing over vaſt ſeas; but it was the ſun who attracted the clouds from the ſea; but whence ariſes this power of the ſun? Behold him then ſoon entangled in the reſearches of ſpeculative phyſics, by ſeeking a cauſe, an abſolute foundation, from which he may, finally deduce the explanation of ſo many phenomena.

Thus, the hiſtorian who inquires what was the cauſe which led to the reduction of the authority of the Popes, to the terrible thirty years' war, to the humiliation of the houſe of Auſtria, the eſtabliſhment of a powerful oppoſition in the heart of the empire, the foundation of Holland as a free ſtate, and ſo of other occurrences, will, at firſt, ſee the origin of all theſe events in the reformation, and will attribute them abſolutely to its influence. But urging his inquiries farther, he diſcovers that this reformation itſelf is evidently only a neceſſary reſult of other circumſtances, which precede it, an event of the ſixteenth century, with which the fifteenth, to uſe the expreſſion of *Leibnitz*, was pregnant; at moſt, the cataract of the river. How many are there who are ſtill of opinion they have found the firſt cauſe of the French revolution in the *deficit*, in the convocation of the ſtates-general, in the *tiers-etat*, in the curates! Others, who carry their views a little farther, attribute it to the parliament *Maupeo*

the extinction of the Jeſuits, &c.—They are all right in that limited point of view which they have taken. Thoſe, however, who contemplate the progreſs of human nature during a ſucceſſion of ages, ſee this enormous maſs of individual cauſes roll on, each of which, animated by its intereſt, its paſſions, and its peculiar ſpirit, ſtrives deſirous to counteract the progreſs of all the others; but notwithſtanding their infinite diverſity, all theſe motives have common features tending towards certain ends, which, finally, are the ſame; theſe features, theſe tendencies common to all, form a collection of powers, or rather a ſingle power, which is that of the human race, that of a univerſal ſpirit, which, concealed through ages, guides and governs them. Under the dominion of providence (that ſun of the moral world, to uſe again the expreſſion of a philoſopher), this ſpirit of humanity, by its continual action, prepares and diſpoſes events. This great revolution which ſurprizes us, is only a product, a reſult, a ſtriking manifeſtation. Is it therefore to it, is it not rather to the influence of the cauſes which have themſelves preceded and led to it, that the events which have followed it ſhould be attributed?

In the caſe in queſtion, therefore, it is requiſite for the hiſtorian to attend to what had paſſed before the great event which he examines: to aſcertain the influence of the cauſes by which the event itſelf was brought about, and, in what

be made to control for deviations in intellectual ability through the use of the WISC. Thus three sets of scores were generated: intelligence quotients, pretest and post test reading scores.

It would have seemed appropriate, in this case, to have used two co-variates, intelligence quotients and pretest reading scores, with post test scores in reading providing the criterion measure; however, minimal linear correlation must exist between co-variates in order to ensure against the possibility of an interaction effect of one co-variate with the other. To be more specific, in this investigation it would seem probable that intelligence, as reflected in the quotients, is also implicit in the pretest reading score, thus producing an interaction effect.

When such interaction occurs, a disproportionate adjustment is made on the criterion measure. The adjustment is, in fact, compounded by the interaction effect of the two co-variates. Further to the notion of a compounded adjustment is the fact that, although the sum of the squares of the error term is reduced proportionately, the loss of an additional degree of freedom inflates the mean square error; thus, the probability of detecting true differences when true differences actually exist is greatly decreased.

It is recommended, therefore, that three aspects of the differential effects of the co-variate be subjected to

degree theſe ſame cauſes have influenced the ſeries of ſubſequent events. It is alſo requiſite for him to conſider what would have happened through the ſlow and progreſſive courſe of humanity, which is ſometimes called the natural courſe of things, if the great event, if the convulſion in queſtion, had not ſupervened. Finally, he muſt determine what particular modifications in its reſults have been occaſioned by the proper and individual character of this event; the character of the age and of the nation in which it occurred, and that of the men who had the principal ſhare in it.

tion effected by *Luther*, carries the European nations forward in the career of knowledge and of intellectual culture.

CONCLUSION.

