CHAPTER II

PHILOSOPHY AND EXPERIMENTAL SCIENCE

I
THE OBJECT OF THIS CHAPTER

1. IN HIS IMPORTANT WORK on *Explanation in the Sciences*, Émile Meyerson says: "True science, the only one that we know, is in no way, and in none of its parts in accordance with the positivist scheme."[1] At this point in our work, we are not undertaking to show that the critical-intellectualist or critical-realist[2] scheme, while maintaining for philosophy and metaphysics their eminent character as science, corresponds more exactly to the vast logical universe of whose modern development the sciences offer us some picture. A whole treatise would be needed for that. We would only like to propose, in summary fashion and from the point of view of the philosopher, a general sketch of this scheme—such at least as it appears to us in the light of the history of the sciences. We are not unaware of the gaps in our outline: it is subject to many retouchings and many additions. Such as it is, however, and in spite of its inadequacies, we hope it will permit the reader, in reference to his own experience, to estimate the worth of a doctrine which the indolence of many of its defenders and the neglect of modern critiques of science have for a long time caused to be misunderstood.

This chapter is devoted to the relations of scientific experience and philosophy. In other words, the experimental level of knowing (wherein knowing is further specified according to the diverse sciences of the phenomena of nature) is here considered, especially in its relation to the higher levels (wherein knowing is universalized and unified). This will be a kind of introduction to the three following chapters, in which an attempt will be made to envisage the conception that critical realism fashions of philosophic knowing in all its generality. And, indeed, this point of view will at one and the same time

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1 Émile Meyerson, *De l'explication dans les sciences* (Paris, 1921, t. I, p. 31.

2 These seem to us the most appropriate terms to designate a philosophy that no overly simplified label can define for the very reason that its proper objective is so lofty that empiricism and idealism, realism and nominalism are all transcended at one stroke and reconciled within it. Concerning the notion "critical realism," see below, Ch. III.

include a more profound treatment as well as a larger synthesis of the problems herein involved.

While reserving for the next chapter an examination of the foundations of Thomistic noetic, we will at this point take the principles and metaphysical structure of that noetic as granted by hypothesis. It is a noetic that recognizes the existence of things outside the mind and the possibility of the mind's attaining these things and constructing within itself and by its own activity, beginning with the senses, a knowledge which is true or in conformity with what is. Those of our readers who might still be doubtful about these principles may, in any event, provisorily suppose them as postulates. Moreover, they will recall that even for science they are not doubtful. Science is naturally realistic. If experimental science does not in itself constitute an ontology of nature, nevertheless, according to the remark of the very discerning philosopher cited above, a background of ontological values is at least, and in fact, inevitably demanded of it.

Science in General

2. What notion should we have of science in general, understood in the sense of that specific form of knowledge at which the mind aims when it is aware that it is striving towards what men call knowing scientifically?[3] The concept that Aristotle and the ancients had of it is very different from the one that moderns have constructed because, for the latter, it is the eminent dignity of the experimental sciences, the positive sciences, the sciences of nature, the sciences of phenomena as we say, which appropriates the notion of science.

3 It is perfectly clear that only by reflective abstraction can such a specific form be disengaged from the various sciences already constituted among men. It is not, however, a mere residual mean (statistical "totality") set forth in *abstractio totalis* or abstraction of a logical generality, but it is, rather, a question of a pure type (ideal "formality") disengaged in *abstractio formalis* or abstraction of a formally constitutive element (see below, Ch. II, § 12). The different existing sciences in which such a pure type has been disengaged still leave much to be desired in offering an adequate presentation of it, as those sciences are at present constituted.

E. Husserl has recourse to a substitute for *abstractio formalis* (all notion of which is lacking in most modern philosophers) when he sets about "living" the scientific task in his meditation (cf. *Méditations cartésiennes*, pp. 7–11), and thereby grasping the "intention" of science. That is really possible only through a reflection (which is at least implicit) upon sciences as really given. On the other hand, the Cartesian method followed by Husserl compels him to brand with temporary invalidity those sciences whence he has drawn the idea of science. If, on the contrary, we maintain the perspective of spontaneous realism actually required by the sciences themselves, it is because we presuppose that critical reflection (which will be treated in the following chapter) can achieve an awareness of knowledge in general and subsequently of the validity of the different sciences, at least their general and undetermined validity.

For the ancients, on the contrary, it was the eminent dignity of metaphysics which oriented this notion. It is necessary, then, to avoid applying haphazardly and without due precaution the Aristotelian-Thomist notion of science to the whole vast noetic material that our contemporaries are accustomed to call by that name. One would only expose oneself to worse mistakes. However, for both the ancients and the moderns—and in this sense they are in agreement—the clearest, the most perfect type of science, the one most perfectly within our grasp[4] is provided by mathematics. It may, then, be considered conditionally—I do not mean that it has to be corrected and adapted, but rather that it must be adequately dwelt upon and refined—that the critical-intellectualist or critical-realist theory of science, whose principles have been set down by the metaphysicians of antiquity and of the middle ages, alone provides us with the means of seeing clearly into epistemological problems that have in our day become a veritable chaos.

How, then, define science in general and in accordance with its ideal type? We would contend that science is a knowledge perfect in its mode, or more precisely a knowledge in which, under the compulsion of evidence, the mind points out in things their reasons for being. For the mind is not satisfied when it merely attains a thing, i.e., any datum whatever, but only when it grasps that upon which that datum is founded in being and intelligibility. *Cognitio certa per causas*, the ancients would say: knowledge by demonstration (in other words mediately evident) and explanatory knowledge. We see at once that it is a knowledge so rooted as to be necessarily true, that it cannot not be true, or is in conformity with what is.[5] For it would not be a knowledge perfect in its mode, an infrangible knowledge, if it could be found false. That holds good for the pure type of science, whatever may be the role of hypothesis in its development and of the vast element of conjecture and probability upon which the most concrete sciences rely for their certitude and which, moreover, they rigorously determine.

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4 The contention that mathematics constitutes the kind of science that is most perfectly within the grasp of the human intellect (there are infant prodigies in this science) is exactly correct, especially as regards classical mathematics. But it is no longer correct with reference to a mathematics from which axiomatics have almost entirely eliminated intuition. It is true that the axiomatic method, no matter how precise it may be, "can never be self-sufficient" nor "justify its own existence by itself alone. . . . An abstract science cannot be isolated from its intuitive origins—even though it be mathematics—without depriving it of its deepest meaning and its inner life" (F. Gonseth, *Les fondements des mathématiques*, Paris, 1926, pp. 13, 96).

5 Taken in itself and abstracting from its systematic connections, the notion of scientific truth proposed by Husserl and "conceived as an ensemble of well-founded predicative relations or relations founded in an absolute fashion" (*Méditations cartésiennes*, 1931, p. 10) does not seem very far removed from such a conception.

3. If, however, this knowledge is necessarily true, should not the object on which it lays hold be just as necessary? How could a changeable and contingent object give rise to a stable knowledge, one which could not be false? Furthermore, would a thing be explained, would we be giving a reason for it, if, once its reason for being were posited, it could be otherwise? That is the problem which from the very beginning has been thrust upon philosophical reflection; it is the problem which led Plato, when confronted with the fact of certain knowledge, to set up a world of Divine Ideas. Let us not try to escape with any timid reply in which the primary demands of scientific knowledge would be obscured. Let us grant from the beginning—and we will immediately see how this statement must be understood and restricted—that there is knowledge of the necessary only, and that the contingent, as such, is not the object of science. Science bears directly and of itself on a necessary object.

The difficulty is immediately evident. The object of science is necessary. But the real, the concrete, flowing world of things, involves contingency. This table could not—exist there in front of me today, and I who am writing could not—be here at this very hour. Does science, then, not deal with the real? No, it does not bear directly upon the real in all its nakedness, on the real taken in its concrete and singular existence. (In this sense, Mr. Goblot is right in insisting on the difference between *reality* and *truth*.) But, on the other hand, it does not deal with a Platonic world separated from things. It is absolutely necessary to distinguish the *thing* with which science is concerned (this table, for instance) and the perfectly precise *object* ("the formal object") upon which it lays hold and from which it derives its stability (for instance, the geometric properties of this table when considered in its shape or the physico-chemical properties of the wood from which it is made or the laws of its manufacture). The latter (the object) does not exist when separated from the thing (except in our mind) and yet it is not confused with it.[6] Science bears directly and of itself upon the abstract,[7] on ideal constancies and supramomentary determinations—let us

6 It is distinguished from it by a distinction of reason.

7 We are well aware that the notions "abstraction" and "abstract natures" are quite repulsive to the nominalism, confessed, or not, admitted by many of our contemporaries. Yet are they unaware of the curious spectacle they themselves present when, while denouncing such notions as vain and old-fashioned, they themselves have on their lips such notions as *science, spirit, method, mathematical reasoning*, and so forth—all of which are objects of thought in which it is difficult not to recognize abstract natures? You might as well pursue a phantom. For the critical intellectualism of an Aristotle or a St. Thomas has never, as they imagine, made scientific abstraction consist in placing an individual in a logical class, or beneath the hypostasized generality of its proper characteristics, but rather in disengaging from it the reality that may be thought by, and consistent with, the mind, that is to say, in disengaging from it the whole complex of intelligibility of which it is the bearer. That is what the Scholastics called *abstractio formalis* (see below, Ch. II, § 12).

Scientific understanding cannot do without this *abstractio formalis* in any way

say, on the intelligible objects that our mind seeks out in the real and sets free from it. They are there, they exist there, but not at all in the condition of abstraction and universality that they have in the mind. On the contrary, they exist in a concrete and singular condition. Human nature exists in each of us. But only in the mind is it a universal nature common to all men. In each of us, it is Paul's or John's nature.

Let us note that scientific law never does any more than express (in a more-or-less direct way, or more-or-less devious way) the property or requirement of a certain ontological indivisible which of itself does not fall under the senses (is not observable) and which for the sciences of nature remains an *X* (albeit indispensable), and which is nothing other than what the philosophers designate by the name *nature* or *essence*.[8] In virtue of an ontology immanent to our reason (or spontaneous philosophy) we *know in advance* that the network of phenomena or relations selected by us as an object of observation has as its support just such natures or essences, such ontological *X*'s. The experimental sciences do not penetrate these essences in their intelligible structure. And, more often than not, it still remains doubtful whether the more-or-less provisory and unstable categories that those sciences construct, and on which their rational task operates, correspond to those essences. It is, however, exactly within these *ontological non-observables*, which are taken for granted, that there resides the reason for the necessity of those stable relations, which are formulated by science, among the elements the mind selects from phenomena or

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whatsoever. Whatever may be the way knowing proceeds, even though it proposes only to put phenomena into equations and establish their empiriological connections and so gives up any thought of seeking the essence, abstraction is always at hand. It is abstraction that permits us to establish the rules of measurement and calculation thanks to which phenomena are mathematicized; and it is abstraction that disengages the empirical specificity of phenomena which is a substitute for essence and which presupposes the existence of that essence.

8 Following E. Meyerson, let us quote two significant texts here: "Whatever may be said in modern scientific schools (wherein the great fear, above all other, is to seem to be constructing a metaphysics), moderate atomism, as well as pure atomism, implies the claim that they grasp the essence of things and their inner nature in some way" (Cournot, *Traité de l'enchaînement* . . . Paris, 1861, p. 264). "We are in search of each thing's essence or necessity and these two expressions are equivalent because, when we know the essence, we see that the thing to which it belongs could not . . . be other than it is" (Sophie Germain, "Considérations générales sur l'état des sciences et des lettres aux différentes époques de leur culture," *Oeuvres Philosophiques*, Paris, 1878, p. 158). And in his own turn, Mr. Bertrand Russell writes: "Logic and mathematics force us to admit a kind of realism in the scholastic sense, i.e., to admit that there is a world of universals and truths that do not bear directly on this or that particular existence. This world of universals has to subsist, even though it could never exist in the same sense as that world exists in which particular data exist" ("L'importance de la logistique," *Rev. de Meta. et de Mor.*, xix, May 1911.

which it builds on their foundation. The necessity of laws derives from the fact that they properly and in the final reckoning concern essences or natures, and from the fact that essences or natures are the locale of intelligible necessities. For every nature or essence, as a result of its intrinsic structure, necessarily possesses certain properties (for example, the diagonal of a square is incommensurable with a side) or necessarily tends to produce a determined effect in certain conditions (for example, heat tends to expand solids). What does the law of the expansion of solids by heat mean? Does it mean that a certain concrete event, the expansion of a certain bit of iron placed over a certain flame, is a necessary and inevitable affair? No! This flame might not have been kindled; this bit of iron might not have been placed there; it could have been protected by an insulator, cooled by a stream of water, and so forth. The law means that *solid* (an abstract object which I see in this fragment of iron) has within the secrets of its nature a certain something, I know not what, which (at least, within the conditions of my sphere of observation, which experience will perhaps one day compel me to make more precise)[9] necessarily and unfailingly determines it to expand according to certain specific coefficients under the action of *heat* (an abstract object which I see in this flame and which I can define thanks to a difference in certain calibrated readings). It goes without saying that I may not realize these abstractions as such. Heat may rather appear to me to be the kinetic energy of a multitude of molecules whirling around in disarray; so that, in the corpuscular scale, the law in question becomes a statistical law and only states the stability of a mean result. But if essence or nature with its *determinatio ad unum* thus recedes (and perhaps continually) before the scientist's gaze, it would still not disappear from the field of the real. Absolute chance is a contradictory notion. A crossing of preordained things, which itself is not preordained, supposes the things which are preordained. To know that at a certain age death occurs according to a certain percentage, the actuary depends on statistics alone and on the law of large numbers. But behind this very law and behind the statistics, there is the nature of the human body and the natures of all those physical, moral and social beings in the midst of which this body is placed and whose action it

accidentally undergoes. Chance gives rise to fixed numbers only because at the outset there are elements which are not determined by chance, and amongst these chance can be at play. As primary laws or specific determination are, for experimental science, substitutes for natures and essences that are not attained in themselves, so statistical laws are second degree substitutes for them, and like the others, they, too, presuppose that there are natures, the final foundation for the stability of knowing.

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9 Such a reservation must necessarily be presupposed in the case of every law established by induction. And the law of the expansion of solids by heat has been established in purely inductive fashion before it was tied in once more with a physical theory of heat.

To the question why does not the necessity of laws—and these are the objects of science—extend to each of the particular events that takes place here below? this answer must be made: the world of actual existence and concrete reality is not the world of pure intelligible necessities. Essences or natures do exist within existing reality; from it they (or their substitutes) are drawn by our mind, but they do not exist there in a pure state. Every existing thing has its own nature or essence. But the existential positing of things is not implied in their nature, and amongst them there are encounters which are themselves not natures, the necessity for which is not prescribed in any nature. Existing reality is therefore composed of *nature* and *adventure*. That is why it has a direction in time and by its duration constitutes an (irreversible) *history*—these two elements are demanded for history, for a world of pure natures would not stir in time; there is no history for Platonic archetypes; nor would a world of pure adventure have any direction; there is no history for a thermodynamic equilibrium.

Necessity and Contingency

4. It is clear, then, that the precise notion of abstraction and the universal will provide the explanation we were seeking. Unless individual thing and universal essence are distinguished, it is impossible to understand how the *event* can be *contingent* while the *law* known by science is *necessary*; how things flow and change while the object of science is of itself immutable and enduring. But so it is precisely because contingency depends on the singular as such (more exactly, in this visible world, on matter, the principle of individuation), whereas of itself science bears not upon the singular as such but on universal natures that are realized in the singular and which the mind draws out of the singular by abstraction.

