INTRODUCTORY BOOK OF THE SCIENCES, ADAPTED FOR THE USE OF SCHOOLS AND PRIVATE STUDENTS. IN TWO PARTS. PART I. - PHYSICAL SCIENCES. PART II. - NATURAL SCIENCES

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JAMES NICOL

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THE USE OF SCHOOLS AND PRIVATE STUDENTS.

In Two Parts.

PART I.—PHYSICAL SCIENCES.

PART II.—NATURAL SCIENCES.

BY JAMES NICOL.

ILLUSTRATED BY ONE HUNDRED AND FIVE ENGRAVINGS ON WOOD.

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PREFACE.

The utility and importance of Physical and Natural Science as branches of general education are now almost universally recognised. Some acquaintance with their more general laws and common facts is admitted to be not only useful, but even necessary, to persons of all professions and in every sphere of life. The design of the following Treatise is to furnish a short yet connected and comprehensive view of these departments of knowledge, which may serve as an introduction to a more extended study, either of the whole or of particular portions. The Work is divided into Two Parts,—the first of which, on the Physical Sciences, contains a view of the more important laws of the material universe, with a few of their more remarkable applications, whether to works of art or to the explanation of natural phenomena. In the Second Part will be found a sketch of the history of nature in the three great kingdoms of Minerals—comprising of course the land, water, and atmosphere—of Plants, and of Animals; concluding with Man, the head of the earthly creation.

From its limited nature, the Work is very much condensed, and some important subjects are, on account of their abstruseness and difficulty, altogether omitted. It is hoped, however, that it contains enough to show the student the richness of the fields here laid open to him, the attractive nature of many of the subjects treated, and the great advantages to be derived from an acquaintance with them. Even to the more advanced such a recapitulation may not be without use; whilst the very numerous Engravings by which every part of it is illustrated, will materially aid those who are entering on the study of these important sciences.

Edinburgh, *January* 1844.

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INTRODUCTORY BOOK OF THE SCIENCES.

PART I.

Physical Sciences.

Section I.—GENERAL PROPERTIES OF MATTER.

By Matter we understand that substance which composes the various objects that surround us in nature, and which we observe by means of our senses. It is through affecting these,—that is, by acting on our organs of sight, touch, taste, smell, or hearing,—that matter is made known to us; and its properties are only another name for its power of exciting various sensations in our minds. Some of the properties of matter have been thought necessary to its very existence, and have on this account been named essential or primary properties; whilst others, which might be changed or altered without destroying the body, have been termed secondary. The former are principally extension, figure, impenetrability, divisibility, and power of motion; the latter, colour, heat, and some other such qualities; but the distinction is not one of much consequence, especially in physical science. Extension is that property of matter by which it fills a portion of space; and as a body cannot do this without excluding every other, it is said to possess Impenetrability. It is in consequence of this that one body can rest on another without sinking into it; or when we press two together, that they are not lost in each other, however great the force we may employ. When a vessel is full of water, if we push a piece of wood, or drop a stone into it, as much water must run over as is equal in size to the wood or the stone. The water that fills it must also have displaced the air it formerly contained, and could not enter till this was done. Hence, when a glass is forced under water with its mouth downwards, the air it contains prevents the water from rising and filling the glass, which it does whenever it is placed in such a position that the air can escape. The Divisibility of matter is the possibility of cutting or dividing it into many parts; and as we cannot conceive of any portion of matter so small that it might not be divided, it is common to say that matter is infinitely divisible, or may be separated into as many parts as we choose. Properly speaking, however, the

division is always finite; and it is thought probable that in reality there are certain limits beyond which matter cannot be divided. It then forms bodies named atoms, from a Greek word meaning fine indivisible particles; but these cannot be seen by our eyes, even when aided by the microscope; and we can always imagine something smaller than the minutest portion of matter we behold. A few examples will show how far bodies have actually been divided. Common writing-paper is only one-250th part of an inch thick, and goldbeater's skin is six times thinner, whilst gold itself may be beat out till one grain covers fifty square inches; and it would take nearly three hundred thousand leaves, laid above each other, to have the thickness of an inch. The gold wire used for embroidery is silver covered with gold, which is only the four or five millionth part of an inch thick. In nature, matter is also very minutely divided. The finest human hair is about one-600th of an inch in diameter; the thread of the silkworm is ten times finer; and that of some spiders only the 30,000th of an inch. Some animals are so small as to be invisible by the naked eye; yet with a powerful microscope we can see that they have various organs and vessels, in which, as in our veins, fluids circulate; and when they are placed in water coloured with carmine, the grains of this substance which they swallow may be seen in their stomachs, necessarily reduced to exceedingly minute particles.

