Society of Colonial Wars in the
Commonwealth of Pennsylvania

Address

by

Dr. Persifor Frazer

"Some Wars in Science"

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IN the history of the world there has never been so great a change in the customs and thought of men as about the epoch which has been set as the latest at which our ancestors are permitted to have distinguished themselves sufficiently to qualify their descendants for membership in this Society; and I have thought it might be interesting to consider some of the motives, methods, opinions, customs, and equipment of our forefathers, and to compare them with our own.

It will be granted that among the arts whose fundamental principles have been least revolutionized since the middle of the Eighteenth Century, is War—that genteel accomplishment which our Association consecrates, and in which success is the universally honored passport to wealth, fame, and exclusive society. No improvements in arms or tactics will ever make men fight more bravely than Marlborough's army at Blenheim, yet we have excellent authority for the belief that not one in ten of his English contingent had the slightest idea of the object of the war, not to mention the still more difficult problem of Marlborough's real sympathies. But while it may be conceded that time cannot break that or many earlier records for bravery and audacious generalship in a regular army, yet the resources of militia armies and their knowledge of the game of war have been greatly increased since the first siege of Louisburg in 1745, which is our partic-

This feat is more remarkable than the capture of the Bastille.

But a far better instance of the change referred to, as well as one more in the line of my work, is that which has been produced in our notions of chemistry and physics.

In presuming to bring before an audience of this kind questions of science of the profoundest import, I wish to say that I have done so just because they are of that character. The wider and deeper a problem, the greater number of men it must interest, and those problems with which I intend to deal are so wide and deep that they have interested, and do interest, all persons of every profession and calling.

The universal interest of mankind in every important new discovery affords the surest ground for belief in a constantly rising standard of education. Terence's "*Homo sum et nil humane a me alienum puto*" (I am a man, and nothing that concerns man do I deem a matter of indifference to me), is consciously or unconsciously a guiding maxim with all cultivated people.

And again it is self-evident that no other kinds of questions than those reaching into the substratum of man's reasoning faculty, and through the top dressing of his more or less vaguely conceived beliefs, prejudices, assumptions and creeds, can arouse sufficient interest to occasion wars, which are my theme.

Furthermore, I must explain that in the limited time allotted to me I must treat these wars as the dramatists do, by leaving the battles to be imagined. It would be amusing, certainly, to recall the words in which some venerated sage of the past has ridiculed propositions, then new, which have since been so incorporated into the very essence of our fundamental conceptions that it requires an effort to consider the objector as sane, not to speak of his being on other subjects a leader of thought of his time. The progress of truth towards acceptance is like that of the Rugby football towards the goal posts. No matter in what direction its advance, there will be found a strong force opposing its carrier, and not without bruises and strains will he make his touch-down.

So the denunciations, and sarcasms and disparagements; the heart burns, and animosities which make up intellectual warfare have been suppressed in favor of a short sketch of the forward movement of the ideas which were the *casus belli.* But let it not be imagined these battles were wanting. Homes have been disrupted through disputes on the relative merits of the Ptolemean and Copernican Astronomy; Aristotelian and Baconian philosophy; Huttonian and Wernerian Geology; Newtonian and Leibnitzian mathematics; Humean and Berkeleyan metaphysics, etc., etc. And similar battles will never cease so long as man continues to believe that he is better than his neighbor, or that any one man, thing, or principle contains all the good or all the bad.

The earlier chemists regarded combustion as the essential phenomenon of chemistry, both because heat produced such profound changes in many bodies, and the majority of changes were accompanied by heat, and also because when the ingenious phlogistic theory was conceived by Becher (1635–'82) and perfected by Stahl (1660–1734) a number of remotely related phenomena, like that of solubility, came to be recognized as dependent upon the phlogiston which a body contained.