Science deals with things, but, thanks to abstraction, by "considering apart"—whether it perceives them clearly or lays hold of them in a blind fashion—the universal natures which are realized in things and the necessities proper to these natures. This, then—and not the flux of the singular—constitutes its object. Contingency properly concerns singular events; it is only "according to the intelligible constituents of universal natures" that the necessities known by science apply to singular things.[10] That is why the necessary laws of science do not impose any necessity on each of the singular events in the world of nature. A certain workman has fashioned this stone into a cube; it is necessary that it have the geometric properties of a cube; but it could have had a different shape. This bridge has been constructed in a faulty way because the engineer calculated the stresses inaccurately, or with faulty materials, or because the contractor cheated the government. Inevitably, by reason of the

10 "Illa proprie ad singularia pertinent quae contingenter eveniunt; quae autem per se insunt vel repugnant, attribuuntur singularibus secundum universalium rationes" (St. Thomas, *In Perihermeneias*, lib. I, cap. 9, lect. 13, n. 6).

nature of iron or stone, one day this bridge will collapse. But the fact that the engineer calculated inaccurately, or that the contractor lacked integrity, or that a prudent inspector did not give the order to strengthen the work, or that a certain stroller crossed the bridge at the moment of the accident—all that is entirely independent of this natural necessity. It is contingent. These contingencies of the singular escape science. The necessities of the universal are the proper objects of its grasp.[11]

Thus, the *universality* of the object of knowledge is the condition of its *necessity*, the very condition of perfect knowledge or science. By the very fact that there exists scientific knowledge only of the necessary, there is scientific knowledge only of the universal.[12]

5. In this sense Aristotle, following Plato, taught that there is science, absolutely speaking, only of things incorruptible and eternal. However, he corrected Plato by adding that these incorruptible and eternal things (incorruptible and eternal as essences, or negatively) are universal natures which exist outside the mind only in things singular and perishable. Thus, as a result, there can "accidentally" be science of corruptible things, insofar as we apply to the singular the universal truths of science, and to the extent that understanding, "leaving, so to speak, its own sphere, returns, through the ministry

11 It can be predicted with certainty that a certain number of children born today will pass the age of *n* years; but none the less that does not tell what age this particular youngster X will attain. The eclipse of 1999 is as certain as an insurance company's schedule of life-expectancy; the leap that an atom will take is as uncertain as my life or yours" (A. S. Eddington, *The Nature of The Physical World*, Cambridge, University Press, 1929, p. 300). It seems that the greater and greater importance assumed by statistical laws in science (and here we are not speaking of "relations of uncertainty" in corpuscular mechanics, for we will have to treat of them later on; we are only speaking of the host of chance shocks on which, in the last analysis, "the leap that an individual atom or individual molecule will take" depends) can be looked upon as an illustration of Aristotelian ideas about the bond between the contingent and the singular. Statistical law seems, then, as we have pointed out above, to be a substitute at second hand for the intelligible necessities inscribed in the universal, which experimental science cannot quite succeed in deciphering.

12 On this point certain rather easy misunderstandings should be avoided. We are stating that there is no science of the individual *as such*. And that does not mean at all that there cannot be an *indirect intellectual knowledge* (by "reflection" upon the senses—or by means of affective connaturality) of the individual as such. From this point of view, we even admit with John of St. Thomas, that there is a proper (indirect) concept of the singular.

Nor does it mean that there could not be a science of the individual—but not as such (i.e., in its singularity, in its very incommunicability). Study of character, graphology, the science of temperaments, etc., are sciences of the individual which, in order to grasp the singular, grasp it under a network of subspecific universal notions and, over and above that, fortify themselves with an art in which experience and the *ratio particularis* play an essential part.

of the senses, to things corruptible in which the universal is found realized."[13] "Although sensible things," says St. Thomas on this score, "are corruptible when taken in their individual existence, they have, however, a certain eternity if they are taken universally."[14] And thus, just as there is no knowledge and demonstration of sensible things except when taken in their universal nature and not in their individuality, it follows that science and demonstration only bear indirectly and "accidentally" on the corruptible; of themselves, they deal with what is "eternal." The immutability and the necessity of the object of knowledge are conditioned by its universality.

This whole doctrine is admirably summarized by St. Thomas in the following text: "The understanding knows the universal and necessary reasons of contingent things. That is why, if the universal reasons of the objects of knowing be considered, all science is of the necessary," although to take things materially, and "to consider the very things about which science is practiced, certain sciences," such as mathematics, for example, "have for their matter necessary things, and others," physics, for example, "have contingent things."[15]

A Digression on "Determinism in Nature"

6. The error of pseudo-scientific mechanism clearly supposes and involves the error of nominalism. If the universal does not directly or indirectly designate an essence or nature but only a collection of individual cases, it is not at all possible to understand how scientific law can be necessary and the succession of singular events contingent. The point that mechanists misunderstand is that law expresses nothing else but the order of a cause, *taken abstractly in its universal nature,* to its effect. And even though the positing of that cause in actual existence is contingent or though, in the flux of particular events, another cause comes along to interfere with the realization of its effect, that order always remains.

If it be supposed that there are no *free* (intelligent) agents in the universe, it is clear that a certain event which has occurred here below (for example, the fact that a certain squirrel is climbing up a certain tree at a certain moment, or that lightning struck a certain mountain at a certain moment) was infallibly predetermined in the configuration of *all* the factors in the universe posited at the beginning. But in that case, there is only a necessity *of fact*, no necessity *of right*. Not only

could this configuration of factors have been otherwise at the beginning, but also none of the numberless meetings between the diverse causal series produced in the course of the world's evolution down to the production of this

13 Cajetan, *In Anal. Post.*, lib. I, cap. 8.

14 "Etsi enim ista sensibilia corruptibilia sint in particulari, in universali tamen quamdam sempiternitatem habent" (St. Thomas, *In Anal. Post.*, lib. I, cap. 8, lect. 16).

15 *Sum. Theol.*, I, 86, 3.

event had its sufficient reason in the essential structure of the universe nor in any essence whatsoever. The proximate causes involved in the production of this event *could of themselves* (even though they could not with regard to the whole multitude of situations that in fact preceded and accompanied it, supposing that they themselves were not disturbed) have been prevented from producing it without violating any rational necessity. Of itself, it was a *contingent* event.[16] (And as a result, the supposition that a free agent intervened to modify or prevent it does not imply any impossibility.)

These remarks indicate the sense in which one may speak of the determinism of nature. This expression is quite legitimate if it means that every cause in nature is necessarily determined or ordered by its essence to an effect (which can in fact fail if the cause is not posited or if other causes intervene), and that such necessary determinations are the object of the sciences of nature, or rather their foundation (for the more they free themselves from ontology in their own structure, the more do they escape causality in the philosophical sense of that word).[17] But it is a mistake and a complete blunder to say that science supposes "the universal determinism of nature" if that means that all the events that take place in nature are made necessary and inevitable by right from the very instant that nature itself is posited. Again, it is an error to suppose that such a universal necessity is the object of science which should, from that moment onward, deal with all the individual events occurring in nature, when, on the contrary, if dealt with in this way, they escape it by nature.

7. It is curious to note that Fichte, for example, was led to his "theory of science" and to vast delicate constructions in his metaphysics of liberty, largely by his desire to escape this "universal determinism," a more rigorous criticism of which would have been enough to show him that it is only a murky idea and posits only a pseudo-problem. The same melancholic remarks can be made about Renouvier's philosophy and, more generally, about most of the modern systems that have sprung from Kantianism.

The Aristotelian-Thomist view, on the contrary, by showing how contingency in the course of singular events is reconciled with the necessity of laws known by science, shows how it is possible to insert into nature the liberty proper to spirits which, as such, do not form part of sensible nature and of the corporeal universe but which do, however, act in that universe.

Another Digression. How Do We Attain Essences?

8. Let us close this parenthesis to open a new one. We have just been speaking of natures and essences. Does that mean that, from our point of view, the first intellectual operation, abstraction, immediately yields the *essence of*

16 Concerning this question, cf. our *Philosophie bergsonienne*, 2nd ed., pp. lxix–lxx, and 217.

17 See below, Ch. IV, § 10.

things in its intrinsic structure? Is it enough to form the idea of fire, or better still of fieriness, to penetrate the ontological secret of combustion? That would surely be chemistry at a bargain.

Such a reproach forms the basis of criticisms levelled by many contemporary philosophers at what one of the more serious of them calls pre-Cartesian thought. It is rather humiliating to have to reply to it. It may come partly from the misdeeds of decadent scholasticism, partly from a superficial reading of an elementary textbook. Above all, it comes from a profound ignorance of philosophic tradition.[18]

Abstraction (as has been explained very often), from the very fact that it transfers us from the level of sensible and material existence to the level of objects of thought, introduces us into the order of intelligible being, or of *what things are*. But at first it only attains the commonest and poorest aspects of this intelligible being. The idea of fire only represents to us *something, some determined being*, which produces certain sensible effects, for example, burning and glowing. Abstraction reveals certain intelligible aspects which really are in things. But the very essence of things, i.e., the notes that properly constitute their intelligible being and explain their properties, is only attained—when it is attained—at the expense of hard labor. For the discovery of that essence must always be in keeping with the imperfect manner of knowing suited to man, and only in virtue of the properties which reveal it. And I hasten to add that in a whole vast area, that of the inductive sciences, we do not attain it and we have to content ourselves with substitutes, manageable equivalents.[19]

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18 The philosophers of whom we are thinking, if they undertake to speak of St. Thomas without taking the time to read him (and to read him with scrupulously scientific objectivity and the desire for information they have a right to expect of others and would have even more right to demand of themselves), would only have to cast their lofty glances over some very clearly written pages on this subject—the work of L. Noel (*Notes d'épistémologie thomiste*, p. 142) and J. de Tonquédec (*La critique de la connaissance*, pp. 42, 138; *Immanence*, Appendix I)—and their illusions would be dispelled. Also, see A. Forest, *La structure métaphysique du concret selon saint Thomas d'Aquin*, Ch. III, pp. 72–97; and below, Ch. V, §§ 1–6.

19 On this score let us quote a remarkable page written by Mr. Gaston Rabeau (*Realité et relativité*, Paris, 1927, p. 203) in connection with Mr. Leon Brunschvicg's work on *Expérience humaine et la causalité physique*. "The analysis of causality, facts and the connections between facts, which science seeks, gives us the idea of an interpretation of the real that would not coincide at any point with a more refined Kantianism, a Kantianism without fixed categories and in which functions of judgment are indefinitely flexible. Basically, Mr. Brunschvicg has brought to light the fact that essence (and by that term let us understand laws and theories) is not achieved all at once, that experience suggests truths more than it imposes them, that processes of knowing do not allow themselves to be isolated from the object of knowing, that it is necessary from time to time to turn back by an act of reflection upon the processes that have been used with a view to putting them in a condition to help in more complicated tasks. But all of that is undeniably

We succeed in gaining an intimate knowledge of the real in philosophy, wherein we study things not from the particular point of view of their specific diversity, but from the universal point of view of transcendental being soaked into them. But are we then dealing with a knowledge which is particularized even to the very specific essences themselves? As regards physical realities, we succeed in attaining quidditative definitions only of ourselves and of things belonging to man. And only of these things can we intelligibly attain the nature to a specific degree. For all the rest of the corporeal world, for everything that is below us, since we are unable to attain a perception of their intelligible structures themselves, we are forced to have recourse to a knowledge inductively built on sensible effects alone, one that does not provide us with the essence, but only with simple outward *signs* of it.

It is all too often forgotten that if a metaphysics appears incapable by right (if not in fact) of giving recognition to the process proper to inductive sciences and shows itself imbued with an outrageous ambition and dogmatic intemperance as regards the science of the corporeal universe (to the very point of admitting an exhaustive knowledge of the essence of matter which is thus supposed to lie naked before our mind), then it is the metaphysics of Descartes and Malebranche. This is the very metaphysics from which flows, more-or-less camouflaged by experimentalism, the ever-present mechanist ideal of many contemporary scientists; it is not the critical realism elaborated by the ancients.

That is the end of our second parenthesis. We can now determine more accurately what we had been setting forth above.

Sciences of Explanation (In the Full Sense of the Word) and Sciences of Observation

9. We have said that science as such, and thus every science, by its direct[20]

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true and we find no difficulty in it, only it is opposed to the phantasmagory of a world of essences made entirely in the mind and to the naiveté of a philosophy that would think it had the divine plan of the world in its head. Besides, in the *Transcendental Analytic*, Mr. Brunschvicg sets forth as a concrete element that stands in the way of a deduction of the categories, irreversible duration which is the matter of real causality: he points out certain invariables that may serve as points of reference in diverse systems; he speaks of something irreducible that is the very basis of experience. In short, he points out the *fact* to us, along with the intelligible nature that constitutes it, and the *spirit*, too, which, in its attempt to compare facts, works at reconstructing the table of essences through separate threads that are only joined together with difficulty. This history of the drama of thought at grips with nature for the purpose of stripping it of its secrets is a powerfully attractive one; and it only seems a bit removed from our own doctrines because these analyses are connected with postulates they (i.e., our doctrines) do not make."

20 In opposition to the movement of *return* whereby it turns back upon the singular.

movement, deals with universal natures or essences; by its very nature it is directed towards these natures. Let us now make the following distinction:

There are sciences which deal with these essences as known; not known in any exhaustive fashion (for indeed we do not know all about anything)[21] but nevertheless known or revealed (by their externals).[22] These are deductive sciences, philosophical or mathematical—deductive, however, for very different reasons. In the latter case, mathematical knowledge, the mind grasps entities it has drawn from sensible data or which it has built on them. It grasps them through their constitutive elements, and constructs or re-constructs them on the same level. These things in the real (when they are *entia realia*) are accidents or properties of bodies, but the mind treats them *as though* they were subsistent beings and *as though* the notion it makes of them were free of any experimental origin. In the former case, on the contrary, in philosophic knowledge, it does not lay hold of substantial essences by themselves but through their proper accidents and it only proceeds deductively by being constantly revitalized by experience (the "analytic-synthetic" method).

These sciences are properly sciences of explanation, διότι ἐστιν, *propter quid est*, in the terminology of the ancients. They reveal to us intelligible necessities immanent in the object; they make known to us effects by principles, or reasons for being, by causes, taking this latter term in the quite general sense that the ancients gave to it. It can happen, it is true, that when confronted by a very exalted reality, one whose essence can be known only by analogy, they must limit themselves (and this is the case of metaphysics when confronted by God) to a knowledge of simple factual (supra-empirical)[23] certi-

21 As far as Thomists are concerned, if we knew essences exhaustively (*adequate ut sunt in se*), there would be *as many specifically different sciences* as there are essences so known. Thus, our science, from the mere fact that it embraces a multitude of different natures under one and the same light and on the same level of abstraction, bears witness to the fact that the real remains inexhaustible for it. Cf. John of St. Thomas, *Curs. Phil.*, Log. II P., q. 27, a. 1, ed. by Reiser, t. I, pp. 819 and 824: "Et hoc totum ex eo tandem provenit, quia nostrae scientiae imperfectae sunt et non omnino adaequantur ipsis rebus neque eas adaequate comprehendunt. Nam si quaelibet res perfecte comprehenderetur, quaelibet res fundaret scientiam sibi propriam et specie distinctam ab alia, neque scientia requireret coordinationem specierum, sed quaelibet res per suam speciem adaequatam perfecte repraesentata suas passiones demonstraret."

