THE STRUCTURE OF MATTER.

Read before the New York Academy of Sciences by Prof. C. F Kroeh, of the Stevens Institute of Technology.

It is a well recognized fact that much of the progress in chemical and physical science is due to the increased attention given by investigators to the molecular structure of matter. The labors of Clausius in founding the mechanical theory of heat, of Tait, Sir William Thomson, and others in studying the motions of gases, the researches of Helmholtz in hydro-dynamics, of Clerk-Maxwell in electro-dynamics, of Julius Thomsen in thermo-chemistry, and of Crookes on residual gases, may all be attributed to this cause; while Graebe and Liebermann have shown by their discovery of a method for preparing artificial alizarine, that "mere theory," as the practical man of the past was wont to call it, may become of great industrial utility.

Seeing, then, the obvious importance of the results already reached, and believing that we are only upon the threshold of higher achievements in the same direction, it occurred to the writer that the interests of science might be promoted by bringing together precise information concerning the views held at present by the most prominent workers in this field, and the evidence upon which these views rest.

In a series of articles published in the SCIENTIFIC AMERICAN of May 17, June 7, June 14, July 19, and August 23, 1879, the arguments, from which the following results are derived, were presented:

1. That the elements and compounds combine in invariable simple or multiple proportions by weight.

2. That this fact is explicable by the assumption of ultimate particles having different weights.

3. That gaseous bodies combine in invariable proportions by volume.

4. That this fact, together with the behavior of gases under variations of temperature and pressure, enables us to ascertain the relative weights and volumes of the ultimate particles of gaseous bodies.

5. That the ultimate particles, whose relative weights are thus found, and which we may now call molecules, must themselves consist of still smaller particles or atoms, about which we have no definite information, except that the number of them contained in the molecule of one substance bears a simple numerical ratio to the number of them contained in the molecule of another substance.

6. That, until the absolute size of molecules is known, a molecular volume can be regarded only as the cubical space of which, at a given moment, the molecule forms the center.

7. That, starting with this conception, ingenious attempts have been made to determine the relative molecular volumes of elements in their compounds, and that different investigators have reached different results. To this I might add,

8. That finally considerable insight has been gained by this means into the properties of compounds.

These papers were preceded by a statement of a few facts warranting the assumption that matter is composed of exceedingly minute particles. It will be necessary in the following papers to give further evidence, after showing what opinions the master minds of the past held concerning the structure of matter. Impressed as I am with the consciousness that we are but too liable to be biased by prevailing hypotheses, and to accept them as demonstrated truth, simply because the erosive action of habitual use has worn channels in our minds from which our thoughts cannot escape without a great effort, it has seemed to me an imperative duty of scientific men to return, from time to time, to first principles, and to review the opinions of the past by the aid of the new light of modern thought.

THE EXISTENCE OF MATTER.

It seems to be a prevalent belief that no one but a metaphysician would take it into his head to doubt the existence of matter and the reality of the universe outside of ourselves. However, it was but a few years ago that a friend, standing on one of the balconies of Horticultural Hall at the Philadelphia Exhibition, and lost in admiration of the region of wonders before him, was accosted by a stranger who persisted in trying to prove that it was all unreal.

It was recognized early in the history of philosophy that the perceptions of our waking hours do not differ much from those of our dreams, and the question naturally arose: How do we know that life is not a continual dream? This and all similar questions have been long ago disposed of, however, by the recognition of the fact that our reason sits in judgment upon our perceptions and decides upon their validity. In other words, we know when we have been dreaming. Yet the fact remains that our senses do deceive us.

When we look at the starry heavens, science teaches us that there is no reality in what we see. Light, with its enormous velocity of 186,000 miles per second, takes 3½ years to reach us from α Centauri, 22 years from Sirius, and 50 years from the Pole Star. It is evident, therefore, that what we see simultaneously is not simultaneous in reality. We see at the same moment one star at the place where it was 3½ years ago, and another where it was 50 years ago. The sun himself has traveled onward for over eight minutes since the light started from the place where we see him at a given moment. Have we then ever really seen the sun?

If our senses so obviously deceive us in this as well as in many other experiences, what guarantee have we that they do not deceive us in all? Simply this, that we are not really deceived even in these experiences, but we have the power to make the necessary corrections. No argument in favor of the unreality of the material world based upon such considerations can prevail against the universal experience of mankind. When many persons receive the same impression under the same conditions, there must be something external to them to produce that impression. According to the calculus of probabilities, the chances that they would all, each of his own accord, think the same thoughts or dream the same dreams, are infinitesimal.

