for hospitalities extended to members in connection with their visits to this splendid institution, and for the exceptional courtesies tendered in connection with the Shaw banquet.

The association is under obligations to the officers of the Louisiana Purchase Exposition for the luncheon and reception at the grounds of the exposition, and to the chiefs of departments under whose guidance the members were privileged to witness the progress already made toward the completion of this monumental work.

The association must further acknowledge its indebtedness to the press, to the St. Louis Transit Company, to the president of the Board of Public Improvements and to all other organizations, corporations and individuals who have extended so many privileges to members individually and in groups in connection with visiting the great industries and points of interest in St. Louis and vicinity.

The association is under deep obligations to the Mercantile Club, to the University Club, and finally and in especial measure, to the Wednesday Club for the thoughtful hospitalities extended to the ladies registered at the meeting.

It was unanimously voted to extend the thanks of the association to Professor Rutherford for his lecture on radium and radio-activity.

At the meeting of the general committee, held Thursday evening, it was decided to hold the next meeting in Philadelphia, beginning Tuesday, December 27, 1904, and closing Monday, January 2, 1905, it being understood that the Executive Committee of the Council will meet Tuesday, December 27, and the opening session of the meeting will be held Wednesday, December 28. New Orleans was recommended as the place of meeting two years hence.

The following officers were elected for the Philadelphia meeting:

President—W. G. Farlow, Cambridge, Mass.

Vice-Presidents:

Section A—Alexander Ziwet, Ann Arbor, Michigan.

Section B—William F. Magie, Princeton, New Jersey.

Section C—Leonard P. Kinnicutt, Worcester, Massachusetts.

Section D—David S. Jacobus, Hoboken, New Jersey.

Section E—Eugene A. Smith, University, Alabama.

Section F—C. Hart Merriam, Washington, D. C.

Section G—B. L. Robinson, Cambridge, Mass.

Section H—Walter Hough, Washington, D. C.

Section I—Martin A. Knapp, Washington, D. C.

Section K—The present vice-president, Mr. H. P. Bowditch, will serve another year.

General Secretary—Charles S. Howe, Cleveland, Ohio.

Secretary of the Council—Clarence A. Waldo, Lafayette, Indiana.

CHARLES S. HOWE,
General Secretary.

THE ELEMENTS: VERIFIED AND UNVERIFIED.*

IT is the sad duty of the retiring chairman of this section to chronicle the death of two members. One of them, James Francis Magee, B.S., University of Pennsylvania, 1887, devoted his life chiefly to commercial pursuits, in which he was most successful. He joined the association at the fifty-first meeting, being one of the youngest members. The other was H. Carrington Bolton, Columbia, 1862 (Ph.D. Göttingen, 1865), who, with the exception of four (Gibbs, Boye, Brush and Hilgard), was the senior of the section, having joined at the seventeenth meeting. I beg permission to quote from an article of his in the *American Chemist*, 1876, the year following his elevation to fellowship in the association, as it exemplified in telling words one of the great aims in his life, with the fruitful accomplishment of which you are familiar:

"So rapid are the strides made by science in this progressive age and so boundless is its range, that those who view its career from without find great difficulty in following its diverse and intricate pathways, while those who have secured a foot-

* Address of the vice-president and chairman of Section C, Chemistry, of the American Association for the Advancement of Science, St. Louis meeting, December 28, 1903.

ing within the same road are often quite unable to keep pace with its fleet movements and would fain retire from the unequal contest. It is not surprising, then, that those actually contributing to the advancement of science, pressing eagerly upward and onward, should neglect to look back upon the labors of those who precede them and should sometimes lose sight of the obligations which science owes to forgotten generations."* His numerous contributions to and intimate knowledge of the history of chemistry, his gentle and generous sympathy aided and stimulated many active in research or technical applications of chemistry. His monumental bibliographies put out by the Smithsonian Institution are masterpieces. The grief and keen regret of his loss are not confined to one nation.

On another occasion it has been the good fortune of him who has the honor of addressing you to-day to indicate that events of literary moment, governmental modifications, inventions and forward stridings in science, have apparently accommodated themselves to historical periods during the past century.† Striking, novel facts and fancies, gleaned in the realm of inorganic chemistry, have crested not a few of the high waves of those human tides that beat against the coasts of the untried and unknown.

The human mind knows by contrasts. For the day we have night; for the good there is evil. Where man would have a God, he also had a devil; for the true there is the false; the verified and unverified. The false may be true through ignorance; the true may be false in the light of new knowledge. Or, as Hegel put it, 'Sein und das nicht Sein sind das Nämliche.'

* 'Notes on the Early Literature of Chemistry—The Book of the Balance of Wisdom,' New York Academy of Sciences, May 29, 1876.

† 'The Rare Earth Crusade; What it Portends, Scientifically and Technically,' SCIENCE, N. S., XVII., 722–781.