22 See below, Ch. V, §§ 1 and 2, 4 and 5.

23 *Scire an sit* or *quia est* (knowing in the range of or within the perspective of fact) is not at all limited to knowing of an inductive type, for in a general way (in opposition to *scire quid est* or *propter quid est*, knowing in the range or perspective of a reason for being) this expression designates any knowledge that does not succeed in laying hold of the essence itself in all its intelligible constitution. Thus, for example, in a discipline of the deductive type like metaphysics, *scire quia est* plays a very important role since all the knowledge of God we have here below issues from this sort of knowing.

As for sciences that are termed inductive, they belong to *scire quia est*, to the

tude. But at that very moment they transcend explanation. It remains true, however, that of themselves they still yearn to discover the essence.

And then there are sciences which have to do with essences *as hidden* without ever being able to uncover in themselves the intelligible necessities immanent in their object. These are inductive sciences, sciences which (to the extent, at least, that they remain purely inductive—and that is not the case with physics and the experimental sciences of the moderns: Bacon and Mill are quite wrong on that score) are of themselves only sciences of empirical observation (a particular case of knowledge in the simple line of fact, ὅτι ἐστιν, *quia est*, and which fall short of explanation properly so called. It is by effects that they make causes, or reasons for being, known to us and so these causes or reasons are not made known in themselves but in signs which, for us, are substitutes for them. We know that heat expands metals, that ruminants have cloven hooves. We grasp thereby in a rather blind fashion a necessity whose reason we do not see since a well-established experimental constancy is a sign of necessity, and this latter a sign of some essential connection. Inductively established law is thus much more than a simple general fact; it enfolds an essence but without revealing it; it is the practical equivalent of the essence or cause which in itself remains hidden to us.

The former sciences, sciences of explanation, set before the mind intelligibles freed from the concrete existence that cloaks them here below, essences delivered from existence in time. Even though no triangle existed, it would always be true that the sum of the angles of the Euclidian triangle is equal to two right angles. In that sense, these sciences can be said to give us eternal truths.

The other sciences, sciences of observation, do indeed tend to such truths, but they do not succeed in emerging above existence in time, precisely because they attain intelligible natures only in the signs and substitutes that experience furnishes for them, and therefore in a manner that inevitably depends on existential conditions. Thus, the truths stated by them affirm, indeed, a necessary bond between subject and predicate, but also suppose the very existence of the subject, since the necessity they evince is not seen in itself but remains tangled with existence in time—and to that extent, if I may say so, garbed in contingency.

10. To sum up, we can say that science in general deals with the necessities immanent in natures, in universal essences realized in individuals, in the world of concrete and sensible existence. We have distinguished sciences of explanation or deductive sciences which attain these essences openly (by construction in the case of mathematics, by proceeding from the outside inward in the case of philosophy), and sciences of observation or inductive sciences, which attain these natures only in signs and substitutes, blindly, if

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very extent that they are inductive, and constitute the supreme type of this kind of knowing in the realm of knowledge of nature.

one may so speak. These latter do indeed have a certain explanatory value, for without that, they would not be sciences. But this consists in noting necessities in things by means of sensible experience, not in assigning their reasons by intelligible means.

The distinction between these two categories of science is absolutely sharp: they are not reducible to each other.

But it is plain that sciences of the second category, sciences of observation, inductive sciences, since they are less perfectly sciences and do not succeed in realizing the perfect type of scientific knowledge, are not sufficient unto themselves. Of their very nature, they tend to sciences of the first category, to sciences of explanation properly so called, deductive sciences. *They are necessarily attracted to them.* In virtue of their very nature as sciences, they invincibly tend to rationalize themselves, to become more perfectly explanatory. In other words, they tend to take on a deductive character, and to that extent they are subject to the regulation of one of the disciplines which are properly deductive, that is to say, either philosophy or mathematics. This point, one should never forget.

11. Let us try now to go even further into the domain of the sciences and discover their essential divisions and hierarchy.

To that end, what we must consider are the diverse degrees of intelligibility in objects of knowledge. If we reflect that what philosophers call matter (Plato's existing non-being) is in the final analysis nothing but the ontological principle of relative unintelligibility (or irrationality to use modern parlance) which affects the very substance of things in nature and signifies, so to speak, the distance separating them from the intelligibility in pure act proper to uncreated Being, then the fundamental thesis that intelligibility goes with immateriality, so forcibly propounded by St. Thomas Aquinas, is immediately understood. The essential divisions of the sciences will therefore have to be established in accordance with the different ways or degrees in which the objects of thought discovered in things by intellectual operation are free of matter. We shall restrict our attention to these essential divisions without pretending to enter in detail into the sub-divisions of the classification of sciences. Moreover, we shall consider only speculative sciences and leave aside the moral sciences which, concerned as they are with the practical order, and proceeding by way of synthesis to the very concrete determinations of action,[24] belong to quite a different chapter of epistemology.

II
THE DEGREES OF ABSTRACTION

12. On this problem we find the guiding thread in the doctrine of the three degrees of abstraction, i.e., the three degrees according to which things present

24 See below, Ch. VIII, and Appendix VII.

to the mind the possibility of attaining in them a more-or-less abstract and immaterial object, I mean abstract and immaterial as regards the very intelligibility which flows from premise to conclusion and, in the final analysis, as regards the mode of defining.[25] The mind can consider objects abstracted from, and purified of, matter but only to the extent that matter is the basis of diversity amongst individuals within a species, i.e., insofar as matter is the principle of individuation. In this way, the object remains; and remains to the very extent that it has been presented to the intellect, impregnated with all the notes coming from matter, and abstracts only from the contingent and strictly individual peculiarities, which science overlooks. The mind thus considers bodies in their mobile and sensible reality, bodies garbed in their empirically ascertainable qualities and properties. Such an object can neither *exist* without matter and the qualities bound up with it, nor can it *be conceived* without matter. It is this great realm that the ancients called *Physica*, knowledge of sensible nature, the first degree of abstraction.

Secondly, the mind can consider objects abstracted from, and purified of, matter insofar as matter is the general basis for the active and passive sensible properties of bodies. In this case, it considers nothing more than a certain property which it isolates within bodies—a property that remains when everything sensible is left aside—quantity, number or the extended taken in itself. This is an object of thought which cannot *exist* without sensible matter, but which can be conceived without it. For, nothing sensible or experimental enters into the definition of the ellipse or of square root. This is the great field of *Mathematica*, knowledge of Quantity as such[26] according to the relations of order and measure proper to it—the second degree of abstraction.

25 Cf. John of St. Thomas, *Curs. Phil.*, Log. II P, q. 27, a. 1, ed. Reiser, t. I, pp. 822–823.

26 Certain clarifying remarks will be found below on the notion of quantity and the proper object of mathematics (cf. Ch. IV, § 6, and Ch. V, § 2). But let us note at once that, in making quantity as such, or ideal quantity, the object of mathematics in general, we do not have it in mind to exclude every qualitative determination from the mathematical order. Quite the contrary! For whether it be a matter of qualities or formal determinations that are included in the notion of the entities under consideration, or of the "irrational" entities from which they originate (for example, the primary specifications that serve to define the structure of the continuum or which, in the final analysis, rest upon a factual datum—as is the case with the specification "three-dimensional" concerning the space of classical geometry), it is clear that no science of quantity would be possible without qualities. *Analysis situs*, the theory of abstract spaces, the properties of order that are at the basis of topological concepts are excellent witnesses, to the importance of the qualitative element as it essentially affects the domain of mathematics. But then the qualities proper to quantity itself are in question, rather than qualities that refer to the nature of the radical principle of activity in bodies, i.e., qualities that can be reduced to the sensible order (physical qualities).

On the other hand, it will be noted that, for the scholastics, the science of the continuum and the science of number, while belonging generically to the second degree, or the second order, of abstraction, none the less do present a difference

Finally, the mind can consider objects abstracted from, and purified of, *all* matter. In this case it considers in things only the very being with which they are saturated, being as such and its laws. These are objects of thought which not only can *be conceived* without matter, but which can even *exist* without it, whether they never exist in matter, as in the case of God and pure spirits, or whether they exist in material as well as in immaterial things, for example, substance, quality, act and potency, beauty, goodness, etc. This is the wide domain of *Metaphysica*, knowledge of that which is beyond sensible nature, or of being as being—the third degree of abstraction.

We should note here with Cajetan and John of St. Thomas that these three degrees of abstraction refer to the abstraction called *abstractio formalis*.[27] Actually, there are two kinds of abstraction. First, there is *abstractio totalis*. Let us call it an abstraction, or an extraction, of the universal whole whereby we get

at the very heart of that order—and a specifying difference at that—in the level of immateriality they achieve: the second is higher in abstraction and immateriality than the first (cf. John of St. Thomas, *Curs. Phil.*, Log. II P., q. 27, a. 1. ed. by Reiser, t. I, p. 825; *Phil. Nat.*, I P., q. 1, a. 2, Vives, t. II, p. 16). Modern mathematics, while striving to overcome this difference and amassing in the process the most fruitful discoveries, has only succeeded in the final reckoning in making its significance more marked and precise. For if geometry and arithmetic have become co-extensive, it is still right to think that the numerical continuum presupposes the first and irreducible notion of extension, and that irrational number, in virtue of which "the body of numbers" acquires "the same amplitude or the same continuity as the straight line" (Dedekind), is in reality an arithmetic symbol of a point arbitrarily designated on a straight line, an indivisible common to two segments that are continuous through it [(cf. F. Gonseth, *op. cit.*, p. 40). The vicious circle (that Mr. Weyl denounces) apparently involved in the way the existence of irrational numbers is ordinarily established would only result if an attempt were made to establish that existence in a purely arithmetical way, beginning with rational and whole numbers]. At all events, we are forced to fall back upon the distinction between two "schools" in mathematics, and two only, to wit, "the school of the numerable, Arithmetic, and the school of the continuum, Geometry" (Gonseth, *op. cit.*, p. 72).

Generally speaking, it is important to notice that the three basic degrees of abstraction which are taken *ex parte termini a quo*, according as the mind lets these or those material conditions slip aside, only define the primary, bold determinations of speculative knowledge, and within them discriminations of a specific kind can be found which are taken *ex parte termini ad quem*, according as the mind further sets up the object on a certain fixed level of immateriality (John of St. Thomas, *Log., loc. cit.*). One and the same specific knowledge, for example, the Philosophy of Nature, can consider objects of very different universality (cf. St. Thomas Aquinas, *Comm. in de Sensu et Sensato*, lect. I) which are still on the same level of intelligibility as long as the *modus definiendi* is the same for all of them. But if it is a matter of a different mode of defining, of a different way of establishing scientific notions, then a specifically different type of speculative knowledge is involved.

27 Cajetan, *In de Ente et Essentia*, Prooemium, q. 1; John of St. Thomas, *Curs. Phil.*, Log. II P., q. 27, a. 1, ed. by Reiser, t. 1, pp. 822, 829.

"man" from "Peter" and "Paul," "animal" from "man," etc. In this way we proceed to wider and wider universals. This kind of abstraction, whereby the mind rises above simple animal knowledge of the singular perceived by the sense *hic et nunc*, and which in reality begins with more general and undetermined notions, is at the root of all human knowing. It is common to all the sciences. At this level, every science proceeds towards the greatest possible determination, demanding that its object be compressed, so to speak, into a proper notion, and not enveloped in a more-or-less variable common notion. Second, there is a kind of abstraction, *abstractio formalis*, which we may call an abstraction, or extraction, of the intelligible type whereby, from contingent and material data, we separate what belongs to the formal reason, or essence, of an object of knowing. The speculative sciences differ from one another according to the degrees of this *abstractio formalis*, the objects of the higher science being, as it were, a form or regulating type, with respect to the objects of the lower science. The objects of metaphysics are undoubtedly more universal than those of physics, but it is not on this score, that is, as more common notions on the same level, that the metaphysician considers them, but in virtue of an intelligible form or type on a higher level. The metaphysician considers an object of knowing of a specifically higher nature and intelligibility, and from it he acquires a proper knowledge, a scientific knowledge, by means that absolutely transcend those of the physicist or mathematician.

If a figure of speech be permitted here, let us say that the work of the intellect can be compared to an immaterial magic. From the flux of singular and contingent things, as given to the apprehension of the sense, a first glance of the intellect reveals the world of corporeal substances and their properties. A second glance reveals quite another universe, the ideal world of the extended number. A third glance discloses still another, wholly different, universe, the world of being as being and all the transcendental perfections common to spirits and bodies, wherein we can attain purely spiritual realities, and the very principle of all reality, as in a mirror.

13. Now how are we going to classify the sciences which only a short time ago we called sciences of observation, those, namely, that do not succeed in clearly attaining the natures at which they aim? They are clearly on the lowest level of abstraction. They form a part of *Physica*. From now on, therefore, we can distinguish, within this *Physica*, two classes of science as opposite extremes: sciences of observation (sciences which are above all inductive and which we may call empirical sciences of sensible nature),[28] and a properly explanatory science of corporeal being (the philosophy of sensible nature).

28 They can also be called *physico-physical* sciences, as we call them in our *Réflexions sur l'intelligence*, Ch. VI, or even *empirio-schematic* sciences, as we will call them below (Ch. IV). Generally speaking, that was the science among the ancients which had to do with the details of phenomena (i.e., when they were not absorbed in philosophical pseudo-explanations). And even in our own day they

To be more exact, let us note that all our concepts are resolved in being which is the first object attained (*in confuso*) by intellectual apprehension. The concepts of METAPHYSICS are resolved in being as such, *ens ut sic*; those of MATHEMATICS in that sort of being (isolated within the real) which ideal quantity is; those of PHYSICS in mobile or sensible being, *ens sensibile*. But for the philosophy of nature, the accent must be on *ens* in the expression *ens sensibile*. As a science of explanation, it discovers the nature of its object and the reasons for its being. And, since it is true that the nature of substances below man is not clearly accessible to us in its specific diversity, it must be said that the proper object of the philosophy of nature does not extend to that specific diversity of bodies, nor to the whole multitude of their phenomena, and is constituted only by transcendental being as determined and particularized in the corporeal, mobile and sensible world. We thereby note two things: First, that the philosophy of nature is in a certain continuity with metaphysics, in spite of the essential difference separating them, and that, on this score, it is above mathematics. Second, we note that philosophy does indeed provide a deductive science of corporeal being, but that it is incapable of providing a deductive science of the phenomena of nature.

As regards the empirical science of nature, on the other hand, in speaking of *ens sensibile*, the stress will have to be put on *sensibile*, not on ens. It will tend to resolve all its concepts in the sensible itself, in the visible itself, in observable determinations, at least to the extent that it strives to constitute an autonomous science of *phenomena*. Every definition, for example, the definition of geosynclinal, or of word-blindness, is then taken with reference to sensible observations and indicates something which presents certain well-determined observable properties. Empirical science will, to the same extent, tend to set up a conceptual lexicon entirely independent of the conceptual lexicon of sciences which, like the philosophy of nature and metaphysics, determine their definitions by referring to intelligible being.

