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Contents.

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TABLE OF CONTENTS OF

THE SCIENTIFIC AMERICAN SUPPLEMENT

No. 160,

For the Week ending January 25, 1879.

THE TRANSMUTATION OF ELEMENTS.

Not a little nonsense has been written with regard to Mr. Lockyer's recent assertions concerning the probable composite nature of several, possibly all, of the substances hitherto accounted elementary, and the probability that all the elements so-called are but varying phases of some fundamental matter-stuff.

It has been commonly assumed that if these assertions should be verified, the dreams of the alchemists would come true, and chemists would be able to change one form of matter into another, as lead into gold or silver. This assumption is altogether gratuitous. In his studies of the spectra of different substances under varying conditions of heat and pressure, Mr. Lockyer has indeed come to doubt the integrity of the elements as commonly understood; and to believe that substances as unlike as calcium, lithium, iron, and hydrogen, may be not only not fundamentally distinct, but that they may be merely different aspects of some basic matter-stuff, of which hydrogen is the simplest form at command. As yet, however, the evidence he has offered is far from convincing; and able chemists who listened to his paper before the Royal Society, among them Professors Roscoe, Williamson, Frankland, and Gladstone, are of the opinion that he has merely demonstrated the presence of impurities in elements supposed to be perfectly pure.

But supposing these gentlemen to be wrong, and Mr. Lockyer right; supposing it true that all matter is fundamentally one—would we be any nearer to the practical realization of the alchemist's dream?

If matter be at bottom only hydrogen or some still simpler substance, the existence of strongly marked phases of matter, like oxygen, iron, gold, and so on, can be explained only by supposing them to be the result of a process of natural selection operating through past ages, under conditions about whichwe can have but the vaguest knowledge.

We know that life in all its phases is fundamentally the same, yet those phases are in the main, so far as we are concerned, unchangeable, certainly not transmutable. Even if the common origin of the horse and the zebrashould be demonstrated beyond the possibility of a doubt, we should be no better able to transmute zebras into horses than we are now. So if it be demonstrably true that two phases of one matter-stuff, like silver and lead, have resulted from the cosmical processes of material evolution, acting through the cycles of the past, the probability of our being able to change the one into the other would be scarcely greater than if they were fundamentally distinct. The chemical behavior of the different sorts of matter is quite independent of any theoretical notions with regard to the ultimate constitution of such substances; and chemistry will remain substantially what it is, whatever may be the outcome of the investigations of Mr. Lockyer and those engaged in similar work. By this we do not mean that the prevailing theories and practices of chemists may not be materially changed—such changes are the necessary result of increasing knowledge—but simply that the popular talk about the radical overturning of the science, as the result of Mr. Lockyer's alleged discoveries, is sheer nonsense, even if his utmost expectation should be realized.

THE FOURTH STATE OF MATTER.

That the three states of matter, the solid, the liquid, and the gaseous, though widely different in their properties, are yet only so many stages in an unbroken chain of physical continuity, has been amply demonstrated. The solid passes into the liquid, the liquid into the gaseous form of matter, by insensible gradations; and there is nothing any more improbable in the supposition that these three states do not exhaust the possibilities of material condition, than in supposing the possibilities of sound to extend to aerial undulations to which our organs of hearing are insensible, or the possibilities of vision to ethereal undulations too rapid or too slow to affect our eyes as light.

Indeed, while Pictet and others have been converting into liquids and solids the most tenuous of gases, by successively shortening the range of their molecular movements, Prof. Crookes has, on the other hand, succeeded in refining gases to a condition so ethereal as to reach a state of matter fairly describable as ultra-gaseous, and exhibiting an entirely novel set of properties.

The means by which this remarkable result was achieved were exhibited and described by Prof. Crookes at a meeting of the British Royal Society early last December; and the processes by which the discovery was made were discussed at length in a paper unfortunately too long even to be summarized here. It may be possible, however, to give an idea of their character and drift without the aid either of graphic illustrations or abstrusely scientific terms.

Our readers need not be told that the physical properties of gases are due to their molecular condition; in other words, to the swing and impact of their molecules, and the average length of flight of the molecules between collisions. As the number of molecules in a given space is reduced by mechanical exhaustion, the frequency of molecules collision is of necessity reduced, and the mean molecular flight is correspondingly extended. Now it is obvious that if the tenuity of the gas is very greatly increased, as in the most perfect vacua attainable, the number of molecules may be so diminished that their collisions under favorable conditions may become so few, in comparison with the number of misses, that they will cease to have a determining effect upon the physical character of the matter under observation. In other words, the free flying molecules, if left to obey the laws of kinetic force without mutual interference, will cease to exhibit the properties characteristic of the gaseous state, and take on an entirely new set of properties. That this is a matter of fact, and not of theoretic speculation, is demonstrated by the researches of Prof. Crookes.