Stahl in his " Fundamenta Chymiae," published in 1720, while he was Leibartzt to the King of Prussia, defines chemistry as the *art* of resolving compounds into their constituents and recombining the constituents to again form the original or other compounds. All combustible bodies according to him (*i. e.*, sulphur, carbon, phosphorus, alcohol, sugar, resin, the oils, etc.), were compounds containing phlogiston (meaning " burnt ") combined with some other material; and the grade of combustibility depended upon the amount of phlogiston combined in a body. The metals contained this constituent in varying quantity, and when subjected to heat became " calxes," which were often soluble in water, whereas the more combustible the substance (sulphur, phosphorus, carbon, etc.) the less soluble it was. It was thought that this theory was proven because if phlogiston or any substance containing it were heated with the calx, the original substance reappeared. The pertinent question, "Why is the weight of the dephlogisticated substance increased, and the compound with phlogiston *lighter* than the essential calx ?" was answered by the assertion that the phlogiston possessed the attribute of *levity* instead of gravity.

This so-called theory (merely an ingenious hypothesis) of chemical action is an instructive lesson as to several things. In the first place, considered together with the theory which displaced it, illustrates how two diametrically opposite suppositions, when pursued each on a single line without checks from any other line, may equally well explain a given phenomenon. It illustrates also the radical difference between the knowledge obtained through inductive processes and that alleged to have come from revelation. The former never pretends to be fixed and unalterable, or the whole truth of the subject. How could it when from the very nature of its acquirement only a limited number of facts can have been employed, and every day adds to the number which must be consistent with each other and with the theory ? If they be not consistent with each other there has been an error of observation, which must be found and corrected. If any single fact be not assimilable by the theory, the latter must be abandoned in favor of some better. When you read in the papers that "scientific men claim that this is or that cannot be so," be assured that you are reading the unauthorized statement of an ignoramus or a wilful perverter of the truth. Scientific men never assert or deny in this manner.*

* For example : the Rev. Dionysius Lardner, LL.D., F.R.S., in a book entitled "The Steam Engine Familiarly Explained" (Carey & Hart, Phila., 1841) said that the steamboat of that time could not, in his judgment, carry coal for a journey of more than 2,000 miles, but added "we are on the brink of such improvements as will" * * "render it available as a means of connecting the most distant parts of the earth." This guarded skepticism has been the delight of the

The character of Professor Stork in Mallock's "New Republic" is an absurd caricature, and bears no sort of resemblance to John Tyndall, who is said to have been its prototype.

When ingenious guesses based like that of the phlogistic theory on insufficient data are dressed up in Sanford and Merton style they become pathetic. Here is a fragment of a little book printed in 1806 by Jane Marcet, an admirer of Sir Humphry Davy, who had attended his lectures at the Royal Institution. It gives part of a supposed conversation between Mrs. B., a teacher, and two young ladies, Emily and Caroline.

* * * * * * * * *

"Emily.—How do you obtain the oxy-muriatic acid?" (Chlorine.)

"Mrs. B.—In various ways; but it may be most conveniently obtained by distilling liquid muriatic acid over oxyd of manganese, which supplies *the acid with the additional oxygen.* One part of the acid being put into a retort, with two parts of the oxyd of manganese, and the heat of a lamp applied, the gas is soon disengaged, and may be received over water, as it is but sparingly absorbed by it. I have collected some in this jar."

"Caroline.—It is not invisible like the generality of gases; for it is of a yellowish color."

"Mrs. B.—The muriatic acid extinguishes flame, whilst, on the contrary, the oxy-muriatic makes the flame larger, and gives it a dark red color. Can you account for this difference in the two acids?"

"Emily.—Yes, I think so; the muriatic acid will not supply the flame with the oxygen necessary for its support; but *when this acid is*

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enemies of science. It was misquoted by the New York *Herald* originally to read as a prophecy against transatlantic navigation by steam. After numerous refutations the St. Louis *Republic* sixty years later stated "a great mathematician" had just deduced the impossibility of the transit when the first steamer glided into port. Finally the Hon. Carroll D. Wright, now President of the American Association for the Advancement of Science, while Vice-President of that body and chairman of Section I at the Washington meeting, December, 1902, declared that "a distinguished physicist" made this discouraging prophecy during a lecture in Philadelphia on the very evening of the arrival of the first steamer from Liverpool. In answer to an inquiry by the writer he said he had heard this story related at a meeting by an eminent clergyman, now deceased, and though the name of the "distinguished physicist" was not given, Professor Wright thought the fact was generally accepted. P. F.

further oxygenated, it will part with its additional quantity of oxygen and in this way support combustion."