Is matter continuous or discrete? argued the opposed schools of Grecian philosophy led by Leucippus, Democritus and Epicurus and dominated by Aristotle. Despite the clarity of the statements of the Roman Lucretius,* the atomic hypothesis received scant attention until the seventeenth century of the Christian era, when Galileo's experimental science assailed Aristotelian metaphysics and demanded verification of the premises of that philosophy which had governed all the schools of Europe for two thousand years.† While Gassendi, Boyle, Descartes, Newton, perhaps Boscovich, Lavoisier, Swedeborg, Richter, Fischer and Higgins had to do with our modern atomic theory, Dalton one hundred years ago 'created a working tool of extraordinary power and usefulness' in the laws of definite and multiple proportions. As Clarke‡ remarked, 'Between the atom of Lucretius and the Daltonian atom the kinship is very remote.' Although the lineage is direct, the work of Berzelius, Gmelin and others; the laws of Faraday, Guy Lussac, Avagadro, Dulong and Petit; the reformations of Laurent and Gerhardt, but particularly Cannizzaro; the systematizations of de Chancourtois, Newlands, Hinrichs, Mendelejeff and Lothar Meyer; the stereochemistry of van't Hoff and LeBel have imperialized the ideas of the Manchester philosopher, so that the conceptions of the conservative atomists of to-day are quite different from those at the beginning of the closed century.§

* "Nature reserving these as seeds of things
Permits in them no minish nor decay;
They can't be fewer and they can't be less."

Again, of compounds—

"Decay of some leaves others free to grow
And thus the sum of things rests unimpaired." Book II., 79.

† See 'The Atomic Theory,' the Wilde Lecture by F. W. Clarke at Dalton Celebration, May, 1903.

‡ *Loc. cit.*

§ While I have examined much of the original literature, Venable's 'History of the Periodic

These have not come about solely through the additive labors of the savants mentioned, for they have been shaped quite as much by speculative and experimental opposition exemplified by Brodie* and Sterry Hunt.†

In Graham's 'Speculative Ideas Respecting the Constitution of Matter'‡ we have the conception that our supposed elements possess 'one and the same ultimate or atomic molecule existing in different conditions of movement. § *Apropos,* we have the suggestion of F. W. Clarke || that the evolution of planets from nebulæ, according to the hypothesis of Kant and Laplace, was accompanied by an evolution of the elements themselves. Even Boyle—'the cautious and doubting Robert Boyle,' as Humboldt said of him—was inclined to the belief that 'all matter is compounded of one primordial substance—merely modifications of the *materia prima.'*

The Daltonian ideas had scarcely reached adolescence before Prout (1815), giving heed to the figures concerned, would have all the elements compounded of hydrogen. The classical atomic mass values obtained by sympathetic Stas and the numerous investigations of those who followed him, with all the refinements human ingenuity has been able to devise, temporarily silenced such speculations, but not until Marignac had halved the unit, Dumas had quartered it, and Zängerle, as late as 1882, insisted upon the one thousandth hydrogen atom.

The notion, like Banquo's ghost, will ever up, for if one may judge from the probability calculations of Mallet* and Strutt,† a profound truth underlies the now crude hypothesis.

Crookes,‡ from observations made during prolonged and painstaking fractionations of certain of the rare earths, supported his previously announced 'provisional hypothesis' as to the genesis of the elements from a hypothetical *protyle,* which existed when the universe was without form and void. He designated those intermediate entities, like yttrium, gadolinium and didymium, 'meta-elements,'§ a species of compound radicals, as it were. *Urstoff,* fire mist, protyle, the ultra-gaseous form, the fourth state of matter || was condensed by a process analogous to cooling; in short, the elements were created. The rate of the cooling and irregular condensation produced 'the atavism of the elements,' and this caused the formation of the natural families of the periodic system. Marignac¶ criticizing this hypothesis, states: "I have always admitted** the impossibility of accounting for the curious relations which are manifested between the atomic weights of the elements, except by the hypothesis by a general method of formation according to definite though unknown laws; even when these relations have the character of general and absolute laws."

Further, "I do not the less acknowledge

Law' has been most helpful. I have, furthermore, had the privilege of reading very carefully the manuscript of a work entitled 'The Study of the Atom' (in press), by Dr. Venable.

* 'Calculus of Chemical Operations,' *J. Chem. Soc.*, 21, 367 (1866), and his book, 'Ideal Chemistry,' 1880.

† Numerous papers summarized in 'A New Basis for Chemistry.' New York, 1887 and 1892 (fourth edition).

‡ *Proc. Roy. Soc.*, 1863.

§ Venable, 'The Definition of the Element,' vice-presidential address, Section C, American Association for the Advancement of Science, Columbus meeting, 1899.

|| 'Evolution and the Spectroscope,' *Pop. Sc. M. Jour.*, 1873.

* *Phil. Trans.*, 171, 1003, 1881.

† *Phil. Mag.* (6), 1, 311.

‡ *Chem. News*, 55, 83, 1886.

§ Address before Chemical Section of the British Association, *Chem. News*, 54, 117, 1885.

|| Crookes, Royal Societies, June 10, 1880.

¶ *Archives des Sciences Physiques et Naturelles*, 17–5; *Chemical News*, 56, 39.

**Remarks made in 1860–5 after publication of Stas's 'Researches on Atomic Weights,' Archives, 9, 102, 24–376.

that the effect of constant association of these elements is one of the strongest proofs that can be found of the community of their origin. Besides, it is not an isolated fact; we can find other examples such as the habitual association in minerals of tantalum, niobium and titanium."