In his previous studies of molecular activity in connection with the radiometer, the molecules were set in motion by means of radiations producing heating effects. In the present series of experiments the molecular motion was determined or increased by the induced current from an induction coil. The investigation began by a study of the dark space which surrounds the negative pole when an induction spark is passed through rarefied gas. The width of this dark space was found to vary with the degree of exhaustion of the tube; with the kind of gas employed; with the temperature of the negative pole; and in a slight degree with the intensity of the spark. For the study of these phenomena Prof. Crookes devised a very ingenious instrument, which he calls an electrical radiometer, and a variety of other apparatus, of wonderful delicacy and power, by means of which he was able to illuminate lines of molecular pressure; to converge streams of molecules upon a focus, with the evolution of light and heat and mechanical action; to deflect streams of molecules by means of magnets; to study the laws of magnetic deflection; to observe molecular shadows, so called, and other novel and extremely interesting phenomena.

The nature of the dark space around the negative pole Prof. Crookes interprets as follows: The thickness of the dark space is the measure of the mean length of the path between successive collisions of the molecules. The extra velocity with which the molecules rebound from the excited pole keeps back the more slowly-moving molecules which are advancing toward the pole. The fight occurs at the boundary of the dark space, where the luminous margin bears witness to the energy of the collisions of the molecules. When the exhaustion is sufficiently high for the mean length of the path between successive collisions to be greater than the distance between the electrode and the glass, the swiftly-rebounding molecules spend their force, in part or in whole, on the sides of the vessel, and the production of light is the consequence of this sudden arrest of velocity. When streams of molecular discharge are focused upon a strip of platinum wire or foil, the metal becomes not only luminous but highly heated by the severity of the bombardment; so, too, the molecular impact upon the side of the inclosing glass may be sufficient to make the spot too hot to be borne by the finger.

The limits of our space forbid any attempt to describe at length the phenomena of magnetic deflection or the ingenious apparatus by means of which the action of the magnet upon the trajectory of molecules was made visible. Under the influence of a magnet the behavior of a stream of molecules is likened to that of a stream of cannon balls under the influence of gravitation. In Prof. Crookes' words:

"Comparing the free molecules to cannon balls, the magnetic pull to the earth's gravitation, and the electrical excitation of the negative pole to the explosion of the powder in the gun, the trajectory will be flat when no gravitation acts, and curved when under the influence of gravitation. It is, also, much curved when the balls pass through a dense resisting medium; it is less curved when the resisting medium gets rarer; and, as already shown, intensifying the induction spark, equivalent to increasing the charge of powder, gives greater initial velocity, and, therefore, flattens the trajectory. The parallelism is still closer when we compare the evolution of light seen when the shot strikes the target with the phosphorescence on the glass screen from molecular impacts." Applied to a stream of molecules the magnet twists the trajectory of the molecules round in a direction at an angle to their free path, and to a greater extent as they are nearer the magnet, the direction of the twist being that of the electric current passing round the electro-magnet. The two poles of the magnet, we may add, twist the stream in opposite directions.

Prof. Crookes, very improperly, we think, speaks of the stream of molecules thus brought under observation as rays of molecular light. True, light is evolved by their impact under suitable conditions; so it may be by the impact of a stream of cannon balls. The impact of the flying molecules raises the temperature of any body interposed to arrest their flight, just as the impact of a stream of cold cannon balls would heat a resisting body arresting their flight; but we cannot call the one stream a ray of light or heat any more properly than the other. With this reservation, we may assent to Prof. Crookes' assertion that the phenomena he has investigated in his exhausted tubes reveal to physical science a new field for exploration, a new world—"a world wherein matter exists in a fourth state, where the corpuscular theory of light holds good, and where light does not always move in a straight line, but where we can never enter, and in which we must be content to observe and experiment from without."

AMERICAN INDUSTRIES.—No. 3.

BY HAMILTON S. WICKS.

REFINING SUGAR.

One of the best thermometers of a nation's prosperity is the sugar it consumes. In epochs of great financial depression and commercial stagnation the consumption is small as compared with periods of general prosperity. Indeed the proportionate consumption of sugar is so accurately distributed with respect to national prosperity or depression that it really constitutes a true gauge of both. It is also a good test of civilization and cultured taste—the more civilized