I.

INTRODUCTION.

"WE have no reason to believe that the sheep or the dog, or indeed any of the lower animals, feel an interest in the laws by which natural phenomena are regulated. A herd may be terrified by a thunder-storm; birds may go to roost, and cattle return to their stalls during a solar eclipse; but neither birds nor cattle, so far as we know, ever think of inquiring into the causes of these things. It is otherwise with man. The presence of natural objects, the occurrence of natural events, the varied appearances of the universe in which he dwells, penetrate beyond his organs of sense, and appeal to an inner power of which the senses are the mere instruments and excitants. No fact is to him either final or original. He can not limit himself to the contemplation of it alone, but endeavors to ascertain its position in a series to which the constitution of his mind assures him it must belong. He regards all that he witnesses in the present as the afflux and sequence of something that has gone before, and as the source of a system of events which is to follow. The notion of spontaneity, by which in his ruder state he accounted for natural events, is abandoned; the idea that nature is an aggregate of independent parts also disappears, as the connection and mutual dependence of physical powers become more and more manifest; until he is finally led to regard Nature as an organic whole, as a body each of whose members sympathizes with the rest, changing, it is true, from age to age, but without any real break of continuity, or interruption of the fixed relations of cause and effect."

TYNDALL.

ANALYSIS OF THE INTRODUCTION.

INTRODUCTION.

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- II. General Properties of Matter.
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     - (1.) *Compression.*
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     - (4.) *Flexure.*
  5. Hardness.
  6. Brittleness.

INTRODUCTION.

I. GENERAL DEFINITIONS.

1. Matter.—Whatever occupies space is called *matter.* A definite portion of matter is termed a *body.*—*Examples:* A lake, a dew-drop, a quart of oil, an anvil, a pendulum. A particular kind of matter is styled a *substance.*—*Examples:* Gold, wood, stone, oxygen.

2. General and Specific Properties.—A *general property* of matter is a quality that belongs to all substances.—*Example:* Extension. A *specific property* is one which distinguishes particular substances.—*Examples:* The yellow color of gold, the brittleness of glass, the sweetness of sugar. These properties are so distinctive that we say, "yellow as gold," "brittle as glass," "sweet as sugar."

3. The Atomic Theory supposes

(1.) That the smallest particle of matter we can see is composed of still smaller particles or *molecules* (tiny masses),* each possessing the specific properties of the substance to which it belongs.

* A molecule is a group of atoms held together by chemical force, and is the smallest particle of a substance which can exist by itself. Even in a simple substance, *i. e.*, one in which the atoms are all of one kind, it is thought that they are generally clustered in molecules. (See "Chemistry," p. 4.) In water, the molecules are the small masses which, when driven

(2.) That each molecule consists of indivisible portions, called *atoms*,* which can not be changed by any material force.—*Examples:* A molecule of water is made up of two atoms of hydrogen and one of oxygen. A molecule of salt consists of one atom of chlorine and one of sodium. The smallest piece of salt contains many molecules. By dissolving in water, we divide it into its separate molecules, and the solution has a briny taste, because each one possesses the savor of salt.

4. Physical and Chemical Changes.—A *physical change* is one that does not destroy the molecule, and so does not alter the specific properties of a substance.—*Examples:* The falling of a stone to the ground, the dissolving of sugar in water. A *chemical change* is one that implies the re-arrangement of the atoms into new molecules and so destroys the specific properties of a substance.—*Examples:* The rusting of iron, the burning of coal.

5. Energy.—The power of producing change of any kind is called *energy.* When it is manifested

apart, form steam. In a gas, they move like so many worlds through space. Striking against the sides of the containing vessel, they produce the pressure of the gas and cause this to escape if the vessel be opened.

* Animalcules furnish a striking illustration of the minuteness of atoms. In the drop of stagnant water that clings to the point of a needle, swarming legions swim as in an ocean, full of life, frisking, preying upon one another, waging war, and re-enacting the scenes of the great world about them. These tiny animals possess organs of digestion and assimilation. Their food, coursing in channels more minute than we can conceive, may be composed of solid as well as liquid matter; and finally, at the lowest extreme of this descending series, we come to the atoms of which the matter itself is composed. The most powerful of microscopes fails completely to reveal the separate molecule.

in producing some particular kind of change, we speak of it as *force.*

6. Physical and Chemical Forces.

A *physical force* is one that produces a physical change in matter.—*Examples:* Heat, when it changes water into steam; light, when it illumines a room; magnetism, when it causes a knife-blade to attract a needle.

