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Contents.

(Illustrated articles are marked with an asterisk.)

BERTHELOT'S NEW ELECTRO-CHEMICAL DISCOVERIES.

M. Berthelot, the distinguished French chemist, has lately brought before the French Academy of Sciences a series of remarkable experiments, which, in addition to affording other results, point to an important and brilliant discovery relative to the reactions which occur between the gaseous elements of the air and the organic compounds of the earth. The nature and effect of these reactions on vegetation constitute no small portion of the science of agricultural chemistry. And regarding the question of the source of the supply of nitrogen to plants, it is well known that none is more closely enlisting the attention of chemists who find, in the doubt encircling present accepted theories, the stimulus for further and deeper investigation.

We know that, for the support of vegetation, carbon, hydrogen, oxygen, and nitrogen are needed, and that the source of carbon is the carbonic acid which exists in the atmosphere in the proportion of $\frac{1}{2500}$ of its volume. Similarly, the water always present in the air supplies hydrogen and oxygen necessary. It is not so easy to trace whence the nitrogen is derived, and here opinions have fiercely conflicted. Previous to Liebig's time, it was supposed that organic matter (humus) supplied the chief nutriment of plants; but this the great German chemist denounced as "baseless and absurd;" and after detailing his own experimental researches and those of others, he affirms that nitrogen "is derived either from the air, whence it is conveyed to the earth in rain or dew, or from organic substances accumulated from a series of generations of dead or decayed plants, or else from animal remains contained in the earth or incorporated with it by man in the form of excrements. * * * The remains of extinct animal life, which are embedded to an enormous extent in sedimentary strata, or which of themselves constitute whole masses of rock, attest the extraordinary distribution of organic life in the former ages of the earth: and it is the nitrogenous constituents of these animal bodies, passing over into ammonia and nitric acid, which still play an important part in the economy of the vegetable and animal world." Such is the present theory. It is difficult to conceive of its more complete reversal than must follow the acceptance of the facts which M. Berthelot now places before us—facts which the clearest of subsequent investigation must substantiate before they will prevail over Liebig's conclusions—facts which lead to the assertion that free atmospheric nitrogen is fixed in organic nature, unchanged in form by atmospheric electricity.

It has long been known that the silent electric discharge is capable of producing special chemical reactions. In order to study these, M. Berthelot devised a simple little apparatus, composed, first, of a bell-mouthed test tube about which a ribbon of platinum was coiled; and second, a V tube of glass closed at one extremity. The test tube filled with the gas or liquid to be tested was inserted over a mercury bath, and the closed end of the V tube was inserted in it. One pole of a Ruhmkorff coil was attached to the platinum ribbon, the other communicated with a conducting liquid (acidulated water) in the V tube. The current then passed through the then annular space comprised between the vertical leg of the V tube and the inner periphery of the test tube, which space was of course filled with the material under examination. By this instrument he found that organic compounds, at ordinary temperatures, absorb free nitrogen, while under the influence of the current. In a few hours, 15·4 grains absorbed from 0·24 to 0·3 cubic inch of nitrogen, the greater part remaining unaltered; a solid resinous polymeric product was generated, which, on being heated, decomposed with evolution of ammonia. Turpentine and marsh gas acted similarly. Taking the constituent principle of vegetable tissues—in the shape of a piece of white filtering paper, which is none other than cellulose or ligneous principle—after having slightly wet it, he submitted it to the action of the current in presence of pure nitrogen. In eight or ten hours, a notable quantity of gas had been absorbed, and subsequently the nitrogen, combined with the paper, was extracted in the state of ammonia.

The presence of oxygen does not hinder the absorption of nitrogen. By causing the discharge to act on atmospheric air in contact with a sirupy solution of dextrin, M. Berthelot observed that a certain quantity of nitrogen and oxygen combined with the organic matter. Furthermore, hydrogen is absorbed in the same manner and even more rapidly than nitrogen; 0·06 cubic inch of benzine took up 15 cubic inches of hydrogen, or about 2 equivalents, and the result of the combination was a resinous substance analogous to a dried varnish, possessing a very strong and disagreeable odor.

