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Does Natural Science Attain Nature or Only the Phenomena?

Pessimism About Science

WHAT ARE scientists today trying to do? Neither the scientists themselves, for philosophers of science agree on an answer. The main views are three:

1. The scientist seeks to describe the world by a mathematical theory which summarizes the phenomena and predicts new facts to be verified. This is the *positivist* view of science.[1]
2. The scientist seeks to create a picture of the world which is meaningful to man yet consistent with the phenomena and which presumably approximates ever more closely to the hidden noumena. This is the *idealist* view of science.[2]
3. The scientist seeks to achieve insight by means of sensible phenomena into the natures of material things as they really are in themselves and in relation to each other.[3]

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[1] For an example *see* P. Frank, *Modern Science and its Philosophy,* (Cambridge, Mass., 1950).

[2] For an example *see* H. Margenau, *The Nature of Physical Reality* (New York, 1929), or A. Eddington, *The Nature of the Physical World,* (New York, 1929).

[3] For an example *see* V. Smith, *The General Science of Nature* (Milwaukee, 1959).

Formerly this last view was taken by Thomists but is commonly abandoned now by them because many believe that this is one element in the Thomistic synthesis which in the light of contemporary knowledge must be regarded as obsolete.

If the facts require us to abandon this view, let us do so cheerfully. Yet, to anyone who has a deep admiration of the material world and of men who dedicate themselves to its patient study, the abandonment of this ancient view which inspired the Greeks who first undertook this study, and so many of the great minds who followed them, must seem a desperate one.[4]

For it is plain that this third view is the most favorable to the high value of the scientific endeavor. It attributes to science the power to break through the surface of phenomena, to dispense eventually with mere hypothesis, and to arrive at the inner reality of natural things as they exist and develop in their own right. It claims for natural science (not uniquely, but truly) the ancient and honorable title of a philosophy, a genuine wisdom whose value is not mere utility, but contemplative delight.

In our bitter age, however, it will seem to many a dangerous claim which can only encourage that arrogance of scientists which has already led many of them to throw off the control of a higher wisdom and to bring our world close to insanity and destruction. To others this view will seem naively medieval in its simple optimism, an attempt to go backward to a day when the discovery of truth seemed a very straight-forward enterprise, before the Copernican revolution and a dozen other scientific revolutions had proved that every scientific theory is only tentative and shortlived.

Nevertheless, I personally would prefer this view as more honorable to science and to the dignity of man endowed by God with an intelligence whose proper object is material things, if it can be reasonably maintained. As far as I can make out, there are only two basic objections which have led to its abandonment by so many Thomists.

One is the historical objection just referred to: the history of science shows that every scientific theory is merely tentative, and that if any theory is taught as certain it becomes a fatal block to scientific progress. Here I

[4] Of course even among the Greeks the Platonists doubted the possibility of a true science of the changing world, but in this matter Galileo, Harvey, and Newton were rather followers of the peripatetic tradition, for they did not doubt that it is possible to have a certain and definite knowledge of particular questions about nature, and they rejected the view that natural science is a mere "saving of the phenomena."

will not discuss this objection, although I am convinced it is very bad history.[5]

The other difficulty is more significant because doctrinal. It may be put as follows: Essential definitions which are immediately evident and certain are the necessary premises of any truly philosophical science.[6] But the human intelligence is unable to arrive at the definition of any species of natural thing except man, and attains only to the broadest genera such as element, compound, plant and animal.[7] Hence, we are not able to have a truly philosophical natural science extending to the details of the natural world.

This argument is proposed in one form or another by philosophers associated with the University of Louvain such as the late Fernand Renoirte and Fernand Van Steenberghen, by Jacques Maritain and followers like Yves Simon and George Klubertanz, S.J., and by Charles De Koninck and Emil Simard of the University of Laval.[8] If their view is not valid there seems no serious doctrinal reason to abandon the classical position, and every reason to retain it as more favorable to the dignity of natural science. I do not see how the rapprochement of Thomism with modern thought is served by minimizing the value of natural science.

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[5] One of the reasons that it is bad history is that it fails to take into account the fact that in every age the critical minded have distinguished between what they knew with certitude and what they thought was probable. The scientific "revolutions" have overthrown theories which were previously accepted as probable, but not as certain. Scientific progress, moreover, has not only been blocked by persons who held as certain what was really only hypothetical, but also by persons who were content to accept the hypothetical as the best that can be hoped for. Intellectual history is not only a struggle against blind dogmatism, but also against a lazy probabilism. The medievals were slow to advance astronomy not because they thought the Ptolemaic system was certainly true (they were very doubtful that it was), but because they were influenced by the Platonic notion that the human mind can never find certitudes in the world of sense.

[6] Aristotle, *Post. Anal.*, II, c.3, 90a35 ff.

[7] J. Maritain, *The Degrees of Knowledge*, transl. G. Phelan (New York, 1959), pp. 206 ff. The most extreme form of this position is found in M. Adler, *The Problem of Species* (New York, 1940).

