fully studied, and the formation of a community was traced by rearing a simple solitary embryo in an aquarium until a perfect community has been developed from it by budding. During the process of development the law of growth by which the characteristics of the compound organism are brought about was clearly exhibited, and it is fully illustrated by nearly one hundred drawings.

One of the most interesting results of our work is the explanation, by Mr. Wilson, of the origin of the metamorphosis of the larva of *Phoronis*, a small Gephyrean worm which lives in a tube. Several of the most noted embryologists of Europe have studied the development of *Phoronis*, and our knowledge of its life history is due to their combined labors. Last summer Mr. Wilson reviewed the subject, and added some important points, and during the present season he has shown by the comparison of a great number of allied forms, that the very peculiar metamorphosis admits of an extremely simple explanation. The adult is sedentary and confined to its sand tube, while the larva is a swimming animal totally different in structure. The change from the larva to the adult is very rapid and violent. It occupies only a few minutes, and during the change the larva becomes turned wrong side out, so that what was internal is external. Mr. Wilson's comparison shows that *Phrronis* was originally a free animal, and that the structural peculiarities which fit the adult for sedentary life in a tube are of recent acquisition. The larva has, however, retained its ancestral adaptation to a swimming life in order to provide for the distribution of the species. There must have been a time, in the evolution of the species, when the adult was imperfectly adapted to a sedentary life, and also imperfectly adapted to a swimming life, and if the development of the individual were a perfect recapitulation of all the stages in the evolution of the species, we should have, between the swimming larva and the sedentary adult, a stage of development during which the adaptation is not quite perfect for either mode of life. It is clearly an advantage for the animal to pass through this stage as quickly as possible, or to escape it altogether. The peculiar metamorphosis enables the larva to remain perfectly adapted to a locomotor life until the occurrence of the sudden change which fits it for life in a tube, and Mr. Wilson has pointed out the manner in which the metamorphosis has been acquired in order to bridge over the period of imperfect specialization. This explanation is somewhat similar to that which Lubbock has given of the origin of the metamorphosis of insects, and we may hope that the same method of investigation will throw light upon the significance of other remarkable instances of metamorphosis in the Invertebrates.

THE MATERIALISTIC ORIGIN OF THE SEXES.

By Andrew Dewar.

Materialism is yet in its infancy. Born of human learning, weaned in scientific research, and cradled in the toleration of an enlightened civilization, its advent marks an epoch in the history of humanity. Should there be fearful shadows in its progress, where loiter grim doubts and gloomy forebodings, these are only consequent to its youth, and the necessary result of the light from a sun whose slanting rays only reach us. But even as the noonday sun chases away the shadows in its splendor, so we are assured that no doctrine in these enlightened days will ever be accepted which does not in its maturity shine on the human race for true knowledge and good.

"All knowledge is our province," said Bacon, and we would be less than men if any phenomenon in nature was considered inscrutable by us, the highest outcome of Nature. Thinking thus, one of the most curious problems is that of the sexes; and the value of the doctrine of Materialism is apparent when we come to question its cause, for no natural law professes even to offer an hypothesis on the subject.

It may here be asked, what is the doctrine of Materialism? As enunciated by the most advanced physicists, it is that "Matter contains within itself the promise and potency of every form and quality of life." This, it will be correctly said, is only a statement, not a *cause*—an assumption that requires proof, not a proposition of fact which may be demonstrated with the facility of a problem in Euclid. Granted; but it will be admitted that if we can show how the sexes originate from matter and its inherent properties, Materialism must be more than an assertion. This without further introduction we now propose to discuss.

Taking matter and its properties as the only foundation we can build on with safety, we ask What is Matter?

After long years of experiment and failure we answer this question with a firm assurance in several things:

First. The Indestructibility of Matter. This involves both the eternity of matter and the eternity of the properties of matter. Nothing exists outside of matter. Nothing but matter and its properties exist. Nothing can be taken from matter, nothing can be added to it. Whatever properties matter may have had, matter must have now; and, *vice versa*, whatever properties matter has now, matter has always had.