"Mrs. B.—*This is exactly the case;* indeed, the oxygen added to the muriatic acid adheres so slightly to it that it is separated by mere exposure to the sun's rays." (?) "This acid is decomposed also by combustible bodies, many of which it burns, and actually inflames, without any previous increase of temperature."

"Caroline.—That is extraordinary, indeed. I hope you mean to indulge us with some of these experiments ?"

"Mrs. B.—I have prepared several glass jars of oxy-muriatic acid gas for that purpose. In the first we shall introduce some Dutch gold leaf. Do you observe that it takes fire ?" etc., etc.

It is hardly necessary to say that this supposed compound, "oxy-muriatic acid," about which they are talking is the element chlorine, or to point out the humor of presenting these gross errors as if they were incontestably proven and easy to explain in child-like language.

With Lavoisier's masterly destruction of the phlogistic theory, to which he devoted half of the work and publications of his busy scientific life, the science of chemistry began, and it is one of Fate's ironies that he obtained the two facts which completed its overthrow (*i. e.*, the nature of oxygen as a constituent of the air, and the nature of the product of the union of oxygen with hydrogen), from two eminent scientific Englishmen, Priestley and Cavendish, who to the last days of their lives clung to Stahl's theory as a fact long after it had ceased to be more than a memory. Priestley himself says in another connection: "We may take a maxim so strongly for granted that the plainest evidence of sense will not entirely change and often hardly modify our persuasions, and the more ingenious a man is the more effectually he is entangled in his errors; his ingenuity only helping him to deceive himself by evading the force of truth."

Modern real chemistry [*i. e.*, the study of matter in its minutest subdivisions, force being merely incidentally considered, and only so far as it changes the character (properties) of matter] dates from Lavoisier's demonstrations, and the greatest generalization thought to be established by his experiments was that *the sum of matter in the universe was fixed and constant and could neither be augmented nor diminished* by so much as the millionth of a milligram, however great the changes of portions of matter in appearance or character might seem to be.

This war in chemistry may be likened to a war of independence, by which the science blossomed into a sovereign science on equal terms with her older sisters ; but, true to the analogy with civil states, she was shortly to be subjected to an internecine war of more than fifty years' duration ; and just as Europe was desolated by the thirty years war, during which the greater industries were paralyzed, material advance of civilization was checked, and doubt and distrust dried up the very fountains of confidence which are necessary for civic life ; so here, too, during that period, in this promising new science, observers hastened to attach to their discoveries the assurance that they intended no inferences to be drawn as to ultimate or absolute condition of things. It would burden you too much to recite the technical details of this civil war in chemistry, and I must restrict myself to general statements.

J. J. Berzelius, who was the first to establish accurate atomic weights,—so accurate, indeed, that in spite of his imperfect apparatus and methods, his determinations can be corrected to-day only in decimals,—propounded in 1812 the electro-chemical theory, which led to his dualistic system. He explained chemical action as an electric phenomenon, essentially consisting in the attraction of one body by another with a stronger electric polarity. He says : " If these electro-chemical conceptions are just, it follows that every chemical compound is dependent on two opposing forces, positive and negative electricity, and on these alone ; and that every compound must be composed of two parts, held together by their neutral electro-chemical reactions," etc. Every compound consisted of two parts, one electro-positive and the other electro-negative. Thus, sodium sulphide consisted of positive sodium united with negative sulphur; soda sulphate, of positive soda with negative sulphuric acid; alum, of positive soda sulphate and negative alumina sulphate, etc.

On account of Berzelius' high merit all his results and theories were accepted without question by the world of chemists. If any man ever deserved this tribute it was Berzelius, but no man ever did deserve it, and this blind devotion led to an equally blind abandonment of all the fruits of his well-earned victories just because in one particular place his splendid theoretical structure overhung the building line prescribed by nature for all theorists.