Let us now inquire into the views held by the thinkers of the past concerning the structure of matter.

ARISTOTLE.

The first conception of matter that merits our attention, though not the most ancient, is that of Aristotle (384 to 321 B.C.).

Our daily experience teaches us that the properties of bodies continually change. The tints of the sky, the sea, and the mountains vary from hour to hour; water is at one time a liquid, at another a solid, or a vapor; the air is now at rest, then it assumes a gentle motion, or rushes onward with a frightful velocity.

It is a natural inference that in all these phenomena there is something that changes, something that moves, and that none of the properties, motions, or changes we observe are essential to it. Thus we arrive at Aristotle's conception, that matter is something without any properties whatever, yet capable of assuming all properties; something without power of its own to move, yet capable of receiving motion. It possesses nothing but quantity, and that quantity must be unlimited.

Aristotle recognizes a first cause through whom this matter received motion and properties, but assumes that matter is coeternal with God, *i. e.*, that it existed *from* all eternity.

According to this system the first act of the Deity upon matter was its endowment with properties and motion. This is equivalent to a creation, since the objects we now see are its results, and it is perhaps difficult to conceive why Aristotle did not represent God as creating these objects out and out, matter and properties together. The explanation lies in his conception of the Deity, a conception arrived at as follows:

Passive matter must be moved either by a cause that is itself in motion, or by a cause that is at rest. Now, a cause that is itself in motion would need to have its own motion explained by a cause yet more remote, and soon indefinitely. We have left only a cause that is itself at rest. Such a cause can be only a mind, a spirit. Accordingly the god of Aristotle is pure thought, a perfect mind, that is the object of its own contemplation. Now, a mind could think properties, but it could not think concrete, material objects.

The difficulty with Aristotle's world of uncreated matter without properties is, that motion must be imparted to it by mere thought, and that in such a world there must be a constant intervention of the Deity, a continuous miracle.

LEUKIPPOS AND DEMOKRITOS.

We pass in the next place to a system that has more affinity with modern thought, the system of Leukippos and Demokritos, who maintained, about 400 B.C., in opposition to Anaxagoras, the teacher of Sokrates, that bodies are not infinitely divisible. We finally reach particles infinitely small and invisible, which are called atoms and are indivisible. By reason of their indivisibility they are indestructible and unchangeable, and they completely fill the space they occupy. All atoms are identical in substance and differ only in shape and size. Differences in substance are produced by different groupings of these atoms, which have only one physical property, weight.

All invisible bodies consist of atoms and empty spaces. Motion, it is argued, is a necessary result of this. The atoms have always been falling, like snowflakes, through empty space. The larger ones overtake the smaller and form still larger bodies. Thus accretion goes on, a whirling or vortex motion is produced, and worlds are formed. There is no evidence, according to these philosophers, that motion is the result of purpose or design.

Unfortunately for this system large bodies do not, as a matter of fact, fall faster in vacuo than smaller ones.

EPIKUROS.

Epikuros (342 to 271 B.C.) endeavored to rectify the errors in the system of Leukippos and Demokritos. He reasoned thus:

Matter consists of indivisible atoms differing from each other only in size, shape, and weight. A finite body could not have an infinite number of parts; therefore its divisibility cannot be infinite.

Atoms have a limited number of shapes and sizes; but of each kind there exists an infinite number.

Space and the number of atoms that exist in it must both be infinite. Finite space could not contain an infinite number of atoms, and on the other hand, a finite number of atoms would be lost in infinite space.

Now for motion. From all eternity atoms have been falling through space by reason of their weight. There being no resistance in a vacuum they must all have had the same velocity, and they could never have met and combined to form bodies and worlds, if their fall had always been vertical. So Epikuros invented a lateral deviation that he ascribed entirely to *accident*. Granting this, we may have collisions and repulsions, whirling motions and aggregations that spring into being and pass away again without law.

But we cannot grant this. We cannot at the same time pretend to search out the laws of nature, and admit the word accident into our scientific vocabulary. Accident is simply an unknown cause. When, therefore, Epikuros attributed the meeting of atoms to accident he practically confessed that he did not know what made them meet.