Sir John Herschel thought that all the atoms were alike and the elements, as we know them, 'have the stamp of the manufactured article.'

Hartley* this year says: 'It is more than twenty years since the study of homology in spectra led me to the conviction that the chemical atoms are not the ultimate particles of matter, and that they have a complex constitution.'

The peculiar discharge from the negative electrodes of a vacuum tube was investigated many years ago by Hittorf and Crookes, who arrived at the conclusion that it was composed of streams of charged particles. All are familiar with the very recent proposed 'electrons' and 'corpuscles' resulting from the beautiful physical researches of Lodge and J. J. Thomson. These appear to have caused a trembling in the belief of many in the immutability of the atom, and the complete abandonment of the atom is seriously discussed by others.

"If the electrons of all elements are exactly alike, or, in other words, if there is but one matter, just as there is but one force, and if the elements be but the various manifestations of that one matter, due to a different orbital arrangement of the electrons, it would seem that we are fast returning to the conceptions of the middle-aged alchemist. The transmutation of metals involves but the modification of the arrangement of the electrons." Such efforts as Fittica's* should not be treated with scorn, but given careful examination and merited consideration, as Winkler† gave his. Science should thus ever be 'a foe of raw haste, half-sister to delay.'‡

Although by chemical means, so far, we have been unable to break up the atoms, apparently electrical energy, in the form of cathode rays, for example, follows the grain of atomic structure. Some advanced thinkers look upon the atoms as disembodied charges of electricity. Ostwald has taught it. Electric charges are known only as united to matter, yet Johnstone, Stoney and Larmor have speculated on the properties of such charges isolated. "Such a charge is inertia, even though attached to no matter, and the increase of inertia of a body due to electrification has been calculated by both Thomson and Oliver Heaviside, the conception accordingly being advanced that all inertia is electrical and that matter, as we know it, is built up of interlocked positive and negative electrons. If it were possible in any mass of matter to separate these electrons then matter would disappear and there would remain merely two enormous charges of electricity." We are aware of phenomena attributed to the negative electrons; we await anxiously the announcement of the positive electrons. But here the water is deep and one may not swim too well.

We do know, however, as A. A. Noyes says,§ that 'there exists in the universe some thing or things other than matter which, by association with it, give rise to the changes in properties which bodies exhibit, and give them power of producing changes in the properties of other bodies.'

* Address before the Chemical Section, British Association, Southport meeting, September, 1903, *Chem. News*, 88, 154.

* 'Black Phosphorus, or Conversion of Phosphorus into Arsenic,' *Chem. News*, 81, 257; 82, 166.

† *Berichte*, 33, 10; *Chem. News*, 81, 305.

‡ Van Dyke in 'The Ruling Passion.'

§ 'General Principles of Physical Science,' p. 13, 1902.

Further (p. 15), "* * * matter is that which gives rise to the localization of the complex of properties which certain portions of space exhibit. Even though, on the one hand, it must be admitted that the existence of matter is inferred only from various energy manifestations which bodies exhibit, it must be acknowledged, on the other, that there are no manifestations of energy except those which are associated with the manifestations of it that have led to the adoption of the concept of matter; in a word, the two assumed entities, matter and energy, are indissolubly connected in our experience." Thus, as Dumas said, 'Hypotheses are the crutches of science to be thrown away at the proper time.'

I have dared to sketch these conceptions in a few bold outlines, for

> "We can't enumerate them all!
> In every land and age have they
> With honest zeal been toiling on,*
> To turn our darkness into day."

The imposition upon your good nature practiced in the foregoing craves its pardon in an effort to seek a definition for the term, element. Shall we say, as does Remsen, 'An element is a substance made up of atoms of the same kind?' Can we say that it is not? Venable† truly says: 'An element is best defined by means of its properties.' These conceits are not exclusive. The properties are the result of the action of physical forces and chemical affinity, whatever that may be. Certain of the novel atmospheric gases have so far responded but poorly to the latter, as predicted before their discovery by Flawitzsky, Julius Thomsen and de Boisbaudran in 1887. This necessitates, according to Piccini‡ our dividing them at once into two classes.

* Aikens' poem at Priestley centennial, *Am. Chemist*, 1875, 23.

† The 'Definition of the Element,' *loc. cit.*

‡ *Zeit. Anorg. Chem.*, 19, 295, 1899.

Pattison Muir gives a satisfactory definition.* "The notion of the elements that has been attained after long, continued labor is that of certain distinct kinds of matter, each of which has properties that distinguish it from every other kind of matter, no one of which has been separated into portions unlike the original substance, and which combine together to produce new kinds of matter that are called compounds." The following simpler definition has finally served as my guide: *An element is that which has not been decomposed, so far as we are aware, into anything other than itself.* In short, it is consistent.

It is well to stop occasionally and take stock. The Daltonian centenary could not but be an opportune time. Stable, certified securities are not enumerated in the list which follows. Having in mind the second chapter of the first book of Chronicles, certain so-called elements are mentioned, for yttrium begat cerium, and cerium begat lanthanum, and lanthanum begat samarium and didymium, and didymium begat neodidymium and præseodidymium, and præseodidymium begat α- and β-præseodidymium, *'und so weiter.'*

Unpractised as a reading clerk, I shall spare you the strain of hearing this long list of elements on probation, but submit for leisure perusal printed copies which will form an appendix to the address as published in the *Proceedings* of the association.