Secondly. Matter is composed of elements of which sixty-four are known. Everything consists of those elements, their combinations, changes, and properties. Whatever form they take now, under similar circumstances they would either in the past or future also assume.

This is the foundation of Materialism, and so far as it goes is perfectly clear and logical. Presuming that no force exists outside of matter, the *properties of matter* must account for every phenomenon in matter, and should they fail the premises fail also, and the fact is made certain that a force exists outside of matter, and *ergo* that Materialism is dead.

What, then, are the properties of Matter?

Here there is confusion and disagreement. Gravitation, cohesion, and chemical attraction are the three forces which have been popularly supposed to control matter; but when Huxley pertinently asked what these forces are, he found them not forces at all, but mere names or effects of a cause or causes unknown. Even Evolution, from which so much was expected and preached, has fallen into disgrace, and proved to be no force or cause either, but merely an "orderly sequence of phenomena" from some cause or causes unknown. How are we, then, to discover those unknown causes? If Materialism be true, they must exist; but Materialism cannot be maintained as a doctrine until we show that they do exist and what they are.

We are thus led back to our premises again—to matter and the elements—and we say, according to materialistic doctrine, if sex exists in matter now, sex must always have existed. Consequently, if matter was once a sheer chaos, or, as the most daring of physicists assert, a universal firemist, then sex in some form or another existed in that chaos or in that mist. As, assuredly, it did not exist in the form of any kind of life we are acquainted with, we are led to ask *if matter does not contain within itself some inherent sexual or dual qualities.* If it does, Materialism is alive; if not, Materialism is dead.

Matter is composed of sixty-four elements, more or less; are these elements all alike in kind, or can we trace a sex or duality in them? Fortunately for our doctrine we can. Although stated by eminent chemists to be of no importance, and made "solely for the sake of simplicity," the elements have long been divided into metallic and non-metallic classes. All the elements belong either

to one class or the other. So far success seems to favor us. Doubt is the mainspring of progress, and this doubting of a fact which has long been maintained to be of *no importance* may be the key to open up unknown vistas of research.

It will, however, be conceded in a matter of no importportance that this dual classification may be incorrect. This we believe to be the case, for one very important element—hydrogen—is given in every classification among the non-metallic elements, while the element itself is admitted to be metallic; a strange and incomprehensible misplacement. Whether the others are right or not only extensive experiments will determine. With this rectification, however, they are so far correct that the movements of Nature are opened to us as by a miracle. The lock cleared of this obstruction opens readily to the key, and Materialism rules triumphant. We seem premature; how does the duality of the elements solve all mysteries?

The object of this paper was to prove the materialistic origin of the sexes—that sex had its origin in matter. That matter is dual is part confirmation of it, but, like its antitype, we must also prove dual matter to be productive. Two females will not produce, neither will two males. If a production can be formed from the non-metallic elements only, or metallic only, then our theory is false; production should only ensue from the connection or interaction of opposite sexes and elements. Chemical analysis in this particular shows that we are right. *No natural production can be found containing the elements of only one class;* both metallic and non-metallic are essential to a formation. In simple laboratory experiments the opposite elements will combine readily with one another, while combination cannot be produced among the elements of either class alone. Even the simplest natural productions, such as air and water, are of dual combinations. Air composed of oxygen, nitrogen, carbonic acid gas, *hydrogen*, etc. Water, composed of oxygen and *hydrogen*, is the great medium also of life and production. Even the old *element*, fire or combustion, can only be produced from oxygen and *hydrogen*, with other opposing dual elements. All rock formations, crystals, stratas, are produced from combinations of the dual elements. All plants and vegetation are of dual formation and dual in sex, while all animals are undoubtedly male and female.

Our premises being thus clear and true regarding the elements of the matter, it follows that—as all plants and animals are composed of the same elements, of oxygen, hydrogen, etc., in different proportions and combinations—the conclusion we have been seeking is inevitable, namely, *sex in either animal or vegetable life is derived from and had its origin in the duality of matter.*

What causes dual matter to combine and be productive would lead us into another inquiry as to the origin of life from matter; but this we reserve for future consideration.—*Journal of Science, England.*

THE MECHANICS OF BIRD-FLIGHT.