[8] *See* F. Renoirte, *Cosmology*: *Elements of a Critique of the Sciences and Cosmology*, transl. J. Coffey (New York, 1950). F. Van Steenburghen, "Refléxions sur la systematisation philosophique", *Revue néoscolastique de philosophie*, XLI (1938) 185-216. J. Maritain, *op. cit.*, pp. 21-21, 136-201 and *Philosophy of Nature* transl. I. Byrne (New York, 1951). G. Klubertanz, S.J., *The Philosophy of Human Nature* (New York, 1953) pp. 395 ff. C. De Koninck, "Natural Science as Philosophy," *Culture* (1959); E. Simard, *La nature et la portée de la méthode scientifique*, (Quebec, 1956). *See also* A. Van Melsen, *The Philosophy of Nature* (Pittsburgh, 1953), who holds that the philosophy of nature is in the third degree of abstraction.

Seeking Natural Units

There is no doubt that the contemporary natural scientist is concerned with observing changes and permanences in phenomena. Furthermore, he is concerned with detecting regularly repeated changes and characteristic stabilities. The very great importance of measurement and statistics in science arises from this interest in detecting uniformities.

Does the scientist attempt to find an intrinsic principle which explains these phenomenal uniformities? There is at least one question which he very earnestly asks and tries to settle by his characteristic methods and which requires a penetration of the phenomena. This is the problem of the discovery of *natural units*. By "unit" here I do not mean merely a unit of measurement (although natural units do provide such units of measurement in many cases), but the unit involved in the processes of change or stability.

If "nature" means the whole material universe, then the hope for scientific understanding becomes very remote. If to understand anything we must understand all, then science is impossible. If, however, as is obvious enough, this world is not one single "nature," but many individuals varied in nature and forming distinct and relatively independent centers of activity, then the problem of scientific understanding is worth tackling. We may hope to arrive at some essential knowledge of this or that kind of thing, even if the whole escapes us. The history of science makes clear that scientific progress requires piece-meal procedures.[9]

Of course it is also obvious that there is some general order in the world, some balance of opposing forces, but this is a unity of order among many distinct individual things, which are the primary realities. The existence of so much that is random, and the coincidence of unrelated processes which we call chance in nature, is striking evidence that the world is made up of individual units each pursuing its own way and jostling its neighbors from time to time. To understand such order as the universe has in the large, we must begin with the study of these units of which the universe is only a collection.

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[9] This is perhaps the most significant fact of the great progress in science in the 17th century. Biology, chemistry, and physics each advanced by the study of particular problems whose objects were easily accessible for observation and experimentation. Scholastic thought was in this respect excessively systematic, exhausting its efforts on certain very general and very obscure problems like that of the *impetus*. This is not to say that science can progress without careful attention to general problems, but difficulties about general problems often are cleared up by a detailed study of particular cases when these are more observable.

Often the scientist's initial problem of isolating the units he intends to study is settled quickly and definitively on the level of ordinary unaided observation. It is only a Sunday-supplement notion of the scientific method that supposes a scientist must use a microscope or a telescope to settle every question. What zoologist has any difficulty in determining whether two elephants, or two guinea pigs, or an elephant and a guinea pig are distinct natural units?

Nevertheless, many scientific researches do quickly run into serious problems about the discovery of units. In the case of the lowest plants and animals it is not always easy to be sure that an apparent unit is really an individual or a colony, or perhaps a symbiotic combination of two very different species of things. It is even at times difficult to trace the continuity of an individual through the startling metamorphoses of its life-cycle. Yet the biologist has invented many techniques to solve such questions, for example, the bacteriologist's methods of obtaining pure cultures; and he does not despair of finding an answer for those still unsolved.

The chemist and physicist meet even greater puzzles in dealing with the units of inanimate nature. When we look at the ocean we must ask whether this can really be one immense natural unit spread out before us. When we look at a tiny drop of ocean water we marvel that it too seems to be a unit. What about the salt dissolved in it? Is it there as a true part, or merely as in an imperfect mixture?

In order to seek answers to such questions the scientist first tries to isolate homogeneous or pure substances. By a variety of ingenious techniques chemists are usually able to obtain substances so pure that they can disregard the remaining traces of impurity as accidental and not natural.[10] Once pure substances are isolated then it is possible to know that there are at least two units if they are spatially separated, that is, if there is some other substance (air, glass, etc.) between them.

To go still a step further more refined techniques are necessary in order to determine the smallest part of a pure substance that can exist in separation as a stable unit, what we may call the "minimal unit". This great feat has been accomplished, so that we know that for compounds the molecule, and for elements the atom (or perhaps in some cases the molecule), are such minimal natural units. It is doubtful that the elements can be decomposed into lesser natural units, since it appears that the sub-

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[10] Of course minute impurities may be very important in explaining certain phenomena (color, electrical conductivity, etc.).

atomic particles do not exist stably as isolated units, but tend to reconstitute atoms.[11]

The determination of what we may call the "maximal unit" of a chemical substance has been less explored. While a gas seems to be only an aggregation of independent molecules, in a liquid there is obviously some unity of order at least among these molecules, and in a crystalline solid this order is highly determined. In the addition of an atom or molecule to a crystal, does the minimal unit somehow undergo a modification by which it becomes a true part of a larger natural unit, losing its own individuality? There is no reason to doubt that we can settle questions of this sort by the appropriate experimental techniques, just as we have determined that in a gaseous element like oxygen there are true molecules which can nevertheless be separated into two similar atoms.