From the table have been omitted urstoff, protyle (Crookes), electrons (Lodge), corpuscles (J. J. Thomson) and pantogen (Hinrichs). It appeared also unnecessary to incorporate phlogiston, nitricum (the imaginary body, thought by Berzelius united with oxygen to form nitrogen), and aræon (ponderable caloric). According to

* 'The Alchemical Essence and the Chemical Element,' London, 8vo, pp. 94, 1894.

Meissner, hydrochloric acid is composed of two equivalents of oxygen, one of water, combined with aræon and the imaginary radical murium (*vide* Bolton). Often alloys have been prepared and given names like the elements, 'magnalium,' for example. These are omitted also. Otherwise, I have purposely included every suggestion of an element I could obtain. The summary, while doubtless deficient, may secure an historical vindication.

What shall we do with these numerous aspirants whose recognition is urged? "These elements perplex us in our researches, baffle us in our speculations and haunt us in our very dreams. They stretch like an unknown sea before us, mocking, mystifying and murmuring strange revelations and possibilities," said Crookes, referring to the rare earths. Some have been verified, many unverified; some are true, some are false. Without doubt some have been presented without sufficient stage setting, yet the good faith of many can not be questioned. In fact, from this list, as one reads, he perceives the whole gamut of scientific emotions. There he may find the tragedies of elemental pretension, the comedies, yea, the very farces.

We need not look far to ascertain explanations for certain incorrect conclusions. The extreme rarity of the minerals in which many of the tentative elements have been detected, the excessively small percentages of the new ingredients, and the extraordinary difficulties attending their separation from known and unknown substances combine to render the investigations laborious, protracted and costly. De Boisbaudran required 2,400 kilograms of zinc blend for 62 grams of gallium. Ramsay* has shown one part of crypton in twenty million volumes of air, while a like amount of xenon requires one hundred and seventy million. How patiently and persistently that modest Parisian couple followed Becquerel's rays!

* *Zeit. phys. Chem.*, 44, 74, 1903.

Furthermore, when one feels that he has obtained something novel, the absolute proof is fraught with difficulties and uncertainties. We have decided to define an element by its properties. The alterations produced in the properties of the most characteristic elements by the presence of small amounts of foreign substances are evident in steel. The influence of arsenic upon the conductivity of copper is well known, and Le Bon* has recently shown that traces of magnesium (one part in 14,000) in mercury cause the latter to decompose water and to oxidize rapidly in the air at ordinary temperatures. Thorium with less than a trace of actinium produces an auto-photograph.

This point can not be too strongly stressed in the rare earth field. One who has wrought with thorium dioxide well knows the influence a small amount of cerium has upon its solubility. The conflicting statements in the literature as to the colors of the oxides of the complexes, neodidymium and præseodidymium, cause one to wonder if different researchers have had the same hæcceity.

An appeal to the spectroscope is of course in the minds of all my hearers.

It was once supposed that each element has its characteristic spectrum which remained the same under all circumstances. Keeler† calls attention to modern investigations which have shown that the same element can have entirely different spectra. For example, oxygen may be caused to have five different spectra; nitrogen, two, etc. In fact, there is no indication in the appearance of the spectra that they belong to the same substance; yet through the result of the work of Rydberg, Kayser, Runge and

* *Compt. rend.*, 131, 706, 1900.

† *Scientific American Supplement* 88, 977, 1894, and *Popular Astronomy*.

Precht, series of groups of lines are had which satisfy mathematical formulæ.

"It was proposed by de Gramont, at the International Congress in Paris, in 1900, and agreed, that no new substance should be described as an element until its spark spectrum had been measured and shown to be different from that of every other known form of matter." As Hartley * remarks, 'This appears to me to have been one of the most important transactions of the congress.' Radium † was the first to be tested by this rule. Exner and Haschek obtained 1,193 spark and 257 arc lines for Demarcay's europium. It must not be forgotten, however, that by overlapping, lines in mixtures may be masked or appear, which are absent, in those bodies of the highest state of purity. It must not be forgotten that pressure influences the spectrum, usually producing a broadening of the lines, as shown by Schuster, and that it may occur symmetrically or only towards the least refrangible red. Lest we forget, the spectroscope failed a long time to show radium and we knew it was there. It must not be forgotten, as Krüss§ has shown, that the 'influence of temperature can not be neglected and ignored, but must be considered by every chemist who wishes to make correct spectroscopic observations.' It is well known to spectroscopists that band spectra are obtained at temperatures intermediate between those required for the production of continuous spectra and line spectra.||

* Address before the Chemical Section of the British Association, Southport, 1903.

† Runge and Precht, *Am. Physik.*, IV., 12, 407, 1903.

‡ British Association, *Report*, 1880, 275. *Vide* also Lockyer and Frankland, *Proc. Roy. Soc.*, 27, 288, 1869.

§ 'The Influence of Temperature upon the Spectrum; Analytical Observations and Measurements,' *Liebig's Annalen*, 238, 57; *Chem. News*, 56, 51.

|| 'Spectrum Analysis,' Landauer, English translation by Tingle, p. 70.