Chemical force is that which produces a chemical change.—*Example:* Sand and soda are by chemical force united to make glass.

The same energy may be manifested successively in different kinds of force.—*Examples:* Heat changes water into steam, which turns the wheel of an engine; this motion may be given to part of a dynamo-electric machine and be transformed into electricity, magnetism, light, heat, and sound.

7. Physics.—The most general definition of physics is *the science of matter and energy.*

Commonly a distinction is made between Physics and Chemistry. Physics relates to changes that involve masses and molecules of matter; Chemistry, to those that affect the atoms of matter.

PRACTICAL QUESTIONS.

1. Name some specific property of coal; ink; chalk; grass; tobacco; snow.
2. My knife-blade is magnetized, so that it will pick up a needle; is that a physical or a chemical change?
3. Is it treated in Physics or Chemistry?
4. Is the burning of coal a physical or a chemical change?
5. The production of steam? The formation of dew?

6. The falling of a stone? The growth of a tree?
7. The flying of a kite? The chopping of wood?
8. The explosion of powder? The boiling of water?
9. The melting of iron? The drying of clothes?
10. The freezing of water? The dissolving of sugar?
11. The forging of a nail? The making of bread?
12. The sprouting of a seed? The decay of vegetables?
13. The condensation of steam?

II. GENERAL PROPERTIES OF MATTER.

THERE are two essential properties without which matter is inconceivable. These are extension and impenetrability.

1. Extension is the property of occupying space. The amount of space a body occupies is called its *volume*.

Measurement of Extension.—A body has three dimensions: length, breadth, and thickness. To measure these, some standard is required. The standard of length popularly in use in England and the United States is the yard. Its length is the distance between two lines on a certain bar of bronze, kept in London and measured at a certain temperature, 62° F. (see p. 248). There is only one yard in the world; all that we call yards are imperfect copies from it. The yard is inconveniently divided into three feet, or thirty-six inches. The standard of length used in France, and by scientific men throughout the world, is the meter.* Its length is nearly, but not exactly,

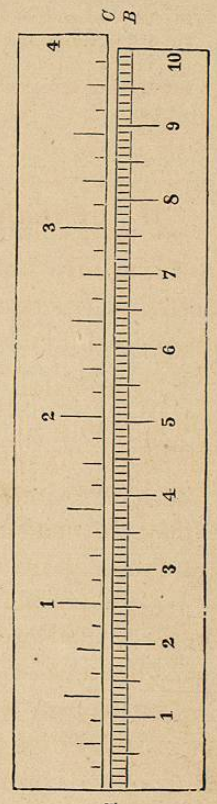
* The meter is divided into ten decimeters (*dm.*); each of these into ten centimeters (*cm.*); and each of these into ten millimeters (*mm.*). In Fig. 1 is shown a line, *AB*, whose length is a decimeter, divided into centimeters and millimeters. At the side of it is another line, *AC*, slightly longer. It is made up of four inches, divided into halves, quarters, and eighths. The length of the meter is about 39.37 inches, or nearly 1.1 yard.

For the measurement of surface, we use square meters (*sq. m.*), square centimeters (*sq. cm.*), etc.

The unit adopted for the measurement of volume is the cubic decimeter. It is called a *liter*. A vessel that contains just a liter of water will hold a little more than a quart of the same liquid. Since the liter has a length, breadth, and thickness of one decimeter, it contains 1,000 cubic centimeters.

$\frac{1}{40\,000\,000}$ of an entire meridian of the earth. There is only one meter in the world. It is the length of a certain bar of platinum, kept in Paris, and measured at the temperature of melting ice. Most copies of the meter and yard are accurate enough for the purposes to which they are applied.

FIG. 1.



Comparison of Metric and English Measures of Length.

2. Impenetrability is the property of so occupying space as to exclude all other matter.* No two bodies can occupy the same space at the same time. A book lies upon the table before me; no human power is able to place another in the same spot, until the first book

* In common language, we say a needle penetrates cloth, a nail enters wood, etc.; but a moment's examination shows that they merely push aside the fibers of the cloth or wood, and so press them closer together. With care we can drop a quarter of a pound of shingle-nails into a tumbler brimful of water, without causing it to overflow. The surface of the water, however, becomes convex.