THE NATURALISTIC APPROACH TO NATURAL SCIENCE THROUGH MOTION AND MATTER

THE most fundamental questions which are raised in modern science are concerned with matter and energy, which are said to be different aspects of the same reality. This reality is described in terms of particles and waves, and there is good experimental evidence for both. Particles can be recognized by their tracks in a photographic emulsion or in a cloud chamber, and they can be recorded with a Geiger counter. Diffraction and interference phenomena serve for the study of the continuous field or wave character of matter, which is manifested not only by light but also by electrons, neutrons and protons. Thus particles appear as waves and waves as particles: the two seem inseparable. Yet the difficulty of combining these two aspects of things in a unified picture is so great that it has been called the main stumbling block which prevents the formation of a stable and certain concept of matter.

It has been suggested that the particles may be more or less temporary entities within the wave field whose form and behavior are determined by the laws of the waves themselves, which in certain cases permit waves to appear as if they were permanent substantial beings. Or perhaps the wave field is merely a device for computing the probability of finding a particle of given properties at a given position. At any rate most theoreticians will probably admit that the individual particle is not a well-defined and permanent entity whose identity or sameness can be detected experimentally. In a word, the modern analysis of matter leaves us uncertain whether the world is a system of waves or particles or both. The only thing which seems certain is that there are no well-defined and permanent entities.

This picture of physical reality may at first seem very dis-

concerting and quite opposed to ordinary ways of thinking. For reassurance we may take hasty refuge in the common view that nothing is certain in science, nothing final. New data will surely be uncovered, and new principles will be formulated. After all, science gives us only a tentative and partial view which is always subject to revision and revaluation. But the hypotheses of science are not opposed to previous valid findings. On the contrary, agreement with the data of experience is what validates a scientific principle. When new data exceed the limits of former principles, new hypotheses must be formulated which include as special cases the facts and correlations already established.

The primary datum of our sensory experience is the fact of change in the world around us and in us. When we realize that we ourselves were born and will die; that we came into being and will cease to be in this world at least; that not only organisms of all kinds but also the chemical compounds are generated and corrupted, why is it surprising to be told by modern scientists that even the chemical atoms and the elementary particles of which they are composed are not permanent entities but transitory things? Perhaps it is because we had become accustomed to think of the atoms as indestructible building blocks out of which all bodies are made.

Perhaps there is also a deeper reason for wonder. If everything is changing, how can there be anything even relatively permanent in the world? What are air and water, rocks and trees, animals and men? How can there even be change? Can there be a wave without something waving? How can anything come to be and cease to be in this world? To these questions there is no certain answer in modern science. Yet these are the very questions which the primary data of experience raise in our minds. If we desire a fundamental understanding of natural things we must account for change. We must explain in terms of its own proper principles what a changeable thing is and how it comes into being and ceases to be.

It is not customary in modern science to look for basic prin-

ciples. Often we are told by philosophers of science and scientific methodology that there are no principles which are certainly first, and no universal or necessary truths. Of course those who say these things do not hold that it is possible to affirm and deny the same thing at the same time, or that something can both be and not be at once and under the same aspect. They do not mean to deny that the world around us is a source of our nourishment both physical and mental, or that from it we draw the air which we breathe and the food which we eat, and from it in a mysterious way we draw also our knowledge of things. It is obvious that our life and our happiness depend upon our valid knowledge of the world around us and within us. What they mean is that we do not know any first or basic principles by which we can understand natural things in a scientific way, by which we can judge of them with certitude and organize all our knowledge of them in an orderly way.

At the present time many scientists also are convinced that we cannot attain any initial or final certitudes about natural things. We must take them as given with all their marvelous complexity and variety, but we cannot hope to determine what they are in their inner essence or nature. The principles which are admitted and employed in scientific reasoning are tentative and subject to revision and reformulation. The conclusions which are derived from these principles are verified only approximately. They are not universal and necessary consequences from certain basic truths, but more or less probable consequences from principles which are convenient, useful or fruitful but not strictly first or certain.

Many are the attempts which have been made to understand and explain the world around us and within us. The child asks, What is the sun or the moon? What is the firefly? How and why do they shine or not shine? The scientist realizes that it is difficult to answer such questions. He sees that every natural thing is beautifully and wonderfully made. He sees an endless variety and complexity of natural things which are distinct from one another and which pursue their own objectives more

or less independently of one another, or interdependently. He sees that from their complex relations a certain order results which is beautiful, vast and mysterious. He well knows that in order to succeed in understanding the natural world we must find some way to simplify the wealth of experience. We must discover a way of knowing the whole through its parts, and a method of comparing the less known with the better known, if we desire to attain an objectively warranted, accurate and systematic understanding or explanation of the world around us and within us.