The explanations of these facts do not concern us at present.

It has been shown by the researches of Newton, Dale, Gladstone, Jamin, Schrauff, Landolt and others that the refractive power increases in all liquids, except in water, between 0° and 4° with the increase of density—that is, with decrease of temperature. Rydberg showed that various solid bodies, such as quartz and aragonite, follow the same law. There are some exceptions, however. Among these is glass, as proved by Arago and Neumann prior to Rydberg. "On a rise of temperature all phenomena of absorption or emission are displaced toward the violet with the glass prisms, but toward the red with quartz prisms. These displacements are the greater the more refrangible the region of the spectrum in which they occur." As the result of a large number of observations, Krüss learned that by a variation of 25°, marked changes would be observed in the spectroscopic lines. From a table given, it could be seen that errors may spring from neglect of the temperature (of the instrument?) in stating wave-lengths, since a rise of 5° is sufficient to transfer the D_1 to the position D_2. Roscoe obtained an entirely new spectrum with the metal sodium, whereby it appears that this metal exists in a gaseous state in four different degrees of aggregation, as a simple molecule, and as three or four or eight molecules together.

Grünwald in a series of papers on his theory of spectrum analysis* endeavors "to discover relations between the spectra and thus to arrive at simpler, if not fundamental 'elements.'" He came to the conclusion that 'all the so-called elements are compounds of the primary elements *a* and

* 'Uber das Wasserspectrum, das Hydrogen—und Oxygenspectrum,' *Phil. Mag.*, 24, 304, 1887. 'Math. Spectralanalyse des Magnesiums und der Kohle,' *Monatshefte für Chemie*, 8, 650. 'Math. Spectralanalyse des Kadmiums,' *Monatshefte für Chemie*, 9, 956.

b' (coronium and helium). Ames,* having called attention to the use of uncorrected data by Grünwald, remarks: 'The concave grating gives the only accurate method of determining the ultra-violet wave-lengths of the elements; and as a consequence of not using it, most of the tables of wave-lengths so far published are not of much value.'

Hutchins and Holden,† after a comparative study of the arc spectra of metals and the sun with a twenty-one-foot focal Rowland grating, state: "We are convinced that there is much in the whole matter of coincidences of metallic and solar lines that needs reexamination; that something more than the mere coincidence of two or three lines out of many is necessary to establish even the probability of the presence of a metal in the sun. With the best instruments the violet portion of the solar spectrum is found to be so thickly set with fine lines that, if a metallic line were projected upon it at random, in many places the chances for a coincidence would be even, and coincidences could not fail to occur in case of such metals as cerium and vanadium, which give hundreds of lines in the arc."

"Moreover, a high dispersion shows that very few lines of metals are simple and short, but, on the contrary, winged and nebulous, and complicated by a great variety of reversal phenomena. A 'line' is sometimes half an inch wide on the photographic plate, or it may be split into ten by reversals."

Lockyer maintained that the lines of certain brilliant substances vary not only in length and in number, but also in brilliancy and in breadth, depending upon the quantity of the substance as well as temperature.* Being unable to decompose the elements in the laboratory, he studied the spectra of the stars. The spectra of the colder stars† show many more metals, but no metalloids, whereas the coldest stars, *A. Orionis,* show the Crookes spectrum of metalloids which are compounds. None of the metalloids are found in the spectrum of the sun. Over 100,000 visual observations and 2,000 photographs were made in the researches.

Liveing,‡ as the result of the work of Young, Dewar, Fievez and himself on the spectrum of the sun, by which some lines were resolved with a new instrument, which they before had not been able to devise, comments on Lockyer's work: That the coincidence of rays emitted by different chemical elements, especially when developed in the spark of a powerful induction coil, and the high temperature of the sun and stars, gives evidence of a common element in the composition of the metals which produce the coincident rays. "This result can not fail to shake our belief, if we had any, in the existence of any common constituent in the chemical elements, but it does not touch the evidence which the spectroscope affords us that many of our elements, in the state in which we know them, may have a very complex molecular structure."

Hartley§ in his recent admirable address said:

"I have always experienced great difficulty in accepting the view that because the spectrum of an element contained a line or lines in it which were coincident with a line or lines in another element, it was evidence of the dissociation of the elements into simpler forms of matter. In my opinion, evidence of the compound nature of the

* *Am. Chem. J.*, 11, 138, 1889.

† 'On the Existence of Certain Elements, Together with the Discovery of Platinum, in the Sun,' *Am. Jour. Sci.; Sci. Am. Supp.*, 25, 628, 1888.

* *Roy. Soc. Proc.*, 61, 148, 183; *Chem. News*, 79, 145.

† *Chem. News*, 79, 147.

‡ Address before the Chemical Section of the British Association, *Scientific American Supplement*, 14, 356, 1882.

