NATURAL PHILOSOPHY AND THE PHYSICAL SCIENCES

by

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The problem of integrating modern science and philosophy is one which vexes all educators, Catholic and non-Catholic alike. In some ways, it represents a particular aspect of a greater challenge facing the culture and civilization of the Western World: the assimilation of the rapid growth in our knowledge of the physical universe, and its accompanying surge in technology, with an intellectual tradition that has hitherto concentrated on human and divine values, somewhat to the disparagement of purely physical ones.[1] The educator must perforce take cognizance of the dichotomy that has consequently arisen in our twentieth century culture, and take steps to form the minds of students in a way that is open to development in all areas, while at the same time allowing for a progressive unification of contemporary thought. I shall attempt to assist him in this task by treating one of the 'trouble-spots' in higher education where the problem comes clearly into focus. The area consists of two fields of study commonly referred to as "natural philosophy" and the "physical sciences." Both disciplines, it seems to me, create 'trouble' precisely because they are 'in trouble,' and this more seriously than is apparent on the surface. It will be my contention in this paper that they can only be gotten 'out of trouble' by making explicit their mutual dependence upon each other, thereby healing a breach that has had a divisive effect on related disciplines. If integration can be effected in this area, and perhaps propagate itself by a sort of chain-reaction to neighboring ones, I propose that we shall be in a fair way towards solving one of the critical problems in contemporary education.

It is not my intention to treat of the speculative problem of whether natural philosophy and the physical sciences are specifically distinct disciplines, although obviously the answer

one proposes to this problem will greatly influence any further solutions he may offer. For myself, I feel that Catholic philosophers have said as much on this subject as is worth saying, and that any further argument will open up more wounds than it will heal. The issue is very much complicated by history and historical viewpoints. Those who hold that there is a specific distinction between natural philosophy and physical science, understanding "specific distinction" in the sense of scholastic philosophy, usually favor the contemporary meaning of the term "science." They are much impressed by scientific methods and their independence of philosophy, and insist on the fact that modern science has developed in complete historical isolation from natural philosophy and from its methods of argument and of investigation.[2] Those who deny such a specific distinction, on the other hand, favor the medieval understanding of the term "science," which closely resembles the modern notion of philosophy. They are at pains to show that modern science has not been able to escape basic philosophical commitments, even historically, and maintain that when these are made explicit it immediately becomes part of a larger discipline that should be known as natural philosophy.[3] I favor the latter position, and I feel that this gives me some advantage in approaching the problem of unification, since my task becomes one of explicitation in support of a speculative position to which I have already given assent. I realize full well, however, that the abstract arguments leading to this position are neither easy to grasp nor widely accepted, and thus I shall not presume upon your sympathy in this matter. Fortunately, it is easier to broach the concrete difficulties confronting natural philosopher and physical scientist alike, to which I now turn as being closer to our problem and more amenable to a solution that will be generally acceptable.

Natural Philosophy and Empirical Data

I have said that both natural philosophy and the physical sciences are 'in trouble,' and I should like to clarify this sinister remark, beginning with the subject of which I have the greatest knowledge, namely, natural philosophy. Natural philosophy is frequently designated in Catholic philosophical circles as "cosmology" and, to use the expression of one of my colleagues, the precise 'trouble' in which it finds itself today is that it has become "cosmology without a cosmos."[4] The problem which requires investigation here, stated somewhat differently, is that of the relation of empirical data to natural philosophy. It may be phrased in the form of a question. If natural philosophy is to attain the truth and understanding of the reality it sets out to study, can it exist in its own right as a discipline without reference to empirical data and the findings of modern science; or must it of necessity take into account what modern science tells us about the cosmos?

I presuppose that by "natural philosophy" we understand that branch of philosophy which is concerned with nature, or with material being; that the minimum differentiation between such philosophy and modern science is that the former is concerned with a general knowledge of nature while the latter is concerned with detailed investigation of specific types of things. I also presume it to be generally agreed that natural philosophy is not concerned with mathematical reasoning about the world of nature, nor with the use of measurement ordered to the formulation of reasoning processes in mathematical terms, while modern science is sometimes characterized by its use of such mathematical procedures.[5] Thus understood, does natural philosophy, as a form of general and non-mathematical knowledge, require the use of empirical data for its proper elaboration?

There is at least one understanding of natural philosophy, fortunately not current in American scholasticism, which would permit a forthright negative answer to this query. This would conceive natural philosophy as a Platonic or rationalistic cosmology, somewhat in the tradition of Descartes, Kant and Wolff, where an a priori intelligibility is assigned to certain forms or conceptions about the physical universe that can neither be established, corrected, nor improved by experience or experimental investigation. Such a natural philosophy is really 'in trouble' in the present day, if only for the fact that it is rejected by philosophers and scientists alike as being subjective, idealistic, unrealistic, and inconsequential. It is a closed system which stands in isolation from contemporary thought as an intellectual possibility, but is completely sterile for promoting any knowledge of the vast universe now opening up before us.[6]

The more accepted view of natural philosophy in American scholasticism is one which has an empirical orientation, and takes as its historical paradigm the Aristotelian-Thomistic philosophy of nature exposed in Aquinas' commentary on the Physics of Aristotle. Such a natural philosophy has its origin in sense knowledge, and returns to sense knowledge at the completion of its reasoning process.[7] It is dependent on the immediately "given" data of sense for its beginning as for its ultimate verification. In its intermediate reasoning it ascends first to a consideration of universal or common aspects of natural things, and then descends gradually to the specific concretion that is found in nature in the individual thing.[8] Such a natural philosophy obviously depends on knowledge of the specific detail found in the world of nature, and if we equate this knowledge with empirical data, there is no doubt that it requires such data for its proper elaboration.

What invites further examination is the validity of the proposal just made to equate sense knowledge with empirical data, for this is precisely the point where 'trouble' begins to appear. Sense knowledge, in the traditional sense, has the status of physical fact, or an irreducible "given," to which any theoretical explanation of the universe must conform at the price of its own acceptance. Can the same be said for empirical data? In the minds of some, the answer would be "yes," while for others it would be an emphatic "no."[9] The difficulty here can perhaps be isolated with the aid of a threefold query which delineates the precise problem now confronting a realistic natural philosophy. To what extent can it be said:

(1) that the empirical data of modern science have the status of physical facts, unconditionally verified, and themselves independent of any logical or mathematical theorizing,
(2) that such data are adequate for an understanding of the basic features of the cosmos, and
(3) that they are necessary to guarantee the certitude of

general statements made about material being as such?