And this is how it happened. Secure in his dualistic electrical hypothesis, which explained all the facts then known to him, he applied it to the organic compounds, regarding in these a group of atoms of different elements combined with carbon and nitrogen, as a radicle, and the equivalent of an atom of an element. He maintained that every combination between two such radicles was dualistic; having an electro-positive and an electro-negative part, and if in any new compound, obtained by substitution of one of these radicles by some other radicle or atom of an element, the general properties of the first compound were not entirely changed, the replacing radicle or atom must be of the same kind electrically as the radicle or atom displaced, *i. e.*, a positive must be replaced by a positive, and *vice versa*. But in 1839 the French chemist Dumas prepared chloracetic acid from acetic acid by substituting chlorine, one of the most strongly electro-negative of all elements, for hydrogen, a typical electro-positive element. Yet the properties of the two acids were closely alike. No answer was possible except that dualism did not represent the facts in all cases. This, and the discovery that some of the atomic weights given by Berzelius were just twice what they should be,* spread alarm among

* The chemist will understand that this fact is not inconsistent with the statement above of the great accuracy of his atomic weight determinations, but was the result of mistaking the valence, or monad atom saturating power of these elements, an error unavoidable with the knowledge available at that time. P. F.

even his warmest supporters. His own attempts to evade the conclusions only made matters worse, and the effect upon chemists was that which would be produced on financiers by the reported insolvency of the Bank of England. The failure of Berzelius shut up the current coin of generalizations all over the world. Gmelin published his colossal dictionary of chemistry, using the word "equivalents" instead of atoms, and this fashion of over-prudence having been set by Gay-Lussac, Liebig and Faraday, the whole chemical world for more than fifty years avoided the word "atom" as if it were high treason. Yet Berzelius was in all important parts of his philosophy right, and only erred in giving slightly less elasticity to one part of his theory than he should have done.

And the newest views of chemical change sweep away those of both Berzelius and his critics as only part of the truth!

Upon the establishment of chemistry as the science of matter, physics became the study of force in the abstract, or as exerted on indefinitely small masses of matter without changing their properties; or on a medium more tenuous than matter, namely, the ether. Both chemistry and physics maintained, each, a proud, progressive, and independent existence for nearly a century; the one as a study of matter on a background of force, the other as a study of force on a background of the minutest subdivisions of matter and of ether; at the end of which time—the present—the two have again so completely coalesced that it is impossible to trace a fixed boundary between them. This is not saying that the two sciences are the same any more than the science of zoölogy and botany are the same, yet, concerning these latter just as no competent man would be bold enough to profess to fix a dividing line between animals and plants, so no competent man would profess to divide physical from chemical phenomena.

Both physics and chemistry have added hundreds of times the number of exact data to the stores which each possessed in 1750. Chemistry shook off magic which withered into child's play. Physics differentiated itself from mechanics as poetry from statistics, and the changes in the modern conceptions of that science from those held by the most enlightened of the periwigged ancestors to whom we owe our eligibility to membership in this honorable association of the descendants of aristocratic exile head-breakers, are no less striking than we have seen those in chemistry to be.

If combustion be considered the essential phenomenon of chemistry, heat, which is its principal result, may be said to be the essential phenomenon, the monetary basis, as it were, of physics. In a paper published in the Royal Transactions of 1798 Count Rumford (our own countryman, born Benjamin Thompson in Woburn, Mass.) first announced to the world the startling discovery that heat was not a caloric fluid. While superintending work at the Munich Arsenal he endeavored to learn the cause of the heat accompanying friction. His summary of the results is remarkable for its close reasoning and for the word with which it ends, which is the key to modern physics and chemistry; and in fact *at least* to all of the universe which is not thought, and many of the ablest philosophers think to that also. Alluding to the fact that the inexhaustible supply of heat, which was procurable from the continuous friction of two metallic surfaces, was incompatible with the theory which supposed every body to have stored in it a definite quantity of heat he goes on * * * "It is hardly necessary to add that anything which any *insulated* body or system of bodies can continue to furnish *without limitation* cannot possibly be a *material substance;* and it appears to me to be extremely difficult, if not quite impossible, to form any distinct idea of anything capable of being excited and communicated in those experiments except it be MOTION." Sequin of France, Grove and Joule of England, Mayer of Germany, and Colding of Denmark, announced the general doctrine of the intimate relation to each other of the various forces. Helmholtz, Holtzman, Clausius, Faraday, Thompson, Rankine, Tyndall, and Carpenter in Europe, and Henry and Leconte in this country, aided the progress of the generalization which culminated in the joint publication of works by Grove, Helmholtz, Mayer, Faraday, Liebig, and Carpenter in 1865 called the " Correlation and Conservation of Forces." This work produced an immense sensation at the time and was said, like several other works : (La Place's " Mécanique Celeste," Darwin's " Origin of Species," Dalton's law of chemical equivalents, etc.), each in its day, to be the most important deliverance of science in the century.