The reaction produced by the silent discharge appears to be much greater than when the electric spark is used. With the current the proportion of ammoniac gas reaches about 0·03 in the normal mixture of nitrogen and hydrogen; with the spark, but a few hundred-thousandths. The decomposition of ammoniac gas by the current tends to the same limit. This identity of the two limits produced by the inverse action of the current is remarkable, and is as important to be noted as that of the diversity which exists between the action of the silent discharge and that of the spark. Protoxide and binoxide of nitrogen, sulphuretted and phosphuretted hydrogen, sulphurous acid, etc., are all more or less profoundly decomposed; and in brief, the action of the silent discharge, like that of the spark, tends to resolve compound gases into their elements, with the production of phenomena of equilibrium due to the inverse tendency of recombination. Only, in the case of the discharge, a portion of the isolated elements unites with the compound itself to form condensed products, to the formation of which, however, are opposed the longer duration of the spark, and especially the heating effect thereof.

"It is not doubtful," says M. Berthelot, turning to the practical results of his discovery, "that analogous phenomena (accompanied by an absorption of oxygen) manifest themselves during storms, and even when the air is electrified or presents a different potential in its upper strata and in those exposed to the sun, which is, after all, its normal state. Under these conditions, the organic matters in contact with the air very probably absorb nitrogen and oxygen. This absorption may be revoked at the moment of lightning discharges, which correspond to the differences of tension analogous to and greater than those of the Ruhmkoff apparatus; and the same is likewise probable for weaker differences that are incessantly produced. Perhaps even this absorption of nitrogen and oxygen, joined to the molecular condensations and other chemical changes developed in the tissues under the influence of the electric discharge, causes corresponding physiological modifications which play a certain part in the singular ailments manifested in the human organism during storms."

Without stopping to dwell on these points, however, the discovery may be regarded, as we stated in the beginning, as showing a new cause for the fixing of atmospheric nitrogen in Nature. It engenders condensed nitric products, of the order of the humic principles so widely extended over the earth's surface; and however limited the effects may be, at each instant or at each point of the terrestrial superficies, they may evidently become considerable by reason of the extent and the continuity of the reaction universally and perpetually taking place.

IS THE UNIVERSE COMPOSED ENTIRELY OF HYDROGEN?

There are many eminent chemists, Professor Cooke among the number, who believe that, instead of there being 64 elements, there is but one. That this one universal element assumes more than 60 different forms (according to the velocity with which the atom moves), which constitute the molecules, or their arrangement, or number, is not more wonderful than the changes which some of our so-called elementary bodies suffer in their allotropic modifications. Sulphur, phosphorus, and carbon are, to a certain extent, protean; but they are distanced in the allotropic race by isomorphous hydrocarbons. Dr. Wurz defines organic chemistry as the chemistry of the hydrogen compounds, for he believes that it is protean hydrogen, with its ever-changing atomic volume that makes organic chemistry so complex. If we combine the two theories, that all matter is but various forms of one simple body, and that hydrogen is the most protean of our so-called elements, we have an affirmative answer to the query which forms the title of this article.

What force we shall employ to dissociate the elements and convert them into that primitive form, we are at a loss, as yet, to say; but the spectroscope leads us to think that heat, if sufficiently intense, may accomplish it. Lockyer, the great English spectroscopist, has recently been studying the spectrum of calcium, and says that when this metal is heated above a certain temperature the hydrogen line appears, as though, at that temperature, a partial dissociation took place. This fact alone is a feeble basis for the grand hypothesis that all things are hydrogen, and so too is the coincidence of the blue indium line with one of the hydrogen lines; but we shall wait for farther research, thankful that Professor Lockyer has directed our attention to that direction. The hottest known body is the sun, and about it play enormous lambient flames of hydrogen; and perhaps this unlimited supply of hydrogen is due to dissociation. Will spectroscopic astronomers tell us?