To these questions may be added further complications which result when natural philosophy is considered, not as an intellectual discipline in its own right, but as something to be taught:

(4) to students who have access to such empirical data in varying degrees, and
(5) who profess more or less credence in their status as absolute facts, possibly conferring on them a privileged position with respect to data of common sense or conclusions of reasoning processes themselves based on 'ordinary' experience.

The complications arising from teaching natural philosophy to students possessing a wide acquaintance with, and an implicit commitment to, such empirical data are 'troubles' of the professor of natural philosophy more than they are those of natural philosophy. Nevertheless, since we are primarily interested here in an educational enterprise, they cannot be passed over in silence. Whatever speculative resolution we may offer to the prior threefold query, the pedagogical requirement of the present day imposes an obligation on the teacher of natural philosophy at least to consider and evaluate empirical data wherever these pertain to the particular subjects he is teaching. Whether empirical data are relevant to natural philosophy or not, they must be treated as relevant to the student, and thus as exerting influence on the way in which natural philosophy should currently be taught.[10]

To come then to the speculative problem and to the precise difficulty offered by empirical data, I wish to propose a few samples of such data for purposes of analysis. Some scientific data might be called empirical in the sense that they furnish information about things that are themselves sensible or observable, either with the unaided senses or with the help of special instruments of observation. Examples of such empirical data would be: "water evaporates when heated," or "lead melts at 327° C." or "the period of a simple pendulum

is proportional to the square root of its length."[11] Science textbooks are full of such statements, acceptable in that they are statements of verifiable fact. Many differ from common experience in that they add the notion of measurement to simple sense observation, but otherwise they are without immediate interest to the philosopher. Considerably more troublesome, however, are other statements, similarly found in science textbooks, which might also be classed as empirical data. Three such samples would be the following:

(1) "bodies in motion continue in motion unless acted upon by some external force;"
(2) "falling bodies tend to a center of gravity in their local region;" and
(3) "chemical substances are composed of atoms and molecules."

None of these statements is about things that are directly observable, nor do any directly involve measurement, and yet they are all commonly accepted as statements of scientific fact.[12] Needless to say, each statement is of interest to the natural philosopher and has some bearing on the elaboration of his subject matter. Suffice it to mention that the composition of chemical substance relates to his understanding of hylomorphic doctrine, the behavior of falling bodies influences his treatment of place and the structure of the universe, while the principle of inertia affects his analysis of efficient causality as it pertains to local motion.[13]

Considering these data in the light of the first part of our query, namely, to what extent are they unconditionally verified and independent of any hypothetical reasoning, I do not believe that a uniform response can be given for all three above statements. Making allowance for conventional definitions of such terms as "force," "center of gravity," "atom" and "molecule," and also for the approximate character of Newtonian mechanics when applied to the physical world, it does not seem possible to me to accept the first datum (inertial motion) as a primary and irreducible datum to which all philosophical reasoning must conform. The second datum (falling bodies), on the other hand, I regard as having a much stronger title to acceptance on empirical grounds. The third (chemical composition) impresses me as something that can be demonstrated through analysis of empirical data that are directly given.[14] Thus, as a general rule, I feel that it would be unwise to accept everything proposed in the name of empirical science as absolute fact. Critical examination is a necessary propadeutic to the acceptance of such data by the natural philosopher. Who is to make such a critical examination? This is probably the most serious 'trouble' in which the natural philosopher finds himself for, if he is not capable of doing this himself, it is doubtful whether he will find anyone else who will do it for him. Scientists are far from agreed on the ontological value of their statements, and the current trend seems to be away from any explicit committment as to "what is actually the case" in the physical world.[15] But more of this later when we come to discuss the 'troubles' now confronting the physical sciences.

Regarding the second part of the query, namely, are such data adequate for an understanding of the basic features of the cosmos, the samples that I have cited all permit of a uniform and negative answer. The methodological overhauling with which science has been concerned over the past few decades has yielded one satisfying result. Scientific method is not the unique way to study the physical universe; it itself has to be supplemented by common experience and personal knowledge, even to guarantee the meaningfulness of its own endeavors.[16] However helpful empirical data might be to the natural philosopher, they are not the complete and adequate source from which he must derive his knowledge of the universe.[17]

Granting, for purposes of argument, that all empirical data are not uniformly acceptable, and that in themselves they are not adequate for a philosophical understanding of the universe, we come to the third, and most difficult, part of our query, namely, to what extent are such data necessary to guarantee the certitude of general, that is, philosophical statements about material being? My answer to this focusses on the word "general" for, if this be understood in a sufficiently broad sense as very general, I do not think that they are at all necessary for such a purpose.[18] It is my personal experience, however, that one cannot proceed very far in the

elaboration of natural philosophy even at a general level without becoming involved in problems about the origins of things, their inner structure, their natural motions, and their relations to other things in the universe. For all of these problems, the natural philosopher must draw on empirical data, and perforce evaluate critically such data, with all the trouble that this involves. Some general knowledge of the physical universe seems possible, if one is not to concern himself with empirical data, but not very much. I doubt if the natural philosophy elaborated without reference to such data would be very interesting, realistic, or relevant to the intellectual life of the twentieth century.[19]

The 'trouble' in which natural philosophy finds itself, then, is reducible to this: it can make a start, but it cannot get very far without incorporating empirical data, together with ordinary sense knowledge, into the raw material on which it works. This poses a series of problems. Its 'trouble,' however, is not 'serious trouble,' in the sense that it can make some general statements about the physical universe on the basis of ordinary experience. The difficulty respects its perfection and perfectibility, for its progress seems limited without such data, whose very acceptance involves it in knotty problems of criticism, evaluation, and interpretation.

