# AQUINAS' LEGACY IN THE CONTEMPORARY DIALOGUE BETWEEN SCIENCE AND FAITH

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ABSTRACT: We present an introduction to Aquinas' eminent personality and his original view of human cognition and epistemology including theology among the sciences. A sketch of the more relevant results of some recent sciences in order to establish the required *Theory of foundations* common to all of them is presented. