

seen in human laws. Thou shalt not steal is a law; that John has stolen is a fact. The combined result of the law and the fact is that John is locked up in jail. So, that all bodies near the earth gravitate toward it with a force directly as their mass and inversely as the square of their distance from its center, is a universal law of nature. The Niagara River and the precipice are facts—the cataract is the result.

But the general explanation of the course of nature on the mechanical theory is not of this simple kind, because the laws of nature do not act singly, but in combination, so that the result of each is modified by the action of all the others which come into play. The law of gravitation is not that all bodies must fall, but only that they tend to fall, and therefore will fall unless held up by some sufficient opposing force. So long as I support this weight in my hand it does not fall, because the force of gravitation and the resistance of my hand neutralize each other. But the instant I let go, the weight drops according to a certain law known as that of uniformly accelerated velocity.

The doctrine I am endeavoring to elucidate is this: Knowing a few simple laws of nature, of which gravitation is one knowing also the arrangement of material things within the field of investigation, that is, knowing the facts, we can predict with unerring certainty what the result will be, or, if we cannot predict it, it is not because of any quality of the thing itself, but only because of the insufficiency of our powers. Moreover, these results will be, as it were, another layer of facts, from which it is possible to predict new results to follow them, and so on without limit, unless some facts from without intervene to change the course. If we include the whole of nature in our field no outside facts can come in, and her course therefore admits of being predicted with entire certainty from beginning to end.

CHANGES WROUGHT BY MODERN SCIENCE.

Now the point which I wish to bring to your attention is the revolution which modern science has brought to pass in the opinions of mankind respecting the relations of the two classes of causes, or supposed causes, which I have described. That all events could be explained on teleological principles it is not likely that any one ever supposed. That the falling of heavy bodies, the running of rivers, the changes of the seasons and the revolutions of the heavens went on in accordance with mechanical laws, at least so far as the phenomena are concerned, no one ever knowingly denied. But it was thought that the action of these causes was from time to time modified by the introduction of causes of the teleological class, just as the rock might be kept from falling by the force of cohesion. The general rule has been that the more ignorant the age, the more minute and immediate was supposed to be the action of teleological, or, as we might call them, of supernatural causes. * * * According to the theory of the course of nature which I am trying to elucidate, the chain of causes which we have described, each cause acting according to antecedent conditions, but without any regard to consequences, is the type of the whole course of inanimate nature as far in space as the telescope can penetrate, and as far back in time as the geological record can be deciphered. An essential feature of the theory is that the laws which connect the several links of the chain, and thus determine the progress of events, do not possess that character of inscrutability which belongs to the decrees of Providence, but are capable, so far as their sensible manifestations are concerned, of being completely grasped by the human intellect, and expressed in scientific language. Without this, the theory would have no practical bearing whatever, because to say that the course of events is fixed, but by laws which we can never grasp, would give us no clew at all to learning what that course shall be, and would be equivalent to telling us that it is enshrined in the same impenetrable mystery with first causes.

A very important feature of the progress of science is found in the constant resolution of the laws of nature into more simple and elementary ones, until we reach principles so simple that it is impossible to analyze them further. Let us take as an instance of this the laws of the celestial motions. When Kepler discovered that the planets moved round the sun in ellipses having the sun in one focus, he found what were, for his time, simple and elementary laws. They were entirely comprehensible, admitting of being expressed in mathematical language; they enabled him to predict the motions of the planets, and so far as the intellect of the time could penetrate they could not be resolved into more simple expressions.

THE THEORY OF EVOLUTION.