Such are the principal reſults which, I am of opinion, originated in the influence exerciſed on Europe by *Luther*'s reformation. In analyzing the complicated cauſes of the moſt conſiderable events which have occurred during three centuries in the political world, and in the literary world, it is eaſy to go aſtray, to miſtake ſome cauſes, to loſe ſight of ſome effects. Amidſt the confuſion of all theſe entangled threads of European politics and culture, he who ſeeks to unravel thoſe immediately connected with the quarrels on religion, however careful he may be, will too often be in danger of erring. Some of them iſſue from the eſtabliſhment itſelf, from the preaching of the Alcoran, from chivalry, the cruſades, the uſe of artillery, the diſcovery of a new world, the renovation of letters, the inſtitutions of *Peter I.* the ſucceſſion war, and the other major events. Were it required to determine the influence of ſome one of theſe events, perhaps ſuch of the conſequences as I have attributed to the reformation might be claimed as belonging to it. Hiſtorians who narrate facts, are generally ſilent on their cauſes, and frequently alſo are unacquainted

with them. Sometimes they give thoſe which are falſe and contradictory. The writers of the oppoſing parties are excluſive, and render the truth uncertain. To whom muſt credit be given; the Catholics, or the Proteſtants: to *Duperron* or *Dumoulin*; to *Platina* or *Mornay*? How ſhall we decide between *Varillas* and *Maimbourg*, on the one ſide, *Bleidan*, *Bayle*, and *Seckendorf*, on the other; between *Pallavicini* and *Fra-Paolo*; between *Boſſuet* and *Claude*? In the work of the reformation, the one ſees only an infinite ſource of errors and calamities; the others ſee in it only knowledge and benefits to the human race. Among ſo many different opinions, each muſt have his own. We are at preſent better ſituated than ever to judge of a revolution which broke out three hundred years ago: let us conſider what was before it, and what has happened ſince; let us hear all parties, look around us, ſee what exiſts at the preſent day, and judge.

When after the long ſleep of the European nations and of their reaſon, during the middle age, we turn our attention to the ſtate of the human race in this fine part of the world, in the fifteenth, and at the beginning of the ſixteenth centuries, we ſhall ſee it recover from its ſtupefaction, riſe, move unſteadily in all directions, ſeize inſtruments for its activity, forge new ones, try them, develop its powers, take poſſeſſion of the field of ſcience, throw from it the ſwaddling-clothes which embarraſs it, and begin a new epo-

cha. How is this interval crowded with deciſive occurrences and inventions! The happy employment of the mariner's compaſs, the teleſcope, printing, the taking of Conſtantinople, the new world, the ſubmiſſion of the great vaſſals to the crown of France, the golden age of poetry and the arts in Italy, the foundation of numerous ſchools, the books of the ancients revived in it, the eſtabliſhment of poſts, which render all communications rapid, the ſalutary peace of the empire and the imperial chamber, the extravagant increaſe of the Auſtrian power which terrifies Europe, and compels it to arm, *Copernicus* who reforms the heavens, *Luther* and *Loyola* who aroſe nearly at the ſame time! The criſis muſt neceſſarily have a term, the ſtate of things muſt change in the order of civil ſocieties, and in that of human knowledge.

"*Better is an enemy to well*," ſays a proverb of modern Italy. This ridiculous adage, which ought never to have quitted the language in which it appeared, is the unſophiſticated expreſſion of an ultramontane character. Happily it is not in the power of a deſpiſed caſt, nor of a maxim againſt nature, thus to fetter the deſtinies of ſcience and civilization. Men paſs them, and give no credit to ſuch reclamations, the reclamations, ſays *Chénier*,* of thoſe *idle and jealous ſpirits, whoſe reaſon,*

* In his *Diſcours ſur le progrès des connoiſſances, An. IX.* Printed by *Didot*.

without ſtimulus, would paralyze the human mind. None of the inſtitutions of the middle age were calculated for the new humanity. As lances and ſhields had been laid aſide for fire arms, ſo muſt the ſcholaſtic philoſophy be removed by the new arms of reaſon; the inextricable circles of *Ptolemy*, by the ſimple idea of the motion of the earth; and the falſe decretals muſt fall at the firſt looks of criticiſm. The external form of religion no longer correſponded with the new culture, any more than the repreſentation of myſteries correſponded with the ſcene on which *Moliere* and *Corneille* were about to appear; any more than Gothic architecture with the baſilick of *St. Peter*. It was requiſite that every thing ſhould change: the new ſpirit could not ſubſiſt in the ancient forms; a harmony, an agreement muſt be eſtabliſhed between it and things; and ſince it had in itſelf the energy of a new life, the omnipotence of youth, it acted in all directions with ſtrength and efficacy, and was every where ſeconded by enthuſiaſm.