Thus it is apparent that scientists in every field are vitally interested in determining natural units, and that they have made astonishing progress in settling this kind of problem by the methods and techniques which unquestionably characterize modern science. Can the resulting knowledge be called "philosophical," that is, does it pass beyond phenomena to the ontological and intelligible reality of nature?

To know that something is a natural unit distinct from other units is possible only to the intelligence. At the level of sensation and perception we can apprehend units, but we cannot recognize them to be such. It is only the intelligence that sees that the regularity of phenomena, of change and stability, is a *sign* of an intrinsic principle, of a natural unit. The senses perceive the phenomenal sign, but only the intelligence can read its meaning. The scientist seeks the natural unit because his intelligence raises this fundamental question for him. He plans his researches so as to answer this question about reality, and he recognizes when he has found the answer, because he has insight into the ontological situation to which the phenomena lead him.

But are the answers which he finds *certain?* Or is he merely guessing? Are these units, like the molecule and the atom for example, only constructs of his mind which stand for units which he knows must exist, but of which he cannot be sure? The answer to this, as any scientist can confirm, is "sometimes but not always." It is simply absurd to deny that two horses in a field or two bacteria in water, are not distinct natural units. I think that if anyone critically but without prejudice examines the

[11] Outside the atom these particles decay or undergo transformations by collisions with other particles. *See* W. Heisenberg, *Physics and Philosophy* (New York, 1958), pp. 159 ff.

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evidence for atoms and molecules, he will come to the same conclusion about them. The only argument that can be offered for this is the evidence itself.[12] On the other hand without question scientists have used many constructs as a guide in investigating these problems, and many particular questions of this sort remain unsolved.

The strongest objection to the point I have been making is the view of some physicists that the universe is one continuous "field."[13] They have the ambition, as daring as that of Descartes, to find a "general field theory" which will express in one formula the basic law of the universe from which all phenomena can be deduced. Yet even if this is possible will it show that the universe is a single unit? That the universe is a *plenum* with no gaps between one unit and another is an ancient view. That all material units are formed out of a common matter, and therefore may have some basic laws in common is also not a novel idea. A "general field theory" would only establish this conception and clarify it. It would cancel the evidence for the existence of primary natural units only if it could show that all changes form a rigidly deterministic system which could be attributed to one single intrinsic principle, and not to the conflict and balance of many independent units. The whole course of modern physics, on the other hand, has been to reaffirm the fact, which is obvious enough at the macroscopic level, that this universe is not rigidly deterministic.

It is important to notice that mechanist-minded scientists sometimes misinterpret the search for the natural unit which is so important a part of the scientific task.[14] They think that there must be some set of ultimate units (e.g. the "atoms" of Democritus) which are the only natural units, and hence they explain all other units only as phenomenal illusions, mere aggregates of the true units. This type of thinking leads biologists to consider an animal as merely an aggregate of cells, and the physicist to consider all things as merely aggregates of atoms, or of subatomic particles.

[12] Renoirte, *op. cit.*, pp. 1-90, summarizes this evidence beautifully, yet proceeds to tell us that between the atomic theory and reality there is a correspondence which can be expressed as follows: "the theory expresses relations which are attached to the essence of schematic things whose behavior will be more and more analogous to that which is observed in existing objects." p.173. Analogy, however, can tell us something of reality.

[13] Of course the notion that the universe is a *plenum* is Aristotelian, but for the peripatetics this plenum was made up of many distinct bodies contiguous with each other.

[14] *See* J.S. Haldane, *The Philosophical Basis of Biology* (New York, 1931), for a very concrete refutation of the value of mechanism as a guiding principle for actual scientific research. He shows that the mechanistic point of view blinds the research scientist to many problems which are scientifically very fertile.

Some philosophers of science do not seem to see that this view is not a scientific fact, but an interpretation of the facts. As such it is at best a *construct,* since I think that no one can claim that there are any facts which certainly show that in an animal the atoms or subatomic particles exist as a mere aggregation. The facts only indicate that they exist there as parts. On the other hand the evidence both at the level of common observation and of refined experimental observation shows, in many cases with certitude, that an animal is a true natural unit in which every part acts in virtue of the whole, and that the molecule and the atom are similar units. In the face of this evidence the mechanistic construct is of little value, except as a naive model, easy to use for purposes of illustration, but demonstrably false.

Thus, at this first level of investigation, that of determining natural units, the scientist must ask questions that require an ontological answer, and is able to supply them by his proper methods and techniques.