So great is the complexity of things that the very effort toward objectivity and accuracy imposes a need for simplification. This need has been met by scientists in various ways. Some have tried to construct in mind or matter a mechanical model which will illustrate the structure and behavior of natural things, and which will enable us to understand things as if they were like our device or contrivance. Others have sought to interpret natural things in a more refined way by means of mathematical models which transcend sense and even imagination, but which enable us to correlate vast amounts of measurable data and to infer consequences which agree well with experience.

These explanations of natural things by means of mechanical and mathematical models have both advantages and limitations. They do indeed help us to understand the complex and mysterious workings of natural things in terms of something simpler and more familiar, or at least more intelligible. They help us to correlate observable and measurable phenomena, to infer many valid consequences, and to discover new correlations and consequences. In these respects they are powerful instruments for the analysis of natural things and for the control of natural processes.

But these methods of interpretation also have definite disadvantages. In the first place they do not explain things by their own proper principles, but employ extrinsic and very different principles of interpretation. They do not manifest

what a thing is in itself but compare it to something else quite diverse. They explain the natural thing as if it were like the mechanical or mathematical model, and tend to reduce the intricate object to something simpler but dissimilar.

In the second place they are confined to the observable and measurable as such, and do not manifest the natures of things. They do not give us a fundamental understanding of natural things and processes, or tell us the essential reasons of things. The natural and the artificial, the non-living and the living are explained in the very same way without regard for their essential differences.

In spite of these shortcomings it is undeniable that modern methods are both useful and fruitful, and it is not our purpose here to minimize their value or to suggest anything to supplant them. But it is fair to ask whether there is any other way by which the mysteries of nature can be investigated and rendered more intelligible. Is there a way to strengthen the foundations of science and to supplement its deficiencies? Is there a method by which the proper principles of things can be discovered? Can the natures of things be manifested; and the essential reasons and differences of things be explained? Can we determine the first principles and causes of natural things, and establish a body of conclusions which are invariant, universal and necessary? In a word, can we develop an understanding of natural things which is not merely hypothetical and tentative but genuinely demonstrative?

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In the long history of natural science there is a method which has been employed to reveal true and certain principles from which strict demonstrations and genuine scientific knowledge can be attained. This method, of course, is not foolproof, but subject to human understanding and misunderstanding. But if rightly understood and used, it can perhaps supply the solid foundation which is admittedly lacking in modern science.

This method begins with the investigation of first principles, because we are satisfied that we understand particular things

when we see them in the light of first principles. Besides the most general and common first principles or axioms which are required for any and all progress in knowledge, there are the basic and proper principles of each subject of scientific investigation. To know a thing scientifically in the strict sense of the term means to know it perfectly as man can know. We know a thing perfectly when we know the proper reasons or causes of its being or being so, because a thing is what its causes or reasons of being determine it to be. The basic principles of each subject of scientific investigation are understood as proper causes of the subject itself. Hence in order to develop a science of a certain subject we must first determine its basic principles. Then we must determine its essential reasons or causes and the relation of these to the basic principles. Finally we must understand the causes or reasons in orderly relation to their effects or consequences. We must organize our knowledge so as to explain each effect by its proper cause, and see each essential reason or cause as a middle term from which an invariant and necessary conclusion results. Thus the whole effort of scientific investigation is a search for essential reasons or causes whose formulae or definitions can be employed as middle terms in the demonstrations of the science.

Causes which are near to sensory experience are more evident and better known to us than causes which are remote from our experience. Moreover, although the particular is directly sensible, it is the invariant or universal which is directly intelligible. Hence we must begin our investigation of causes with the general consideration of sensory and corporeal things. This is fitting because our knowledge is at first confused and general, and does not attain specific details without special effort. Hence we can conveniently simplify our consideration of things by proceeding from the general to the specific. Furthermore, we must consider first that which is fundamental in things and on which all else depends in order to be and to be understood.

Can these general rules of scientific procedure be applied in

the study of natural things so as to develop a genuine science of nature? Is a strictly demonstrative science of natural things possible, or can we attain only probable and approximate knowledge of these things? It must be admitted that there are serious difficulties that stand in the way. Natural things do not seem to be suitable subjects for science in the strict sense. They are particulars, whereas science is of the invariant and universal: they are mobile and contingent, whereas science is of the necessary. Do natural things have first principles which are basic and proper and on which we can establish all our scientific knowledge of them? How can we determine the natures of things which are manifested to us only by sensory phenomena? How can we discover the causes of things so mysterious? Is there any necessity in things so variable and unpredictable? These are questions which must be answered if we hope to develop a genuine natural science.