It is worthy of note that Epikuros gave as his motive for inventing his system a desire to destroy superstition, to remove the dread of the gods, and to restore tranquillity to the mind. This means, in plain English, to abolish the Deity and personal responsibility.

Curiously enough, these mischievous atoms, after having become the basis of modern science, were so modified and adapted in the course of time that they have furnished Sir John Herschel and Prof. Maxwell with a very powerful argument to show that they could not have been evolved, but must have been created.

DESCARTES.

In more modern times thinkers endeavored to find in matter some fundamental property that inhered in it, while all other properties were only accidental or derived. Descartes, the inventor of analytical geometry (1596 to 1650), was led by the universality of geometric truth to regard extension as the very essence of matter. According to his system there can be no material atoms. A particle, however small, must still have dimensions, and it must therefore be divisible. If there are no atoms, there is no further necessity for imagining empty spaces. Nothing existing in nature corresponds to the conception of a void. If a void existed, no motion could be communicated through it. Space is only a figment of the imagination, and motion is possible by contact only. The whole universe is everywhere equally full of matter. When a body moves it does so by displacing other matter. It crowds out what is before it, while at the same time the matter behind it fills its former place. It is thus that a fish swims. While Descartes denied the existence of atoms, which, by their own nature, are indivisible, he admits that the Deity may have made certain particles indivisible in the sense that no creature can divide them.

According to this conception the sum total of motion imparted to the world at the creation remains unchanged. The universe is a vast machine, which transmits motion from one part to another, but does not destroy it.

(To be continued.)

NEW INVENTIONS.

Mr. Levi H. Roberts, of Cadillac, Mich., has patented an improved fastening for tool handles. The object of this invention is to secure handles to tools in such a manner that they will be held in place firmly, and can be attached and detached easily and quickly. The invention consists in a fastening for tool handles formed of a key and a plate roughened upon one side and smooth upon the other. The plate and key are inserted between the rear edge of the handle and the rear edge of the tool eye.

An improved attachment for fire-places has been patented by Mr. Frank S. Elsberry, of Montgomery, Ala. The object of this invention is to so construct the back of a fire-place or fire-place grate, and to provide it with such attachments in the form of pipes and valves that it shall be adapted for receiving a supply of water and holding it while being converted into steam, which is distributed in pipes to different parts of the dwelling or other structure in which the grate is located.

An improved double-tree has been patented by Mr. John J. H. Parrott, of Salem, Oregon. The object of this invention is to provide a device to be applied to a vehicle whereby the hindmost horse shall be enabled to pull with more advantage than usual when endeavoring to draw abreast with the foremost horse. The invention consists of a straight rack fixed centrally on the front edge of a double-tree and gearing into a corresponding segment rack that is fixed on the tongue of the vehicle.

Mr. David James Rogers, of Bardstown, Ky., has patented an improved ice cream freezer of that form in which the can containing the cream is rotated upon a central pivot, and is provided with a vertical lifting beater or scraper, which removes the frozen cream from the sides of the can as it freezes.

An improved nose piece for bridles, patented by Mr. Rhodes Arnold, of Waltham, Mass., consists in the combination with the bit and the head piece of a bridle, of straps for counteracting the pressure of the bit on the mouth and lower jaw of the animal.

Mr. Francis M. Foster, of Coffeyville, Kan., has patented an improved sulky plow, which is so constructed that the plow shall be in front of the wheel, so that the plowman can see the plow and the team without changing his position.

Successful Treatment of Tetanus.

Dr. John C. Lucas, in the *Medical Times and Gazette*, strongly advocates the treatment of tetanus by smoking Indian hemp. The leaves of the cannabis indica are mixed with three or four times their quantity of ordinary tobacco Directly there are indications of a spasm coming on, the fumes are inhaled until the attack ceases. The patient is then left quiet, but carefully watched, so that the pipe may be instantly handed to him on any appearance of the spasm returning. In this way the patient is kept continuously under the influence of hemp, day and night, nourishment being carefully administered at the same time. The advantages claimed for this mode of treatment are these: 1. The spasms are cut short. 2. They reappear gradually at longer and longer intervals. 3. They gradually become not only less frequent, but less severe. 4. This saves the patient's vital powers. Mr. Khasligir, of India, has also treated five cases of traumatic tetanus, all recovering by this method.