It is therefore under this point of view that the reformation muſt be conſidered as a neceſſary product of a new age, as a manifeſtation of a new ſpirit. What *Dante* and *Petrarch* were to poetry, *Michael Angelo* and *Raphael* to the arts of drawing, *Bacon* and *Deſcartes* to philoſophy, *Copernicus* and *Gallileo* to aſtronomy, *Columbus* and *Gama* to the ſcience of the earth, ſuch was *Luther* to religion. Organs of the univerſal mind, theſe emi-

nent men expreſſed correctly what was lurking in a great number of their cotemporaries, and at one ſtroke, ſatisfied the wants of their time. As ſoon as the ſpark flaſhed from their genius, the flame, ready to appear, ſpread in all directions. What was only a preſcience, a vague idea, inſulated in a number of heads, acquired a conſiſtence, a fixed direction, appeared externally, was communicated from individual to individual, and a continued chain connected all thinking minds. Such is the natural mode of the tacit conſpiration which governs all reformations. Thoſe effected in the dominion of the arts and of the major part of the ſciences, being foreign to the paſſions and to the volcanic commotions of the maſs of the people, are generally accompanied by peace, and are accompliſhed without cauſing the tears of humanity to flow. It could not be thus with that provoked by *Luther*. Religion was not then a ſimple opinion, a ſimple moral being; it had an immenſe body, which oppreſſed all the political bodies, which laid claim to all thrones, to all the poſſeſſions of the earth. At the firſt wound it felt, the coloſſus ſhuddered, and the world was ſhaken. Princes and nations flew to arms and engaged in a dreadful ſtruggle, a ſtruggle of opinions and intereſts, the reſults of which were ſo varied and ſo important.

The Inſtitute has demanded an account of ſuch of theſe reſults as have influenced the political ſituation of the ſtates of Europe, and

the progreſs of knowledge. This taſk was enormous, and far above my powers. What would it have been if the Inſtitute, beſides the political and literary conſequences, had required an expoſition of the influence of the reformation on the morality of the European nations, on their belief and their religious diſpoſitions? But this new point of view might be the ſubject of a work, perhaps more extenſive and more difficult than mine. I was obliged to confine myſelf within the preſcribed limits, which circumſcribe a field of vaſt extent. It has not been my intention to diſguiſe either the evil or the good produced by the reformation. I have only ſought to prove that, every thing being balanced, and the definitive account cloſed, this revolution offers a ſurplus of good to humanity; and, finally, that it muſt be ranked in the number of the major events which have contributed moſt powerfully to the progreſs of civilization and knowledge, not only in Europe, but in every part of the earth where Europeans have carried their culture.

I have alſo thought that I might expreſs myſelf with the open freedom of an hiſtorian, who, if poſſible, ſhould not belong to any age or any country: ſupporting myſelf with an opinion that prejudice could not find acceſs into the ſanctuary of the ſciences; and that an illuſtrious ſociety ſo philoſophical as to chuſe ſuch a ſubject, and to aſk for the truth reſpecting it, would, doubtleſs, be diſpoſed to liſten to it.

ESSAI

SUR

L'ESPRIT ET L'INFLUENCE

DE

LA RÉFORMATION

DE LUTHER.

Ouvrage qui a remporté le prix sur cette question proposée dans la séance publique du 15 germinal an X, par l'Institut national de France :

« Quelle a été l'influence de la réformation de LUTHER » sur la situation politique des différens Etats de » l'Europe, et sur le progrès des lumières ? »

Par CHARLES VILLERS.

A PARIS,

Chez HENRICHS, Libraire, rue de la Loi, n°. 1231.

Et à METZ,

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AN XII. — 1804.

ESSAI

SUR L'ESPRIT ET L'INFLUENCE DE LA RÉFORMATION DE LUTHER.

PREMIÈRE PARTIE.

CONSIDÉRATIONS GÉNÉRALES.