* * * The most startling attempts in the direction I have indicated are those which are designed to show that those wonderful adaptations which we see in the structure of living animals, and which in former times were attributed to design, are really the result of natural laws acting with the same disregard to consequences which we see in the falling rock. The philosophy of Darwinism and the theory of evolution will be at once brought to your mind as forming the modern system of explanation tending to this result. On these theories the eye was not made in order to see, nor the ear in order to hear, nor are the numberless adaptations of animated beings to the conditions which surround them in any way the product of design. Absurd as this theory appears at the first glance, and great as is the anxiety to secure its rejection, the question of its truth is to be settled only by a careful scientific study of the facts of nature and the laws of hereditary descent. One principle which is to aid in its settlement is universally admitted in quarters where it is fully understood. We are not to call in a supernatural cause to account for a result which could have been produced by the action of the known laws of nature. The question, then, is whether the laws of hereditary descent and of natural selection are adequate to account for the gradual growth of such organs as the hand, the eye and the ear, and for all the adaptations which we see in nature. If they are, it would be idle to call in any other cause, except we place it behind the laws; and if we place it behind these laws, we must equally place it behind all others. Of course, such a cause lies beyond the field of sight, and does not, therefore, belong to scientific observation. Granting the theory, then, so far as the eye of science can penetrate, the whole result is brought about by laws acting in the same way as the laws of nature with which we are more familiar.

SUMMARY OF POINTS.

* * * To sum up: First—When men study the operations of the world around them, they find that certain of those operations are determined by knowable antecedent conditions, and go on with that blind disregard of consequences which they call law. They also find certain other operations

which they are unable thus to trace to the operation of law.

Secondly—Men attribute this latter class to anthropomorphic beings, or gods having the power to bring about changes in nature, and having certain objects, worthy or ignoble, in view, which they thus endeavor to compass. Men also believe themselves able to discern these objects, and thus to explain the operations which bring them about. The objects aimed at by these supernatural beings are worthy or ignoble, according to the state of society; in ancient times they were often the gratification of the silliest pride or the lowest lusts.

Thirdly—As knowledge advances one after another of these operations are found to be really determined by law, the only difficulty being that the law was before unknown or not comprehended, or that the circumstances which determined its action were too obscure or too complex to be fully grasped by the mind.

Fourthly—Final causes having thus, one by one, disappeared from every thicket which has been fully explored, the question arises whether they now have or ever had any existence at all. On the one hand it may be claimed that it is unphilosophical to believe in them when they have been sought in vain in every corner into which light can penetrate. On the other hand, we have the difficulty of accounting for these very laws by which we find the course of nature to be determined. Take, as a single example, the law of hereditary descent; how did such a law, or rather, how did such a process, for it is a process, first commence? If this is not as legitimate a subject for inquiry as the question, How came the hand, the eye, or the first germ into existence? it is only because it seems more difficult to investigate. If, as the most advanced scientific philosophy teaches, creation is itself but a growth, how did that growth originate? We here reach the limits of the scientific field, on ground where they are less well defined than in some other directions; but I shall take the liberty of making a single suggestion respecting a matter which lies outside of them. When the doctrine of the universality of natural law is carried so far as to include the genesis of living beings, and the adaptations to external circumstances which we see in their organs and their structure, it is often pronounced to be atheistic. Whether this judgment is or is not correct, I cannot say, but it is very easy to propound the test question by which its correctness is to be determined: "Is the general doctrine of causes acting in apparently blind obedience to invariable law in itself atheistic?" If it is, then the whole progress of our knowledge of nature has been in this direction, for it has consisted in reducing the operations of nature to such blind obedience. Of course, when I say blind, you understand that I mean blind so far as a scrutable regard to consequence is concerned—blind like justice, in fact.

If the doctrine is not atheistic, then there is nothing atheistic in any phase of the theory of evolution, for this consists solely in accounting for certain processes by natural laws. I do not pretend to answer the question here involved, because it belongs entirely to the domain of theology. All we can ask is that each individual shall hold consistent views on the subject, and not maintain the affirmative of the question on one topic and the negative on another. My object in laying before you these ideas has been not so much to propound any new views as to promote consistency of view among those who discuss this theme in its several aspects, and if I can make it clearly appear to a disputant that in discussing scientific questions he is to confine himself to their phenomenal side, and to maintain no theory which is not in accord with his everyday views of life, I shall have accomplished my purpose.

MAGNESIUM NITRIDE.

By J. W. MALLET.

THE existence of a nitride of magnesium was first noticed by Deville and Caron,* in connection with the purification of the metal by distillation.