OCULAR COLOR SPECTRA AND THEIR CAUSATION.

It is a well known fact that by certain simple combinations of lines the eye can be so completely deceived as to make it altogether unreliable as a means of estimating distance and direction. Similarly, by certain grouping of masses of light and shade, the organ can be misled into recognizing apparently tangible and solid objects from mere pictorial representations. These deceptions, however, are independent of color. When that element is added a remarkable group of optical phenomena is engendered, by which the eye is led even more completely, and with less obvious reason, into error.

The reader will gain an idea of these appearances by the performance of a few simple experiments which we will indicate. On a black background, place a disk of white paper about the size of a half dollar piece. Gaze at the disk fixedly for a couple of minutes, then suddenly regard a blank white wall: when a dark spot, having the outline of the disk, will be beheld on the white surface. If a dark body on a white ground be first looked at, then, on lifting the eyes to the wall, a brilliant white figure of corresponding shape will appear, To these appearances the name negative spectra has been given; they may be considered, in fact, as genuine specters, ghosts, of the solid objects gazed on. Next, prepare from brilliantly colored paper, red, blue, yellow, and green circles. After gazing fixedly at the red circle and transferring the eyes to the wall, a green circle will appear thereon, the blue will cause a yellow specter, the yellow a blue one, the green a red, and so on, each color producing a specter of complementary hue. These are termed complementary color specter, and they may be produced in a variety of ways. Near sunset, the rays of the sun passing through an orange colored cloud cast blue shadows; the shadows of objects seen behind red curtains are green. If the sunlight be transmitted through colored glass so as to fall on white ground, the shadow of an object, placed so as to intercept the light, will have a shadow of the color complementary to that of the transmitting pane. And yet, if we look at the shadows so thrown through a tube, so as to shut

off all else from the eye, the shadow appears without color; or, if the same shadow falls on a black surface, no shadow appears.

The theory advanced by Dr. Thomas Young, and accepted by Helmholtz and others, to explain these phenomena, asserts the existence of different susceptibilities to color rays in different portions of the retina, or among the different optic nerve filaments. Color spectra and color shadows are all explained by partial or local fatigue of the retina under impressions of light; so that the part of the retina impressed by a particular color becomes, through fatigue, less sensitive to the same color, kind, or degree of light; and therefore an impression is, during the time of that fatigue, made upon our visual consciousness only by the opposite or complementary rays: these affecting those parts or elements of the retina which are fresh not having been wearied by use. We become, in short, color blind to certain hues, while our capacity for perceiving other colors remains vigorous.

This theory has recently been reviewed by Professor Henry Hartshorne, and the results of that author's investigations are opposed thereto, while they have led him to suggest a new hypothesis. The more prominent experiments of Professor Hartshorne are easily repeated. It is obvious that, for the retina to become fatigued, an appreciable length of time is necessary. To show that no interval of time elapses in which fatigue can occur, it is only necessary to make a few black lines on, for example, a piece of bright green paper. Cover these lines with a sheet of very thin writing paper, such as is used, on account of its light weight, for foreign correspondence. The black lines, seen through the thin paper, at once appear red, and appear so instantaneously on the placing of the covering sheet. Any other colored paper than green may be used; the colored lines will always show the complementary color. Professor Hartshorne goes on to show that the same instantaneous color is seen in color shadows. Another experiment which he describes consists in looking at sunlight through panes of colored glass, and then turning the eyes toward a white wall. In each case a strong complementary (so-called negative) color spectrum was seen; but on closing the eyes an almost equally intense positive spectrum, having the same color as the stained glass looked through, appeared. On opening the eyes the complementary spectrum returned; on closing them, the positive one, and so on for several times in succession. This seems obviously to be quite fatal to the supposition that retinal fatigue can account for any class of spectra such as has been considered; for if ordinary luminous impressions produce temporary fatigue and loss of sensibility, stronger impressions ought to produce still greater fatigue and greater loss of sensibility: whereas the reverse is the fact.