§. 1. *Sur l'état de la Question.*

Si durant un des siècles qui ont précédé le seizième, alors qu'aucune barrière ne s'était encore élevée contre la suprématie des Pontifes romains, une assemblée savante eût voulu peser les résultats d'un schisme, d'une opinion contraire à celle de Rome, la question, sans doute, eût été conçue ainsi : « Quels sont les maux et les scandales dont l'Eglise a été affligée à l'occasion de telle doctrine impie et pernicieuse ? » — Aujourd'hui que plusieurs

nations respectables se sont séparé de l'Eglise romaine, que les relations intimes qui unissent entr'eux tous les Européens, ont habitué les chrétiens sectateurs de Rome à voir dans les autres des gens aussi vertueux, aussi policés, aussi éclairés qu'eux, la question doit s'énoncer d'une autre manière. Une assemblée de philosophes, au milieu de la France rendue au catholicisme, propose : « de fixer l'influence de la réformation de *Luther* sur l'état de la société européenne, sur le progrès des lumières. » Ce changement dans le langage en suppose un grand dans les opinions ; et sous ce point de vue, on pourrait dire que la question se répond à elle-même.

L'Institut n'ayant accompagné cette question d'aucun programme explicatif, les considérations suivantes, qui ont pour but de déterminer le sens et la latitude de la réponse, ne pourront paraître déplacées.

Il semble, au premier aspect, qu'une révolution religieuse ne devrait exercer son influence que sur ce qui touche la religion, sur le culte et la discipline de l'Eglise; mais l'Eglise et l'Etat, longtems avant la réformation de *Luther*, s'étaient tellement amal-

gamés dans tous les corps politiques de l'Europe, leurs droits et leurs constitutions étaient tellement confondus, qu'on ne pouvait ébranler l'une sans que l'autre n'éprouvât la même secousse. L'Eglise, qui avait partout formé un état dans l'état, avait poussé si loin ses usurpations sur celui-ci, qu'elle menaçait de l'engloutir. L'Europe entière fut longtems en danger de passer sous le joug d'une théocratie absolue. Les empereurs du nouvel empire d'Occident, qui la sauvèrent de cette destinée, l'effrayèrent ensuite du projet d'une monarchie universelle. Les rois de France, d'Angleterre, de Suède et de Danemarck, les princes et cités libres de l'Allemagne et de l'Italie, ne s'opposaient que partiellement et tour-à-tour aux prétentions de l'un et de l'autre concurrent. — Une impulsion nouvelle, un lien nouveau et puissant qui unissait ensemble les opprimés contre les deux oppresseurs à-la-fois, un évènement qui réveillait toutes les passions, l'amour de la liberté, le fanatisme religieux et politique, qui décuplait les forces des princes en exaltant les peuples, qui offrait enfin aux chefs, avec l'indépendance, la riche proie des

dépouilles du clergé ; un tel évènement, dis-je, dut alors produire dans l'Europe une agitation universelle. Le système des états modernes en fut ébranlé jusques dans ses fondemens. Durant la longue et douloureuse lutte qui s'ensuivit, tout prit une forme et une assiette différente. Un nouvel ordre politique sortit de la fermentation et de la confusion générale ; les divers élémens qui le composent, longtems agités en sens divers, obéissant enfin à la loi de gravitation du monde moral, y prirent la place assignée par leurs poids respectifs, mais qui n'était plus, pour la plupart, l'ancienne place qu'ils avaient occupée. Un nouvel ordre d'idées sortit aussi du choc des opinions ; on osa penser, raisonner, examiner ce qui auparavant ne comportait qu'une soumission aveugle. Ainsi une simple atteinte portée à la discipline ecclesiastique, amena un changement considerable dans la situation politique des états de l'Europe et dans la cul ure morale de ses habitans. L'Institut a donc eté anime du vrai génie de l'histoire, en provoquant la solution du problème qu'il a si bien posé. Il est glorieux pour tout écrivain d'avoir à traiter devant un semblable

tribunal de la religion et de la politique, ces deux points cardinaux de la vie humaine. Un des premiers apanages de la vraie liberté, est le pouvoir de s'expliquer sans contrainte sur ces objets importans ; et le pays où ce pouvoir s'exerce, est infailliblement un pays libre.

L'Institut en demandant quelle *a été* l'influence de la réformation de *Luther*, indique assez qu'il considère cette influence comme n'existant plus aujourd'hui d'une manière active. En effet, près de trois siècles se sont écoulés depuis la première explosion. L'ébranlement qui en résulta s'est calmé par degrés ; la force, qui originairement donna l'impulsion, et qui produisit tant de choses nouvelles, a cessé d'agir comme force vive, comme principe productif. Les institutions qu'elle créa, celles qu'elle modifia, sont restées la plupart ; quelques-unes se sont évanouies : mais celles qui ont demeuré suivent de nos jours le cours universel des évènemens, et la réformation n'est plus la cause immédiate qui dirige ce cours. Elle a fait à-peu-près tout ce qu'elle devait faire ; son influence ne se manifeste plus que médiatement,