Making a Descriptive Definition

Until a scientist has isolated a natural unit he does not know whether he has anything to study. The question "does it exist" is primary, and no scientist would be so foolish as to investigate the merely possible, an essence abstracted from existence.[15] He deals only with what he can observe as really existing or something whose existence can be inferred from its observed effects. True, a scientist often finds it extremely useful to give his imagination free-play in the *preliminary* stages of an investigation, but however brilliant the creations of his fancy they have scientific value only to the degree that they can be reduced to facts. Newton's famous objection to hypotheses meant just this, that a good scientific theory must eliminate the hypothetical.[16]

In isolating a natural unit, a scientist has to examine, compare, contrast, and classify phenomena. By the time he has solved this first

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[15] Thus G. Klubertanz, "Being and God According to Contemporary Scholastics," *Modern Schoolman,* XXXII (1954) 1-17 wishes to contrast the philosophy of nature and metaphysics in this that the former is an "abstract science" because it is reached by abstraction from existence and deals with essences, while metaphysics is not an abstract science but deals with existence. For St. Thomas only mathematics is an abstract science in this sense. Not indeed that the philosophy of nature deals with this universe as an individual existent, but in the sense that it deals with natures that are known to be really existent, abstracting only from their individuality.

[16] *See* his reply to the second letter of Father Pardies (1672) printed in *Isaac Newton's Papers and Letters on Natural Philosophy* ed. I. Cohen, (Cambridge, Mass., 1958) p. 106.

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problem, he already knows a great deal about *what kind* of a unit he has discovered, and it is to this problem of definition that he next turns. Once the unit has been isolated it is a much more handy object for study and observation, and it becomes possible to complete its description in much more detail.

In describing the unit the scientist does not merely catalogue all of his observations in a Baconian manner. He looks for what seems *significant,* those traits that have enabled him to isolate the object, and which now permit him to classify it in various ways. His intelligence tells him that not all the sensible phenomena are equally relevant. Some are significant because they point the way to a *unified* view of the object, while others seem merely incidental.

There is one rule of describing things subject to change which is sometimes neglected by scientists, but carefully observed by the best.[17] It is to begin observation with a *good specimen,* that is with a mature, healthy plant or animal, a normally developed crystal, or stable atom. Not that it is always easy to be sure just what a good specimen is, but by comparing similar individuals, we are eventually able to pick out typical examples. The reason for this rule is that any investigation ought to go from what is more evident to what is less evident, not vice versa. All seeds look pretty much alike, and the easiest way to know what made them different is to let them grow up and compare the mature plants.

In describing the good specimen every scientist tries to analyze its *structure*. This term no doubt has rather mechanical connotations, and may imply in the minds of some the Cartesian notion that material things have only quantitative, not qualitative, characteristics. Nevertheless, we may use the term without committing ourselves on this point. When we try to describe the structure of something, we have to look at two correlative aspects. On the one hand, we describe the thing by telling what parts it is made out of, and what these parts are made out of, and so on until we come to homogeneity. On the other, we have to indicate how these parts are put together to form more complex parts, and so on until we come to the natural unit as a whole. Thus we have to describe both the *composition* and the *organization* of the unit. Because these are correlative

[17] I do not mean to deny the usefulness in observation of the pathological or monstrous specimens which are also enlightening because they show the exaggerated effect of some factor ordinarily kept in balance by an opposing factor. I am also aware that taxonomists today deal rather with *populations* than types, with a range of variation rather than a single ideal specimen, but this does not eliminate the necessity of determining which type is most stable in a given environment.

we cannot describe the one aspect without implying the other. It may be, however, that one aspect is more evident than the other. For example we often can discover the elements which make up a compound, long before we know the structural formula of the molecule.

The structure of a unit, however, is often extremely complex and in large degree hidden from observation. How difficult it is, for example, to get at the organization of the human brain, or the atomic nucleus! Fortunately there is a necessary relation between the dynamic *function* of a thing and its static structure. By observing how a thing is altered by attacking forces we get an idea of its hidden composition, and by observing its activities we get an idea of its hidden organization. A stirring example is provided by genetics. The hidden structure of the chromosomes becomes more and more evident to us as we try to bring about mutations in the materials which compose it, and to observe the varying activities that result. Again we study the atomic nucleus both by bombarding and splitting it, and also by observing its action in preserving the atom as a stable unit.

The most significant activities in the living thing are those by which it grows and attains maturity and the capability of maintaining and reproducing itself. These activities when accurately described cast a most brilliant light on its structure. We see the embryo develop and differentiate, and step by step we see how each stage in this process was required to produce the mature unit, the good specimen with which we started. This is less clear in inanimate things, but here too working back from the stable atom, or compound, or crystal we are able to understand why each step in the process was necessary if the complete unit was to be produced.

The processes of growth and reproduction, or the building up of the atom, molecule, or crystal imply agents of change. Consequently, to complete our description of a thing we must also see what produced it. Again, just as the composition and organization are correlative aspects of the thing which cannot be described separately, so the forces which produce a thing and their end product (sometimes spoken of as "cause and effect") cannot be described separately. We can only understand the agent or force in terms of what it produces, and we cannot understand the product perfectly without seeing the forces and processes required to produce it.