Briegleb and Geuthert† afterward obtained this compound by passing ammonia or nitrogen over strongly heated magnesium. The amorphous mass produced, of greenish-yellow color, had approximately the composition Mg_3N_2 . I have lately observed the formation of the same substance in large quantity in the simple combustion of magnesium with limited access of air.

Using the burning of a piece of magnesium ribbon, as it so often has been used, to illustrate to students the fact that the metal gains in weight by oxidation, I held the coiled-up ribbon pretty well down in a porcelain crucible to diminish the loss of magnesium in fume carried up by the heated air, and finally dropped a part of the metal, still burning, into the bottom of the crucible.

Washing the vessel out afterward, I noticed that water at once produced effervescence and a distinct smell of ammonia.

On repeating the experiment with a larger piece of the ribbon, placed at once at the bottom of the crucible, the same result was obtained, and with far greater distinctness when magnesium filings were used, the residue in this latter case having a well marked greenish-yellow color, and giving off abundance of ammonia on addition of water or a solution of a caustic alkali. When but a few drops of liquid are added, the heat evolved is so great as sometimes to ignite a portion of the mass, and much of the powder is scattered by the escaping ammonia and vapor of water.

The porcelain being attacked, and a dark brown film of silicon formed upon it, I wished to ascertain whether this element had anything to do with the absorption of the atmospheric nitrogen, and therefore substituted an iron crucible, but without changing the result. The magnesium used was itself examined, and found free from silicon.

The chief part of the metal burned is, of course, converted into oxide, with the production of a temperature high enough to induce the remainder, when the supply of oxygen is limited, to unite with nitrogen. The amount of nitride formed varies with the manner in which the combustion is managed. I have found the best result to be obtained when the crucible, of usual Berlin porcelain shape, is filled to about one-third its depth with the filings, and heated gently over a lamp, the filings ignited at the top by a red-hot iron wire, and from time to time, but not continuously, gently stirred with the wire. A peculiar orange glow, unlike the brilliant light of the magnesium burning with free supply of air, and a slight apparent clotting together of the filings, indicate the formation of the nitride.

To determine approximately how far nitrogen may thus

be taken up, I in several instances weighed the metal, and, cooling the crucible rapidly by standing it upon an iron block, transferred its contents to a small flask, in which was a test-tube of water or a solution of potassium hydrate. Attaching a set of absorption-bulbs with a measured volume of normal sulphuric acid, I very gradually tilted the flask so as to bring the alkaline liquid in contact with the powder, and, after action in the cold was over, heated to the boiling point, and drew air through the apparatus with an aspirator. The unsaturated acid in the bulbs was determined with a normal alkaline solution.

The three experiments showing the largest absorption of nitrogen gave the following results. A little magnesium was lost in the fumes, but that, doubtless, altogether in the form of oxide:

	Mg. used. Grms.	NH ₃ obtained. Grms.	Equiv. Mg. Grms.	Equiv. Mg. Grms.	Mg. converted into nitride per 100 pts. used.
No. 1.	2.635	0.292	0.859	0.618	23.5
No. 2.	2.204	0.286	0.841	0.606	27.5
No. 3.	3.117	0.365	1.074	0.773	24.8

This mode of treating magnesium furnishes a simple and effective lecture-table illustration of the formation of a metallic nitride, and of some of the reactions presented by bodies of this class.—*Chemical News*.

CHEMICAL NEWS NOTICES.

Telephone without Electro-Magnet.—Th. du Moncel.—Hitherto the microphone has only been regarded as a telephonic transmitter, there being scarcely any suspicion that it might constitute a receiver destined to reproduce to the ear the sounds transmitted by an apparatus of the same kind. A microphone suitably arranged speaks distinctly, though less strongly than the telephone, and the ordinary microphone itself can reproduce to the ear the sounds resulting from mechanical vibrations produced upon the board supporting the apparatus. Thus scratchings upon the board, the trepidations and sounds occasioned by a musical box placed upon the microphone are distinctly heard. The mercurial telephone of A. Breguet requires no electro-magnetic apparatus, and emits sounds by the vibrations resulting from the oscillations of the mercurial column. But in the apparatus in question the effects produced are much more extraordinary, as the vibrations destined to produce them can only result from variations in the intensity of a current closed by the intervention of imperfect contacts, and to hear the sounds it is sufficient to place the ear against the stand upon which the charcoals are mounted.