sans secousses, et par la marche des institutions qui ont pris d'elle leur naissance. Le tems est donc venu qu'on peut la juger, dénombrer et discuter les avantages ou les désavantages qui en ont résulté pour le genre humain. C'est, il n'en faut pas douter, se conformer aux vues de l'Institut, que de se borner à spécifier exactement toutes les suites prochaines qu'a eu la réformation, et se contenter d'une indication légère de ses suites éloignées. Si on voulait s'engager dans le détail de ces dernières, il faudrait refaire l'immense tableau de l'histoire des états européens depuis cette époque, puisqu'il n'est presqu'aucun grand évènement où quelque résultat de la réformation, tel que la constitution actuelle du corps germanique, par exemple, ou la république des Provinces-unies, n'ait influé à son tour plus ou moins. On ne sortirait jamais de ce labyrinthe des suites *médiates*; car, à le prendre ainsi, l'influence de toute commotion politique ou religieuse se propage à l'infini. Nous nous ressentons encore aujourd'hui plus ou moins de ce qui s'est passé dans l'Inde, l'Arabie, la Grèce, l'Italie, en des tems fort reculés; nous vivons sous l'in-

fluence encore très-sensible de l'invasion des peuples du Nord, des croisades, et d'autres mouvemens politiques devenus des principes d'action parmi les peuples. La ligne déviatrice, souvent tortueuse, quelquefois rétrograde de la culture des nations, procède de l'action compliquée de tant de forces diverses : marquer ses échappemens, ses déviations, en évaluant les forces qui y ont concouru, est l'office de la philosophie de l'histoire. L'auteur du présent écrit s'estimera heureux, si ses juges pensent qu'il a rempli une tâche pareille relativement à cette période de l'histoire moderne où la réformation a été la force prédominante.

Cependant, on ne peut s'engager dans la recherche des effets de la réformation, sans être en quelque façon contraint de se livrer à cette réflexion : « Le grand évènement que je considère comme une cause, n'est-il pas lui-même un simple résultat d'autres évènemens qui l'ont précédé, tellement qu'il faudrait que je rapportasse à ceux-là, et non pas à lui qui n'a été qu'un intermédiaire, la vraie origine de tout ce qui a suivi? » — Sans doute; tel est le sort de l'esprit dans ses recherches. Tant qu'il re-

garde en avant, son point de départ lui semble être la base fixe d'où procèdent tous les pas suivans. Jette-t-il ses regards en arrière, le premier point ne lui aparaît plus que comme une suite nécessaire de ceux qui l'ont précédé, et seulement comme le passage pour arriver à ceux qui suivent. Aux yeux de l'esprit, chaque cause en remontant devient un simple effet; chaque effet devient cause à son tour en descendant. Le penchant qui nous porte à attribuer tout ce qui suit un évènement à cet évènement lui-même, comme s'il en était la cause, est le fil conducteur qui nous aide à ranger tous les faits historiques; c'est la loi de cohésion par laquelle le présent se rattache au passé. Remonter ainsi de l'effet à la cause, jusqu'à une cause première subsistante par elle-même, et qui ne soit plus l'effet d'aucune autre cause, est un besoin de notre intelligence, qui cherche un principe absolu où se fondent ses spéculations. C'est sur cette voie glissante que se perd la métaphysique. — Un homme qui ignorerait ce que c'est que le cours d'un fleuve, et qui arriverait sur ses bords, le voyant ici couler dans une vaste plaine, là pressé dans

d'étroites vallées, écumant ailleurs au saut d'une cataracte; cet homme prendrait pour l'origine du fleuve le premier détour où il serait caché par une gorge; remontant plus haut un nouveau détour, la cataracte lui ferait la même illusion; enfin, arrivé à la source, il prendrait la montagne dont elle jaillit pour la cause première du fleuve: mais bientôt il pensera que les flancs de cette montagne s'épuiseraient par un torrent aussi continu; il verra les nuages amoncelés, les pluies sans lesquelles le mont desséché ne fournirait aucune source. Voilà les nuages qui deviennent la cause première; mais ce sont les vents qui apportent ceux ci en balayant les vastes mers; mais c'est le soleil qui a tiré les nuages de la mer. Mais d'où vient cette force dans le soleil? Le voilà bientôt entraîné dans les recherches de la physique spéculative, par celle d'une cause, d'un fonds absolu, duquel il puisse déduire en dernier ressort l'explication de tant de phénomènes.