From the title it may be at once seen that the result claimed by these invaluable treatises was entirely analogous to that of the indestructibility of matter deduced from Lavoisier's experiments. It concluded the indestructibility of force in spite of constant change of character. The result reached was that no force could ever be destroyed or affected in any other way than by a translation into another kind of force.

As a result then of the independent development of chemistry and physics each reached the conclusion that its own subject of investigation was eternal, fixed, and definite ; the two subjects being matter and force.

The Nineteenth Century boasted of having established this. We shall see how the young Twentieth Century has respected this claim.

The inventor of the binomial theory, and of fluxions, the discoverer of the universal law of gravitation, and of the composite character of white light, in short, the peerless Sir Isaac Newton, announced the corpuscular theory of the origin of light and rejected that of Christian Huyghens, improperly ascribed to Descartes, which explained light as a series of vibrations or undulations in a tenuous ethereal medium. The war between these two theories lasted nearly a century. Sir John Herschel, Mr. Airy, Dr. Young and others sided with the Hollander, as did Sir David Brewster in his article " Newton " in the Penny Cyclopaedia for 1843, but the author of the learned article on the " Undulatory

Theory of Light," of that same edition and publication, after intimating that there were some phenomena difficult of explanation by the undulatory, which were easily comprehended by the aid of the corpuscular assumption, and other phenomena perhaps impossible of explanation by the latter which were readily accounted for by the former, finally sums up the subject thus: "Much stress is laid on the accuracy with which the phenomena of diffraction are accounted for on the undulatory hypothesis; but while there yet remains unexplained by that hypothesis so important a circumstance as the refrangibilities of light, which are satisfactorily accounted for on the corpuscular theory, and while our knowledge of the action of material particles on one another as well as the propagation of motion through elastic media is so imperfect, philosophers seem to be fully justified in suspending their judgment concerning the relative merits of the two rival theories."

This was written sixty years ago, and at any time from thirty to three years ago it would have provoked a smile from the students of physics in the lower classes of a High School. How many such would have thought it a proof that even a genius of all time like Sir Isaac may err once in a while. The omniscient class of *didaskoloi* was busily engaged in hammering the doctrine into its scholars, as if it were the easy and natural consequence of the reasoning of a child—quite in the Jane Marcet style—that neither sight nor hearing can be produced by emanations or flying particles, but by w a v e s ; sight resulting from waves in e t h e r transverse to the direction of the light impulse, and resembling the ripples in water; while sound is caused by longitudinal waves of compression and dilation in a i r back and forth along the line of direction of the sound impulse.

It must have seemed strange to their pupils that Sir Isaac had been taken in by an appearance so easily comprehended by such an enormous number of very commonplace purveyors of knowledge.

The following is a very condensed digest (with a few interpolations) of Sir William Crookes' great paper on " Modern Views of Matter " before the Congress of Applied Chemistry at Berlin, June 5, 1903. (Reprinted in "Science," June 26, 1903.)

Sir Humphry Davy said in 1809 : " If particles of gases were made to move in free space with an almost infinitely great velocity they might produce the different species of rays so distinguished by their peculiar effects." Faraday (1816) said : " To decompose metals, to re-form them, and to realize the once absurd notion of transmutation, are the problems now given the chemist for solution." Prof. W. K. Clifford (1875) remarked : " There is great reason to believe that every material atom carries upon it a small electric current *if it does not entirely consist of this current.*" Crookes (1879) observed : " The particles constituting the cathode stream at high exhaustions of the vacuum tube are not solid, nor liquid, nor gaseous " * * * " but consist of something much smaller than the atom " * * * "the foundation stones of which atoms are composed." And these phenomena are obtainable of all matter thus treated.

In 1886 Crookes announced his grand hypothesis of the genesis of the elements out of a formless fire-mist (protyle) more tenuous than any form of matter or perhaps even than ether, by the working of three forms of energy, electricity, chemism, and heat ; the result being an evolution analogous to that announced by Darwin through the survival of the most stable.