Let us see whether we can determine the basic principles which are proper to all sensory things. We shall proceed in the light of that which is first and best known to us about the sensory world. If we consider it as known by touch, we find it pressing upon us or resisting us. It heats or cools us; it acts upon the tongue and we taste its flavor; it acts in our nostrils and we smell its odor; we hear its sounds, and see color and shape, figure and movement. All these are particular sensory aspects of the world around us. We are aware also of the self, of our activities and our unity. If we generalize these sensory experiences we realize that the world is presented to us as something which is changing sensibly: something which is subject to sensory change. It is something which is not static but dynamic: something which is not purely intelligible but both sensory and intelligible. Furthermore, it is not simply one thing, but many. There are the self and others. There are many primary units with various operations and modifications. There is an orderly system or world composed of multitudes of primary units of different kinds complexly interrelated, each moving itself or being moved in various ways and subject to manifold change.

It is then a mobile or changing world which is presented to us and of which we are a part, a system of mobile things both living and non-living, intelligent and non-intelligent. Do mobile things as such have principles which are basic and proper to themselves? A careful analysis of what is presented to us in our sensory experience reveals that a mobile thing is not simple but complex. It has various sensory qualities according to which it is changable: color, sound, odor, etc. It has a where in place and a when in time. It has measurable aspects, magnitude and figure. It has motions or activities, and principles of motion. A mobile being is something which can come into being and cease to be, either simply as a primary unit—a compound or organism—is generated and corrupted, or in some secondary respect such as color or figure.

The newly generated organism or compound is a primary unit which previously did not exist. But things are not made from nothing in the course of nature, nor do they pass into nothing. Nor are they intrinsically made and constituted from something which was and remains actual, because whatever is actual already exists and cannot be made. Besides the actual there is a real medium which is the inner subject of change. This subject of change is potential, a real potency, something capable of receiving a new determination called a form and becoming actualized by it, or of being deprived of a form. The potential subject as such is not directly observable, but inasmuch as it is actual in other respects, or in sensory motion or transition from potency to actuality, it is observable. The stone which can be moved from place to place can be apprehended by sight or touch. Modern theories tend to describe things as if they were entirely actual, and do not acknowledge the potential as such. Yet the potential subject of change is required in order that a mobile being might become actual or cease to be actual, yet not be made from nothing or turn into nothing. Thus the basic and proper principles of mobile things as such are the potential subject and the form. Every mobile being inasmuch as it is one, whether a primary unit or something secondary, is made of and consists of a potential subject and a form.

The primary units, living or non-living, are subjects of secondary modifications or forms according to which superficial changes occur. Water can be heated; metals can be moulded; gases can be condensed or rarefied. But the fundamental subject from which a primary unit is made or generated, and into which it becomes corrupted, is a purely potential principle. Of course, a purely potential principle can neither be nor be conceived apart from all determination or form. Whatever is or can be conceived is determined in one way or another. The potential is known only in relation to the actual, as something which can be determined or actualized. It is the mobile as such which requires both a potential and an actual principle in order to become and to be, and it is motion or change which more or less directly reveals the potential subject. The generation and decay of primary units, such as organisms and compounds, requires a purely potential subject from which they are generated and into which they become corrupted.

A genuinely new primary unit, which previously did not exist actually, is generated from a purely potential subject. It is generated from something, not from nothing; from something which is not itself formal or actual, because what already is cannot be made; from something which is indifferent and capable of becoming and being this or that, because all kinds of things are freshly made, although in a certain order and in various ways. Consequently, the primary form in a mobile being is the first and fundamental actuality from which the new unit is composed and constituted. The primary subject which is a purely potential always has an appropriate fundamental or substantial form by which it is actualized. Nor is the first subject ever without some fundamental form, even when fundamental or substantial change takes place, because the generation of the new is the corruption of the old: a new form is actualized in the primary subject by an appropriate agent and the old form ceases to be actual. When some water is generated, the hydrogen and oxygen as such cease to be.

It is generally admitted today that the actually existing

individual, whether wave, particle or organism, is not permanent in this world. The world endures because the primary subject of change which is purely potential, which is in all sensory things and from which all are made, cannot be corrupted, but acquires a new form with the passing of the old and is itself indifferent to all. This account goes to the roots of the matter and explains what a mobile being is through its first, basic and proper principles.

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These principles, the subject and the form, are common to everything which is capable of sensory change, whether natural or not. But in natural science we are interested only in natural things with their properties, and so we must determine the principles which are basic and proper to natural things as such. In a word, we must determine what nature is, or what is meant by the nature of a thing, because a thing is said to be natural because of its connection with nature.