Ainsi, l'historien qui recherche quelle cause a amené l'affaiblissement de l'autorité des Papes, la terrible guerre de trente ans, l'abaissement de la maison d'Autriche, l'éta-

blissement d'une opposition puissante au sein de l'Empire, la fondation de la Hollando comme état libre, et ainsi du reste, doit voir d'abord l'origine immédiate de tous ces évènemens dans la réformation, et les attribuer absolument à son influence. Mais poussant ses recherches plus haut, il aperçoit que cette réformation elle-même n'est évidemment qu'un résultat nécessair d'autres circonstances qui l'ont précédée, un évènement du seizième siècle, dont le quinzième était gros, pour me servir de l'expression de *Leibnitz* : tout au plus la cataracte du fleuve. Combien de gens s'obstinent encore à trouver la cause première de la révolution française dans le *déficit*, dans la convocation des états-généraux, dans le tiers-état, dans les curés ! D'autres, qui portent la vue un peu plus loin, la veulent trouver dans le parlement *Maupeou*, dans l'extinction des Jésuites, etc.... Ils ont tous raison sous un certain point-de-vue borné, qui est le leur. Ceux dont la vue contemple cependant la marche de l'humanité pendant une suite de siècles, voient se rouler cette masse énorme d'individus, dont chacun, animé par son intérêt, ses passions et son

esprit propre, semble vouloir contrarier la marche de tous les autres; mais, malgré leur infinie diversité, tous ces esprits ont des traits communs, tendent vers de certains buts, qui sont finalement les mêmes; ces traits, ces penchans communs à tous, forment une réunion de forces, ou plutôt une force unique, qui est celle du genre humain, celle d'un esprit universel, qui, caché dans les siècles, les guide et les gouverne. Sous l'empire de la Providence (ce soleil du monde moral, pour me servir encore de l'expression d'un philosophe), cet esprit de l'humanité, dans son action continuelle, prépare et dispose les évènemens. Telle grande révolution qui nous surprend, n'en est qu'un produit, un résultat, une manifestation éclatante. Est-ce donc à elle, n'est-ce pas plutôt à l'influence des causes qui l'ont elle-même précédée et amenée, qu'on devra attribuer les évènemens qui l'ont suivie ?

Il convient donc à l'historien, dans le cas donné, d'avoir égard à ce qui était avant le grand événement qu'il examine: de déterminer par l'influence de quelles causes cet évènement a été lui-même

amené, et jusqu'à quel degré ces mêmes causes ont influé sur la série des évènemens postérieurs? il lui convient encore de considérer ce qui serait arrivé par la marche lente et progressive de l'humanité qu'on nomme quelquefois le cours naturel des choses, si le grand évènement, si l'éclat dont il est question, ne fût pas survenu? Enfin il doit déterminer ce que le caractère propre et individuel de cet évènement, le caractère du siècle et de la nation où il a eu lieu, celui des hommes qui y ont pris la principale part, a pu apporter de modifications particulières dans ses suites.

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§. 2. Sur l'essence des réformations en général.

Tout comme l'esprit remonte la chaîne des évènemens, et passe de chaque effet à sa cause, pour arriver enfin à une cause première qui lui serve de principe, et où il consolide le premier anneau de la chaîne; de même il redescend de causes en effets, avide de parvenir à un résultat dernier, à un effet absolu, qui se suffise par lui-

Conclusion.

Tels sont les principaux résultats que j'ai cru dérivés de l'influence qu'a exercé sur l'Europe la réformation de *Luther*. En analysant les causes si compliquées de ce qui s'est passé de plus considérable depuis trois siècles, dans le monde politique et dans le monde littéraire, on peut facilement s'égarer, prendre le change sur quelques causes, perdre de vue quelques effets. Au travers de la confusion de tous ces fils embarrassés de la politique et de la culture européenne, lorsqu'on veut démêler ceux qui vont se nouer immediatement aux querelles de religion, quelque soin qu'on y apporte, on risque trop souvent de se méprendre. Les uns se rattachent à l'établissement du christianisme lui-même, à la prédication de l'alcoran, à la chevalerie, aux croisades, à l'usage de l'artillerie, à la decouverte du nouveau monde, à la renaissance des lettres, aux institutions de *Pierre I*, à la guerre de la succession, et à d'autres évènemens