Table of the Sciences

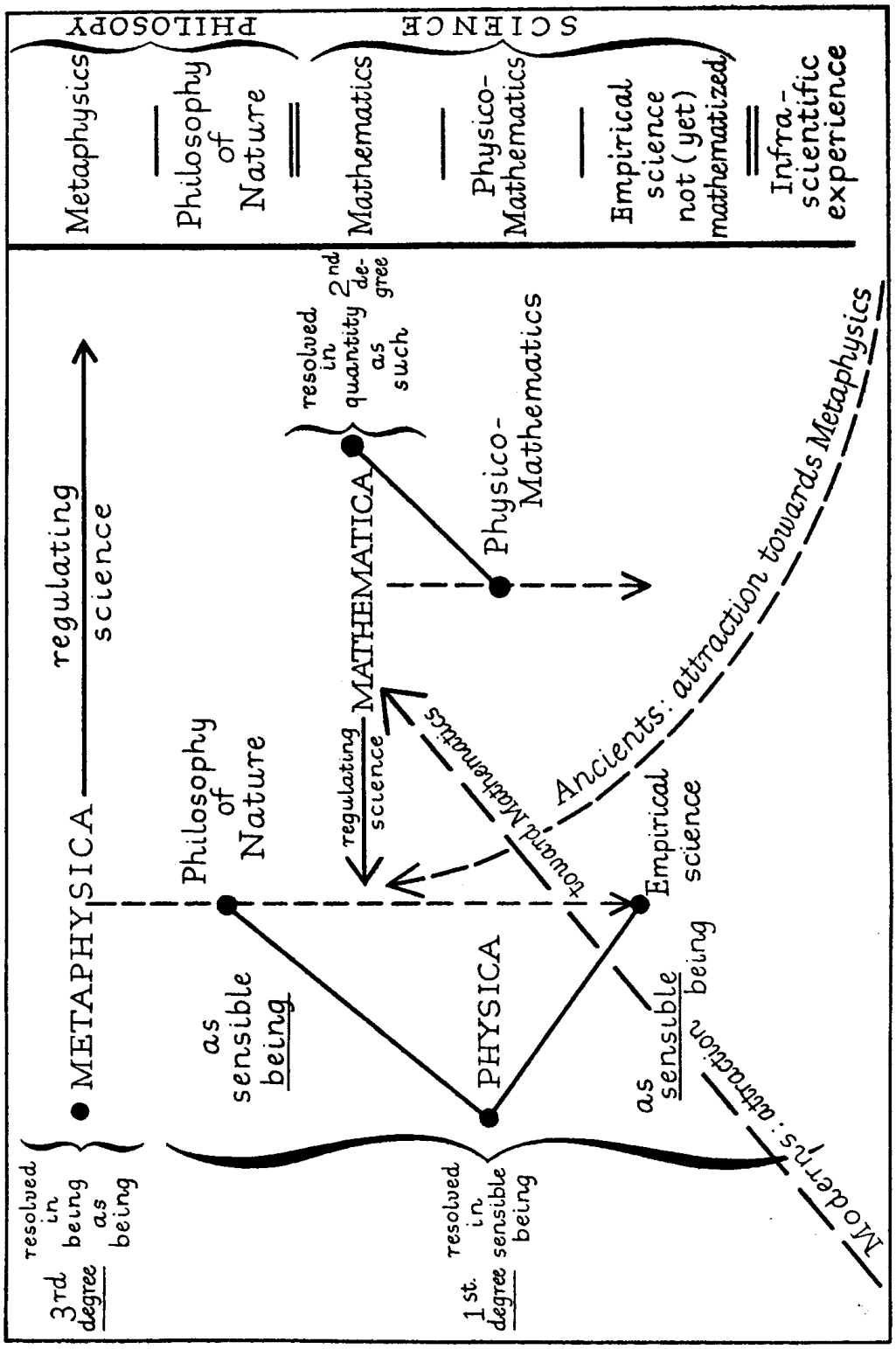
14. To sustain our interest in so complex and abstract a matter, we will arrange the notions we have so far derived in a synoptic table.

What do we see in this table?

I. The second degree of abstraction is not only depicted, as it should be, on a level midway between the first and third: it has also been drawn along another vertical line set off to the right of the table.

Why? Because mathematical abstraction is of a type quite apart. Although they differ specifically, *physica* and *metaphysica* have this in common, namely, that they deal only with intelligible objects which *can exist* in things, let us say *real* beings, insofar as the word *real* not only designates actual existence but

constitute those vast scientific areas that escape the rule of physico-mathematics and the way in which it rationalizes.


PHILOSOPHY
SCIENCE
Metaphysics
Philosophy of Nature
Mathematics
Physico-Mathematics
Empirical science not (yet) mathematized
Infra-scientific experience
3rd degree resolved in being as being
1st. degree resolved in sensible being
METAPHYSICA
regulating science
Philosophy of Nature
as sensible being
PHYSICA
resolved in quantity as such 2nd degree
MATHEMATICA
regulating science
Physico-Mathematics
toward Mathematics
Empirical science
as sensible being
Moderns: abstraction
Ancients: attraction towards Metaphysics

possible existence outside the mind as well. Mathematics, on the contrary, deals with an object which is not necessarily real, but one that may be an imaginary or fictive being (*permissive*, the ancients said) [29] a being of reason as well as a real being. As a result of this main difference, the three degrees of abstraction are not three steps on the same line of ascent, and the first and third, on the one side, the second on the other, require opposite ways of approaching things.

II. On the other hand, empirical science, philosophy of nature and metaphysics are along the same hierarchical line. Although specifically different, the light of the first degree of abstraction is, as it were, a participation in that of the third degree.[30] It is a lower and divided light, but still capable, in the

29 Cf. John of St. Thomas, *Curs. Theol.*, I P., q. 6, disp. VI, a. 2, n. 20, *Mathematica an sint bona* (Vivès, t. I, p. 680).

30 In our synoptic sketch we have placed the philosophy of nature at a higher level than mathematics insofar as it shares in the light of the third degree of abstraction. It still remains true, however, that the first degree of abstraction, to which it in itself is reduced, is inferior in immateriality to the second degree, and this point has also been depicted in the table.

On the one hand, these remarks enable us to understand that the sciences of nature presuppose mathematics. "Scientia quae se habet ex additione ad aliam, utitur principiis ejus in demonstrando, sicut geometriá utitur principiis arithmeticae; magnitudo enim addit positionem supra numerum, unde punctus dicitur esse unitas posita. Similiter autem corpus naturale addit materiam sensibilem super magnitudinem mathematicam: et ideo non est inconveniens si naturalis in demonstrationibus utatur principiis mathematicis . . ." (St. Thomas Aquinas, in lib. I, *de Caelo et Mundo*, lect. 3). "Quaecumque impossibilia accidunt circa mathematicalia corpora, necesse est quod consequantur ad corpora naturalia; et hoc ideo, quia mathematica dicuntur per abstractionem a naturalibus; naturalis autem se habent per appositionem ad mathematica: superaddunt enim mathematicis naturam sensibilem et motum, a quibus mathematica abstrahunt: et sic patet quod ea quae sunt de ratione mathematicalium, salvantur in naturalibus, et non e converso" (*ibid.*, lib. III, lect. 3). From this point of view, the fact that real space has three dimensions is certified by necessities discovered in the course of construction in mathematical intuition—which is always the privilege of classical geometry. "Naturalis praesupponit a mathematico ea quae circa dimensiones considerat. Et ideo probare demonstrative, esse solum tres dimensiones, pertinet ad mathematicum, sicut Ptolomaeus probat per hoc, quod impossibile est conjungi simul lineas perpendiculares plures quam tres super idem punctum; omnis autem dimensio mensuratur secundum aliquam lineam perpendicularem" (*ibid.*, lib. I, lect. 2). If the notion of displacement is brought in, then we will say: "Let us consider a free solid, fix it at three points, it is immobile, fix it at two only, and each point along the axis of the other two describes a circle; fix it at only one point, and every point at a finite distance from that point can be moved on a sphere" (R. Poirier, *Essai sur quelques caractères des notions d'espace et de temps*, Paris, 1931, p. 105).

On the other hand, we can also understand that the philosophy of the continuum and of numbers returns to the philosophy of nature, to such a point that, according to St. Thomas, the mathematician's "postulates" would have to be

case of the philosophy of nature, of penetrating inside things, but in the case of empirical science, halted on the surface and at signs.

We know that, among the ancients, following the universal law of attraction of the lower by the higher, the empirical sciences of nature have undergone the attraction of the philosophy of nature and metaphysics. And, since only by being informed by a deductive science could they be established as sciences, they have sought this information from notions elaborated by the philosophy of nature and metaphysics.

III. Every higher discipline is regulative with respect to its inferiors. Since metaphysics considers the highest reasons for being, it will, as a result, be the regulating science par excellence, *scientia rectrix*. But mathematics is also a deductive science, a science of the *propter quid*. It will also tend to rule the lower sections of knowing, if not to encroach upon metaphysics itself. We thus understand the struggle for dominion so often engaged in by these two sciences in the course of history.

IV. The great discovery of modern times, foreshadowed by the Parisian doctors of the fourteenth century and by Leonardo da Vinci, and achieved by Descartes and Galileo, is the discovery of the possibility of a universal science of sensible nature informed not by philosophy but by mathematics: *physico-mathematical* science. This tremendous discovery has changed the face of the world (without, apparently, being able to change in any way the essential order of the things of the mind as we have tried to discover it here),and has given rise—as we have tried to show elsewhere[31]—to the terrible misunderstanding

proved by the philosophy of nature. "Sunt enim quaedam propositiones, quae non possunt probari nisi per principia alterius scientiae; et ideo oportet quod in illa scientia *supponantur*, licet probentur per principia alterius scientiae. Sicut a puncto ad punctum rectam lineam ducere, supponit geometra et probat naturalis; ostendens quod inter quaelibet duo puncta sit linea media" (St. Thomas Aquinas, *In Anal. Post.*, Lib. I, cap. 2, lect. 5, n. 7). If this way of looking at the matter is correct, then the rational necessities seen by philosophy in the analysis of the continuum as it is set free by abstraction from sensible and mobile reality (in other words, in the axiomatic analysis of the continuum insofar as it can be constructed in imaginative intuition), necessities that would be the basis for the postulates of Euclidian geometry, i.e., that would "discover" the Euclidian axiomatic in the notion of the continuum that can be represented intuitively (as Mr. Hamelin has tried to do from an idealistic point of view in several noteworthy pages of his *Essai*), and that would by the same token justify the non-Euclidian geometries, would give the mind complete security insofar as the compatibility of their axioms is concerned—inasmuch as these geometries, which contain Euclid's geometry and are contained by it, can always be translated into Euclidian language by the addition of extra dimensions; and inasmuch as the compatibility of Euclidian axioms, the absence of any contradiction hidden in their origin, is certified by the fact that the Euclidian continuum can be constructed in intuition: *ab actu ad posse valet consecutio*; for if the Euclidian continuum can be constructed in imaginative intuition and thus given as a fact, it is because there is no hidden incompatibility in its notion.

which, for three centuries, has embroiled modern science and the *philosophia perennis*. It has given rise to great metaphysical errors to the extent that it has been thought to provide a true philosophy of nature. Of itself, it was an admirable discovery from an epistemological point of view, and one to which we can quite easily assign a place in the system of sciences.

It is a *scientia media*, of which geometric optics and astronomy were typical examples among the ancients. It is an intermediary science, straddling mathematics and the empirical sciences of nature, a science for which physical reality provides the matter (through the measurements it permits us to gather from it) but whose formal object and method of conceptualization remain mathematical: a science *materially physical* and *formally mathematical*.[32] In such sciences, the rule of explanation leaves aside physical principles and causes with their proper intelligible value (as Duhem saw very clearly). And yet these sciences remain preponderantly physical, as St. Thomas notes in his commentary on the second book of Aristotle's *Physics*[33] (and as Einstein and Meyerson saw very clearly), because they have their terminus in sensible nature

31 Cf. *Réflexions sur l'intelligence*, Ch. VI.

32 Cf. *Réflexions sur l'intelligence*, Ch. VI, and the texts we have quoted from St. Thomas on page 286, especially *In Boet. de Trin.*, q. 5, a. 3, ad 6: "Quaedam vero sunt mediae, quae principia mathematica ad res naturales applicant, ut musica et astrologia, quae tamen magis sunt affines mathematicis, quia in earum consideratione id quod est physici, est quasi materiale, quod autem mathematici, quasi formale." See also below, Ch. II, § 29.

33 This is the way he has understood the expression : τά φυσικώτερα τῶν μαθμάτων. (*In Phys.* II, 2, 194a, 7), used by Aristotle concerning geometric optics (*perspectiva*), harmony and astronomy. "Hujusmodi autem scientiae, licet sint mediae inter scientiam naturalem et mathematicam, tamen dicuntur hic a Philosopho esse magis naturales quam mathematicae, quia unumquodque denominatur et speciem habet a termino: unde, quia harum scientiarum consideratio terminatur ad materiam naturalem, licet per principia mathematica procedat, magis sunt naturales quam mathematicae" (*In Phys.*, lib. II, lect. 3).

St. Thomas has written elsewhere (*Sum. Theol.*, II–II, 9, 2, ad 3) "Quilibet cognoscitivus habitus formaliter quidem respicit medium per quod aliquid cognoscitur; materialiter autem id, quod per medium cognoscitur; et quia id quod est formale, potius est, ideo illae scientiae quae ex principiis mathematicis concludunt circa materiam naturalem, magis cum mathematicis connumerantur, utpote eis similiores, licet quantum ad materiam magis conveniant cum naturali; et propter hoc dicitur in II Physic. quod sunt magis naturales." In his Commentary, Cajetan has these remarks to make about this text: "Non dicitur quod scientiae mediae sunt magis mathematicae quam naturales: cum falsum sit absolute loquendo; quia simpliciter sunt scientiae naturales, utpote non abstrahentes a materia sensibili. Omnis enim scientia non abstrahens a materia sensibili, est naturalis, ut patet VI Metaph. Sed dicitur quod connumerantur magis cum mathematicis, utpote eis similiores."

Thus, physico-mathematical science is at once *formally mathematical* (through the principles and *means* of demonstration it uses) and more physical than mathematical through the *terminus* or matter in which it verifies its propositions.

These two characteristics are in no way incompatible and are simultaneously affirmed by St. Thomas and Cajetan concerning *scientiae mediae*. Perhaps the more complete explanation of our thought which we are giving in the present work will satisfy Fr. Pierre Hoenen's scruples, for he seems to confuse our position with that of Duhem ("Maritain's Rede te Amsterdam," in *Studien*, May 1927) and he does not see that as far as we are concerned physico-mathematics is, indeed, a science of the *physical real*, but a science that knows that real only by transposing it, and *not as the physical real*. In any event, the distinguished professor will, we hope, find some consolation in making his own the lines with which Cajetan concludes the commentary we have already quoted(in II–II, 9, 1 and 2): "Verum, quia medium utrumque sapit extremum, et scientiae istae ex parte formae ex mathematica veniunt et pendent, ex parte vero materiae physicae sunt, sermones doctorum pie interpretandi sunt, si quando ad alterum extremum nimis declinant."

Moreover, it seems that Fr. Hoenen has read the texts he is criticizing rather rapidly. In our *Réflexions sur l'intelligence* (p. 198), we really have not said that physico-mathematical science is a logical monstrosity; we have said that a *false* notion of this science, one that would confuse it with a philosophy of nature, would make a logical monstrosity of it.