Proper Contributions of Philosophy and Science

Such a general statement about the relation of empirical data to natural philosophy requires further elaboration, and I propose now, in the second part of my paper, to do this through an analysis of two examples of interest to the natural philosopher. In the process, I shall be explaining my conception of the proper contributions of natural philosophy and modern science to the full understanding of physical reality.

A perennial topic which interests natural philosophers in the Aristotelian-Thomistic tradition is the definition of place. Aristotle himself, building on Plato's conception of space as sketched in the *Timaeus*,[20] replaced this by the more refined notion of place. He formulated for it a definition which has since become classic: "place is the innermost motionless boundary of what contains."[21] Two noteworthy features of place are expressed in this definition:

(1) it is the innermost surface of a body or bodies which immediately contact or contain the body said to be in place, and
(2) this surface is by its nature immobile.

The analysis through which Aristotle delineates these features is one based on ordinary experience and interpreted in terms of the astronomical theories of the early Greeks. Things are said to be in place the way they are said to be in containers. But the containers of which we speak are all capable of changing place, while the place they 'change' remains itself unchanged or is motionless. Place is akin to the very first surface surrounding a thing, like the water around a ship; but the particular water around the ship may flow by, while the place of the ship still remains the same. Consider then the shore which contains the water: it, like place, remains stationary. So simply refer the first surface surrounding a thing to something that itself remains stationary, and one has that surface considered under the aspect of immobility. This satisfies the requirements for the definition of place.[22]

The proposed definition is obviously not so simple as it sounds. A question immediately arises as to the stationary or motionless referent to which the circumambient surface has been referred. If this is in turn a movable thing, can it not itself change place? Is the shore absolutely immobile? Can it not be disturbed, say by an earthquake or volcanic eruption? If so, to what stationary thing will it then have to be referred in order to save the definition? This takes us out of the local region, away from objects of ordinary experience like ships and shores, to the larger dimensions of the earth and the universe. Aristotle and the Greeks, relying on observation and rudimentary geometrical reasoning, conceived the universe as a system of concentric spheres, with the earth fixed at the center and the heavenly bodies rotating around it.[23] In this scheme of things, Aristotle was not at loss for an answer. All movable objects on earth must move with respect to the center of the earth: it and the ultimate sphere enclosing the universe are therefore the final referents for immobility. They guarantee the propriety and universal applicability of the definition of place which has been formulated.[24]

This brief excursion into Greek thought sets the stage for the entrance of empirical data into natural philosophy. St. Thomas Aquinas, writing in the thirteenth century and already influenced by the empirical findings of Ptolemy and Arab astronomers, does not have the simple cosmological views of Aristotle, although he preserves the latter's line of reasoning. For Thomas, natural movable bodies constitute the place of the bodies they enclose "through reference to the whole spherical body of the heavens, which has fixity and immobility because of the immobility of the center and of the poles."[25] In another place the reference is to the "ultimate sphere, whatever that might be."[26] The "poles" of Ptolemy's complex system are here given mention, hypothetical as Thomas thinks they themselves are, and there is a provisional cast to his notion of an ultimate sphere which is not definitively known as such.[27] Aquinas' place is the place of Aristotle, without doubt; but, even at this early stage in the development of scientific thought, he is concerned to explain with reference to the empirical data of his time the reality Aristotle has defined.

The Thomist of the present day, in my mind, cannot ignore the empirical data of twentieth-century science any more than he can allow the definition of place to have the status of an antiquated medieval notion in the eyes of his contemporaries. Those who would confine themselves and natural philosophy to the mere data of ordinary experience are extremely limited in what they can say about place. This applies equally to local or mechanical motion, which is basically change according to place. They can say that place is a relative thing, and this is certainly true, for the circumambient surface has to be related to something external which is motionless. But then, does ordinary experience lead us to anything external which is motionless in the order of local motion? Or, should one say that common experience shows us things which are at least relatively motionless? If so, he must be ready to answer the question: relative to what? Aristotle could not avoid this question, nor could St. Thomas. I do not see how a contemporary Thomist can avoid it either. In this day and age, there seems to be little value in a philosophy that restricts itself to discussing foundationless local motions of men and fish and raindrops, and forces itself to remain inarticulate about the motion of molecules and satellites and planets, or even galaxies in the remote depths of space.

I state the problem strongly because I believe it to be an important one, and because I think it is soluble with the aid of empirical data from modern science. Let me refer back to one such datum, the statement that "falling bodies tend to a center of gravity in their local region." Most scientists would understand this in the context of Newtonian mechanics, and would delineate a 'local region,' through application of the inverse-square law of gravitational attraction, as a system of massive bodies either unaffected or uniformly affected by other massive bodies in the universe. In such an understanding it is meaningful to speak of the mechanical motion of ions in a mass spectrograph, as it is meaningful to speak of the motion of an earth satellite, or of a peculiar advance in the perhelion of Mercury, or of the motion of our solar system with respect to stars in our galaxy. There is something immovable to which place can be "anchored," as it were, and this something is the terminus of gravitational tendency. I do not think it necessary to confer the status of absolute fact on every tenet of Newtonian mechanics in order to make this statement. The mathematical formulations of Einstein and others reduce physically to the same conclusion: place (and space) is inextricably tied up with gravity, or with massive tendencies.[28] The particular mathematics used, while indispensable for the dialectic which suggests the empirical generalization to us, is absolved from the final result. We may not be able to compute the center of gravity of a complex system at any moment, but massive bodies still have tendencies, and they manifest the termini of such tendencies, if we are only patient enough to analyze the empirical data available to us.

