can hope to approach and none to excel. Taken from our midst in the early prime of life, it can nevertheless, with all truth, be said that in the voluminous records of his incessant work he has indeed left behind him *monumentum aere perennius.*"

G. BROWN GOODE.

SCIENTIFIC MATERIALISM.

AT the meeting of the Naturforscher-Versammlung, held last September, at Lübeck, Germany, Professor W. Ostwald, of Leipzig, delivered an address which was received with great interest, and gave rise to much discussion. The address has since been published in the *Zeitschrift für Physikalische Chemie* (Volume XVIII., p. 305), under the title 'Die Ueberwindung des wissenschaftlichen Materialismus,' and it seems desirable to call attention to it in this place, as it is highly suggestive, and its careful study is likely to be of benefit. The following is in the main a free translation of the more important parts of the address:

There is one point upon which scientific men agree, and that is that all things consist of moving atoms, and that these atoms and the forces acting upon them are the final realities. According to this, a natural phenomenon is explained when the exact nature of the motion of the atoms of the substance exhibiting the phenomenon is known. There is nothing beyond this. Matter and motion are ultimate conceptions. This is *scientific materialism.* The author believes that this view is untenable. It must be given up and a better view substituted for it. He states particularly that what he has to say has, at present, nothing to do with ethical and religious conceptions.

In investigating natural phenomena we first *register* and *classify*. From *registration* we reach the *system*; from this the *law of nature*, the most comprehensive form of which is the *general conception*. The most important element in the law is the *invariant*, a quantity that remains unchanged whatever changes may take place. Such an invariant is *mass*. This did not at first appear broad enough, and thus the conception of *matter* came to light, and the *physical law* of the *conservation of mass* was transformed into the *metaphysical axiom* of the *conservation of matter*. By this step a number of hypothetical elements are introduced into the conception that was originally free from hypothesis. It is now held that when, for example, iron and oxygen combine, the two forms of matter are in the compound, only they have new properties. This the author considers nonsense, for all that we know in regard to a certain stuff is that it has certain properties.

Galileo introduced the conception of the constant working *force* and thus explained the phenomenon of falling bodies. Newton assumed the same force as acting between the heavenly bodies and governing their motions. These great successes led to the conviction that all physical phenomena might be explained in the same way. Thus arose the *mechanical conception* of nature. It is not generally noticed to what an extent this conception is hypothetical, indeed metaphysical. On the other hand, it must be noted that this mechanical conception of heat, electricity, magnetism, chemism, has not been confirmed in a single case. It has not been possible to express the relations by a corresponding mechanical system, so that nothing is left unaccounted for.

The history of optics furnishes an excellent example. As long as optics included only the phenomena of reflection and refraction, the mechanical conception of Newton was satisfactory, according to which light consists of small particles sent out in straight lines. When later the phenomena of interference and polarization came to be studied, it was found that Newton's mechanical conception could not explain them, and the vibration theory of Huygens and Euler was adopted. But it was then necessary to imagine some medium which could transmit the vibrations, and thus the hypothetical ether took its place in the scientific mind. The phenomena of polarization require that the vibrations shall be transverse, and therefore the ether must be a solid. The calculations of Lord Kelvin have shown that a medium with properties, such as must be ascribed to the ether to account for the facts known, would not be stable, in other words, that it could not exist. Probably in order to save the electro-magnetic theory from a like fate, the immortal Herz, to whom this theory owes so much, expressly declines to see anything in it but a system of six differential equations.

The task of science is to find the relations that exist between realities, measurable quantities, so that when some are known others can be deduced. This idea is not new. Mayer, fifty-three years ago, discovered the equivalence of the natural forces, or, as we say to-day, of the different forms of energy. Then Clausius, Helmholtz and W. Thompson thought it necessary to interpret the law of the equivalence of the different forms of energy by assuming that all the different forms of energy are fundamentally the same, that is to say, *mechanical energy*. This was distinctly a backward step.

How is it then possible, by means of such an abstract idea as energy, to form a conception of the universe, which in clearness can be compared with the mechanical? What do we then know of the physical world? Plainly only that which comes to us through our sensory organs. What conditions must be satisfied in order that one of these organs shall be affected? We may turn the matter in any way we please, we find no common feature but this: The sensory organs are affected by energy changes between them and their environment. In a world, the temperature of which is everywhere the same as that of our bodies, we could not know anything of heat, just as we do not feel the constant atmospheric pressure under which we live. Only when we produce spaces with other pressures do we gain any knowledge of it.