By contending, as he does in his communication to the Thomist Congress in Rome (*De Valore theoriarum physicarum*, Rome, 1925, pp. 61–74, 269–275; cf. also the interesting articles published in the review *Gregorianum*, 1925, pp. 248–265; 1927, pp. 229–242; 1928, pp. 417–460), that physical theories furnish knowledge of physical reality *by analogy*, without stating exactly what kind of analogy he is referring to, Fr. Hoenen seems to take the risk either of giving rise to serious misunderstandings regarding analogy or of giving himself up to a quest for some deceptive sort of concordism. As a matter of fact, what is it that is primarily understood in philosophy by "analogical knowledge"? It is that knowledge by analogy of proper proportionality which metaphysicians employ in order to reach some understanding of spiritual beings. This kind of knowledge teaches or informs us clearly, no doubt, but from a certain stage of conceptualization onward, symbolically, about mathematized physical reality, i.e., physical reality transposed to a level other than its own. The perpetual renewals in science (for instance, at this very moment, the recent ideas on photons and the new mechanics of Louis de Broglie and Heisenberg) show that it is prudent not to ask the philosopher to decide what is true and false in the physical theory of light or in the theory of the atom; all that he needs is to hold as true those experimental facts on which such theories are based and borrow from those very theories a provisional *picture* of things, intended to sustain his thought, rather than to shape it.

One point remains true, and this is what we would have liked to see Fr. Hoenen bring out. It is this: On each side of that knowledge which grasps the object in its essence (and which, later on, we shall call "dianoetic") there is seen to correspond symmetrically (a) the knowledge *by analogy* of proper proportionality (for things above) which metaphysics employs when it rises to the First Cause and (b) the knowledge *by signs* (for things below) which the sciences of phenomena provide us with concerning nature, especially that *symbolic* knowledge with which physico-mathematical theories end up in their loftiest deductive elaboration of the experimentally "given." We realize only too well that this latter kind of knowledge, as the word "symbolic" indicates, belongs to the logic of analogy

[The point that Émile Meyerson has so strongly made against positivism (and also against Duhem), is that a concern for "ontology"—explanation by physical causes—cannot remain foreign to science. But the encounter between the law of causality, which is immanent to our reason, and the mathematical conception of nature, has as its result the construction in theoretical physics of more and more remote and geometrized universes. In these universes, fictive causal entities based on the real (*entia rationis cum fundamento in re*), whose sole function is to serve as a support for mathematical deduction, come to include a very detailed account of empirically determined real cases or conditions. Actually, more often than not, physico-mathematical science will be thus led to revive the old hypotheses of mechanistic metaphysics (while at the same time it radically transforms them, or else, as is evident in our own day, it introduces into them vast areas of displacement and irrationality). This does not happen, however, in virtue of the essential requirements of causal explanation. Émile Meyerson thinks it does because he seems to conceive the rational process only on the Eleatic type; he remains a rationalist in spite of everything. The reason is, rather, that mechanism is the only way of representing causality that can stand up, however precariously, within a general reduction of physics to geometry.

Pierre Duhem, on the other hand, as Amyl Picard recalled in his lecture of December 16 1929 at l'Académie des Sciences,[34] thought that a physical theory is not an explanation; it is a system of mathematical propositions which have, for their purpose, to represent, as completely and simply as possible, a whole complexus of experimental laws."[35] It does, indeed, actually happen that in some of its parts (for example, energetics as Duhem conceived it, or in our own day, wave mechanics according to the interpretation that Heisenberg proposes and to which Louis de Broglie has rallied) physics makes use of pure mathe-

taken in the widest sense of the word: but then, properly speaking, it is a question of a metaphorical analogy the use of which it is the privilege of mathematics to permit for the sake of knowledge of the physically real (cf. below, Ch. IV, §§ 16 and 17). With Fr. Hoenen it can be said: "Secundum maximam Cajetani (*De Nom. Anal.*, cap. 4): *quidquid assimilatur simili ut sic assimilatur etiam illi cui illud tale est simile*, concludendum est: causa quam hypothesis verificata proponit assimilatur causae verae; quod nihil aliud est ac principium analogiae theoriae physicae quod supra delineavimus" (*De valore . . .*, p. 69). But then the *assimilatio* in question is either (a) a univocal substitution insofar as physical theory translates facts and shows us observable and measurable structures and causations (co-determinations) that have the value of *entia realia*, or (b) a symbolic or metaphorical substitution, insofar as physical theory constructs beings of reason on its own, that help it to gather and interpret such data in a deductive explanation. This combination (in many, many varied degrees) of the univocal description of experimental reality and the symbolic interpretation of this same reality appears to us characteristic of physico-mathematical knowledge.

34 *Un coup d'oeil sur l'histoire des sciences et des théories physiques* (Paris, Gauthier-Villars, 1929).

35 See particularly Duhem's book on *La théorie physique.*

matical symbols without therein attempting either *causal explanation* or the constructing of figurative hypotheses through which the mind may in some way take the mechanism of phenomena apart. But to tell the truth, when it does refrain from doing so, it makes a virtue of necessity because it cannot do otherwise. Where Duhem went wrong was in seeking the very model of physical theory in these rather exceptional cases, which he regarded as pure cases. Actually, these cases stand at the very limit of physical theory and in them the mathematical transposition of phenomena is momentarily sustained all alone in the mind without any supporting physical image. So little are they typical of physical theory that the mathematical symbols they use are just awaiting a chance to leave the realm of pure analytical forms and become explanatory entities. (This is what happened in the case of energy. For, "almost all scientists today admit that it is not merely an abstract conception," let us say a pure mathematical symbol. The somewhat crude case of atomic number could also be cited, for it has finally ended up by designating the charge of an atomic nucleus and the number of electrons gravitating about it, when at the outset it was simply a periodic number.) On the other hand, causal entities, and the structural patterns built by the physicists, derive their noematic consistency only from the mathematical symbolism they, so to speak, embody. The interpenetration of mathematics and entitative representations thus seem essential to physico-mathematical knowing. Whence it happens that, in accordance with Amyl Picard's remark, These academic quarrels seem quite outmoded and the two points of view are curiously mingled in the work of scientists today."[36] Let us say, rather, that they constitute but one point of view. Moreover, Duhem's over-rarefied conception would have destroyed the main incentives arising from the discovery of facts, without which physics would not exist at all.

These explanations were necessary; we hope they will eliminate any misunderstanding concerning the positions herein maintained. Let us now return to our business.]

V. A science of *phenomena* as such became possible with the physico-mathematical scientia media, materially physical and formally mathematical. We no longer have to deal with a science of sensible nature which tries to find, as best it can, beneath phenomena, the intelligible connections that philosophy feeds on—philosophy which can explain phenomena only by already transcending them. We now have a science of sensible nature that applies to the details of phenomena themselves, just as they are coordinated in space and time, the formal connections of mathematical relations; and which, thanks to the science of ideal quantity, approximates the deductive character to which it aspires and without which it would not be a perfect science. Thus, to be at once experimental (in its matter) and deductive (in its form, but above all as regards the laws of the variations of the quantities involved), is the proper ideal of modern

36 *Op. cit.*, p. 37. Cf. below, Ch. II.

science. It provides truly scientific knowledge and devises wonderful means of utilizing sensible nature (from the point of view of quantity indeed, but not from the point of view of being). It has given up the direct search for real causes in themselves and aims to translate, first and foremost, its measurements of things into a coherent system of equations. In all these ways physico-mathematical science is evidently bound to end up by inserting itself, like a wedge, between pure empirical science and the philosophy of nature and so to rupture the continuity in which the optimism of the ancients delighted.

For the ancients, it was the philosophy of nature and metaphysics that drained, so to speak, the whole terrain of empirical science and infra-scientific experience and strove to bring it to the level and nature of science. This is the point we depict on the chart by an arrow pointing in the direction of metaphysics.

For the moderns, it is mathematics that performs this function. Thus, an arrow has to be drawn whose direction will be quite the opposite, its trajectory must mark a break, a very clear split, an irremediable fracture, between science and philosophy.

The intersecting of these two arrows symbolizes the epistemological drama of modern times.

As regards the science of the phenomena of nature, the ancients' attempt ended up in a resounding failure, at least, in respect to all that concerns matter and motion. Let us say that it has come a cropper over physics (in the modern sense of the word).

The moderns' effort has been a brilliant success in physics; and in our own day we are witnessing in this realm a crisis of growth which is a prelude to even more brilliant successes. But what will happen—even without quitting the realm of the scientific knowledge of phenomena—in the case of sciences whose objects do not so easily lend themselves to mathematization? They cannot be satisfied with algebraically symbolizing nature; and the real will continue to hold sway over them in the mind, in function of the notion of being. It could well be that the modern conception of science has been brought up short in face of biology and experimental science (to say nothing of the moral sciences which concern philosophy even more closely), just as the ancient view was in face of physics

VI. We have given a very brief survey of the organic relations obtaining between the principal categories of science. If we now list these categories in a single column, we will see that they rank one above the other in a hierarchical order. Thus we get back to the classical distinction between sciences, in the strict sense of the word, and philosophy.

Science in general includes two great areas. First, there is the realm of wisdom, which knows things through first causes and the highest reasons for being; then there is the domain of science in the narrow sense, which knows things through second causes or proximate principles. Metaphysics is a wis-

dom. It is *the* wisdom pure and simple of the natural order, that order which is of itself accessible to natural reason. In a certain respect, the philosophy of nature is wisdom, because it deals with the first principles and first causes *in a given order*, to wit, in the order of corporeal nature. (I note, parenthetically, that the study of the basic ontological roots of mathematics, the philosophy of number and the continuum, enters into the sphere of the philosophy of nature, because inasmuch as mathematical abstraction does not of itself deal with real being, it does not include a wisdom in its own proper order.)

We shall, therefore, group these two wisdoms—wisdom pure and simple and wisdom in a certain respect, metaphysics and philosophy of nature—under the name PHILOSOPHY.

As for the other sciences—mathematics, physico-mathematical sciences, experimental sciences or historical sciences (paleontology, linguistics, etc.) which have not (as yet) been, and will likely never be informed, in their essential structure and scope, by mathematics—these we shall group under the name SCIENCE in the narrow sense of the word.

III
SCIENCE AND PHILOSOPHY

15. Although it may happen that the *material object* of philosophy and science are the same—for example, the world of bodies—nevertheless, the *formal object* is essentially different in each case; and it is this that determines the specific nature of intellectual disciplines. In the world of bodies, the scientist will study the laws of phenomena by linking up one observable event with another. If he is trying to discover the structure of matter, he will do this by representing to himself—through molecules, ions, atoms, etc.—how, in accordance with what laws, the ultimate particles (or the mathematically conceived entities that take their place) with which the whole edifice is constructed behave in the framework of space and time. The philosopher will seek to learn *what*, definitively, that matter *is* whose behavior is thus depicted, and what is the nature of corporeal substance as intelligible being. (The fact that, in view of a spatial or spatio-temporal reconstruction, it may be broken down into molecules, ions, atoms, etc., or into protons and electrons whether or not they are linked together in a wave system is irrelevant to the philosopher's problem.)

The scientist proceeds from the visible to the visible, from the observable to the observable (I mean "to what is at least indirectly observable"; I do not mean "to what is always able to be pictured or represented in imagination." For the imagination represents things as they appear to us in our scale of large dimensions, that is, as possible objects of full and continuous observation. But the moment the scientist passes to an order [the atomic order] in which the

very possibility of full and continuous observation of phenomena is eliminated,[37] he passes from a world of objects imaginatively representable to a world of objects without any imaginable form. Such a world is unimaginable by default, or "privatively").

The philosopher proceeds from the visible to the invisible, I mean to what is *of itself* outside the order of sensible observation (for the simple reason that the principles which he reaches are in themselves pure objects of understanding and not objects of sensible apprehension or imaginative representation. Here is a world unimaginable by nature, or "negatively").

Since they have utterly different formal objects, other principles of explanation, diverse conceptual instruments, and, on the part of the knowing subject himself, quite distinct intellectual virtues or discriminating lights, the domain proper to philosophy and the domain proper to the sciences do not overlap. No explanation in the scientific order will ever be able to displace or replace an explanation belonging to the philosophical order, and vice versa. One would have to be very naive to imagine that recognizing, on the one hand, an immaterial soul in man, and studying, on the other hand, the glycogenic function of the liver or the relations between idea and image are two explanations that both belong to the same field and run counter to each other.

Truth to tell, scientific explanations do not reveal the very being of things. Since they explain only proximate causes or even that kind of formal cause which is the conformity of phenomena to mathematical law (and such more-or-less arbitrarily constructed entities fashioned as a support for this type of law), they can never satisfy the mind. For the mind will always, and necessarily, raise questions of a higher order and strive to penetrate into the purely intelligible.

16. From this point of view, we can say there is a certain dependence of the sciences on philosophy. Inasmuch as they seek the *raison d'être* and yet reveal it only imperfectly, the sciences themselves inspire the mind with a desire for philosophy and look for support to a higher knowledge. It is quite remarkable how strongly this need has been felt, after the positivistic period of the nineteenth century, in every domain of science. It is no less remarkable that the need manifested itself in a most disorderly fashion. For, those who dealt with philosophy without adequate philosophical equipment inevitably lacked competence in this field, even when they were scientific geniuses like Henri Poincaré.

Let it be clearly understood that the sciences do not depend on philosophy for their intrinsic development. They only depend upon it in principle (not, indeed, in the sense that they would need philosophy to know their own principles and use them, but in the sense that it belongs to philosophy to explain and justify those principles). Perhaps scientists sometimes miscon-

37 See below, Ch. IV, §§ 10, 13.

ceive the sort of dependence we are speaking of precisely because they have no need of express recourse to philosophy in order to exercise their properly scientific activity. Yet, if they reflect carefully upon the very activity they exercise (and this is, in truth, to philosophize), they cannot help recognizing that a whole philosophy is involved, so to speak, in practical guise.

The whole use of experimental methods and critique, as for example, the determining of the degree of approximation of acquired results, constitutes an applied or lived logic (*logica utens*). This only becomes pure logic, and the object of a particular science and a speculative art studied for its own sake (*logica docens*) when the logician reflects upon it. But in itself, this is nothing but logic, a properly philosophical discipline, in the state of exercise.

On the other hand, every scientist as a scientist, whatever the conscious or unconscious metaphysical opinions may be which lie at the root of the conception of the world on which he bases his life as a man, in the very exercise of his science, asserts practically (*in actu exercito*) a certain number of eminently metaphysical propositions (M. Meyerson should be thanked for having so forcibly called attention to this point), and he does so with a dogmatism that is all the more intransigent the less it is reflected upon. These propositions may concern the reality of the sensible world, the existence of *things* outside us, stable ontological nuclei, substantial x's, that serve to support phenomena.[38] They may raise the question of the power of our knowing faculties to lay hold of things—with difficulty, no doubt, and in a way that brings with it all sorts of more-or-less obscurely experienced limitations, but that can also enclose incontestable certainties—or, to put it otherwise, they may raise the question of a kind of intelligibility of the world, badly determined, perhaps, and felt to be imperfect, but one which they do not scruple to presuppose. Or again they may raise the question of the value of principles, especially the principle of

38 "The habit of calling a spade a spade keeps the scientific fraternity from too much vain quarrelling. It is splendid to agree on words and on the perceptions they designate. This remarkable accord creates among scientists an atmosphere of confidence, a unison from which they derive a certitude that is only a robust belief. There is perhaps not a single chemist who confuses the reality of barium sulfate with the idea he has formed of it. I was once curious enough to put the question to some of them. They all found it rather queer. From the startled looks they gave me I could see they all thought me mad to ask such a question. This, then, is settled: the modern chemist thinks bodies are the absolute substratum of their properties, without bothering his head about the hypothetical character of this conception" (G. Urbain, "Essai de discipline," *La Grande Revue*, March 1920). This remark made by a scientist of unquestioned authority, as M. Meyerson points out (*op. cit.*, II, p. 235), and phrased as it is in language that suggests quite different philosophical opinions, constitutes a testimony that is all the more precious as "this scientist professes, in theory, a quite orthodox positivism and evidently finds the type of thinking he so accurately depicts, utterly blameworthy."

causality,[39] in connection with the world of experience, that is to say, the inadequacy of change to explain itself by itself. . . .