Please do not overestimate the role I am assigning to physical science in this matter. Newton and Einstein were not the first ever to speak of gravity. If you read Aristotle and St. Thomas Aquinas closely, you will find already implicit in their treatment of place the notion of natural tendency to place, with which they associated gravitas and levitas.[29] This too is what we recognize in common experience, when we speak of "up" and "down," and the nature of a heavy body. My point is merely this: a refined notion of place, one applicable to

the wide range of mechanical motions pertaining to our twentieth century civilization, cannot stop with these common notions, even though it can start with them. If you wish to be very general, and very vague, you can define place without empirical data, without mentioning anything about gravity, for example, leaving this implicit in Aristotle's 'immobile' (akínēton). But you do much better when you incorporate the notion of gravity explicitly into your defining process, for not only do you gain more precision in the process, but your definition becomes more universal and applicable to a wealth of concrete instances in which it is seen to be verified. The use of empirical data in no way detracts from the defining process, and it can confer a great deal towards its precision, provided of course that one knows what data to employ and how to employ them.[30]

Another topic of perennial interest to the natural philosopher is the structure of the physical continuum, or if you will, the structure of inorganic bodies. Aristotle, the Arab philosophers, Aquinas, and other medievals studied this problem at length, and came to some criteria by which they differentiated a physical continuum from a mathematical one. I cite only one statement from St. Thomas, although it is representative of many others that could be mentioned in this connection:

> Although mathematical bodies can be divided indefinitely, natural bodies admit of division only up to a certain point, since the quantity which is proper to each form is, like other accidents, determined by the nature.[31]

This statement is based on common experience, for it is an observable fact that visible natural bodies can be divided only up to a certain point, beyond which they are seen to lose their specific nature. From this macroscopic observation, the medievals argued that natural physical minima exist which constitute such bodies under the formality of minimal parts, and that for a body of a given nature, such minimal parts must all be equal to one another. Thus they conceived the structure of the physical continuum as made up of a diversity of parts, each with a characteristic size and a qualitative heterogeneity proper to the specific nature.[32]

Supposing a natural philosopher wishes to inquire further about these minimal actual parts. Are sense data adequate to the task? I should say "no." But, in this connection, I find extremely interesting one empirical datum already mentioned in this paper, namely, "that chemical substances are composed of atoms and molecules."[33] However this may be established as a fact of modern science, it is extremely relevant to the problem of the structure of inorganic bodies, and I do not think it can be neglected by the natural philosopher.[34] Time does not permit a development of this theme, but my conclusion in this matter is completely analogous to what I have just said about place and gravity. The philosopher can make a beginning, he can state the problem of minimal parts without taking into account the empirical data of physics and chemistry, but he cannot make a satisfactory investigation of the precise status and characteristics of such parts if he ignores the information that modern science has to offer. Just as his general statements about the universe take him into regions of the very large, so they also take him into regions of the very small, and both regions are now the recognized domain of the physical scientist. He cannot afford to be ignorant of the latter's data or his speculations: both are immediately relevant to the development of his own discipline.

Areas of Fruitful Discussion

Empirical data, then, are obviously of some importance to the natural philosopher. They also present difficulties, however, because unlike sense knowledge they cannot be taken on face value, as I have intimated in the first part of this paper. In fact, the problem of exactly what value can be assigned to them is a considerable one, and a major source of the 'trouble' in which physical scientists now find themselves. I should like to discuss this summarily, for it leads naturally to the third topic to be treated, namely, areas of fruitful discussion between the philosopher and the contemporary American scientist. But before coming to this, I shall first have to sketch briefly for you some recent history of science.

The period of science's history from the seventeenth century to the end of the nineteenth was one of rapid and confident

growth, in which self-criticism on the part of the scientist was practically unheard of. Philosophers who were critical of science were looked upon as antagonists who would quickly be banished from the intellectual arena. Newtonian space-time absolutism came to be incorporated into the Kantian critique of knowledge, and mechanism, working its way down to the world of the molecule, the atom, and the electron, explained all the phenomena of the microcosm with the same facility as it explained the macrocosm and the megalocosm. Everything discoverable was coming under the control of scientific method: theory and experiment were working hand in hand in all areas of thought. It was only a matter of time before even scientists would be reduced to extending, to *n* decimal places, the basic constants of the universe.[35]

Then, with the turn of the twentieth century, came two great achievements, within science, that shook the confidence of scientists and forced a recognition of the value of philosophical inquiry. These two developments were quantum theory and relativity theory. Relativity theory demolished the space-time absolutism of Newton, and with it, the *a priori* forms of knowledge espoused by Kant. Quantum theory took a close look at the mechanical atom, and decided it was only a fiction of the mind: the experimental data on which this construct was based might be real, but beyond such data it was meaningless to talk about reality. A philosophical position, quite popular among present-day physicists, gradually emerged; known as "quantum philosophy," it has recently been described as follows:

> Quantum philosophy consists in translating the restrictions imposed upon physical theory into epistemological and metaphysical statements. The epistemological problem is the decisive one, since their metaphysics ultimately consists in a denial of the possibility of metaphysics. In a grossly oversimplified form the epistemological argument might run as follows. All knowledge comes through the senses -- and the men under consideration. . .will admit of no knowledge essentially distinct from sense knowledge. The greatest re-

> finement of sense knowledge is had in the experimental data of modern physics. This data manifests an intrinsic limit in the amount and type of knowledge which can be obtained. Hence it is literally meaningless to speak, in any way, of anything beyond these limits. . . . This epistemology, a logical extension of sensism, plays a determining role in the 'metaphysics' of complementarity. Only phenomena can be known; nothing more can be said to exist. Bohr has repeatedly explained that we cannot attribute autonomous physical reality (that is, a reality independent of the experimenter) to objects on the atomic scale.[36]

As those of you who are philosophers know, this represents an extreme philosophical position.[37] Although it enjoys currency among reputable physicists, -- to name a few, Bohr, Heisenberg, Pauli, Dirac and Born -- it is not universally accepted by scientists. Some eminent men, including Einstein and De Broglie, and among the younger group, Bohm and Bunge, have rejected it categorically on realist grounds.[38] In fact, because of this position, there is evidence of an argument shaping up among scientists about the reality behind empirical data that is extremely interesting on two counts:

(1) it is essentially a philosophical argument; and
(2) it is the type of philosophical argument to which the natural philosopher in the Aristotelian tradition can take an interest, and even have something to offer towards its resolution.

Physical scientists, then, have begun to reflect on the meaning of empirical data. They are 'in trouble' because the "real" significance of their findings is in doubt, and because they cannot agree among themselves; clarifications are not only in order, but are felt to be necessary for the progress of physical science. For such clarifications, scientists do not come to the philosopher directly, particularly not to the scholastic philosopher, nor are philosophers invited to get tangled

up in the experimental apparatus of the scientist. Instead, a middle ground is forming, designated broadly as the "philosophy of science." This middle ground, in my opinion, may well help the physical scientist out of his 'troubles' with empirical data; I should not be surprised if it offered the natural philosopher a way out of his 'troubles' too.