Professor Hartshorne's hypothesis is simply as follows: The eye becomes charged, saturated, with the particular colored light, and this, having a certain strength, is neutralized by the similar colored rays in light reflected from the white surface, so that only the complementary rays of that light affect the sight. The minute retinal nerve elements respond in vibration to the luminous ether waves of the color reflected to the eyes, and are excited to motion thereby; and by irradiation or communication of vibrations, all retinal elements which have the same period of vibration are made to partake in some degree of this movement. Then, when turning from the colored object, white light, consisting of all the color rays or waves together, impinges upon the eyes; those ether waves of the white light, which belong to the color first acting on the retinal nerve elements, interfere with and for the time relatively diminish or annul the special vibrations already produced in the retina; leaving the other waves of white light to take effect upon the retinal elements which respond to or "resonate" with them, so that the complementary color only is seen.

A NEW THEORY OF HAY FEVER.

Hay fever, rose cold, peach cold, hay asthma, or autumnal catarrh—the names being indifferently applied to the same malady—is a disease which has so long baffled medical skill that a deep-rooted popular notion has been engendered that it is incurable. Having the characteristics of a cold or asthma in some respects, it differs widely from them in others, and fails to succumb to timely remedies which, in the early stages of the ordinary catarrh or cold, induce perspiration and so break up the affection. As to the nature of the strange ailment, physicians have long disagreed; but up to the present time, the dominant theory has been that suggested by Helmholtz in 1869. The German physiologist stated that he had found in the nasal secretion "certain vibrio-like bodies" (infusoria), very delicate and small, and observable only through microscopes of high power. These he endeavored to eradicate by injections of quinine solution, and met with apparent success. Helmholtz, however, experimented only upon himself, and there is a failure of evidence throughout his investigation which may justly prevent the acceptance of its results without the corroboration of much more extended inquiry.

In 1872 Dr. Morrell Wyman, of Cambridge, Mass., published a treatise on the disease in which he recognized two distinct forms, namely a "rose cold" or "June cold," occurring in May or June and corresponding to the hay asthma of England and the Continent, and a later form beginning in August and lasting several weeks into the fall, to which he gave the name of "autumnal catarrh." Subsequently Dr. Blackley, of Manchester, England, pursued a series of ingenious researches to support a theory that hay fever is caused mainly if not exclusively by the pollen of grass. The studies of Helmholtz, Wyman, and Blackley we refer to because, in point of time, they are among the latest, and for the reason that they have each been regarded as important steps toward the thorough comprehension of the malady. A new work on the subject has now just left the press, in which all previous theories are reviewed, and the results of probably the most extended investigation ever made into the causes and nature of the disease are placed before the public. The author is Dr. George M. Beard of this city, and the method in which the inquiry has been conducted, together with the facts elicited, will commend the work even to those who may not be disposed to accept the theories adduced. Following the example of Darwin and Galton, Dr. Beard prepared a series of fifty-five questions, which were designed to exhaust all sources of facts of which the majority of physicians and patients were capable of judging. From the answers, critically compared and statistically arranged, covering the circumstances of two hundred cases, the author reaches the following general conclusions:

Hay fever is essentially a neurosis, that is, a functional disease of the nervous system. In order to induce an attack there is necessary, first of all, a predisposition, frequently hereditary, to special and excessive sensibility of the nerves supplying the affected parts. All forms of the disease in all countries, whether occurring in the spring, summer, or autumn, are but manifestations of one disease, for which the most appropriate name is "summer catarrh," which may be subdivided into an early form, middle form or July cold, and the latter form or "autumnal catarrh." As the disease is not due to any single specific cause, animal or vegetable, as has been supposed, no specific will ever be found for it. The attacks may be prevented and relieved, and some remedies will act specifically on individuals; but no one remedy will ever be found to act in all cases. The leading indications in the prevention and treatment of the disease are the avoidance of light, heat, worry, dust, vegetable and animal irritants, and other exciting causes, fortifying the system by tonics before and during the attack, and relieving the symptoms by those sedatives and anodynes, locally or generally administered, which are found by experience to be best adapted for each individual case.