Finally, every scientist has a certain idea of nature proper to his own science. Perhaps it is often explained in a very partial or a most confused way but it is one that is in practice very active and efficacious. It is an idea that undoubtedly plays a major part in the intellectual orientation of the great innovators. From this point of view, what is more remarkable than the aphorisms about the nature of physics that so often came to the lips of Mr. Einstein? Now these considerations about the proper nature of this or that science do not, frankly, appertain to that science itself, but to philosophy; it is a lived *gnosiology*.

In short, there is no science without first principles to which all our reasoning must be reduced, since an infinite regress in this order clearly renders all demonstration impossible. Every scientist, from the very fact that he applies himself to deciding any question, already clings in a very positive, although not conscious way, to an important number of philosophical data. It is evident, then, that it would be well to bring into clear light, to face squarely and see as an object of a perfect mode of knowing, everything that is involved, in a merely implicit fashion, in the mind of the scientist: that is, to philosophize. The objective bonds that link the sciences to philosophy would then be explicitly noted. Their axioms are determinations of the principles of metaphysics; for example, the mathematical axiom: two quantities equal to a third are equal to one another, is a particularizing of the metaphysical axiom: two things identical with a third are identical with one another. Philosophy justifies and defends their principles. It is philosophy that determines the nature of the primary objects the sciences work on and, consequently, their own very nature, value and limits. For example, philosophy, not mathematics, will tell us whether or not irrational numbers and transfinite numbers are real beings or beings of reason; whether non-Euclidian geometries are constructions of reason based on Euclidian geometry and so leave a privileged value to the latter, or whether, on the contrary, they constitute a much vaster whole of which Euclidian geometry is but a species; whether the frontiers between

39 We mean that the scientist affirms *in actu exercito*, in the very exercise of his scientific activity, the value of the principle of causality (prior to any philosophical reflection on the meaning, the import of the various modes of verifying that principle, and still less, its critical justifications). For if he were not convinced in practice that everything that happens has a cause, he would never give himself over to his work of research, he would never even begin it. But it so happens that as it makes progress into the meaning of what we call below its empiriological autonomy, science has to re-establish or transpose the concept of cause, and perhaps even admit into the picture of the world it is constructing lacunae that leave many gaps in the field of what is, for it, "causality" (cf. below, Ch. IV, §§ 10 and 33). Thus, between the scientific picture of the world and the energies of the mental work from which it emanates there is a disparity analogous to the one we have explained elsewhere between the scientific universe of the physicist as physicist and the universe familiar to the same physicist as a man.

mathematics and logic are invariable, etc. Finally, philosophy assigns the order reigning among the sciences: *sapientis est ordinare.*

In all of this, philosophy in no way encroaches on the proper scope and method of the respective sciences. For, as we have just seen, it would be absurd to treat a problem belonging to the scientific order by the methods of philosophy, and vice versa. Philosophy acts as a superior science.

17. Since philosophy is superior, and consequently independent—at least, in that which formally constitutes it—it is of itself independent as regards the sciences.

Let it be understood that there is no formal dependence of philosophy on the sciences. Never will a result in the scientific order, never will a scientific theory, never, in short, will science suffice, by its own means, to settle a philosophical question, for such questions depend on principles and on a light which are beyond the scope of science.

There is, to be sure, a great MATERIAL dependence of philosophy on the sciences. In the first place, within the hierarchy of knowledge, philosophy is like a culminating point, one that consequently comes last pedagogically. The philosopher, if he is to judge the value, limits and subordination of the sciences to each other, must obviously know them from that angle and closely follow their development. Moreover, scientific data normally serve the philosopher as illustrations to exemplify his ideas and render them more concrete. Finally, and above all, the progress of science (at least, as regards the established facts, if not the theories) should normally renew and enrich the material it provides for the philosopher's elucidations, especially in all that has to do with the philosophy of nature. Thus, for example, modern discoveries in cell structure, of the ovum in particular and its sexual elements, about artificial parthenogenesis, etc., give new and valuable precisions on the approach to the problem of the education of the vegetative soul. In like fashion, the renewal of geometry since Lobatchevski and Bolyai compels the philosopher to purify many of his notions on quantity. Nevertheless, such a dependence remains material. The changes involved affect, above all, the imaginable representation, so important in respect to terminology and the aura of associations that surrounds didactic terms. To imagine that philosophical doctrines have to be changed with every scientific revolution would be as absurd as to think that the soul is transformed with every change of diet.

Clarifications on the Notion of Fact

18. This is the place to deal briefly with the question of the role of experience and experimental fact in the realm of philosophy.

According to St. Thomas, philosophy rests on facts. It has to accept facts. It begins by humbling itself before the real, first known by the senses, and which we experience by our fleshly contact with the universe. So the philosophy of

nature, in contrast with metaphysics, not only takes its origin in sense-experience, but finds there the terminus in which its conclusions must be verified. Yet, it does this in quite another way than the experimental sciences.

What, then, is a fact? It is a well-established existential truth. A certain connection in the objects of our concepts exists in the real. That very fact implies that this existence confronts a mind which can grasp therein those objects. A fact engaging human knowledge is not created by the human mind. A fact is given. But it is given to someone. And if it is given, it is received. A stone is not given to a stone. A fact is given to a mind. That is to say, it is discerned and judged. To conceive it as a pure and simple copy of the external real, devoid of any discrimination, is a deceptive simplification due to the unconscious materialism of the imagination.

Even at the level of the external senses, there is a sense judgment, as St. Thomas says. Sensible perception is itself educed. It is either an instinctive or acquired priming of the internal senses and the *ratio particularis*. Every fact is discriminated. It supposes a judgment either of the sense or of the understanding. Every fact is a witness to the activity of the mind. Idealists are right on that score. They are wrong in thinking that the activity of the mind cannot demand of things or take from them any information expressed by the mind but at the same time *given* by things. Their error is to believe—and this is a gratuitous and, ultimately, an absurd postulate—that every interpretation, or more exactly, every judgment made by our faculties of knowledge, is a deformation or a creation, rather than a more-or-less perfect and profound mode of becoming assimilated to the object and conformed to what is.

19. The error of the idealists is at the same time to challenge the primordial value of sense-intuition. In one way or another, every existential apprehension originates in this intuition, even when the fact in question transcends the whole order of the empirical and the sensible. (The same is true of the experience of our own existence, an experience which, though it is spiritual, not empirical, supposes a reflection on our own acts. This is true, also, of our knowledge of God's existence, which is established from visible things.) In the physical order (knowledge of corporeal nature) facts are given by the sense itself under the discriminating and critical judgment of the intellect. In order to distinguish the register of *fact* from the register of *theory* within this physical order and in the common procedures of the sciences of nature, let it not be said that theory arises from intellect and fact from sense. That would be a very superficial view. Rather, let it be said that, in the register of fact, the intellect intervening with its own natural or artificial resources, even its most scientific stratagems and delicate theoretical constructions, still aims to discern and formulate that which is furnished by sense-intuition.[40] In the register of theory,

40 In orders above the physical order, which will come up for consideration later on, this work of the intelligence which is characteristic of the "factual register"

on the other hand, working with those same resources, the intellect aims to discover essences or laws and explanatory reasons.

The activity of the mind does not intervene in the complex whole perceived by sense in order to create, but rather to pick out that which is of interest to intellectual knowledge. And because at the very moment a science is born, its characteristic point of view as well as the first facts on which it is based stand revealed; because before any advance is made in a science or any new facts are discovered, the mind must first enter that science and acquire the *habitus* proper to it; because before it approaches any particular scientific realm, the mind has already begun to philosophize, has already explicitly disengaged from the real a notion of being as such and the principles pertaining to it—therefore, the discrimination we have been talking about will already have taken place at a certain level of abstraction, and in the light of certain principles with reference to which the fact has a definite value, I mean a value for knowledge and truth. We may therefore conclude that all facts are not of the same *rank*. They do not constitute an indistinct and disorderly agglomeration gathered together in the market of sensible experience, to which the diverse sciences have to come to look for the commodities they need. Facts themselves belong to various orders or hierarchies of knowledge; there are common-sense facts, scientific facts (facts of interest to the sciences of nature), mathematical facts[41] (facts like the existence—the ideal existence—of underived continuous functions), logical facts, philosophical facts.

20. Speaking materially, it may also be said that philosophy is "experimental" and founded on facts. This is true in the sense that for philosophy experience has not the uniquely pre-scientific and infra-scientific role that it has for mathematics. For mathematical science is established entirely by axiomatic and deductive means, beginning with an imaginative intuition and with notions that abstraction simply forms and reconstructs on the basis of experience. On the contrary, the method of philosophy is an analytico-synthetic one. And because it deals with real being, being that is truly apt to exist outside the mind, experimental observations form an integral part of philosophical knowledge.

For philosophy, however, as opposed to the sciences of nature, all this provides nothing more than a material foundation from which the philosopher may rise through a formal deduction to first intelligible truths, known in themselves, to the consideration of the essences and the necessities they imply. Philosophy turns back to experience only incidentally—in natural philosophy, only to verify, within the sensible, the conclusions deduced, and to seek therein ever new data; in metaphysics, only to garner fresh points of departure and

is ordered to the disclosing of an existential position that we conceive by *analogy* with those furnished by an intuition of the sense.

41 Cf. Pierre Boutroux, *L'idéal scientifique des mathématiciens*, Ch. IV.

materials for analogy, not to verify its conclusions which belong to an entirely immaterial order. For metaphysics, formally speaking, is by no means an experimental science; as knowledge, it is far more purely rational than mathematics.

The Structures and Methods of the Principal Kinds of Knowledge

21. Many important consequences flow from the preceding considerations. At this juncture, we can point out only a few of them rather briefly. We shall especially try to give a glimpse of the sort of instrument of epistemological analysis that St. Thomas' principles can provide and to call attention to one of the characteristic marks of his noetic, to wit, the order and organic differences he establishes among the sciences and the care he takes to recognize and respect the structure and method proper to each.[42] Here St. Thomas' theory of knowledge stands in contrast with many modern systems which rank all sciences on the same level.

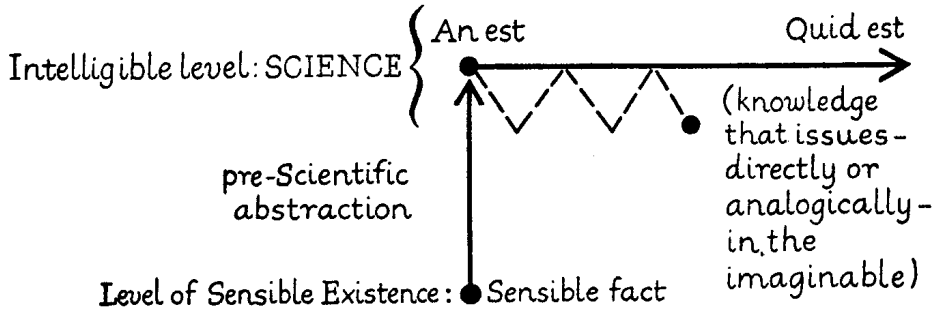
It must be kept in mind that every science has to answer two questions: first, the question, AN EST—whether the thing exists; and then the question, QUID EST—what is its nature.

22. Experience plays only a pre-scientific role in mathematics in the sense that one would not have formed the notion, "circle," or "straight line" if one had never seen a ring or a staff. If we had never pointed out with our finger the parts of a concrete collection one after the other, we would never have formed the notion, "number." However, once we get the notions, thanks to the abstractive power of intellect, they present us with objects of thought in themselves quite independent of experience, so independent in fact, that we can generalize them analogically and set them free from the intuitive structure in which they were first revealed. Although mathematical entities can exist only in matter—to the extent that they can exist outside the mind—nevertheless they do not exist in matter as mathematical entities, or in a mathematical

42 On this point we draw inspiration from certain ideas developed by St. Thomas Aquinas in his commentary on the *Posterior Analytics* of Aristotle (Bk. II) and in his commentary on the *De Trinitate* of Boethius (q. 5 and q. 6). Let us call to mind here the basic text from the *De Trinitate*, q. 6, a. 2: "In qualibet cognitione duo est considerare, scilicet principium, et finem sive terminum. Principium quidem ad apprehensionem pertinet, terminus autem ad judicium, ibi enim cognitio perficitur. Principium igitur cujuslibet nostrae cognitionis est in sensu. . . . Sed terminus cognitionis non semper est uniformiter: quandoque enim est in sensu, quandoque in imaginatione, quandoque in solo intellectu. . . .

"Deduci autem ad aliquid est ad illud terminari: et ideo in divinis neque ad sensum, neque ad imaginationem debemus deduci; in mathematicis autem ad imaginationem, et non ad sensum; in naturalibus autem etiam ad sensum. Et propter hoc peccant qui uniformiter in tribus his speculativae partibus procedere nituntur."

state. "Straight line," "circle," "whole numbers" are all realized in sensible things, but only by lacking the conditions of ideal purity that the mode of existing mathematically imposes upon them.



Mathematics

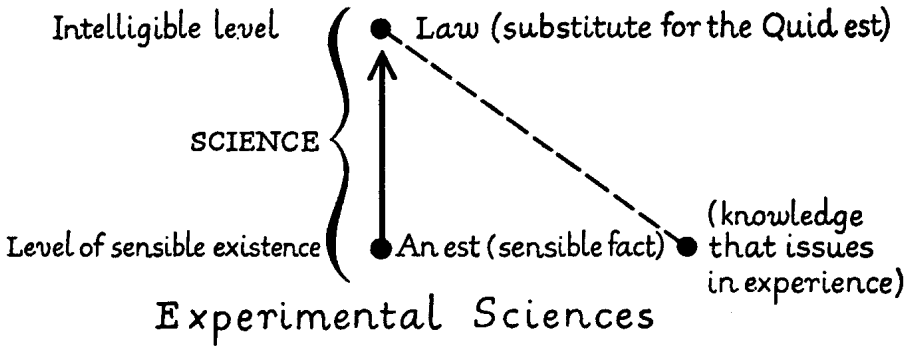
In the mathematical order, the question, AN EST, deals with the ideal existence (*possible existence* or *existence of reason*)[43] of the entity under consideration; and beginning with the notion of this entity, once posited as capable of mathematical existence, the truths concerning it (*quid est*) are deductively established by means of constructive operations which may play a very obvious role but which still remain material. Mathematical deduction formally proceeds in virtue of intelligible connections. These intelligible connections may either guide and determine at each instant the constructive operations, or once and for all establish and justify all the rules for a system of symbols which have simply to be applied by the art so determined. The ancients taught that in mathematics the judgment—whereby knowledge is perfected—does not open upon the sensible, but upon the imaginable. This does not mean that each of the conclusions it establishes must be directly verified in imaginative intuition. They must be verified in it either directly or analogically. That is to say, they either can be constructed in imaginative intuition, or they belong to a system of notions (as, for example, non-Euclidian, non-Archimedian, etc., geometrical entities) stemming from one which may be constructed in intuition (for example, Euclidian entities), and in which they may find an analogical interpretation.[44]

23. In the experimental sciences, experience is essential to the science itself and completely controls it. Here, the question, AN EST bears on facts subject to experimental critique. And the science does not succeed in seeing in itself or

43 The meaning of the word "ideal existence" is determined in keeping with the following division: *real being* { *actual*; *possible*; *being of reason* } *ideal being*

44 See below, Ch. IV, § 18.

dianoetically,[45] but only blindly, the essence which is wrapped up in these facts. It does not grasp it in its constitutive notes, but in the vicarious signs with which *perinoetic* [46] understanding is satisfied (especially in the *constancy* of a well-established relation). It grasps the essence in a substitute which is scientific *law*—the judgment wherein knowledge is perfected thus opens upon experience itself, or, to state it otherwise, every newly acquired conclusion must be verified in sensible fact.