A recent book on the philosophy of science,[39] for example, lists the following topics among its chapter headings:

What is Science?
What is the Method of Science?
What is the Meaning of Scientific Law?
Do the Levels of Science Reflect the Levels of Being?
Is Physics Reducible to Mechanics?
Is Complementarity the Final Interpretation of Atomic Physics?

Another book, reporting a symposium on "The Nature of Physical Knowledge,"[40] reproduced papers entitled:

Is 'Physical Knowledge' Limited by Its Quantitative Approach to Reality?
Does Physical 'Knowledge' Require A Priori or Undemonstrable Presuppositions?
Metaphysics: Before or After Physics?
The Role of A Priori Elements in Physical Theory
Dualistic Pictures and Unitary Reality in Quantum Theory

Within the last few years, at least three sizeable treatises have been written on the subject of causality in modern science.[41] The nature of scientific explanation has been examined from every possible viewpoint: inductively, deductively, psychologically, historically.[42] Critical essays have been attempted on the nature of space and time, as these concepts are employed by the scientist.[43] And behind all this activity is the attempt to define precisely the cognitive status of laws and theories, to ascertain the degree to which the latter enter into empirical data themselves, and the presuppositions on which such data are based.

Much of this work, it is true, has been under the influence of neopositivist and analytical philosophy, which does not recognize the validity of the scholastic's claim to "metaphysical dimensions," "objectivity," "truth," and "certitude." It cannot be assimilated directly into the theological or philosophical synthesis that inspires and gives guidance to the Catholic institution of higher learning. It has to be gone over carefully, purified of its deep-seated, and apparently unnoticed, committment to skepticism (or sensism, or positivism, or logicism), before it can be put to work on the problem I have sketched in the first two parts of this paper.[44] But it does represent a beginning, a delineation of areas for fruitful discussion, the preliminary design, if you will, for a bridge that will one day link natural philosophy with the physical sciences, and furnish the unity and depth we are seeking in our study of the universe.

How such a fusion is to take place I do not pretend to know in detail. In the ideal, speculative order, were we to prescind from the historical order in which our knowledge of the universe was acquired, and dissociate ourselves from the terminological usages (and confusions) of the present day, I think we could reconstruct a unified view of the universe -- call it a "philosophical science of nature" or a "scientific philosophy of nature" or whatever you will. But considering the immediate and practical demands of twentieth century education, such an enterprise may not be practical or realistic. So I suggest a simple alternative. We can imitate the engineer who would link two bustling cities separated by a great river: leave both cities in the midst of their activities, stake out an intermediate area with "Work in Progress" signs so that the passerby who looks in will not expect to see neatly completed structures, and begin working, from both sides at once, towards the middle. Such an enterprise obviously has to employ people from both cities, and they have to be interested in making contact with the other side; otherwise they should not be building a bridge. The biggest difficulty, if I may be permitted to continue this homely simile, consists in finding a few men who can pass some strands from one shore to the other, to assure that the completed structure will meet in the center. I propose that we already have such strands in the concepts of "causality," "natural law," and "explanation." Some have dwelt in the twin cities of "Science" and "Philosophy," and are interested in using such strands to get a bridge started between them. In the initial stages of construction, the bridge could be given two names, if necessary: "Philosophy of Science" at one end, "Science of Philosophy" at the other. Once people begin passing over it, a minimal usage will be required to find out that it is only <u>one</u> bridge, whose entire purpose is to give both cities the opportunity to supply their own mutual needs. Should such a bridge, or series of bridges, ever carry enough traffic to make of the two cities one big metropolis, where residents of either side become really knowledgeable about mutual problems and consider them sympathetically, we will have arrived at the complete solution of our problem, to the mutual benefit of all concerned.

Conclusion

To sum up, then, 'troubles' in contemporary education stem from 'troubles' in natural philosophy and in the physical sciences. The natural philosopher has his cosmology, but he is without a cosmos, while the physical scientist has his empirical data, but he is without a philosophical overview that assures him that these have any meaning in the real world. The natural philosopher would like to use the empirical data of the scientist: these are relevant to his problems, but first he has to examine them critically, unveil their suppositions, separate fact from fiction, before he can assimilate them within his synthesis. The physical scientist would like to turn philosopher, provided he can stick to the concrete problems that interest him, for he now finds that some philosophy is necessary to clarify the cognitive status of his science. In such a formulation, both philosopher and scientist discover that they have a middle ground in which to work. The problems that make up this area are coming to be known, among our contemporaries, as the philosophy of science. It is an area that invites close attention from the Catholic educator who has an eye on integration, for it may well supply the added dimension that will unify hitherto disparate elements in the accepted content of higher education.

FOOTNOTES

[1]The broad dimensions of this challenge have been sketched by Charles Percy Snow in the Rede Lecture delivered at Cambridge University in 1959, and published under the title, The Two Cultures and the Scientific Revolution (New York: Cambridge University Press, 1961).

[2]There are many contemporary Catholic philosophers who are sympathetic to this position, and an extensive literature has developed in support of it. Some of the key references include: Fernand Renoirte, Cosmology (New York: J. F. Wagner, Inc., 1950); Fernand Van Steenberghen, Epistemology (New York: J. F. Wagner, Inc., 1949); Jacques Maritain, Philosophy of Nature (New York: Philosophical Library, 1951); Andrew Van Melsen, The Philosophy of Nature (Pittsburgh: Duquesne University Press, 1953); and George P. Klubertanz, The Philosophy of Human Nature (New York: Appleton-Century-Crofts, 1953).