majeurs. S'il était question de déterminer l'influence de quelqu'un de ces évènemens, peut-être réclamerait-on comme lui appartenant telle des suites que j'ai attribué à la réformation. Les historiens, qui livrent les faits, se taisent d'ordinaire sur les causes, et souvent même les ignorent. Quelquefois ils en indiquent de fausses et de contradictaires. Les écrivains des partis opposés sont exclusifs, et rendent la vérité incertaine. A qui croire, des catholiques, ou des protestans, de *Duperron*, ou de *Dumoulin*, de *Platina* ou de *Mornay ?* Comment se décider entre *Varillas* et *Maimbourg*, d'un côté, *Sleidan*, *Bayle* et *Seckendorf* de l'autre, entre *Pallavicini* et *Fra-Paolo*, entre *Bossuet* et *Claude?* Les uns ne voient dans l'œuvre de la réformation qu'une source infinie d'erreurs et de calamités; les autres n'y voient que lumières et bienfaits pour le genre humain. Au milieu de tant d'avis différens, il faut avoir le sien. Nous sommes aujourd'hui mieux placés que jamais, pour juger une révolution qui a éclaté, il y a trois cents ans : considérons ce qui était avant, ce qui a été depuis; écoutons tous les partis,

regardons autour de nous, voyons ce qui est aujourd'hui, et jugeons.

Quand après le long sommeil des nations européennes et de leur raison, pendant le moyen âge, nous arrêtons nos regards sur l'état du genre humain dans cette belle partie du monde au quinzième siècle, et au commencement du seizième, nous le voyons sortir de son engourdissement, se lever, marcher inquiet sur toutes les directions, saisir des instrumens pour son activité, en forger de nouveaux, les essayer, développer ses forces, s'emparer du champ des sciences, rejeter loin de lui les langes qui l'embarrassent, et commencer une nouvelle époque. Combien les évènemens décisifs et les inventions se pressent durant cet intervalle! L'heureux emploi de la boussole, le télescope, l'imprimerie, la prise de Constantinople, le nouveau monde, la soumission des grands vassaux de la couronne en France, l'âge d'or de la poésie et des arts en Italie, la fondation de nombreuses écoles, les livres des anciens qui y revivent, l'établissement des postes qui rend toutes les communications rapides, la fameuse paix d'Empire et la chambre impériale,

l'accroissement exagéré de la puissance autrichienne qui effraie l'Europe et la contraint à s'armer, *Copernic* qui réforme le ciel, *Luther* et *Loyola* qui naissent presqu'au même tems! Il fallait que la crise eût un terme; que l'état des choses changeât dans l'ordre des sociétés civiles, et dans celui du savoir humain.

« *Le mieux est ennemi du bien* », dit un proverbe de la moderne Italie. Ce ridicule adage qui n'eût jamais dû sortir de la langue où il est né, est l'expression naïve du caractère ultramontain. Heureusement qu'il n'est pas au pouvoir d'une caste blasée, ni d'une maxime contre nature, d'enclouer ainsi les destinées de la science et de la civilisation. Les hommes passent outre, et ne font nul droit à de telles réclamations, aux réclamations de ces « *esprits paresseux et jaloux*, dit *Chénier* (1), *dont la raison sans mouvement voudrait paralyser la pensée humaine.* » Aucune des institutions du moyen âge n'était plus appropriée à la nouvelle humanité. Comme les lances et les écus

(1) Dans son *Discours sur le progrès des connaissances*. An IX, impr. chez *Didot*.

avaient été mis de côté devant les armes à feu, ainsi la scholastique devait être écartée par les nouvelles armes de la raison; les cercles inextricables de *Ptolémée*, par la simple idée du mouvement de la terre; et les fausses décrétales tomber aux premiers regards de la critique. La forme extérieure de la religion ne convenait plus à la nouvelle culture, pas plus que la représentation des mystères ne convenait sur la scène où allaient paraître *Corneille* et *Molière*; pas plus que l'architecture gothique, près de la basilique de *S. Pierre*. Il fallait que tout changeât : le nouvel esprit ne pouvait subsister dans les anciennes formes; une harmonie, une convenance devait s'établir entre lui et les choses; et comme il avait en lui l'énergie du réveil, la toute-puissance de la jeunesse, il opéra sur toutes les directions avec force, avec efficace, et par-tout secondé par l'enthousiasme.