It should now be apparent that, when a scientist attempts a complete description of a thing, he is not looking for mere isolated items, but for related items, and that his description will be a good one in so far as he is careful to consider all these related aspects. I am sure that you have

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been noticing that these questions which a scientist asks in trying to describe something are nothing other than the famous "four causes" of Aristotle. What is called "structure" (with its correlative "composition" and "organization") is the material and formal causes. What is called "function" (with its correlative "agent" and "product") is the efficient and final causes. I am sure I will be accused of "concordism" in making these equations. No doubt there are differences in connotation (I have already indicated the mechanistic overtones of the modern terms), but are not the relations named by these terms the same?

Many scientists, of course, will at once deny that a scientific description could contain any mention of a final cause since they believe that "teleology" is non-observable.[18] They fail to notice that agent and product are correlative, and that commonly the product is more easily observable than the agent. Of course a final cause is not just any kind of product, but it is the product of those natural processes which produce a stable and complete unit, the "good specimen" with which we started our description. We recognize a natural process because it is regular or uniform. This implies that such a process tends to a definite result. Most objections to teleology rest on the idea that since the only force needed to explain the result is that of the original agent, the introduction of another force drawing the process to a goal is unnecessary. Of course it would be, but the goal is not a force; it is the correlate of the force by which it acts from the outset in a definite direction and hence regularly produces a specific result.

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[18] For a more detailed treatment see my article "Research into the Intrinsic Final Causes of Physical Things", *Proceedings of the American Catholic Philosophical Association* (XVI) (1952) 185-197. There is no denying the fact that among contemporary biologists mechanism remains very strong. Writers like Julian Huxley and G. G. Simpson deliberately rule out all considerations of form and finality as anthropomorphic. For them the scientific method is necessarily mechanistic. On the other hand J. S. Haldane and E. S. Russell, R. S. Lillie, and E. W. Sinnott deny that science requires a mechanistic point of view. Perhaps the more common point of view is between these. Many scientists, intellectually aware of the theoretical postulates of their science, see the great usefulness of the mechanistic and materialistic view, but are also convinced that other intuitions may be of value; yet they are anxious not to be identified as "vitalists". For example "We feel no conviction that, for instance, the behaviour of a mass of tissue must be explicable in terms of the properties of its isolated cells. Indeed we hope that investigation of the tissue will reveal new data about the mutual interactions of the cells when aggregated in a mass . . . We must, then, accept the existence of different levels of organization as a fact of nature", C. Waddington. *Organizers and Genes,* (Cambridge, Eng., 1947), pp. 145 ff. *See also* the symposium *Aspects of Form* ed. by L. L. Whyte, (London, 1951).

Some will object that today most scientific descriptions are in terms of measurement and that such descriptions omit everything except the number of parts and their spatial organization; thus structure is reduced to geometry, and function is omitted altogether. This objection would have force if the method of mathematization were the sole method used by science. It is indeed an enormously effective method because it makes possible the discovery of regularities in phenomena, some of them very subtle and hidden. In an indirect way, it can even be used to study the functional aspects of things in terms of the quantitative effects produced by change. But the mathematical method is always used by the scientist as an *instrument,* not as an independent way of understanding nature. Its results must be given a physical interpretation in order to be significant, and in making this physical interpretation the scientist does not limit himself to quantitative descriptions alone.[19]

Can the descriptive definitions of the many-faceted type we have just been analyzing be said to be certain and evident? From the logical point of view they are immediately evident when put in propositional form. This does not mean that they are seen to be true by some simple process of inspection, as Phillip Frank accuses scholastics of asserting.[20] They may be the result of years of patient investigation and extremely complicated experimentation. They are said to be "immediately evident," however, in the sense that they rest not on deductive reasoning, but on direct contact with the facts. They are seen by the scientist to be true not by a reasoning process but by intelligent observation.

As for their certitude this rests on the objectivity of the observations. No descriptive definition is certain in the sense of being certainly *complete*. Further observation may always greatly refine any descriptive definition, but this refinement does not invalidate the objective observations already made. Anatomy, for example, has seen continuous progress in the description of the structure of the human body, and much yet remains to be done. This does not mean that we are going to discover that a man has three legs or two hearts. The old gross description remains valid, except for certain errors of observation which creep in from the influence of subjective factors. The observer records details which he did not really observe but which he "filled in" by conjecture. In order to eliminate subjective factors of this sort science has developed definite

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[19] For St. Thomas Aquinas' conception of mathematico-natural sciences as liberal arts see P. Conway, O.P. and B. Ashley O.P., *The Liberal Arts in St. Thomas Aquinas,* (Washington, D.C., 1959) pp. 29-42.

[20] *Op. cit.,* pp. 251 ff. and 300 ff.

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techniques of confirmation. To conclude, therefore, that because sometimes we make mistakes that we are never certain about what we have observed, is absurd. It is safe to say that science has frequently succeeded in giving well-confirmed descriptive definitions which, as far as they go, are certainly and evidently correct.