Certain things have a nature and are made by nature, whereas other things are not made by nature but by human art, or by chance or violence, and such things lack a nature. Shoes and hats are made by art, and they do not have a nature, save inasmuch as the materials from which they were made are natural and have a nature. The chemical elements and compounds, the plants and animals are made by nature and have their natures. These things manifestly have in themselves the primary and proper principles of their characteristic or typical appearance and behavior. Each of the natural types has its proper structure and functions by which it is characterized and distinguished from all others, as we see, for example, in the periodic table of the elements. But artificial things such as chairs and tables, and things which are not primary units but aggregates, whether heaped together or fastened together from without, do not have in themselves a primary and proper principle of motion.

We see that natural things which have a nature differ from things which are not natural and which do not have a nature,

and they differ by reason of the principle of motion which they have in themselves. The nature of a thing, then, is an intrinsic and special principle of motion, something which is in the thing in which characteristic motion is found as a source of that motion. It is something primary or basic, and proper or specific. It is an inner, primary and special source of the behavior which is characteristic of each type of primary unit, of the horse or dog, of the element or compound. Each primary unit is distinct from all others, and although it does not function in complete independence of others, still it has in itself the primary and proper principles of its own typical behavior. Only a primary unit, an element or compound, a plant or animal, has a nature. That which proceeds from a nature as its intrinsic and proper principle is natural. The primary unit itself and also its typical structure and behavior are natural. The barking of a dog, the motion of a falling stone (supposing that this is a primary unit) and the growth and structure of an oak are natural: they proceed from the natures of these things. The motion of a hammer or saw is not natural: it does not proceed from a principle of motion in the hammer or saw, but from the artisan.

Natural beings have typical passivities as well as activities. Each is generated from its own proper subject, which is a primary and purely potential principle. This principle is derived from primary elements or compounds. Each natural being has its own specific determinant, which is the primary or substantial form. This principle is an actual or formal nature. The formal nature in living things is active, and is the source of vital movement by which organisms move and perfect themselves. These two principles, the primary subject or material nature and the form, are proportioned to each other as a specially disposed potency to its proper act. The matter is differently disposed according to quantity, density, etc., and the form is different in the different natural types. The primary matter and form together constitute the complete nature of each type, as in iron or gold, the oak or the lion.

Artificial things do not have a nature, either material or formal. They are not themselves primary units, but modifications of such units, or compositions of many. Their forms are not primary but secondary, as a chair has a secondary form or modification in wood or metal, and a knife has a secondary form in iron or bronze. There is no principle of motion in something artificial, but at most a coordination of natural agents, as in an automobile. The artifact is not made by nature but by human art, nor is it made from a specially disposed primary subject, but from various secondary subjects, as a garment may be made from cotton or wool. In this case the cotton or wool are in the garment which is made, and the change is not fundamental or substantial. But when a compound is generated in the course of nature, the elements do not remain as such but are modified by the reaction and are changed into something new and different, with a different nature.

Human art cannot make a nature, or something with a nature. Man can indeed mix and apply natural agents, but when something with a new nature is produced it is made by the natural agents, not by any man. A sign of this truth is the fact that no man knows exactly how a thing with a nature is made. The production of the so-called synthetic elements and compounds is not proximately due to human art or human action, but to the action of the natural reagents which specially dispose the matter for the new form.

The natures of things are the principles or sources of sensory characteristics and so they can be known through experience. The typical structure and behavior of natural things is rooted in their natures, and the natures themselves can be defined by their typical manifestations. They are the primary or substantial principles which are the sources of the characteristic stability and regularity, uniformity and difference which we observe in natural things. Hence in natural science we can and should determine the natures of things by accurate observation and experiment. We can define the natures through their typical and proper manifestations, and we can explain the typical behavior of things through their natures.

In this respect natural science differs profoundly from mathematics. Natural science is a consideration of the whole naturally mobile being with its basic principles of motion, or nature both material and formal, and with its characteristic structure and behavior. In mathematics we do not consider the mobile being as such, but we consider something having quantitative determinations and relations which can be understood and demonstrated through the principles of quantity, such as points, lines and units. Mathematical principles do not directly manifest the natures of things.

Yet because natural things have quantitative aspects and because the quantitative regularities of natural things do manifest the natures, mathematics is applicable to natural things. Indeed they are useful and even necessary instruments for the perfection of natural science. Modern mathematics is specially adapted for these applications, and modern physics is characterized by its use of mathematics. Physics of this type does not proceed in terms of the principles of motion, of matter and form or nature, but in terms of mathematical principles applied to physical quantities. Hence modern physics is a mixed science which differs both from pure mathematics and from natural science.

Many well-known physicists at the present time recognize the need to complement mathematical and mechanical formulations and techniques with a genuinely physical picture of reality which will at the same time be not merely naive but scientific. Perhaps the authentic method of the Aristotelian tradition when applied in natural science will furnish the foundation for which they are looking, and will enable them to integrate the various parts of our expanding knowledge of the world in an orderly family of sciences.

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