The mechanics of the flight of birds have been much studied, and considerable space has been recently given to the subject in the columns of the *English Mechanic.* A new contribution has been recently made to a Silesian Society by MM. Legal and Reichel, whose researches deal with the relations of the size of the muscles of flight, and the size and form of a wing-surface, to the power of flight, and a short account may be of interest. (An abstract of the authors' observations appears in a recent number of *Naturforscher.*)

The authors begin by considering the question, whether the absolute size of a bird is of importance with regard to its flying power, *i. e.*, whether two birds, which considerably differ in size from each other, but are geometrically similar in their whole bodily structure, fly equally well. The final answer to this is (as we shall see) a distinct negative. The authors have measured in a great number of birds, the weight of the muscles of flight, especially the most important of these, the great breast muscle, as also its antagonist, the wing raising *musculus subclavius,* and compared it with the body-weight. The ratio of weight of the right and left large breast-muscle to the body-weight varied in the different bird species that were examined, from 1 : 3.4 in the pigeon, to 1 : 10.5 in the gull. But if the bird-species are arranged according to the amount of this quotient, neither the equally good flyers come together, nor birds of equal absolute size; *e. g.*, the partridge stands pretty well forward in the series with 1 : 4.8, near and before the hawk 1 : 5; while the sparrow, stork, and eagle, stand with about 1 : 6 near one another. Certainly, with increasing body-weight, the muscular system concerned in flight does not become relatively greater. The size of the muscles of flight is only one factor in flying-power.

A second, and very important factor is the surface presented by the outspread wing (the wing-surface); and here, again, it is not immaterial in which direction the surface extends. With equal wing-surface, a long narrow surface has more effect than a short and broad one, as a long rudder is more powerful than a short one. The authors have therefore given drawings of the form of the outspread wings for 37 different bird species, and indicated in figures the surface and length (wing configuration). A calculation of the mechanical action showed that where the ratio of the surface and length of the wing to the size of the bird remained the same, the angle of the wing motion and the angular velocity of the wing also remain the same; also that with the absolute size of the bird the air-resistance against the wings increases in the fourth power, but the body-weight only in the third. In order to compare the significance of wing-configuration for flight in large and small birds, one must therefore introduce into the numbers, expressing wing-configuration, a correction according to the absolute size of the bird, and the result of this correction the authors name the wing-number. Now, if the various birds be arranged in series according to wing-number, *i. e.*, according to wing-configuration, with comparative preference of the smaller, the good flyers are found to be at one end of the series, the bad at the other, *e. g.*, partridge 4, wild duck 10, jackdaw 20, sparrow hawk 24, sea-swallow 50. If we now multiply this wing-number with the ratio of the weight of the breast-muscle to the body-weight, *i. e.*, combine the consideration of the actual wing-configuration with that of the relative size of the muscles of flight, which are related to the effectiveness and velocity of wing-beat, we obtain the flight number as measure of the flying power, and this appears, *e. g.*, as follows: Sparrow 0.43, partridge 0.48, wild duck 0.98, jackdaw, 1.72, gull 2.15, kibits 2 92, eagle 2.95, stork 2.97, sea-swallow 3.28.

A comparison of the series thus obtained with the actual flying power, shows that the flight-number in general rises and falls with the flying power and in particular corresponds the better where birds of equal body-size are considered; and less well, the more different the size of the birds compared, so that in larger birds the actual flying power falls behind the comparative flight-number; that even appears, *e. g.*, from a comparison of the partridge with the sparrow. Or conversely, when we compare birds of equal flying power, but different size, *e. g.*, larger and smaller, but adult examples of a species, or species of a genus, the flight-number increases with the body-size. It is indeed difficult and always somewhat erroneous, to measure the actual flying powers of different birds together, one bird accomplishes more in dexterous and quick movements, another in rapid flight in a short time, a third in duration of flight. Still, the result may in general (says the reporter), be regarded as correct. Now, as the flight-numbers express the combined mechanically measurable factors of flight, it follows tha.