Seeing the Nature

Now the crux of the problem: Can the scientist pass from a descriptive definition to a genuine insight into the nature or essence of the natural unit? We can at once eliminate any hope of a scientific understanding of the unit as an *individual.* There have been positivists who have asserted that the aim of science is to write a *history* of the cosmos.[21] Some biologists talk as if the aim of biology is to write the evolutionary biography of individual animals. Some physicists talk as if the aim of physics is to write the biography of an individual particle. Nevertheless, most scientists realize the truth of the old axiom "science is of the universal." Our senses show us individual things, and it is these individuals that we observe and wish to understand, since they are the realities. We are able to understand them, however, not in their unique individuality, but only in a typical fashion.

Limiting our hopes, therefore, to an attempt to understand the natures of things in this typical way, we ask whether even this hope is well-founded. Jacques Maritain has answered in the negative and explained himself by making a famous distinction between *dianoetic* or *ontological intellection* and *perinoetic* or *empiriological intellection.*[22] Dianoetic intellection is that proper to the philosophical understanding of nature and is attained when the human intelligence *through* sensible signs penetrates to the nature or essence. Perinoetic intellection is a knowledge of the nature or essence but only as existing within the sensible signs, not as it is in itself. It is "circumferential knowledge" in which we know that back of the phenomena is some nature which is signified by the sensible phenomena, but a hidden nature. Perinoetic knowledge is a knowledge of the nature not by and *through* the sensible signs, but by and *in* the sensible signs, i.e., it terminates in the signs, not in the nature. Or to put it in still more scholastic terms it is a non-quidditative knowledge of a quiddity.

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[21] *See* C. De Koninck, "Abstraction from Matter, Notes on St. Thomas' Prologue to the *Physics*", *Laval théologique et philosophique,* XIII (1957), 133-197 for the reasons that the philosophy of nature does not deal with individuals as such.

[22] *The Degrees of Knowledge,* pp. 202-210.

It is easy enough to invent distinctions and give them names. This is not the same thing as to show that such distinctions are valid. Just what is this perinoetic intellection? Clearly it is not mere knowledge of the phenomena by the senses, since it is intellection. Just what insight then does the intellect attain? Some have interpreted Maritain as meaning that this intellection contains two elements, the sense data and a *construct* formed by the intelligence which correlates these data. This, however, would land us back in the positivistic position which, as we have seen already, does not do justice to the actual work of scientific thought. Nor is it all that Maritain means. He is insistent that the phenomena are seen by the intelligence to be *signs,* not arbitrary signs but natural signs of the hidden essence which they, so to speak, surround. A sign which does not signify could not be recognized as a sign, hence Maritain tells us that by perinoetic intellection we know that there *is* a nature within the phenomena.

This can only mean that such knowledge is that which we have already described as "the discovery of the natural unit," since if we do not know that the unit exists we do not know that any nature exists within the phenomena. Maritain is insistent that perinoetic knowledge does somehow signify the existing nature precisely because he knows that if it did not somehow attain the ontological reality it could not be intellection at all. Nor could it merely be an insight into the phenomena as phenomena, because Maritain understands very well that it is the very nature of sensible accidents that they have their existence only in a substantial nature without which they cannot be or be understood.

Thus perinoetic knowledge ought to be described as an understanding that a nature exists without knowing what it is. It is the state of mind in which we have answered the question *an sit* but not the question *quid sit.* Now Maritain wishes us to believe that the modern scientist somehow suspends his intellectual inquiry at this point as regards the nature of the thing he studies, and then proceeds to deal with the phenomena as phenomena. Why should the scientist frustrate in this way the natural drive of his mind to understand nature? In fact, as I have shown above, he does not. In fact he cannot, although positivistic prejudices may lead him to disguise the insights which guide him.

He cannot because in the discovery of the natural unit he has already learned a great deal in a descriptive fashion about what kind of a thing he is studying, and he is never at rest for a moment in trying to complete this description. The fact that he knows the natural unit exists makes him all the more anxious to try to see what it is, and once he has isolated it this task becomes easier. When Madam Curie discovered that

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there was a new element called radium and had purified it, she lost no time in making an exhaustive examination of its properties.

Since the knowledge that the unit exists already contains an imperfect knowledge of what it is, the notion of a merely perinoetic intellection is inaccurate. What then are Maritain and his followers talking about? They evidently have in mind the difference between a descriptive definition and an essential definition, and they believe that an essential definition is possible only if we can discover the ultimate specifying characteristic, the *essential difference*.

What is the difference between a descriptive definition and an essential definition? It cannot be a difference as regards material content, for we can never know anything about the nature of sensible things except what we discover in their phenomena, and these are included in the descriptive definition. The difference is not in the content of the definition but in its *order*. The descriptive definition is not a mere list. We have seen that in forming it our intelligence sees that the various items are signs of an existing unit, and that we select those phenomena which seem most significant. Yet this collection of meaningful information remains *confused*. We see that somehow the items of information are related to each other (some have to do with composition, some with organization, some with agencies, some with products) but we do not see clearly what these relations are. Thus the descriptive definition contains a *confused* knowledge of the nature, not merely *that* it is but *what* it is. The whole continued process of scientific investigation is an effort progressively to clarify that confusion.