[3]This position was first formulated as a refutation of the teaching of Christian Wolff on the division of the sciences. Its earlier exponents, writing principally in Europe, include: Antonin Sertillanges, "La science et les sciences spéculatives d'après S. Thomas," Revue des Sciences Philosophiques et Théologiques, I (1921), 5-21; Santiago Ramirez, "De Ipsa Philosophia in Universum secundum Doctrinam Aristotelico-Thomisticam," La Ciencia Tomista, XXVII (1922), 33-62, 325-364; XXVIII (1923), 5-35; XXIX (1924), 25-59, 207-22; and Aniceto Fernández, "Scientia et Philosophia secundum S. Albertum Magnum," Angelicum, XIII (1936), 24-59. In America, the position has been taken up by William H. Kane in several articles, including "The Nature and Extent of the Philosophy of Nature," The Thomist, VII (1944), 204-32, and "The Extent of Natural Philosophy," New Scholasticism, XXXI (1957) 85-97; also, with certain modifications, by Charles De Koninck, e.g., in his Natural Science as Philosophy (Quebec: University of Laval, 1959). Some recent statements include: Raymond J. Nogar, "Toward a Physical Theory," New Scholasticism, XXV (1951), 397-438; Benedict M. Ashley, Are Thomists Selling Science Short?, (River Forest, Ill.: Albertus Magnus Lyceum, 1960); and Antonio Moreno, Science and Philosophy (River Forest, Ill.: The Aquinas Library, 1960).

[4]Raymond J. Nogar, "Cosmology Without a Cosmos," in From an Abundant Spring, ed. by the staff of the Thomist (New York: P. J. Kenedy and Sons, 1952), pp. 363-92.

[5]For example, the statement of Karl F. Herzfeld: "All statements in physics are essentially of a quantitative nature and have quantitative limitations. The philosopher wants the answer in terms of 'yes' or 'no.' The physicist wants an answer in terms of 'how much.' " -- "The Structure of the Atom," in The Philosophy of Physics, ed. Vincent E. Smith ("St. John's University Studies: Philosophy Series," Vol. II; Jamaica, N. Y.: St. John's University Press, 1961), p. 42.

[6]Unfortunately many secular thinkers of the present day think that this represents an essential ingredient of all scholastic philosophy. Mario Bunge, for instance, quite unjustly attributes such a view to Jacques Maritain, whom he accuses of making natural philosophy "a kind of scientia rectrix claiming such a final rectorship [over science] that scientists just ignore it." -- Metascientific Queries (Springfield, Ill.: Charles C. Thomas, 1959), p. 7.

[7]St. Thomas Aquinas is explicit on this point: "Knowledge does not always terminate in the same way. Sometimes it terminates in the sense, sometimes in the imagination, and sometimes in the intellect alone. For sometimes the properties and accidents of a thing revealed by the sense adequately manifest its nature, and then the intellect's judgment of the thing's nature must conform to what the sense reveals about it. All natural things, limited to sensible matter, are of this sort. So the terminus of knowledge in natural science must be in the sense, so that we judge of natural things as the sense reveals them, as is clear in the De Caelo et Mundo. And the person who neglects the senses in regards to natural things falls into error." -- In Boethii de trinitate, q. 6, a. 2; English translation by Armand Maurer, St. Thomas Aquinas: The Division and Methods of the Sciences (Toronto: Pontifical Institute of Mediaeval Studies, 1953), p. 63.

[8]The general methodology is outlined by Father Nogar in the article cited above, "Cosmology Without a Cosmos," loc. cit., pp. 372-388, where he bases it on St. Thomas' commen-

taries on the physical works of Aristotle: viz., In I physicorum, lect. 1, nn. 6-8; In I de caelo, lect. 1, nn. 1-3; In I de generatione, lect. 1, nn. 1-2; In I meteorologicorum, lect. 1, n. 1; and In I de sensu et sensato, lect. 1, n. 2. Additional texts from other works of Aquinas, in which his personal views can easily be disengaged from those that might have been imposed upon him as a commentator, are given by Benedict M. Ashley in "The Role of the Philosophy of Nature in Catholic Liberal Education," Proceedings of the American Catholic Philosophical Association, XXX (1956), 62-73.

[9]Alan B. Wolter has characterized diverse reactions to the empirical data of quantum mechanics in these terms: "The reaction of philosophers to this dilemma has been varied. Some take the extreme position that science is 'a fabric woven of myths,' a shadow world of accidents that a philosopher in practice can afford to ignore, for he needs only prescientific and common-sense knowledge based on sensory data to get at the noumena or real essences of things. Others point out that the protons, electrons and quanta of the scientist have no 'real existence' but are purely theoretic entities that have meaning only within the framework of a physical theory. Any attempt to treat them as real leads to a flagrant misuse of language and entangles one in meaningless metaphysics." Father Wolter also mentions the principal schools of interpretation, and gives bibliographical references. Cf. "Chemical Substance," in Philosophy of Science, ("St. John's University Studies: Philosophy Series," Vol. I; Jamaica, N.Y.: St. John's University Press, 1960), 87-130; citation above, p. 89.

[10]I have examined some pedagogical aspects of this problem, in connection with the teaching of sacred theology to science students, in an article entitled, "Theology and the Natural Sciences," in Theology in the Catholic College, ed. Reginald Masterson, O.P. (Dubuque: The Priory Press, 1961), 167-204. Much of what is said there would be applicable to the problem of teaching natural philosophy to students who are "overcommitted" to empirical data.

[11]These particular examples are cited and analyzed in a recent book by Ernest Nagel, The Structure of Science: Problems in the Logic of Scientific Explanation (New York: Harcourt, Brace and World, 1961), p. 79 ff.

[12]Nagel remarks: "Many [scientific] laws employed in some of the most impressively comprehensive explanatory systems of the physical sciences are notoriously not about matters that would ordinarily be characterized as 'observable,' even when the word 'observable' is used as broadly as in the examples of the preceding paragraph. Thus, when the evaporation of heated water is explained in terms of assumptions about the molecular constitution of water, laws of this latter sort appear among the explanatory premises. Although we may have good observational evidence for these assumptions, neither molecules nor their motions are capable of being observed in the sense in which, for example, the temperature of boiling water or of melting lead is said to be observable." -- Op. cit., p. 79. I do not intend to become involved here in a quibble over what constitutes a 'fact,' as opposed to a 'law,' nor over the diverse senses in which the latter may be referred to as 'experimental law' or 'theoretical law.' As Nagel continues: "When the set of assumptions about the molecular constitution of liquids is called a theory, it is not to be understood as asserting those assumptions to be entirely speculative and unsupported by any cogent evidence." -- Ibid., p. 80. Under 'empirical data' I have obviously included scientific facts that are directly observable as well as those that are summarized in 'scientific laws,' for which they can be said to constitute, in Nagel's expression, the 'cogent evidence.'