§ *Loc. cit.*

elements has never been obtained from the coincidence of a line or lines exclusively belonging to the spectrum of one element with a line or lines in the spectrum exclusively belonging to another element. This view is based upon the following grounds: (1) Because the coincidences have generally been shown to be only apparent, and have never been proved to be real; (2) because the great difficulty of obtaining one kind of matter entirely free from every other kind of matter is so great that where coincident lines occur in the spectra of what have been believed to be elementary substances, they have been shown from time to time to be caused by traces of foreign matter, such as by chemists are commonly termed impurities; (3) no instance has ever been recorded of any homologous group of lines belonging to one element occurring in the spectrum of another, except and alone where the one has been shown to constitute an impurity in the other; as, for instance, where the triplet of zinc is found in cadmium and the triplet of cadmium in zinc the three strongest lines in the quintuple group of magnesium is graphite, and so on. The latest elucidation of the cause of coincidences of this kind arises out of a tabulated record from the wave-length measurements of about three thousand lines in the spectra of sixteen elements made by Adeney and myself. The instances where lines appeared to coincide were extremely rare; but there was one remarkable case of a group of lines in the spectrum of copper which appeared to be common to tellurium; also lines in indium, tin, antimony and bismuth which seemed to have an origin in common with those of tellurium."

The last sentence presents the point I wish to emphasize. Tellurium has long obtruded itself before a satisfactory vision of the natural system. The table alone recites not a few efforts to obtain the contaminating constituent of tellurium which *a priori* is present from Hartley's observations (see also Grünwald 1889 table). The fractionation of a rubidium-cæsium mixture, perhaps, is a simpler problem than that confronting Pellini,* who reports a definite amount of an element with a high atomic weight (about 214), similar to and associated with tellurium.

* *Gaz. Chim. ital.*, 33, 11, 35.

What has been said applies especially to the elements of the rare earth class —'asteroids of the terrestrial family'—as phrased by Crookes. Many of them have not been secured with sufficient purity to claim an inherent spectrum; further, the spectra attributed have not been obtained under uniform conditions.

I have referred* somewhat in detail elsewhere to the factors producing variations in the absorption, as well as the advantages and disadvantages of the phosphorescent and reversal, spectra.

Without doubt the spectroscopic criteria are the most valuable we have in judging finally the elements, and mayhap will remain so, but in my humble opinion, such have not alone sufficient authority, as yet, to usher the aspirant to a place among the elect. The contention frames itself, however, in an expression of the need for uniformity.

Whether we follow the most advanced metaphysico-chemical teachings or no, if there be any one concept upon which modern practical chemical thought depends, it is the law of definiteness of composition. There may be, and doubtless are, definite, perhaps invariable, properties of our elements other than their combining proportions, the atomic weights, if you please, yet, as far as we know, they approximate more closely than any fixed, if not permanent, ratios. Many of these values, by which we lay such store, are dependent upon data† in which, I venture the assertion, too great confidence has been bestowed, or opinions to which sufficient attention has not been given.

Although in this connection we shall give little heed to the suggested variability of the relative values, it may be remarked that Boutlerow, noting the variations ob-

* 'The Rare Earth Crusade,' *loc. cit.*

† Others have been referred to in the address to which this is a sequel. *Loc. cit.*

served in 1880 by Schützenberger, who, by the use of different atomic weights, obtained analyses summing 101 instead of 100, expressed the opinion that the chemical value of a constant weight, or rather mass of an element, may vary; that the so-called atomic weight of an element may be simply the carrier of a certain amount of chemical energy which is variable within narrow limits. (See also Crookes.) Wurtz's summary of Boutlerow's views, at a meeting of the Chemical Society of Paris, provoked an interesting discussion. Cocke later published a statement that he had expressed similar views more than twenty-five years before. That is, in 1855, he had questioned the absolute character of the law of definite proportions and had suggested that the variability was occasioned by the very weak affinity between elements manifesting a fluctuating composition. Without doubt 'The Possible Significance of Changing Atomic Volume,'* in which a suggestion as to the probable source of the heat of chemical combination is put forward by T. W. Richards, bears directly upon this phase of the problem.

While the atomic mass values depend directly upon the ratio between the constituents of the compounds, they rest equally upon the molecular weights. Many of the latter attributed to salts of some of the rare earths depend solely upon the specific† heat determinations of Hillebrand and Norton,‡ Nilson and Pettersson,§ who, in the light of subsequent investigations, we know, worked with complexes. To be sure, those elements which were apparently exceptions to the law of Dulong and Petit, possess low atomic weights (beryllium, boron, carbon, silicon, aluminum and sulphur) and have for the most part been brought into harmony. "The specific heats of all substances vary with the temperature at which they are measured; and though the variation is often slight, it is occasionally of relatively great dimensions. When this is so in the case of an element, the question arises: At what temperature must the measurement of the specific heat be made in order to get numbers comparable with those of the other elements? No definite answer has been given to this question, but it is found that as the temperature rises, the specific heat seems to approach a limiting value, and this value is not in general far removed from that which would make the atomic heat approximately equal 6.4."* In view of this, allotropism, and the work of Richards adverted to, it appears that a revision of the specific heat values now taken is necessary before we can accept fully this law, which has been most helpful.