Porosity is also a general property of matter, or rather of bodies as we find them in nature. The particles of matter seem to adhere to each other without being in actual contact, at least in all their parts; and hence vacant spaces or pores are left among them. In solid bodies, such as wood and stone, these pores are often filled with air, water, or other fluids; and their existence may be shown in various ways. Thus, a stream of air or mercury may be forced through a piece of dry wood, the mercury falling in a fine shower. A lump of marble or granite when placed in water under a receiver, gives out a large quantity of air when that above it is exhausted. Mercury by a slight pressure may, in like manner, be forced through a piece of leather; and the human skin is also perforated with numerous pores. The Contraction and Expansion of bodies, or their capacity of increasing and diminishing in bulk, also shows the existence of pores or vacant spaces among the particles of which they consist. Thus, air may be reduced by pressure, as in the chamber of an air-gun, to a fiftieth or eightieth part of its original bulk; while, on the other hand, in the receiver of an air-pump it expands in far more than these proportions. Water also contracts and expands by pressure, though in a degree many thousand times less than air. Solid bodies also are influenced in the same

way, and diminish in bulk by means of pressure. Some are more easily affected than others, and are named soft; others require greater force to make any sensible impression on them, and are therefore termed hard; whilst those which recover their original form when the pressure is removed are said to be elastic. Bodies, we have above said, consist of numerous small particles or atoms, and among these numerous vacant spaces occur. How, then, it may be asked, are these united, and what prevents them from falling asunder like a handful of dry sand? It might seem that if no external force kept them united, they should all separate from each other even by their mere weight. Such, we all know, is not the case; and as it is no external force that keeps them in union, it must be some internal one. This has been named COHESION; and the particles are said to cohere to each other. Each particle of matter seems to be attracted towards every other, like filings of iron to a magnet or loadstone, and through this property all coalesce into one mass. That this power may act, however, it is necessary that the particles be brought very close together. Hence, two pieces of lead when merely laid on each other do not adhere, but if firmly pressed together can with difficulty be separated. Two pieces of iron also when heated and hammered are brought into close contact, and then cohere or are welded together. Many substances when broken into fine powder, however we may press them, cannot be brought so near as to re-unite; but when melted this happens, and they again form a solid mass. Heat seems to prevent bodies from contracting into the smallest possible space, and to repel their particles from each other, as shall be afterwards explained.

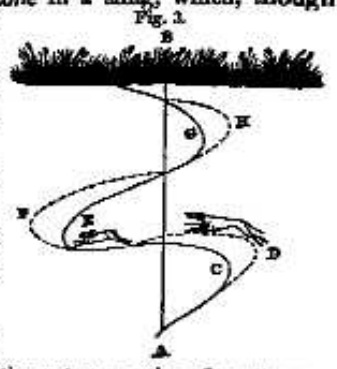
INERTIA is that property of matter in consequence of which it is incapable of changing its state, whether of motion or rest. A body when moving cannot stop itself or change its motion, but, unless acted on by some other body from without, would go on moving in the same direction and with the same speed for ever: neither, if at rest, can it begin to move of itself, but requires some external force to set it in motion. Hence no one expects that a stone lying on the ground or a book on the table will begin to stir of its own accord. We are, however, apt to imagine, that an inanimate body when in motion would stop of itself; but this is incorrect, for it is only the obstacles it meets with that cause the ball rolled along the ground to stop, or the stone thrown from the hand to come to the earth. Hence, the fewer impediments, or the smoother the ground, the farther will the ball roll. This property also makes a body take some time before it can be put in motion, or have its motion stopped or changed. Thus, the pieces of money represented in Figs. 1 and 2, as resting on a card and

Fig. 1.

Fig. 2.

a thin slip of wood, do not yield to the motion communicated by a smart blow at one end to the card or the wood, but remain on the finger, or fall into the glasses. Hence, a person in a carriage suddenly stopped is thrown forward, or if riding fast is pitched from his seat. A body in motion also tends to move in a straight line, as a stone in a sling, which, though whirled round in a circle, flies off in a direct course whenever it is allowed to escape. A hare also often makes its escape by taking sudden turns in a new direction for which its pursuer is not prepared. Thus, as shown in Fig. 3, in running to the cover B, the hare takes the direction A C E G, while the dog is obliged to follow that of A D F H.

Fig. 3.



The power of being moved, or *Mobility*, and the possession of *Weight*, are often termed contingent properties of matter, as they do not necessarily form part of our notion of it. All bodies, however, that we find on the earth have these two properties. The ponderability, gravity, or weight of bodies, depends on the power which the earth has of attracting or drawing them towards itself. That some bodies are heavier than others results from there being more matter in them than in those that are light. Weight depends on the attraction of the earth, and varies with the distance from its centre, as is shown by many experiments. A piece of lead of a thousand pounds weight on the surface of the earth would lose two pounds when carried to the top of a hill four miles high, and one pound if taken as deep into the interior of the earth, there being then less matter below to draw it downwards. If removed from Edinburgh to the Pole,