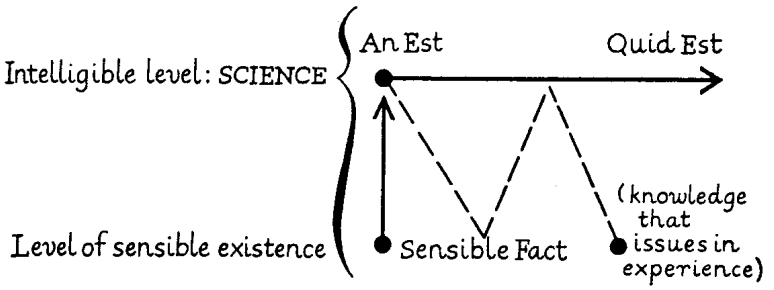


In the physico-mathematical sciences, deductive theory and the system of notions they elaborate hark back to experimental results to verify whether that theory is apt accurately to express those experimental results in an appropriate technical vocabulary. Here the substitute for the ontological *quid est* is not an inductively established law, but a mathematics *quid est*, an algorithm of the physical real.

24. In the philosophy of nature, the sensible fact materially belongs to the science, which still essentially depends upon experience, but it does not formally constitute its medium of demonstration. The question, AN EST, bears on the *real existence* of a nature to which abstraction has been able to rise and to consider in itself—the vegetative soul, for example. Beginning with this nature, once it has been posited, reason establishes its properties by an inductive-deductive coming and going, all the while opening on experience and verifying the conclusions it thus attains in sensible fact.

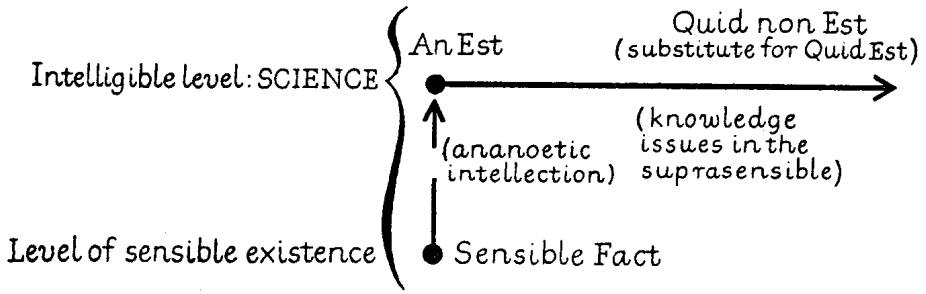
25. Finally, in metaphysics, sensible fact also belongs materially to the science, because one rises to the invisible only from the visible. But it does not formally constitute its medium of demonstration and *does not verify its conclusions*. The judgment wherein knowledge is perfected opens upon the pure intelligible. For it is not because (as in the case of the philosophy of nature) it

45 See below, Ch. V, § 1.
46 See below, Ch. V, § 3.



Philosophy of Nature

depends essentially on sensible experience, but rather because of its transcendence, that metaphysics descends (as mathematics does not) to the world of sensible existence. And it also climbs up to the world of supra-sensible existence. Thus, in natural theology, the question, AN EST bears on the *real existence* of an immaterial object to which knowledge by analogy (*ananoetic* understanding)[47] has been able to rise. Beginning with the existence of such an object, once it has been recognized, reason establishes conclusions about the nature (as analogically known) and the perfections of pure Act through the three-fold way of causality, eminence and negation and without any verification either in the sensible or the imaginable, because it deals with the purely immaterial.



Natural Theology

The Proper Conditions for Philosophy. Its Relation to Facts

26. Philosophy, whether it be the philosophy of nature or metaphysics, emerges from experience and empirical knowledge just as the positive sciences do. But philosophy transcends experience and empirical knowledge in a much purer and more perfect fashion than the positive sciences. First, the proper

47 See below, Ch. V, § 13.

experimental material upon which philosophy operates is much simpler, more universal, immediate and incontestable than the experimental material of the sciences. The facts upon which philosophy rests are absolutely general, primordial facts, not such facts as are observable only with more-or-less difficulty—and which, as science progresses, become more and more points at which the real coincides with the (always more and more complex and refined) constructions previously set up by scientific reason—but absolutely general and absolutely first facts.

Secondly, these absolutely general and primordial facts do not arise out of "vulgar experience" (which is, however, in a sense already more certain than scientific experience).[48] Vulgar experience intervenes in philosophy only as a substitute, when no scientific experience is available. Its claim to be admitted is the same as, though secondary to, that of scientific experience. The material proper to philosophy arises from an experience which is already philosophically elucidated and consequently quite superior to vulgar experience. For philosophy judges and criticizes this material *in its own light* in such a way as to establish it with entire certitude inasmuch as, in virtue of being a wisdom, it can defend its own principles. And so it defends and justifies (in an indirect way) the value of sensible perception itself. It is due to this point of view that the fact *that something exists, the fact that a multitude exists, that change and becoming exist, that knowledge and thought exist, that desire exists,* are properly PHILOSOPHICAL FACTS.

27. As for scientific experience, *scientific facts,* it is clear that although they can, as we said a little while ago, provide new materials for philosophy and be taken over by it (for philosophy can batten even on alien matter), of themselves they do not constitute its proper matter. In any case, they should be judged and criticized under the proper light of philosophy, even as its proper matter is, before they can be put to philosophical use.

Of itself, a scientific fact belongs to the realm of the sciences of nature. If it is true, then, that what characterizes these sciences is the fact that their cognitions are resolved into the sensible, then a scientific fact by itself will only be of concern to this type of explanation. So long as it is illumined only by that light which first revealed it within the real and placed it at the disposal of the scientist, it is of interest only to the scientist, and not to the philosopher. It is also an illusion to believe that by appealing to scientific facts without first illuminating them by a higher light, any philosophical debate—the debate

48 "The layman believes that the result of a scientific experiment is distinguishable from common observation by a higher degree of certitude; he is mistaken, for an account of an experiment in physics lacks that immediate certitude, comparatively easy to check up on, which characterizes common, non-scientific testimony. Though less certain than the latter, scientific certitude has the advantage over it in the number and exactitude of the details it makes known to us; there lies its true and essential superiority" (Pierre Duhem, *La théorie physique,* p. 265).

about hylomorphism, for instance—may be settled. Of themselves, they have nothing to say on that score. Let them not be tortured in order to wring pseudo-confessions from them! Let them never be cajoled! Yet let them be interrogated, however! But that presupposes that one is already provided with certain relevant points of information. Let them be summoned to appear, and in as great a number as possible. But one must refer to the scientist for assurance regarding all that pertains to their "citizenship," i.e., their experimental meaning and the way in which they are established. They must all be respected, and one must be always on the look out for all the new ones that come to light. However, it is only by relating them to philosophical knowledge already acquired from another source and with philosophical principles, that an intelligible content appropriate to philosophy can be drawn from them. Only then is it possible to discover and judge whatever ontological value they may possess and to use them either to put the conclusions of philosophy in contact with sensible verifications and the latest results of experimental science, or to confirm or establish properly philosophical facts—the starting points of philosophical demonstrations.

A whole nest of critical problems is revealed here, but we will be content to point them out in passing. We pointed out above how to distinguish in a general way, within the domain of the sciences of nature, the category of fact from that of theory. But because in the concrete these two orders constantly overlap (since science, in order to build itself up, is constantly going back and forth from facts to the new theories they serve to construct, and from theory to the new facts it serves to discern) it becomes necessary to set up a hierarchy among scientific facts themselves from the point of view of their factual value and to make a division between those "facts" which truly merit the name and those that in some way usurp it. Facts immediately provided by scientific observation themselves presuppose a certain number of theoretical propositions which have already been admitted (the first of which find their origin in the perception of the senses): these include propositions that have to do with the thing to be measured and the means of measuring it, the apparatus that has to be constructed to achieve this effect. As for other scientific facts which are mediately established, they either result from an encounter between an observed datum and a previously constructed theoretical network, or else they flow from the explanation itself when that explanation is seen to be the only possible one. From that point on, the philosopher has to make many distinctions. So, when modern astronomy established the fact that the earth turns about the sun, or when modern physics establishes the existence of atoms, these "facts," because mediately established, have value as data which is incomparably higher (higher, in fact, in the first case than in the second) than the hypothetical "fact" of the Lorentz-contraction or of the curvature of space postulated by Einstein's synthesis. Where can one look for the principle for such a distinction? Nowhere else than in a critical analysis of the rational

processes used in each particular case. The more the mathematical is reduced to the role of enabling one by measurement and calculation to get a surer grasp of the undiluted physical and of those causes and conditions whose character as *entia realia* the philosopher has no reason to question, the more does the result deserve to be considered a fact. But the more the physical is reduced to the role of intervening only as a mere instrument for discriminating between theoretical constructions whose proper value is constituted by their mathematical amplitude and coherence or as simple foundational entities which the philosopher has good reason to regard as beings of reason, the more should the result be transferred to the order, not of fact, but of explanatory image.

28. Given that philosophy is in its own right independent of the sciences, is it not true, nevertheless, that the sciences may indirectly reveal the falsity of this or that philosophical doctrine since a consequence deduced from a principle reveals the falsity of the principle if that consequence is recognized to be false?

That is true if and when a philosophical doctrine happens to encroach upon science itself or to have, as a necessary consequence, a certain scientific conception, or rather a certain general framework imposed on science, whose emptiness is demonstrated.

Despite what certain popularizers may say (and even those thinkers who attribute to the ancients their own carelessness in distinguishing the intelligible from the topographical, and metaphysics from astronomy), these charges do not stand up in the case of the philosophy of Aristotle when carried back to its authentic principles. First, let us consider the human subject. It should be recognized that too great a confidence in the intelligibility of things and in the processes of reason (functioning in an order which is not properly the order of philosophy but the order of experience—an order in which essences are not revealed to us) has played its part (and perhaps an overwhelming part) in the errors of ancient science. On this score, we would quite willingly go very far, for we are convinced that, on the one hand, modern science has rendered philosophy a great service in delivering it from burdens not its own, but which have for a long time oppressed it, namely, the burden of explaining phenomena. And we are convinced, on the other hand, that whereas a loss or weakening of the metaphysical spirit is an incalculable damage for the general order of intelligence and human affairs, it still happens that a predominance of the metaphysical spirit, when it is not accompanied by rigorous critical rectifications, accidentally harms the particular interests of experimental research. And this accident costs us dearly. Experimental research and the smallest step forward in the matter of the tiniest truth of fact is also an affair of the mind. And the mind brooks no interference.

Now let us consider the object. There is no necessary link between the mechanics, the physics and the astronomy of the ancients on the one hand,

and the metaphysics or natural philosophy of the scholastic tradition on the other. The whole structure of the experimental science of the ancients has doubtless crumbled and its collapse may well appear to anxious minds to spell the ruin of everything the ancients had thought. But in reality, their metaphysics and their philosophy of nature, in their essential principles at least (as they can be gathered from the Thomistic synthesis), have no more been affected thereby than the spiritual soul is changed when the body disintegrates.

Now that pure philosophical and metaphysical wisdom has been freed from many foreign elements, it is obviously desirable and necessary that, after this purification, it once more discover its organic relations, broken by three centuries of neglect and misunderstanding, with the total life, the activity, the actuality, of the sciences. For here below, the condition of a soul without a body is a rather uncomfortable one. The prison of the body is good for the soul. (As for the metaphysical systems of modern thinkers, more often than not they have been really nothing but an oppression of metaphysics by the hypostasized ambitions of the science of the sensible world.)

The ideas brought together in the course of this chapter give a glimpse of the conditions under which the work of integration, already begun at several points, can be furthered and brought to a happy conclusion. Whoever seeks to work towards the integrating of philosophy and experimental science must be at once on his guard against both a lazy separatism and a facile concordism and re-establish a vital bond between them without upsetting the distinctions and hierarchies which are essential to the universe of knowing.

To that end, two cases should, it seems, be very clearly distinguished: the case of physico-mathematical science and the sciences of which it is the type on the one hand, and the case of sciences like biology and psychology on the other.

Knowledge of the Physico-Mathematical Type and Philosophy

29. In respect to the explanation of reality, there can be no hope, in our opinion, of ever finding a continuity or dovetailing of the conceptual elaborations of physico-mathematics and the proper texture of philosophical and metaphysical knowledge. That would violate the very nature of things. I am not speaking of a continuity or a dovetailing among facts (to the extent that they can be separated from theories) but among the respective theories themselves. The discontinuity is clear and definite; and it is due to the very essence of these knowledge. Physico-mathematical science is not formally a physical science. Although it is physical as regards the matter in which it verifies its judgments, and although it is oriented towards physical reality and physical causes as the terminus of its investigation, physico-mathematical science does not, however, aim to grasp their inner ontological nature itself. In Chapter IV, we will come back to this observation. It is an observation that has very often

been made by scientists[49] as well as by philosophers, but it may lead to misunderstanding; its epistemological meaning is a delicate matter to determine. But as it stands, it is sufficient for our purpose.

Physics rests upon ontological reality; it is concerned with causes; it is set in motion by a love for the nature of things. But it looks upon this ontological reality, these physical causes, from an exclusively mathematical point of view. It considers them only in respect to certain analytical translations, certain cross-sections effected by mathematics. It retains only the measurable behavior of the real, namely, measurements made by our instruments. (These measurements are, indeed, real and, thanks to them, the entities and symbols of mathematical physics are grounded in reality.) But it is to the measurable that physics reduces all its concepts; for it, only the measurable has meaning.[50] Once in possession of its measures, its essential aim is to weave a network of mathematical relations among them. These relations are deductive in form and constitute the formal object of physics. They undoubtedly need to be completed by a certain hypothetical reconstruction of the physical real, but physics only demands that their final numerical results coincide with the measurements made by our instruments.

There is no pragmatism here. We do not suggest in any sense that in that sort of science useful achievement is substituted for truth. In our estimation, that would be a barbarous notion. As every other science, physics only exists to be true; and the definition of truth—the conformity of our judgments to things—holds good for it just as much as for other sciences. In this case, however, that definition has the following meaning: a physico-mathematical

49 "The object of mathematical theories of physical phenomena is not to reveal to us the true nature of things; that would be an unreasonable claim. Their sole aim is to co-ordinate the physical laws that are made known to us by experiment, but which we could not even express without the aid of mathematics. It is of little importance to us whether ether really exists. That is the concern of metaphysicians. As far as we are concerned, the essential point is that everything happens as if it did exist. . . ." (H. Poincaré, *La science de l'hypothèse*, pp. 245–246).