Time will not admit of detailed statements, and it is unnecessary in this presence to more than call attention to the fact that what has been said is not applicable to each specific case. *'La critique est facile, mais l'art est difficile,'* as Berthelot† has said, yet we must appreciate that all our laws have their limitations. "Man being servant and interpreter of nature, can do and understand so much and so much only, as he has observed in fact or in thought in the course of nature. Beyond this he neither knows anything nor can do anything."‡

A glance at the extensive, even censored, list of claimants will evoke serious thought. "Thus was the building left ridiculous."§ The difficulties briefly outlined and the causes for lack in uniformity are by no means insurmountable, but will continue

* *Proc. Am. Acad. Arts and Sciences*, 27, 1, 1901, and 27, 399, 1902.

† *Berichte*, 13, 1461, 1880.

‡ *Pogg. Annal.*, 156 and following.

§ *Berichte*, 13, 146, 1880.

* 'Introduction to Physical Chemistry,' James Walker, London, p. 33.

† 'Les Origines de l'Alchimie,' Paris, 1885.

‡ Bacon's 'Novum Organum,' Aphorism I.

§ Milton, 'Tower of Babel.'

until more systematic direction and prosecution of the work come about. Investigators in pure chemistry as a rule hold professorships, or other positions making equal demand upon their time. Furthermore, it is extremely rare that one man can become a master of the various delicate operations hinted at. Mallet* made a proposition for systematizing atomic weight work and F. W. Clarke in this country† and abroad‡ has urged the establishment of an institute for its prosecution. This appeals to all interested in what we are pleased to term the exact sciences, and doubtless in time will come about. For the time being, however, it is not unreasonable to suppose that a concerted appeal of the chemists of this country to the direction of the munificent endowment recently made American science for funds to clarify the elemental enigma presented above would not be in vain. There are splendidly equipped chemical departments in some of our great American universities which would make room for, and cordially welcome, I am sure, a selected corps of supported researchers, who would test the claims of each of these and other elemental aspirants. Such a community of effort should receive even greater substantial assistance from governments and corporations than has been accorded individuals. I need only refer to the aid given the Curies by the Austrian government, and generosity shown by the Welsbach Lighting Company in this country to several investigators, especially myself.

It must be evident to all that we are not indulging in special pleading, for every phase of that division of science designated chemistry rests upon what we choose to term the elements.

* Stas memorial lecture, Chemical Society (London), delivered December 13, 1892.

† Presidential address before the American Chemical Society.

‡ Wilde lecture at the Dalton Centenary, Manchester, 1903.

Victor Meyer,* referring to the phantasies of science, said: "He, however, who only knows chemistry as a tradition of perfectly clear facts, or who thinks to see the real soul of chemical study in measuring physical phenomena which accompany chemical transformations, feels no breath of this enjoyment." Reflecting upon the good and ill that have come to us through unrestrained imagination, we may give a careful acceptance of Newton's 'Physics, beware of metaphysics' for as Clifford wrote, 'Doubtless there shall by and by be laws as far transcending those we know as they do the simplest observations.'

The graphic representation of the elements, 'the foundation stones of the material universe which amid the wreck of composite matter remained unbroken and unworn,' as Maxwell gracefully spoke of them, has often been mistaken for the periodic law. Carnelley's 'reasonable explanations' of the periodic law were given a respectful hearing and forgotten.†

"Granting that the chemical characteristics of an element are connected with its atomic weight, we have, however, no right to assume them to be dependent upon that fact alone" (Liveing). Hinrichs says weight and form,‡ concerning the latter of which I am ignorant. No doubt the pendulum lately has swung back toward Berzelian thought revivified by the like masters, van't Hoff and Arrhenius.

Le Verier predicted the planet Neptune

* Lecture on 'The Chemical Problems of To-day' before the Association of German Naturalists and Physicians at Heidelberg, September, 1889; *Chemical News*, 61, 21.

† He regarded the elements as compounds of carbon and ether analogous to the hydrocarbon radicals, and suggested that all known bodies are made up of three primary elements—carbon, hydrogen and ether—truly an assumption which can not be disproved. Aberdeen meeting, British Association.

‡ 'Atom Mechanics,' Hinrichs, Vol. I., St. Louis, 1894, p. 242.

and his predictions were verified. While all of Mendelejeff's predictions, specific and tacit, have not been verified, some have. Ramsay* and others, without a periodic guide, predicted certain of the inert gases, which predictions have been verified.

Victor Meyer, in speaking of the completion of the Mendelejeff table, calls attention to the summing up of one hundred elements, from which it appears that 258 would be the limit to our atomic mass equivalents. I am not prepared positively to contradict such a conclusion at the present time, but there are reasons for thinking otherwise.

Clarke† has shown that the mean density of the earth, 5.5 to 5.6, is more than double that of the rocky crust, and 'the difference may be accounted for as a result of pressure, or by supposing that, as the globe cooled, the heavier elements accumulated towards the center.' While it is quite impossible to judge of the order of this intramundane pressure, I am not aware of such marked changes being brought about in the specific gravities of the heavier solid elements of their compounds, either by pressure, allotropic or isomeric changes, except the cerebral argentaurum of the late S. H. Emmens.‡ The examinations of volcanic dusts by Hartley,§ Fleet|| and others appear to contradict the latter explanation, although we are unable to state the depth, perhaps within the shell considered by Clarke, at which volcanoes begin their boisterous activity. While awaiting a fulfillment of Martinez's* project to explore the earth's center, we may offer a third solution, not wholly unscientific, as it can do no harm, and has nought to do with any yellow peril in science, namely, the existence of elements with atomic weights higher than those set by the silent limit of periodic tables.

