LECTURE-NOTES ON PHYSICS. PART I.

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ALFRED M. MAYER

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LECTURE-NOTES

ON

PHYSICS.

By ALFRED M. MAYER, PH.D.,

PROFESSOR OF PHYSICS IN THE LEHIGH UNIVERSITY, BETHLEHEM, PA.

PART I.—Containing

PHILADELPHIA:
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"Who hath measured the waters in the hollow of His hand, and meted out heaven with the span, and comprehended the dust of the earth in a measure, and weighed the mountains in scales, and the hills in a balance?" (ISAIAH xl. 12.)

"Thou hast ordered all things in measure and number and weight." (BOOK OF THE WISDOM OF SOLOMON, chap. xi. 20.)

"It ought to be eternally resolved and settled that the understanding cannot decide otherwise than by induction, and by a legitimate form of it."

"Francis of Verulam thought thus, and such is the method which he determined within himself, and which he thought it concerned the living and posterity to know."

"Let no one enter here who is ignorant of geometry." (PLATO.)

LECTURE-NOTES ON PHYSICS.

§ I. *Definitions and Introduction to the Inductive Method.*

Physical science is the knowledge of the laws (*c*) of the phenomena (*b*) of matter (*a*).

(*a*.) Matter is that which affects the senses. It always presents the three dimensions, or, in other words, occupies space.

It exists throughout all known space as a highly elastic and rare medium called *ether* (proof of this given in optics), and in this medium circulate dense bodies of spheroid forms, separated from each other by distances which are immense when compared with the size of these bodies; such are the planets and asteroids of celestial space, and the earth on which we live.

Shooting-stars or Aërolites are celestial bodies of smaller size, which at certain periods (November 13th and August 10th) cross the orbit of the earth.

Comets are highly rarified nebulous bodies of various and changing forms, circulating in orbits which are so eccentric, that they are not visible to us in their remote situations; while at other times they are much nearer to the sun than any of the planets. The comet of 1680, when nearest to the sun, was only one-sixth of the sun's diameter from his surface.

The motion of comets retarded by the resistance of the *ether?*

The above is a statement of all known matter, and physical science is that branch of knowledge which considers all the various phenomena which this matter presents.

From the investigations of chemists on terrestrial matter, and from the spectroscopic examination of celestial bodies, all matter can be resolved into (at present) sixty-three *elements*.

According to the atomic theory see (§V.) all matter consists of exceedingly minute, absolutely hard and unchangeable *atoms*, separated from each other by distances which are very great when compared with the dimensions of these atoms.

As in interplanetary space exists the rare ether, so interatomic space is occupied by the same elastic medium. (Proofs of above given under Undulatory Theory of Light and Heat.) Matter exists in the three states of solids, liquids, and gases.

Each organ of our senses is so constructed that it can only take cognizance of those effects which it was specially designed to receive. Thus, through the eye we perceive light, but not sound; and the ear does not take cognizance of light, nor of flavor, nor of odor.

All the senses are modifications of touch.

In touch, taste, and smell the organs of these senses come in contact with the matter that we touch, taste, and smell. In the cases of sound, of light, and of heat, these effects are propagated through an intervening elastic medium whose particles, vibrating in unison with the particles of the sounding, luminous, or heated body, cause the nerves of the ear, of the eye, or of the skin to pulsate; and thus we have special sensations which we severally interpret as sound, light, and heat.

Experiments showing the transmission of sound—vibrations through the air, through a liquid and through a long rod to the ear. The human body can be the intervening vibrating medium to transmit the sound.

Experiment. Sound not propagated through a vacuum. *Ether* is the intervening vibrating medium in the case of light and heat.

A *shadow* is not matter, because it does *not* affect the senses. The light reflected from the surface, contiguous to the shadow, affects the eye; but from where the shadow is, no effect emanates, and the consciousness of the *absence of an effect* on that part of the eye where the shadow is projected gives us the idea of darkness.

According to Helmholtz and Du Bois Raymond an effect is propagated along the nerves with a velocity of 93 feet in one second.

(*b.*) Phenomena. A collection of associated facts.

Example. Compression of air. Here the associated facts are two. (1) The volumes of air corresponding to (2) different pressures. The fall of a stone, associated facts. (1) Spaces fallen through, and (2) the times occupied in falling through the spaces.

Every physical phenomenon is either motion or the result of motion.

Examples. In the phenomena of astronomy, mechanics, acoustics, light, heat, electricity, chemistry, botany, zoology.

The idea of *motion* necessarily embraces two others viz: that of *space* and that of *time;* for a motion must take place in space, and must happen with more or less rapidity, whence our idea of time. (See Instruments used to Measure Time, under § II.)

(c.) Law. The expression of the general relation which pervades a class of facts, or the rule according to which a cause acts.

Examples. The law of the compression of gases; volumes of gases are inversely as the pressures to which they are subjected. Gravitation; the gravitating effect is directly as the masses, and inversely as the square of the distance between the gravitating bodies. Sound, light, heat, electric and magnetic attraction diminish in intensity inversely as the squares of the distances from their centres of origin. Reflection and refraction of light.