For complete success in this enterprise it would be necessary to discover some ultimate principle of order by which all the different bits of insight could be fitted into a single picture. This ultimate principle is the *essential difference* (to speak in logical terms) or better the *highest perfection* of the thing's nature. In the case of man we are sure that this highest perfection is his rationality, and this is the clue by which we are able to find relations among many of his other characteristics. Notice that I say "many" not "all," because even for man we do not have a perfect knowledge of just what human rationality is, since we do not know it directly but through signs, through human acts.

We are dealing, therefore, not with an absolute difference between one kind of human knowledge in which is attained a perfectly ordered knowledge of a nature (dianoetic intellection) and another which knows nothing of nature except its existence (perinoetic intellection), but rather with a type of intellection proper to man by which he knows at first confusedly and then more and more clearly as he continues his investigation both the existence of a natural unit and its nature. This will be recognized, I think, by any scientist as the process he goes through in any work of research, moving gradually from a dim intuition that he is dealing with a special type of thing to a clearer and clearer notion of just what makes it special.

The doubt which still may remain, however, is this: can we be said to have an essential knowledge of the thing until we at last reach its specific difference? And is it not true that we know this specific difference only in the case of the human species? To this I would answer that we cannot be said to know a nature until we know what is specific to it, but this does not demand that we be able to distinguish its highest perfection clearly and distinctly from its other *properties*. When we know true properties of a thing, we implicitly and confusedly know what is specific to it, since this specification is contained in the properties as a cause in its effects. Thus before we studied philosophy and had it clearly pointed out to us that man's reason is his highest perfection, we certainly had some true idea of human nature. If someone had asked us what makes a man different from an ape, we probably would have replied, "A man can talk; men make themselves clothes and houses." The definition of man as a rational animal does not add anything to this notion except clarity and distinction.

Indeed St. Thomas makes quite clear, in a text which Maritain quotes but fails to apply,[23] that the human mind does not know the essence of anything sensible (including man apparently) except through its *common accidents* which are not properties in the strict sense. The properties in the strict sense are known only *after* the thing has been defined and through this definition. Nevertheless, these common accidents (color, shape, size, and especially activity) taken as a group are sufficient to be equivalent to a property because they are a sign of the essence revealing it to our intelligence.

[23] ". . . since essential forms are not known to us *per se*, it is necessary that they should be manifested through some accidents, which are signs of such a form, as is evident in *Metaphysics VIII*. However, it would not do to take accidents proper to that species, since it is necessary that such [accidents] should be demonstrated through the definition of the species; but the form of the species must be made known through other more common accidents; and thus the differences so taken are called as it were "substantial," because they are used to declare the essential form; they are however more common than the species, because they are taken from certain signs which follow on the superior genera." *In II Post. Anal.* 13, n.7. *See also* the excellent explanation of this passage given by T. Zigliara, in the Leonine edition, tome I, p. 375 a-b.

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Let us see how this applies to an example which is frequently cited by followers of Maritain. According to them a typically empiriological definition proper to the scientist, as distinguished from a philosopher, would be the definition of silver as an unknown but real nature which melts at 960.5°, boils at 2000°, is white, metallic, ductile, highly conductive of electricity, etc.[24] This is indeed a list of known properties of a certain pure substance which the chemist has isolated. But is this really the descriptive definition of silver as it is now known to the chemist? By no means. The contemporary chemist's conception of silver is not merely a list of phenomena, but (1) a list of characteristics which taken together are found regularly and repeatedly so that a substance possessing them can be isolated; (2) a significant list which has been discovered as answers to questions about the structure and behavior of this isolated substance; (3) an ordered list in which some characteristics, and above all the atomic number, are known to be much more fundamental than the others.

It will be still objected that this conception of silver is a construct, a particular theory of how atoms are put together which is only probably verified. To be sure our conception of the details of the atom is highly conjectural, but then so are our conceptions of the details of human nature. If we omit all that is hypothetical and conjectural there is still left a very definite and unified conception of silver as distinct from any other element, a conception resulting from a certain degree of insight into very well established experimental data. We know that silver is sharply distinguished from any other element by its atomic weight, valence, specific heat, electrical conductivity, etc., because these manifest its special type of atomic nucleus which is endowed with a definite electrical charge.

I am sure that there are some philosophers who will still be completely dissatisfied with this sort of knowledge of the nature of silver. Perhaps they are touched with that Cartesian *angelicism* which Maritain long ago so brilliantly exposed as characteristic of the modern mind. For such a mind knowledge is true only when it has the clarity of mathematics, a clarity sufficient to be the basis of a *deductive* system.