"Most molecules — probably all — are wrecked by intense heat, or, in other words, by intense vibratory motion, and many are wrecked by a very impure heat of the proper quality. Indeed, a weak force, which bears a considerable relation to the construction of the molecule, can by timely savings and accumulation accomplish what a strong force out of relation fails to achieve."†

As hinted at in the earlier portion of this unduly prolonged address, many have theorized as to the ultimate composition of matter. The logic of Larmor's‡ theory, involving the idea of an ionic substratum of matter, the support of J. J. Thomson's§ experiments, the confirmation of Zeeman's phenomenon, the emanations of Rutherford, Martin's|| explanations, can not fail to cause credence in the correctness of Crookes's idea of a fourth state of matter.¶ In the inaugural address as president of the British Association (1898), he acknowledges in the mechanical construction of the Roentgen ray tubes a suggestion by Silvanus Thompson to use for the anticathode a metal of high atomic weight. Osmium and iridium were used, thorium tried, and in 1896 Crookes obtained better results with metallic uranium than platinum.

These and the facts that most of the elements with high atomic weights, in fact

* Address before the Chemical Section, British Association, Toronto meeting (1898).

† 'The Relative Abundance of the Chemical Elements,' F. W. Clarke, read before the Philosophical Society of Washington, October 26, 1899; *Chem. News*, 62, 31.

‡ Argentaurum papers published by Emmens, New York.

§ Royal Society, February 21, 1901; *Chem. News*, 83, 174.

|| Abstr. *Proc. Geol. Soc.*, 1902, 117; *Journ. Chem. Soc.* (Land), 81–82, ii., 518, 1902.

* 'La Nature,' *Sc. Am. Sup.*, 21, 546, 1886.

† Tyndall in *Longman's Magazine.*

‡ *Phil. Mag.*, December, 1897, 506.

§ *Phil. Mag.*, October, 1897, 312.

|| *Chem. News*, 85, 205, 1902.

¶ *Phil. Trans.*, II., 1881, 433.

all above 200 (thallium not reported on),* exhibit radio-active properties, are doubtless closely associated and have to do with the eventual composition of matter. I have unverified observations which go to show the existence of at least one element with a very high atomic weight. If it be confirmed, then we have them now or they are making, and probably breaking up, as shown by that marvelous class of elements in the discovery of which the Curies have been pioneers.

If our ideas that all known elements come from some primordial material be true, then it stands to reason that we are coming in time, perhaps, to that fixed thing, a frozen ether, the fifth state of matter. I may make use of dangerous analogy and liken our known elements, arranged in a perfected natural system, to the visible material spectrum, while electrons, etc., constitute the ultra-violet and *cosmyle* composes the infra-red, either one of the latter by proper conditions being convertible into perceptible elemental matter. No positive evidence supports these ideas, but I like to fancy scientific endeavor as the sea—calm and serene, supporting and mirroring that which is below it, bearing that which is upon it, reaching to and reflecting that which is above it, moving all the while; yet, torn and rent at times by conflict from without and contest within, it runs; it beats against the shores of the unknown, making rapid progress here, meeting stubborn resistance there, compassing it, to destroy but to rebuild elsewhere; and the existence of those within it! 'Like that of Paul, our life should be a consecrated unrest.'

CHARLES BASKERVILLE.

* See the exquisite paper by Madame Curie on 'Radioactive Substances,' also 'Radio-active Lead,' Hofmann and Strauss, *Berichte*, 34, 3033, Pellini (*loc. cit.*) on 'Radio-active Tellurium'; Strutt, *Phil. Mag.*, 6, 113, Elster and Geitel, Giesel, Marckwald, etc., etc.

MEETINGS OF AFFILIATED SCIENTIFIC SOCIETIES AT PHILADELPHIA.

THE Association of American Anatomists, the Society of American Bacteriologists, the Society for Plant Morphology and Physiology, the American Physiological Society, the American Society of Zoologists (Eastern Branch), the American Society of Vertebrate Paleontologists, met in Philadelphia, Pa., December 28–31, 1903. All of these societies except the last, which was organized only one year ago, have heretofore been affiliated with the American Society of Naturalists, and, with the exception of the annual discussion and dinner which the Society of Naturalists holds, the meetings this year were wholly similar to those which have been held by these societies during the past ten or twelve years.

On Monday evening there were informal meetings of the members of the various societies. The Society for Plant Morphology and Physiology was given a reception at Biological Hall, University of Pennsylvania; the American Physiological Society held a smoker at the Hotel Walton, while the other societies held smokers at the 'Rathskellar.'

Tuesday morning and afternoon, sessions of all the societies were held at the University of Pennsylvania, and all the societies except the physiologists held morning and afternoon sessions there on Wednesday also. The Physiological Society met on Wednesday at Jefferson Medical College. Luncheon was served by the University of Pennsylvania to all the societies on Tuesday and to all except the physiologists on Wednesday; on this day the latter society was entertained at luncheon at the Philadelphia Club.

Tuesday evening all the societies were the guests of the local committee at a smoker at the University Club.

Wednesday evening a lecture was given