C'est donc sous ce point-de-vue qu'on doit envisager la réformation : comme un produit nécessaire du nouveau siècle, comme une manifestation du nouvel esprit. Ce que *le Dante* et *Pétrarque* furent pour la poésie, *Michel-Ange* et *Raphael* pour les arts du

dessin, *Bacon* et *Descartes* pour la philosophie, *Copernic* et *Galilée* pour l'astronomie, *Colomb* et *Gama* pour la science de la terre, *Luther* le fut pour la religion. Organes de la pensée universelle, ces hommes éminens exprimèrent avec vérité celle qui couvait dans un grand nombre de leurs contemporains, et ils satisfirent d'un coup au besoin de leur siècle. Aussitôt que de leur génie se fut échappé, l'étincelle, la flamme prête à paraître pointa de toutes parts. Ce qui n'était qu'un pressentiment, qu'une idée vague, isolée dans une foule de têtes, prit une consistance, une direction fixe, parut au dehors, se communiqua d'individus en individus, et une chaîne continue lia toutes les têtes pensantes. Tel est le mode naturel de conjuration tâcite qui préside à toutes les réformations Celles qui s'opèrent dans le règne des arts et de la plupart des sciences, étrangeres aux passions et aux commotions volcaniques de la masse des peuples, sont d'ordinaire accompagnées de la paix, et se consomment sans qu'il en coûte de pleurs à l'humanité. Il n'en pouvait être ainsi de celle provoquée par *Luther*. La religion n'était pas alors une simple opinion, un

simple être moral. Elle avait un corps immense, qui oppressait tous les corps politiques, qui prétendait à tous les trônes, à tous les biens de la terre. A la première blessure qu'il ressentit, le colosse tressaillit, et le monde fut ébranlé. Les princes et les nations s'armèrent, et se livrèrent à une lute terrible, à une lute d'opinions et d'intérêts, dont les résultats furent si variés et si importans.

L'Institut a demandé qu'on lui rendît compte de ceux de ces résultats qui influèrent sur la situation politique des états de l'Europe, et sur le progrès des lumières. Cette tâche était énorme, et bien au dessus de mes forces. Qu'eût-ce été si l'Institut, outre les suites politiques et littéraires, eût encore prescrit qu'on exposât l'influence de la réformation sur la moralité des nations européennes, sur leur croyance et leurs dispositions religieuses? Mais ce nouveau point-de-vue serait l'objet d'un travail peut-être plus étendu et plus difficile que le mien. J'ai dû me renfermer dans les bornes prescrites, qui déja circonscrivent un assez vaste champ. Il n'a pas été dans mes vues de déguiser ni le mal ni le bien produits par la réformation.

réformation. J'ai cherché seulement à prouver que tout étant compensé, et le bilan définitif étant arrêté, les suites de cette révolution offrent un excédent de bien pour l'humanité; et qu'enfin elle doit être rangée au nombre des évènemens majeurs qui ont le plus puissamment contribué aux progrès de la civilisation et des lumières, non-seulement en Europe, mais dans toutes les parties de la terre où les Européens ont porté leur culture.

J'ai cru d'ailleurs pouvoir m'expliquer avec la franchise libre d'un historien, qui doit, s'il est possible, n'appartenir à aucun siècle, ni à aucun pays : m'affermissant par cette pensée, que nul préjugé n'avait accès dans le sanctuaire des sciences; et qu'une société illustre assez philosophe pour choisir un tel sujet, et provoquer à son égard la vérité, était, sans nul doute, disposée à l'entendre.

FIN.

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* The works marked with an asterisk are held in the Partington Collection, John Rylands Memorial Library, Manchester.

ABSTRACT

The turn of the nineteenth century was a transitional stage in the terminology of chemistry. An extremely flexible nomenclature system was developed in France by a team of four distinguished members of the Academy of Sciences. The terminology of operations and transformations, however, remained largely untouched for some time to come.

One of the four scientists who drew up the nomenclature was Claude-Louis Berthollet, a distinguished industrialist and public figure. He was also a theoretical chemist, whose theories were proven essentially correct only years after his death.

In 1803 Berthollet published the Essai de statique chimique, his most important work. The introduction to the two volume essay embodies the essentials of his chemical theory. In 1804 the work was translated into English by an obscure translator known only as B. Lambert. Both the original and the translation are considered very difficult to understand.

The following is a discussion of the barriers to comprehension of both the original "Essai" and the Lambert translation, including the difficulties Lambert faced, and an attempt at retranslating the introduction into more readily understandable English.