Universality of these general relations throughout the universe. Importance of these general expressions in assisting the memory. A law embraces in itself all the myriads of facts of which it is the generalization.

The use of a law is shown in its application to the practical purposes of life.

Examples. Application of the law of the compression of gases; of the reflection and refraction of light; of the pressure of steam at different temperatures; of the laws of dynamic electricity.

Without the knowledge of the law of a class of facts, we are obliged to make experiments to solve each individual problem, while if we have the knowledge of the law, the solution of the problem is a mere deduction from the law to which it belongs. Examples drawn from above laws.

The money value of a law to the engineer, and to the industrial and commercial world.

The discovery of laws is the object of science.

The logical arrangement of all the known physical laws constitutes physical science.

"*Classification of the Physical Sciences.*

I. INORGANIC.	II. ORGANIC.
a. Celestial Phenomena.	
1. Astronomy.	1. Botany.
2. Meteorology (part of).	2. Zoology."
b. Terrestrial Phenomena.	
1. Physics.	
2. Chemistry.	
3. Geology, including Mineralogy.	

PROF. J. HENRY.

Physics considers the laws of the general phenomena of matter, or is the study of the laws of those phenomena which do not bring about a permanent change in the constitution of bodies.

Examples. Fall of a stone, compression of gases, expansion of bodies by heat, reflection and refraction of light, &c.

Chemistry considers the peculiar or individual phenomena of bodies, or is that science which studies those phenomena which bring about a permanent change in the nature of bodies.

Examples. Burning of a candle, rusting of iron, union of sulphur and iron, union of oxygen and hydrogen.

The fundamental principle on which we repose in all our scientific reasoning is, that *the laws of nature are constant*, or, in other words, that *like causes will always produce like effects.*

"The mode of reasoning, in physical science, which is the most generally to be adopted, depends on this axiom which has always been essentially concerned in every improvement of natural philosophy, but which has been more and more employed ever since the revival of letters, under the name of induction, and which has been sufficiently discussed by modern metaphysicians. That like causes produce like effects, or that in similar circumstances similar consequences ensue, is the most general and most important law of nature; it is the foundation of all analogical reasoning, and is collected from constant experience by an indispensable and unavoidable propensity of the human mind." (Dr. Thomas Young's *Lectures on Natural Philosophy*, Lecture I., page 11. London, 1845).

"Most of the phenomena of nature are presented to us as the complex results of the operation of a number of laws."

Examples. In astronomy, in sound, in light, in heat, and in electricity.

"We are said to explain or give the cause of a simple fact when we refer it to the law of the phenomena to which it belongs, or to a more general fact; and a compound one when we analyze it and refer its several parts to their respective laws.

"The indefinite use of the term cause has led to much confusion and error. We distinguish two kinds of causes, *intelligent* and *physical*.

"By an *intelligent cause* is meant the volition of an intelligent and efficient being producing a definite result.

"By a *physical cause*, scientifically speaking, nothing more is unstood than the law to which a phenomenon can be referred.

"Thus we give the physical cause of the fall of a stone or of the elevation of the tides, when we refer these phenomena to the law of gravitation; and the intelligent cause (sometimes also called the moral or efficient cause), when we refer this law to the volition of the Deity."

[It is generally easy to know to what physical cause we should refer a class of physical phenomena; but what is often difficult, is to determine the nature and manner of acting of that cause, and to show how the phenomena and their laws are consequences of its properties. This is the nicest point in physical science.]

"In the investigation of the order of nature, two general methods have been proposed—I. The *à priori* method, and II. The inductive method.

"I. The *à priori method* consists in reasoning downwards from the original cognitions, which, according to the *à priori* philosophy, exist in the mind relative to the nature of things, to the laws and the phenomena of the material universe."

[Examples given of ancient and medieval *à priori* reasoning in their explanations of the motions of the heavenly bodies, and of the law of falling bodies.]

"II. The *inductive method*, which is the inverse of the other, is founded on the principle that all our knowledge of nature must be derived from experience. It therefore commences with the study of phenomena, and ascends from these by what is called the inductive process, to a knowledge of the laws of nature. It is by this method that the great system of modern physical science has been established. It was used in a limited degree by the ancients, and especially by Aristotle, but its importance was never placed in a conspicuous light until the publication of the *Novum Organum* of Bacon in 1620."

"In the application of the *inductive method* to the discovery of the laws of nature, four processes are usually employed.

"1. *Observation*, which consists in the accumulation of facts, by watching the operations of nature as they spontaneously present themselves to our view.

"This is a slow process, but it is almost the only one which can be employed in some branches of science,—for example, in astronomy.

"2. *Experiment*, which is another method of observation, in which we bring about, as it were, a new process of nature by placing matter in some new condition."

[In making an experiment we should not only evolve the phenomena whose laws we wish to determine, but should also so produce these phenomena that we can *measure* their related parts.]