50 "The whole of our physical knowledge is based on measurement. . . . The physical world consists, so to speak, of groups of measures resting on an obscure foundation that is outside the realm of physics. . . . The whole object of the exact sciences consists of pointer-readings and similar indications. We cannot at this point enter into an examination of what can be classified as 'similar indications'; observing the approximate coincidence of a needle with a division on a scale can, in a general way, be extended to include every sort of coincidence or, according to the customary expression used in the language of relativity, an intersection of lines of the universe. This is the essential point: even though we would appear to have very definite conceptions of the objects of the external world, these conceptions form no part of the realm of exact science and are in no way confirmed by it. Before exact science can begin to handle the problem, it must replace them with quantities representing the results of physical measurements" (A. S. Eddington, *The Nature of the Physical World*, Cambridge, University Press, 1929, pp. 252–253).

theory will be called "true" when a coherent and fullest possible system of mathematical symbols and the explanatory entities it organizes coincides, throughout all its numerical conclusions, with measurements we have made upon the real; but it is in no wise necessary that any physical reality, any particular nature, or any ontological law in the world of bodies, correspond determinately to each of the symbols and mathematical entities in question.[51]

51 This is a generalized application of the method which the ancients designated as consisting in "saving sensible appearances," and first made explicit apropos of astronomic theories and, later, of certain parts of physics. As Pierre Duhem has pointed out in a very noteworthy page, the Aristotelian astronomy with its homocentric spheres, even though it was destined very soon to be seen to be irreconcilable with observed facts, was the first application of this method, "the first of the physical theories." For the first time, indeed, in setting up this theory, the geometrician starts with a certain number of simple principles that were given to him from other sources and, following those principles, constructs a hypothetical mathematical system, touches up and complicates that system to the point where it saves the appearances described by observers with sufficient exactness.

"When observation had made us aware of phenomena which the whole system of homocentric spheres was quite incapable of ever saving, then the geometer-astronomers accepted other principles and with the help of these new principles fashioned new hypotheses; but the method they followed in constructing their new astronomic systems was not different from the method they had used in building up the system of homocentric spheres.

"There was no delay in transferring that method of astronomy to the other parts of physics; the author of the *Mechanical Questions*, attributed to Aristotle, tried to apply it to the equilibrium of weighty solids, and Archimedes gave a rational form of rare perfection to this science of the equilibrium of weighty solids; and, following the same method, he extended that admirable form to the equilibrium of liquids and of floating bodies.

"And in turn, Euclid showed how the single hypothesis of the equality between the angle of incidence and the angle of refraction was sufficient to save the phenomena presented by plain, concave and convex mirrors.

"Thus, two centuries before our era, astronomy, the science of equilibrium of weights and a part of optics, had taken the form of precise mathematical theories in their desire to satisfy the demands of experimental control; many parts of physics, in their turn, took on this form only after long centuries of groping about; but to do so they only had to follow the method whereby the first sciences had achieved the status of rational theories.

"Attribution of the title 'creator of the method of the physical sciences' has given rise to many squabbles; some have wished to give it to Galileo, others to Descartes, still others to Francis Bacon, who died without ever having understood anything about this method. Frankly, the method of the physical sciences was defined by Plato and the Pythagoreans of his day with a clarity and precision that have not been surpassed; it was applied for the first time by Eudoxus when he tried to save the apparent movement of the stars by combining the rotation of homocentric spheres" (P. Duhem, *Le système du monde*, t. I, pp. 128–129).

The same discussions, moreover, must have taken place among the Greeks and among the medieval Arabs and Christians concerning the significance of the

The need for causal physical explanation, still immanent to the mind of the physicist finally issues (in the highest of his syntheses) in the construction of a certain, number of beings of reason based on the real and providing an image of the world (or a shadow of an image) apt to support his mathematical deduction. It would betray a quite uncritical optimism, a truly naive optimism, to hope to establish any continuity between the way in which physico-mathematical theories get hold of things and the way philosophical theories do. (For philosophy sets out to grasp ontological principles according to their very reality.) As we have tried to show elsewhere,[52] the conceptions introduced by Einstein must accordingly be admired to the extent that they constitute a

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results obtained in this way, as occur in our day concerning "the value of science." St. Thomas has clearly pointed out the bearing of the method in question in the following text: "Ad aliquam rem dupliciter inducitur ratio. Uno modo, ad probandum sufficienter aliquam radicem. . . . Alio modo inducitur ratio non quae sufficienter probet radicem, sed quae radici iam positae ostendat congruere consequentes effectus; sicut in astrologia ponitur ratio excentricorum et epicyclorum, ex hoc quod, hac positione facta, possunt salvari apparentia sensibilia circa motus caelestes; non tamen ratio haec est sufficienter probans, quia etiam, forte, alia positione facta salvari possent" (*Sum. Theol.*, I, 32, 1 ad 2).

To avoid any misunderstandings, let us add that σώζειν τά φαινόμενα does not in any sense imply the rejection of causal research and explanatory hypothesis that Duhem, on his part attributes to physical theory (cf. above, Ch. II, § 4). These are causal explanations themselves and the depictable entities which the physical sciences elaborate, and which are ordered to *the saving of phenomena* and are true (but not in the absolute sense in which a metaphysical doctrine is said to be true) to the extent that they succeed in doing so, without making any claim to penetrate the nature of things by themselves. From that point on it becomes a secondary question to find out whether a scientist attributes to a theory the value of a mere mathematical representation or the value of a causal explanation, or both at once, or whether he moves back and forth from one point of view to the other (as Ptolemy had already done in astronomy; or as, in our own day, in physics "some wonder whether or not the electron does not have a purely analytical existence since it is only a center of vibration in a wave-system to which reality truly belongs. For others only the waves have an analytical existence; a fictitious continuous field has been substituted mathematically for a discontinuous surrounding field" [E. Picard, *op. cit.*, p. 44]); for, this "causal" explanation itself remains within the "empiriological" order and does not have a properly and directly "ontological" significance (cf. Ch. IV, §§ 8 and 9, and Ch. IV, n. 95). As Mr. René Poirier has written, from a viewpoint that is withal very different from our own, "there is no essential difference between the way in which a logical or numerical allegory rationalizes the real, and that in which a structural plan, a figurative hypothesis does so. . . . The most abstract designs of statistical dynamics and general relativity do not issue from a different spirit; they do not correspond to another type of understanding than do mechanical models of the atom or the solar system; the difference between abstract theories and intuitive theories does not belong to an order different from that between painting and sculpture" (*Essai*, pp. 145–379).

52 *Réflexions sur l'intelligence*, Ch. VII.

powerful physico-mathematical synthesis; but they must be rejected if given properly philosophical meaning.

30. Does that mean to say that every organic link between philosophy and mathematical physics is broken? Certainly not! In the very order of the explanation of reality, there exists a continuity between the philosophy of nature and mathematical physics, not indeed in respect to the explanatory theories elaborated by physics, but rather from the fact that, as we have said above, science provides philosophy with a vast supply of facts; and this is an acquired gain which appears to remain permanent through all the changes in theory. Thus, for instance, the existence of atoms (and they no longer have anything in common with those of Democritus) has reached a degree of probability bordering on certitude. I say "The existence of atoms." I do not say "The nature and structure of atoms which science attributes to them." These latter are subject to constant alterations; and scientific symbolism plays a very great role in that. Today, for example, the Rutherford-Bohr atom is vanishing to make room for the Schroedinger atom and (while awaiting other avatars) to become "a wave center having *psi* as its probability." Nevertheless, the existence of those elements called "atoms" which constitute the molecule (and the existence of their own constitutive elements, "protons," "electrons," "neutrons," or whatever other name science may use tomorrow to designate them), although they be thus conceived successively according to different models and although they be thought of only as mathematical symbols, does not seem shaken in the least.

On the other hand, in the epistemological order, the order of the theory of knowledge, the organic link between mathematical physics and metaphysics is exceedingly close. In determining the nature and true value of physico-mathematical science, the place, role and extent of its explanations, not only does metaphysics keep the system of our cognitions in order, but it renders mathematical physics the essential service of protecting it against distortions that would be almost inevitable without it; above all, against the harmful illusion that leads it to regard itself as a philosophy of nature and to believe that things begin to exist only when they are measured by our instruments. Let physico-mathematical explanations use dislocated times and non-Euclidian spaces; they are free, they do well, they must always progress along their own line; the mind settled about their meaning knows its limits.

Perhaps there is something a bit sad about thus observing that the image of the universe, or, more exactly, the images or shadows of images (more-or-less discordant amongst themselves), in which the effort of physical theories to give an explanation, in the final analysis, results, could not be, as was believed for so long, the natural extension of ontological explanations provided by philosophy. Yet for the latter, all this is an excellent purification. It must give up being satisfied with images, whether they be the explanatory but fictional

images of science, or the natural but untenable image of common sense (untenable, at least, from the moment it is given an explanatory meaning). In a later chapter,[53] we shall try to show how it is, however, quite proper for philosophy to have recourse to the images of science and to incorporate them into itself, but only in an order quite different from the order of wisdom properly so called.

Knowledge of a Biological and Psychological Kind

31. In the realm of life and of organic wholes, the distinction between the point of view of philosophy and that of the experimental sciences becomes very clear, inasmuch as their respective conceptual vocabulary, their ways of verification and their laws for resolving concepts and organizing knowledge are necessarily heterogeneous. But in such a realm, a certain "continuity" or solidarity between the specifically rational part and the specifically experimental part of knowledge can be established—in spite of an essential epistemological difference—in that which concerns the explanatory theories furnished by the sciences and the ultimate explanation provided by the philosophy of nature. For, while resolving their concepts in sensible and observable being, inasmuch as it is sensible and observable, experimental biology and experimental psychology do not undertake to reconstruct a closed universe of mathematicized phenomena, and it is quite normal that the type of deductive explanation whose attraction they undergo should be of a philosophical type and not of a mathematical type.

It is not that we would want to deny or belittle *a priori* the role of physico-chemical explanations (which are themselves directed towards the ideal of an integral mathematicization of the real) in biology. If it is true that in the living thing physico-chemical forces are the *instruments* of a superior ontological principle, then it is possible to conceive the field of these explanations as stretching out indefinitely, even though they must stop short at certain specific "irrationals" which inevitably arise all by themselves.[54] But it might also be held that, to the extent that the biologist retains a feeling for the reality proper to the living thing, and demands, in the study of the phenomena themselves, a type of explanation which, in the final analysis, does not dissolve that reality into constructed elements (an explanation, in short, that harks back to the very notion of a living being), he would subordinate the physico-chemical explanations thus discovered to a conception "autonomous" to biology. Such an explanation, in which the penetration of the details of phenomena and their grouping under more and more general experimental laws—without thereby claiming to resolve them in the universally explanatory mathematical deduction aimed at by physics (and without at all leaving the level of the observable

53 See below, Ch. IV, § 28.

54 See below, Ch. IV, §§ 34 and 35.

and measurable)—would still be built upon an *understood* ontological structure of concepts supplied by philosophy.

On the other hand, unless the biologist and psychologist put blinkers on their intellect, they will inevitably be led by the very object of their science to ask metaphenomenal questions to which they might try to reply with their own conceptual equipment and their proper methods of analysis; then they will obtain, in the most favorable cases, and by indirect paths and the delimitation of unknowns, solutions that resemble philosophical solutions and are tangential to them. It is thus that in his remarkable works Driesch[55] has realized that embryonic development depends on a nonspatial *factor E*, which maintains the specific type; or, again, that the actions of animals also depend on a non-spatial factor, thanks to which stimulations coming from without are individualized, and that the functioning of the animal-machine is enriched by its exercise—a non-spatial factor that the scientist prudently calls *psychoid*.

But it is only by using the equipment of the philosopher, by becoming philosophers themselves, that they will be able to give a proper and adequate solution to supraexperimental problems that their own experience compels them to envisage; only then will they be able, for example, to learn the true name for the *psychoid* and the *factor E*.

Conclusion

32. One is right in holding that Thomistic philosophy is, more than any other philosophy, in a position to provide the sciences with metaphysical frameworks within which they may deploy their own necessities unhampered and suffer no violence. This is so not only because Thomistic philosophy is essentially realistic and gives a critical justification for the extramental reality of things and the value of our powers of knowing, which every science implicitly takes for granted, but also because it guarantees the autonomy and specific character of each and because its metaphysical explanations of the real have as their necessary consequence no systematic deformation tyrannically imposed on experience.

And here the reproach levelled at Scholasticism by poorly informed minds recoils against modern systems. For it is indeed from these systems that necessarily and *per se* derive such systematic prejudices as mechanism, monism, psycho-physical parallelism, the Cartesian theory of consciousness, universal evolutionism, etc. These systems impose on science the most deplorable metaphysical shackles.

It is not a question of seeking between the sciences and Aristotelian-Thomistic philosophy the concordance of detail that we rejected just a moment ago, but rather of noting a general over-all agreement, a good understanding, a natural friendship, of which the very freedom of science, the ease with which

55 Cf. our preface to the French translation of *La philosophie de l'organisme*, by Hans Driesch (Paris, Reviere, 1921).

it develops, is the best indication. This statement is explicitly made by many representatives of the sciences of nature, while elsewhere, a striking renewal of themes proper to the moral philosophy of Thomas Aquinas is evinced in the moral and legal sciences of which we have not spoken in this essay.

If workers are not wanting, if unreasonable prejudices (due above all, it seems, to a morbid fear of ontological research and of all philosophy ordered to a knowledge of things—as though a philosophy of being could not also be a philosophy of mind) do not turn them back from the study of the only philosophy that claims to face the universality of the extramental real without at the same stroke pretending to absorb all knowing into itself, it might well be hoped that we will see a new dawn break upon a new and glorious scientific era—putting an end to misunderstandings engendered in the realm of experimental research by the conflict between Aristotle and Descartes—in which the sciences of phenomena would finally achieve their normal organization, some, physics above all, undergoing the attraction of mathematics and continuing their remarkable progress along this line, others, biology and psychology especially, undergoing the attraction of philosophy and finding in that line the organic order they need and the conditions for a development that is not merely material, but truly worthy of the understanding. Thus there would be a general redistribution springing from the natural growth of the sciences of phenomena, but one that would also suppose—and this point is quite clear—the supreme regulation of metaphysical wisdom.

The divine good of intellectual unity, shattered for three centuries now, would thus be restored to the human soul.

33. Kant denied to metaphysics the character of science because for him experience was the product and the terminus of science, since science built it by applying to sensible data necessities which are pure forms of the mind. But St. Thomas recognized in metaphysics the supreme science of the natural order because for him experience is the starting point of science, which, reading within the sensible "given" the intelligible necessities that surpass it, can transcend it by following those necessities and thereby achieve a supra-experimental knowledge that is absolutely certain.

Being is, indeed, the proper object of the intellect; it is embowelled in all its concepts; and it is to being, wrapped up in the data of the senses, that our understanding is first of all carried.

Should it set this object of its concept free so as to look at it in itself, insofar as it is being, it sees that it is not exhausted by the sensible realities in which the intellect first discovered it; it has a supraexperimental value. So, too, have the principles based on it. In that way, the intellect, if I may say so, "loops the loop," in coming back, to grasp it metaphysically and transcendentally, to that very same being which was first given to it in its first understanding of the sensible.

And so, because it has in its metaphysical concepts, such as being and the transcendentals, an intellectual perception of objects which can be realized otherwise than in the matter in which it perceives them, it will also attain these objects (this time, without directly perceiving them, and, as it were, by the mirror of sensible things) wherever they are realized without matter, as facts established in the world of experience compel us to infer. Thus, the suprasensible cannot be, at least in the natural order, the object of an experimental science. Nevertheless, it is the object of a science properly so called, and indeed, of the science par excellence. For if the universe of being as being, set free by the mind when it delivers its objects from all materiality, does not fall under the senses, intelligible necessities, on the other hand, are discovered there in the most perfect manner. Thus, the knowledge ordered to such a universe of intelligibility is most certain in itself even though we find it difficult to acknowledge it. For we are an ungrateful and mediocre race which only asks to fail in the highest in what it is capable of, and which, of itself, even when higher gifts have strengthened its eyes, will always prefer the dark.