Those elements of least atomic weight were first formed (Hydrogen 1, Helium 4.26, Lithium 7, Beryllium 9, etc.), and those of highest atomic weight last (Platinum 195, Gold 197.3, Mercury 200, etc.). Of the latter then known the highest were Thorium with an atomic weight of 232.6, and Uranium with an atomic weight of 239.6. " What comes after Uranium ? " Crookes asked, and answered " the formation of compounds capable of being dissociated by our terrestrial resources of heat." In 1888 he suggested that the elementary atoms themselves might not be now the same as when first generated, *i. e.*, that the primary motions which constitute the existence of the atom might slowly be changing, and even the secondary motions which produce all the effects we can observe, heat, chemic, electric, etc., might be affected. Even the atoms are not eternal but share with all else decay and death. The atomic weights were not invariable quantities. In 1891 he proved that the stream of cathode rays near the negative pole are always negatively electrified, the other contents of the tube being positively electrified.

Lenard and Roentgen (1893–'95) showed the phenomena outside the vacuum tube more remarkable than those inside, in producing phosphorescence, penetrating opaque substances, etc. Zeeman (1896) showed that a spectrum line was caused by the motion of an elektron. Dewar found relative opacity to the Roentgen ray proportional to the atomic weights of bodies. Becquerel showed that salts of uranium give emanations which penetrate opaque substances, and affect a photographic plate in total darkness.

Mme. and M. Curie and Bémont demonstrated the existence of radio-active bodies which accompany the compounds of uranium; and all these isolated facts were welded together by the discovery of RADIUM with its atomic weight of about 258. According to Crookes' prophecy the segregations of protyle of greater atomic weight than uranium would dissociate, and this was about to be more than realized by the discoveries that thorium and uranium had already been doing this unknown to their investigators, and the new element radium was preëminent in this property.

Radium causes soda glass to turn violet. It acts strongly on the skin through leather, paper and clothing, causing severe pains; and pours out quantities of emanations. These emanations are of several kinds, and produce a separate kind, as follows:

I. **Elektrons.** 1. Move with a velocity of $\frac{1}{10}$ to $\frac{2}{3}$ that of light. 2. Deviable in a magnetic field. 3. Gradually obstructed by collisions with air atoms to which they impart conducting powers. 4. They turn corners. 5. They can be concentrated by mica cones into a bundle, and these produce phosphorescence. 6. An elektron is about $\frac{1}{700}$ the mass of an atom of hydrogen, or one 30,000000,000000,000000,-0000000th gram. 7. Elektrons will affect a photographic plate through 5 or 6 mm. of lead, and several inches of wood or aluminium. 8. They make a photograph of a closed case of instruments in three days.

II. **Ions.** 1. Emanations 1000 times the energy of elektrons, and of enormous mass, moving with something like the velocity of light. 2. They are slightly deviable in the magnetic field, and their deviation is of the contrary kind from that of the elektrons. 3. They render air a conductor. 4. They are obstructed by the thinnest plate. 5. They are material particles, indefinitely smaller than the chemical atoms, dissociated from their elektrons with which when combined they form radium, polonium, actinium, uranium, etc.

III. An emanation recently discovered and only announced night before last (November 25, 1903) by Sir William Ramsey at a meeting of the London Institution. The discovery was printed for the first time in the telegraphic news of this morning's newspapers (Nov. 27 . It is a heavy gas which, at first exhibiting all the spectroscopic peculiarities of radium, slowly changes before the eyes of the observer (as it were) to a body identical with the element helium discovered in the atmosphere of the sun. A month's confinement in a glass vessel suffices for this complete change.

IV. **Roentgen (X) rays.** 1. These are ether waves produced by the collision of elektrons and ions with air atoms. 2. They are not at all deviable in the magnetic field. 3. They are much more penetrating than the elektrons. 4. A photograph of a closed case of instruments can be taken by them in three minutes.

One result of the study of radium's properties is to cause the abandonment of the two-fluid theory of electricity in favor of the one-fluid theory of Franklin, which gives the coup de grâce to Berzelius' dualism. The elektron is the atom of electricity. At the rate the elektrons and ions are being constantly projected outward from radio-active metals Rutherford and Scuddy estimate that one gram of uranium or thorium would lose one milligram in weight in 1,000,000 years. Radium, however, loses 1 milligram per gram in a year; therefore, the life of radium cannot be more than one, or, allowing liberally for errors of observation, a few thousand years; and consequently the radium in some minerals cannot have existed as long as the minerals themselves, but must have been and must still be continually produced by radio-active change, and must be continually changing into other elements and into—force.