[13]I am here assuming natural philosophy to be concerned with the essential content of the eight books of Aristotle's Physics.

[14]For a statement of my views concerning the ontological status of Newton's three laws of motion, see the article, "Newtonian Antinomies Against the Prima Via," The Thomist, XIX (1956), 151-92, particularly pp. 155-65, 174-80, 186-89. Ernest Nagel, after analyzing much of the current literature on this subject, comes to the following conclusion: "It thus becomes evident that no brief and simple answer can be given to the question: What is the logical status of the Newtonian axioms of motion? It is quite certain that the axioms are not a priori truths to which there are no logical alternatives; and it is equally clear that none of them is an inductive generalization, in the sense of a generalization that has been obtained by

extrapolating to all bodies interrelations of traits found to hold in observed cases. But beyond these negative characterizations of the axioms, a reasonably satisfactory answer to the question requires reference to the place the axioms occupy in some particular codification of the theory of mechanics, and to the uses to which the axioms are put in various special contexts. What can perhaps be asserted quite generally is that, on the one hand, the Newtonian axioms can often play the role of schema for analyzing the motions of bodies or of stipulations for defining certain experimental notions, and, on the other hand, when the axioms are coupled with additional assumptions (among others, with assumptions concerning force-functions) they can be correctly construed as statements possessing a definite empirical content." -- The Structure of Science, p. 202. Regarding my statement that some material in modern science might be demonstrated through analysis of empirical data, I have elaborated this at some length in an article entitled, "Some Demonstrations in the Science of Nature," in The Thomist Reader 1957 (Washington: The Thomist Press, 1957), pp. 90-118. Others are not so optimistic; for example, Nagel comments that the Aristotelian notion of demonstration, when applied to modern science, is entirely irrelevant: "This conception [Aristotle's idea of science] is true of nothing that can be identified as part of the asserted content of modern empirical science. Accordingly, Aristotle's requirement that the explanatory premises be better known than the explicandum is entirely irrelevant as a condition for anything that would today be regarded as an adequate scientific explanation." -- op. cit., p. 45.

[15]The diversity of opinion is easily noted in a symposium on this subject sponsored by Marquette University. The papers have been published under the editorship of L. W. Friedrich as The Nature of Physical Knowledge (Milwaukee: Marquette University Press, 1960). The essay by Raymond J. Seeger, "Metaphysics: Before or After Physics?" pp. 96-108, gives a summary of the contrasting views.

[16]Two noteworthy studies which have emphasized this point are Michael Polanyi's Personal Knowledge (Chicago: University of Chicago Press, Cambridge University Press, 1958) and Norwood R. Hanson's Patterns of Discovery (New York: Cambridge University Press, 1958).

[17]Frank J. Collingwood has developed this point in one of the papers of the Marquette symposium, entitled: "Is 'Physical Knowledge' Limited by its Quantitative Approach to Reality," op. cit., pp. 25-46. Vincent E. Smith's three books, The Philosophical Frontiers of Physics (Washington: Catholic University Press, 1947); Philosophical Physics (New York: Harper Brothers, 1950); and The General Science of Nature (Milwaukee: Bruce, 1958), are all extended developments of the same theme.

[18]This, of course, is the traditional Aristotelian-Thomistic position. It has been explained afresh in an article by George J. McMahon, "The Proeemium to the Physics of Aristotle," Laval théologique et philosophique, XIII (1957), 9-57. Father McMahon here makes the statement: "The philosophy of nature, which cannot boast of this tremendous success [i.e., of modern science] in the practical order, has been traditionally founded on a general and what we shall call here without defining for the moment, a confused knowledge. It defines in terms of general principles rather than mathematical formulas and proffers as evidence common experience rather than closed experiment. The twentieth century man raised in the climate of opinion of detail and mathematization will have one of two reactions to this philosophy of nature. Either he will respect it and gently raise it to the level of metaphysics and thus be rid of it, or he will accept it as a generally natural science but demand that it wait on the findings of modern science before it dare enunciate its theories. In this second case, the philosophy of nature will adopt as its 'starting point' not a general and confused knowledge but the detailed and precise knowledge of modern science. It will then be free to proceed to its own proper philosophical reflection. The order followed by Aristotle and St. Thomas in their study of nature is quite different. For them, the 'starting point' is a general and confused knowledge which by a process of concretion approaches the particular and the distinct. The purpose of this paper shall be to explain their position." -- pp. 9-10.

[19]This statement is nicely substantiated in a recent article by Benedict M. Ashley, "Does Natural Science Attain Nature or Only the Phenomena," in The Philosophy of Physics (New York: St. John's University Press, 1961), pp. 63-82. It is also illustrated in the previously mentioned publication by

the same author, Are Thomists Selling Science Short?, and in Raymond J. Nogar's "Cosmology Without a Cosmos," loc. cit.

[20]Plato, Timaeus, 49A, 50B, 51B, 52E-53A, 57B-58C, 63A-E.

[21]Aristotle, Physics, IV, 4, 212 a 20.

[22]These elements are sketched in Chapter 4 of Book IV of Aristotle's Physics.

[23]A critical examination of Aristotle's teaching, and of the methodology underlying it, is presented in Benedict M. Ashley's Aristotle's Sluggish Earth: The Problematics of the 'De Caelo' (River Forest, Ill.: Albertus Magnus Lyceum, 1958).

[24]Cf. Aristotle, Physics, IV, c. 4, 212 a 21-27.

[25]In IV physicorum, lect. 6, n. 14.

[26]Ibid., lect. 7, n. 2.

[27]For a brief explanation of the hypothetical elements in the astronomy subscribed to by St. Thomas, see my article, "St. Thomas Aquinas, Galileo, and Einstein," The Thomist, XXIV (1961), 1-22, particularly p. 4.