Single Liquid Battery.—M. Pulvermacher.—In this battery the atmospheric air is employed as a natural depolarizing agent, without the use of any artificial chemical oxidizing agent, and gives a relative constancy to the element. The exciting liquid (dilute sulphuric acid, caustic potassa, or sal-ammoniac) is placed in a porous cylindrical vessel; the positive metal is formed of a rod of amalgamated zinc immersed in the liquid, and the negative element is formed of fine silver or platinum wire coiled round the cylinder. The spirals of silver wire are too remote from each other for the production of capillary action, and the wire is at an infinity of points in contact with the liquid exuding from the porous vessel. The rapidity of depolarization is such that, on closing the circuit (resistance of 10 ohms) during ten minutes, the electromotive force diminishes by about 16 per cent., and returns to its original value in three minutes after opening the circuit.

Trichloric Acetal.—H. Byasson.—Trichloro-acetal is a transparent mobile liquid, of a peculiar odor, staining paper like the fatty bodies. It boils at 197°; its sp. gr. = 1.288. It is sparingly soluble in water, but miscible in all proportions with alcohol, glycerin, common and acetic ether, chloroform, benzol, and the formic carbides. Hydrochloric acid is present among the products of its combustion.

Quantitative Spectral Analysis.—M. Hüfner.—The two halves of the slit of the spectroscopic are illuminated by two pencils of rays, one of which traverses the absorbent, while the other can be darkened at pleasure. As source of light a petroleum lamp is employed, placed in the focus of a lens; half of the pencil of rays falls at the angle of polarization upon a mirror, which throws it back upon a parallel mirror not tinted, placed before the upper portion of the slit; a Nicol's prism fixed before the eye-piece serves to decrease the polarized pencil without acting upon the other. Before the lower part of the slit is fixed a double prism formed of a prism of transparent glass and one of smoked glass. It is rendered equal with the Nicol's prism, and the absorption corresponding with a given rotation is deduced once for all. This instrument gives practical indications as precise as can be desired.—*Journal für Prakt. Chemie*.

Ethyllic Glycolate.—T. H. Norton and J. Tcherniak.—Glycolide is sealed up in tubes with an equivalent quantity of absolute alcohol, and heated for several hours to 200°: the operation is complete when the glycolide has entirely disappeared. The contents of the tubes are diluted with water, and carbonate of potassium is added, enough to separate all the ether which floats upon the surface of the saline solution. It is dried and distilled. The yield is almost theoretic.

Emissive Heat Power.—Prof. Villari.—There is for each body a thickness possessing a maximum emissive power. This thickness varies with the substances, being from 3.45 m.m. for powdered rock salt to 0.03 m.m. for Indian ink. The thickness varies also with the aggregation of the matter; thus, for lamp-black deposited directly it is 0.200 m.m., while it does not exceed 0.069 m.m. if the lamp-black has been previously stirred up with sulphide of carbon. As the same laws extend to the absorbent power of bodies, thermoscopes, in order to produce their maximum effect, should be covered with a layer of lamp-black 0.2 m.m. in thickness. Different bodies have different thermic and thermo-chroic emissive powers—that is to say, if the heat emitted at 100° by each of them were visible they would all appear differently colored with different intensities.

Experiments on Capillarity.—M. Röntgen.—According to Wilhelmy the density of a liquid is augmented by the contact of a solid body immersed in the liquid. The author has repeated these experiments, and has weighed successively in a liquid a solid mass, and the same mass broken into fragments, when the surface is augmented, and according to theory the weight of the body ought also to increase. The results of experiments made upon gypsum immersed in alcohol or in oil of turpentine and upon glass in alcohol are negative.—*Poggendorff's Annalen*.

* *Comptes Rendus*, xlv., 394.

† *Ann. d. Chem. u. Pharm.*, cxxiii., 228.