It is this unconscious influence of Cartesianism on modern scholasticism, I believe, which accounts for the uneasy differences of view on this question found today among Thomists. We see this clearly in the simplest and boldest of the proposed revisions of the Thomistic classification of the sciences, that of the late Canon Renoirte of the University of Louvain.[25]

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[24] *See* the essay of Yves Simon which appears in this volume.

[25] *Op. cit.*

For Renoirte modern science is, or should be, totally purified of any ontological implications, and should confine itself solely to the mathematical correlation of observed measurements. On the other hand, all consideration of the real nature of the physical world pertains to cosmology and this is but a branch of metaphysics. Finally, cosmology can go no further than to show the minimal conditions necessary that "the existence of something diverse and changing should involve no contradiction." [26]

Why this drastic reduction of the pluralistic view of knowledge proposed by Saint Thomas? All types of scientific knowledge are pitilessly reduced to two, modern science which is ontologically blind, and metaphysics which must be confined only to what is absolutely necessary, that which cannot be otherwise without a violation of the principle of contradiction. This led Renoirte to deny the traditional ways of establishing hylomorphism because he was not convinced that we are certain that our bodies are a part of our substances. He insisted that while we may be certain that we are distinct one from another as souls, we cannot be sure that the death of a man requires a substantial change. Obviously this is because he was demanding metaphysical certitude, not the physical certitude that rests on our human insight into such facts as that we feel our bodies to be a part of us and judge that we are distinct from the rest of the physical world.

If we do not make such drastic demands and are content to accept as certain not only that we exist as spirits and that outside us is a material and changing world, but also that the world is made up of natural units whose natures appear more or less clearly through their sensible properties, then the value of natural science as a genuinely philosophical knowledge will appear more plausible. This is not philosophy as metaphysics is philosophy, nor does it attain to the absolute certitude which rests on the necessity of intelligible being. Its certitude is that this universe, contingent as it is, contains natural units which endure for some considerable time, both as individuals, and (in the course of evolution) as species, and that we can truly understand the phenomena about us in terms of these units and their causes. We do not know that God could not have created a very different universe, we do not know by reason whence it has come or why it has its peculiar history or just what its future will be, but we can make real sense out of the way it is. This sense is not a mere projection of our creative imagination, nor is it only a progressive approximation to a hidden

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[26] *Ibid.* p. 211.

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reality that always eludes us. Rather it is a very incomplete, but genuine understanding of the world as it actually is.

The whole of man's effort to understand the natural world forms one integrated enterprise and flows from one single *habitus* of the intelligence, because although we are studying many different kinds of natural units, we understand them all only as they are made known to us by their sensible changes and stabilities. Whether it is a man, an oak-tree, or an atom of silver that we study we know them only as we see them develop and endure. The individual scientist selects one or another area of nature to study, but if he is well-trained and reflective he sees the thing he studies as a particular type of changing thing intelligible in the light of its own essential nature and of wider characteristics common to all things that change.

The techniques used by science in its investigation are many and varied and capable of indefinite invention, yet all of them rest on the one basic method of observation and definition which I have been describing. There is only one technique, and that of major but not sole importance, which is exceptional in this regard. That is the method of converting a physical description into a mathematical description. This constitutes a *habitus* distinct from that ordinarily used by the natural scientist, because it requires him, temporarily, to abstract from the world of change and to retire into the motionless and static world of mathematical objects. Undoubtedly it is this genuine distinction between the intellectual habit of natural science and the intellectual habit of mathematico-natural science that has led so many of our philosophers to believe that our knowledge of nature must be split into two levels. Nevertheless, this mathematico-natural science, important as it is, does not constitute a new level of natural science but is best conceived as an instrument used by the natural scientist, a technique like his other techniques.

This is why the ancients regarded mathematico-natural science as they knew it as a liberal art in the service of natural science. This art, however, is not merely a dialectic. It can in suitable cases arrive at genuine definitions which, as Newton rightly claimed, dispense with hypothesis. The fact, so often emphasized, that measurements are always approximate and rest on scales that are themselves variable[27] does not mean that certitude is impossible in mathematico-natural science. The earth is not a perfect sphere, but when we define it as a spheroid, we state a definition which is certainly true, and from which a number of quantitative properties can be properly explained. When we say that the earth is a spheroid, we are

[27] *See* C. De Koninck, *op. cit.*

speaking in abstract mathematical terms and we are no longer in natural science properly so-called because we have omitted all reference to sensible matter and change. Nevertheless, our definition rests on certain physical facts, and our purpose in considering the earth mathematically is to advance in understanding it physically as a changing thing. Thus mathematico-natural science is a true science and liberal art, formally and specifically distinct in its mode of definition from natural science, but having its value as an instrument of natural science.

Undoubtedly, these techniques of exploration do not always yield certitude and conviction. The areas in which our knowledge is clear and our insights successful are islands joined by bridging hypotheses. The true natural scientist is not discouraged by this fact but is determined to continue his researches until hypothesis yields to genuine insight. This is why he rightly deserves the name of a philosopher. He is humble in admitting that he knows little, but he will not be persuaded that the search is in vain.