[28]A classic exposition of Einstein's theories of special and general relativity is Arthur S. Eddington's Space, Time and Gravitation (Cambridge: University Press, 1920), which has recently been reprinted (New York: Harper Bros., 1959). The very title indicates the close relation in which these entities are held in Einstein's view.

[29]A full explanation of the Aristotelian-Thomistic notion of place as associated with natural tendencies is given in James A. Weisheipl's Nature and Gravitation (River Forest, Ill.: Albertus Magnus Lyceum, 1955).

[30]In this connection, a recent article by Bruno Webb, entitled "Hylomorphism, Gravity and 'Tertiary' Matter," The Thomist, XXIV (1961), 23-46, proposes a new approach to the study of gravity in terms of hylomorphic principles. I am currently at work on a similar paper, to be entitled "A Thomistic Analysis of Gravity," which approaches the subject from a different direction, and which I hope will substantiate the point I am making in the present paper.

[31]De potentia, q. 4, a. 1, ad 5. For other texts, see In I physicorum, lect. 9; In VI physicorum, lect. 3; In II de anima, lect. 8; In de sensu et sensato, lect. 15; Summa theologica I, q. 7, a. 3; In II sent. d. 30, q. 2, a. 2; ibid. d. 14, q. 1, a. 1, ad 4.

[32]For a summary exposition of the way in which medieval and early Renaissance thinkers conceived of minimal parts, and the role that this played in the development of early atomic theories, see Andrew Van Melsen's From Atomos to Atom (Pittsburgh: Duquesne University Press, 1952), Part I, pp. 9-128.

[33]Here I am deliberately avoiding discussion of this particular datum of modern science as it relates to hylomorphic doctrine. For an excellent treatment of this problem, see two articles in Philosophy of Science: "The Constitution of Matter," by Vincent E. Smith, pp. 69-86; and "Chemical Substance," by Alan B. Wolter, pp. 87-130.

[34]One of the first of the recent writers in cosmology to have recognized this fact is Peter Hoenen, who has devoted many pages of his celebrated text, Cosmologia (Romae: Apud Aedes Universitatis Gregorianae, ed. V, 1956), to its eludication. Significant portions of this text have been translated as The Philosophical Nature of Physical Bodies (West Baden: West Baden College, 1955) and The Philosophy of Inorganic Compounds (West Baden, West Baden College, 1960). Others who have approached the problem in the light of more recent data from quantum mechanics are Ernan McMullin, "Realism in Modern Cosmology," Proceedings of the American Catholic Philosophical Association, XXIX (1955), 137-50; and Edward MacKinnon, "Atomic Physics and Reality," The Modern Schoolman, XXXVIII (1960-1961), 37-59, and "Thomism and Atomism," ibid., 121-41.

[35]There is an abundant literature covering this period. A representative work is A. D'Abro's The Evolution of Scientific Thought (New York: Dover, 1950); some recent essays are reproduced in Turning Points in Physics, edited by A. C. Crombie (Amsterdam: North Holland Publishing Company, 1959).

[36]Edward MacKinnon, loc. cit., p. 47.

[37]One of the extremes of the position is indicated in the title of an essay by F. Waismann, "The Decline and Fall of Causality," in the previously cited Turning Points in Physics, pp. 84-154.

[38]We employ the term "realist' here in a very broad sense. Obviously Einstein is not a realist in the Aristotelian or Thomistic sense, as I have indicated in "St. Thomas Aquinas, Galileo, and Einstein," loc. cit., pp. 10-11. Among recent writers, those who are closer to the Thomistic concept of moderate realism include David Greenwood, The Nature of Science (New York: Philosophical Library, 1959), and W. H. Werkmeister, "An Epistemological Basis for Quantum Mechanics," Philosophy of Science, XVII (1950), 1-25, and "The Problem of Physical Reality," ibid., XIX (1952), 214-24. In a recent conversation with Mario Bunge, I asked the latter if he would consider himself a philosophical realist, and he replied with an unqualified "yes," although he does not identify himself with the Aristotelian or scholastic tradition.

[39]Mario Bunge, Metascientific Queries, (Springfield, Ill.: Charles C. Thomas, 1959).

[40]The Nature of Physical Knowledge, ed. L. W. Friedrich (Milwaukee: Marquette University Press, 1960).

[41]Victor F. Lenzen, Causality in Natural Science (Springfield, Ill.: Charles C. Thomas, 1954); David Bohm, Causality and Chance in Modern Physics (New York: D. Van Nostrand, 1957); and Mario Bunge, Causality: The Place of the Causal Principle in Modern Science (Cambridge: Harvard University Press, 1959).

[42]Apart from the previously cited works by Nagel, Hanson and Polanyi, we might mention the following on the logical and psychological aspects of explanation: Richard B. Braithwaite, Scientific Explanation (New York: Cambridge University Press, 1953); Stephen Toulmin, The Philosophy of Science: An Introduction (London: Hutchinson and Co., 1953); Karl R. Popper, The Logic of Scientific Discovery (New York: Basic Books, Inc., 1959) -- an updated translation of Popper's Logik de Forschung; zur Erkenntnistheorie der Modernen Naturwissenschaft (Wien: J. Springer, 1935); Evidence and Inference, David Lerner (Glencoe, Ill.: The Free Press, 1959). There have also appeared several significant historical studies of methodology, among which I might mention: A. C. Crombie, Robert Grosseteste and the Origins of Experimental Science (Oxford: University Press, 1953); James A. Weisheipl, The Development of Physical Theory in the Middle Ages (London: Sheed and Ward, 1959); and my own The Scientific Methodology of Theodoric of Freiberg (Fribourg: Presses Universitaires, 1959).

[43]For example, Max Jammer, Concepts of Space (Cambridge: Harvard University Press, 1954); and Hans Reichenbach, The Direction of Time (Los Angeles: University of California Press, 1956).

[44]An author who has already made a significant start on some of these questions, but whose work is not yet widely known in America, is Philip Soccorsi, De physica quantica (Romae: Typis Pontificiae Universitatis Gregorianae, 1956); and De vi cognitionis humanae in scientia physica(Romae: Apud Aedes Universitatis Gregorianae, 1958).