These indications can be met by spending the season of the attack at sea, or in elevated mountainous regions, or in high latitudes at any elevation where the air is sufficiently cool, or at the sea shore, or, for those who cannot leave their homes, in quiet, cool, closed, and darkened rooms.

For those who, in spite of these precautions or from inability to take them, are attacked with the disease, ther emedies should be quinine, arsenic, iron, and electricity, before and during the attack; local applications of quinine and camphor by the atomizer; and for palliatives, any one or several of the great variety of remedies that experiment shows to be most useful for each individual.

SHALL WE CHANGE OUR WEIGHTS AND MEASURES?

The reasons for and against making the metric weights and measures the only legal standards in this country are pretty thoroughly canvassed in the majority and minority reports of the committee of the Franklin Institute, appointed to consider the question at the request of the Boston Society of Civil Engineers.

The majority report, submitted by Messrs. Coleman Sellers and W. P. Tatham, urgently opposes the change, believing that the possible benefits to be reaped from it would not make up for the damages done during the transition; and that our government has already done all that can fairly be asked of it by making the metric system legal.

In the first place the motive for change which originally gave rise to the French system does not exist with us. There is among us nothing like the legal confusion of weights and measures which existed in France when the Bishop of Autun first proposed a reform. Our standards are few, and have the same value in California as in Maine; those which the metric system was designed to supersede were numerous, widely various, and of narrowly local use. There were, for example, thirteen different lengths of the foot, all legal, in France; eighteen legal yards, twenty-one legal pounds, twenty-four legal *bosseaux*, thirteen legal *tonneaux*, and so on; and the range of quantity represented was often enormous, as between 12,203 cubic inches and 97,980 cubic inches in the various *tonneaux*.

Then the opportunity presented to France was favorable for a change: a time of revolution, when the social order was overturned and a new political system inaugurated. Besides, the people of France had always been used to having the government interfere with their private affairs. We are not. The general government has not even undertaken to enforce compliance with existing standards, which the constitution authorizes it to fix; and if enacted, a law abolishing them and substituting the metric weights and measures would probably remain a dead letter unless enforced by means which the people would not submit to.

The argument of the committee is broken at this point by a digression in regard to the difficulties which the French experienced in bringing about the change: an interesting summary of the history of the origin and development of the metric system, but without any bearing on the present question, since the system is now complete, if not perfect, and many other countries have adopted it without any such difficulty or derangement of trade.

The objections to the meter as a standard are more cogent. It cannot be made universal. It was drawn from the circle and the sphere, yet neither of these forms will submit to the decimal metrical system. "The measurement of time, of the degrees of the circle, of navigation, geography, and astronomy, successfully rejected it, although the prime idea of the Commission was to connect these subjects with ordinary weights and measures, by making the meter (the forty-millionth part of the circumference of the earth) the unit of lineal measure, and the second (the hundred thousandth part of the day) the unit of time, by means of the pendulum beating 100,000 seconds. The meter and the second were then the intermediate links in a long chain connecting Science and practical life, having the solar system at one end and a quart measure on the other. It is singular that the parts of this chain applicable to the calculations of Science were at once abandoned for their inconvenience, and the parts applicable to the uses of yard sticks, pound weights, and quart measures were imposed upon the people by compulsory laws for nearly twenty years, without regard to the still greater inconvenience to them."