It is often said energy is imaginary, while matter is the reality! The author answers: On the contrary, matter is a product of the imagination, that we have constructed very imperfectly in order to represent the permanent in the everlasting changes.

According to the author, matter and energy are not to be thought of as distinct, as for example, body and soul. If we attempt to think of matter as separate from the various forms of energy nothing is left. Matter is, in fact, nothing but a group of different energies arranged in space. He then makes use of this crude illustration. Imagine yourself struck with a cane. What do you feel, the cane or its energy? Of course, it is the energy. The cane at rest is harmless.

Everything that has hitherto been represented by the aid of the conceptions of force and matter, and much more, can be represented by means of the conception of energy. We make a great gain by indulging in no hypotheses in regard to the connection between the different forms of energy except that which is specified in the law of conservation, and we gain the freedom of studying the different phenomena objecttively.

Finally, it may be asked, is energy the last reality? However, necessary and useful for the understanding of nature energy may be, is there nothing beyond it? Or are there phenomena which cannot be fully expressed by the now known law of energy? The author expresses the belief that energy is not sufficient to enable us to deal with all nature. It will probably appear in the future as a special case of still more general relations of the form of which we have at present no conception.

In a later number of the *Zeitschrift für physikalische Chemie*, Ostwald reviews the second edition of J. B. Stallo's 'The Concepts and Theories of Modern Physics' that appeared in 1885, and expresses the hope that the book may find half as many readers as it deserves. The book was first issued in 1882 as one of the *International Scientific Series*, and scientific men as a whole regarded it unfavorably, though some of them certainly recognized the force of many of the author's arguments against the materialistic conceptions which were then and are now generally held.

IRA REMSEN.

ON A NEW KIND OF RAYS.*

1. A DISCHARGE from a large induction coil is passed through a Hittorf's vacuum tube, or through a well-exhausted Crookes' or Lenard's tube. The tube is surrounded by a fairly close-fitting shield of black paper; it is then possible to see, in a completely darkened room, that paper covered on one side with barium platinocyanide lights up with brilliant fluorescence when brought into the neighborhood of the tube, whether the painted side or the other be turned towards the tube. The fluorescence is still visible at two metres distance. It is easy to show that the origin of the fluorescence lies within the vacuum tube.

2. It is seen, therefore, that some agent is capable of penetrating black cardboard which is quite opaque to ultra-violet light, sunlight or arc-light. It is therefore of interest to investigate how far other bodies can be penetrated by the same agent. It is readily shown that all bodies possess this same transparency, but in very varying degrees. For example, paper is very transparent; the fluorescent screen will light up when placed behind a book of a thousand pages; printer's ink offers no marked resistence. Similarly the fluorescence shows behind two packs of cards; a single card does not visibly diminish the brilliancy of the light. So, again, a single thickness of tinfoil hardly casts a shadow on the screen; several have to be superposed to produce a marked effect. Thick blocks of wood are still transparent. Boards of pine two or three centimetres thick absorb only very little. A piece of sheet aluminium, 15 mm. thick, still allowed the X-rays (as I will call the rays, for the sake of brevity) to pass, but greatly reduced the fluorescence. Glass plates of similar thickness behave similarly; lead glass is, however, much more opaque than glass free from lead. Ebonite several centimetres thick is transparent. If the hand be held before the fluorescent screen, the shadow shows the bones darkly, with only faint outlines of the surrounding tissues.

Water and several other fluids are very transparent. Hydrogen is not markedly more permeable than air. Plates of copper, silver, lead, gold and platinum also allow the rays to pass, but only when the metal is thin. Platinum .2 mm. thick allows some rays to pass; silver and copper are more transparent. Lead 1.5 mm. thick is practically opaque. If a square rod of wood 20 mm. in the side be painted on one face with white lead it casts little shadow when it is so turned that the painted face is parallell to the X-rays, but a strong shadow if the rays have to pass through the painted side. The salts of the metal, either solid or in solution, behave generally as the metals themselves.

3. The preceding experiments lead to the conclusion that the density of the bodies is the property whose variation mainly affects their permeability. At least no other property seems so marked in this connection. But that the density alone does not determine the transparency is shown by

* From the translation in *Nature* by Arthur Stanton from the *Sitzungsberichte der Würzburger Physik-medic. Gesellschaft*, 1895.