This continuous pouring out of emanations is not affected by a temperature of 450° C. maintained for several days, nor destroyed by immersion in liquid air (—190°). Here is a continuous stream of emanations being given out, and, according to Count Rumford's reasoning, the emanations cannot be matter. But if not matter they are not transverse waves or ripples in ether, but they are the dislocated parts of which matter is composed; and the splendid generalization of the indestructibility of matter crumbles.

The elektron appears as apparent mass, according to Crookes, by reason of its electrodynamic properties. He adds: "If we consider all forces of matter to be merely congeries of elektrons the inertia of matter" (its distinguishing attribute) "*would be explained without any material basis.*" What then becomes of the great fundamental law of chemistry, said to have been established by Lavoisier, that the total amount of matter in the universe is fixed and constant, when, in point of fact, matter may be simply composed of "atoms" of electricity or force? But whether or not there is *any* matter independent of electricity (or force) the dissociation emanations of radium transform it, at least *partly*, into another element and partly into force.

It was Lord Kelvin (Sir William Thomson) who originally gave authority to Descartes' vortices by supposing each original vortex when set up to continue unchanged and unchangeable forever; and to constitute the smallest unit of matter—the atom—which, combined with other similar vortices, produced all bodies which we know. He was said to have abandoned this view at the time when other chemist-physicists adopted it, but whether so or not this view is held by a numerous and increasing school.

Prof. Larmor regards electricity as atomic in its nature, each atom being a centre of strain in the ether; matter being clusters of those electrical positive and negative atoms or elektrons in orbital motion around each other.

Prof. Osborne Reynolds' view is unique (Rede Lecture June 10, 1902, "On an inversion of ideas as to the structure of the universe"). For ether he supposes a granular medium closely packed, with a density ten thousand times that of water. Here and there a grain is out of place producing a strain. The sum of such occurrences he calls "singular surfaces of misfit" which are wave-like. What we call "matter" are places where the medium which takes the place of ether is *least* dense. So that the heavier the body the less is the mass of this medium which it contains; which completely reverses our notions of things. Where nothing at all existed the result to our senses would be apparently indefinitely heavy matter, according to this view.

At the present state of the war about the elements the pioneer minds to-day are seriously considering the theory that matter is naught but vortices, or ethereal vibrations of electrical energy.* A large number of the occurrences we

* It is worthy of note that in fields of research so separate as physics, chemistry, biology and metaphysics or philosophy, some of the ablest prosecutors of research are moving towards this conception of the oneness of matter and force, or, as a new worker (Ignatius Singer) calls all phenomena, persistence, resistance and equalization.

witness every day; the rubbing of glass with silk, sunshine, rain, lightning, flame, waterfalls, ocean waves, all provoke the dissociation of the atom; and, however slow the process may be, Sir William Crookes terminates his paper before the Berlin Congress by the speculation that in the end "protyle—the formless fire-mist—may once again prevail, and the hour hand of eternity will have completed one revolution."

In speaking of these uprootings of old theories which were thought to be as eternal as the conceptions of time and space, I have not alluded to the battle which followed Darwin's work, supplemented and confirmed by Huxley, Haeckel, and many others, through which the doctrine of special creations of plants and animals has been permanently abandoned and in its stead a chain of life has been shown, in Haeckel's recent book on the "Riddles of the Universe," to lead up from Crookes' protyle to the single organic cell, and from this by short and, in the main, traceable steps to "Homo sapiens" or man.

I have omitted this because the field chosen, the consideration of matter and force, embraces a wider—the widest possible—horizon, within which these other problems, perhaps including that of life itself, are mere features. But the preponderating tendency of scientific thought in the smaller as well as in the larger field, and in fact in all fields, is toward Monism. ONE THING, at once the cause and substance of all things material and not material; matter, force, and thought.

Were it not that the sublime word has been employed for so many and such conflicting ideas, there could be no philosophic objection to calling this All—GOD.