In the end a compromise had to be made for the convenience of commerce, and arbitrary standards, susceptible of divisions into halves, quarters, thirds, and so on, were authorized, "in harmony with the daily wants and usages of practical life."

Another serious objection to the meter as a standard arises from the fact that it is as arbitrary as the foot. Theoretically, it is the ten millionth part of the earth's quadrant, but the adopted length has been proved incorrect, so that the actual standard is not a definite fraction of the earth's circumference, but the arbitrary rod in the public archives. As there remains not even a sentimental reason for accepting the meter as a standard, convenience alone should determine the question of its adoption. On this point the committee hold that it is not nearly so satisfactory as the foot, while the confusion, labor, and expense of changing standards would be enormous. The meter is only decimally divided, whereas the foot, besides being divided into tenths and hundredths, is also divided into inches, giving the even half, third, fourth, fifth, sixth, tenth, twelfth, and hundredth of the foot, and the half, third, fourth, fifth, sixth, eighth, tenth, twelfth, and sixteenth of the inch.

Again, if we change our standard for the sake of uniformity with France, we must sever our uniformity with Great Britain, with which three fifths of our foreign commerce is transacted. And the change would entail a much greater expense than is usually imagined. All our land surveys have been made in acres, feet, and inches, and are so recorded in our public records with the titles to the land. "Hundreds of years would elapse before we could permit ourselves to forget these old measures." The industrial arts have of late years acquired a far greater extent and precision than ever known before, with an infinite variety of costly tools for working to exact measurements. To change our standards would necessitate a corresponding change in all these, entailing enormous loss. A new outfit for a well regulated machine shop, employing 250 workmen, for example, would cost, it has been estimated, not less than $150,000, or $600 for each workman. "If new weights and measures are to be adopted, all the scale beams in the country must be regraduated and readjusted; the thousands of tuns of brass weights, the myriads of gallon, quart, and pint measures, and of bushel, half-bushel, and peck measures, and every measuring rule and rod of every description throughout the land, must be thrown aside, and others, which the common mind cannot estimate, must be substituted." Further, "the great mass of English technical literature would become almost useless, and must be translated from a language which we, and the nation which we have the most to do with, understand perfectly, into a new tongue which is strange to most of our people." The change may seem easy enough to closet scholars who use weights and measures only in calculations; but to practical users of weights and measures, the producers and handlers of the material wealth of the country, the necessary cost of the change would vastly outweigh any possible theoretical benfit to be derived from it.

The report of the minority of the Committee, Mr. Robert Briggs, is less an argument than a vigorous protest against the positions taken by the majority, as untrue, irrational, or absurd. Mr. Briggs agrees with the majority, however, in holding that "it is inexpedient to attempt at present to anticipate by enactment the time when this great step in the progress of human civilization and unity (the adoption of the metric system) shall be taken by the national government of the United States." But he does so "solely upon the grounds of the incomplete preparation and education of the people, and their want of appreciation of the immense advantages in the progress of the arts and the applications of the sciences which the metric system presents."

The opportunity was a favorable one for presenting a strong argument for the change, based on the practical experience of those European and South American States which have adopted the metric system; and it is a pity that Mr. Briggs did not avail himself of it. Much better than any protest against the statements of the majority of the committee would have been an array of facts showing that the metric system had been adopted by countries, other than France, without the evil results predicted.

Chloride of Silver Battery.

For the last year or two Mr. Warren De la Rue, in conjunction with Mr. Spottiswoode, has been making a series of interesting experiments with a gradually increasing series of elements, whose chief interest centers in the employment of chloride of silver as the electrolyte. Starting with a thousand cells, he has increased the number to over five thousand, and has published some remarkable facts in connection therewith. It is not impossible that, some day, chloride of silver may play the part of light producer in addition to its usual well known *rôle*. The experimentalists named estimate that 100,000 of these batteries would give a spark in air of nearly three yards.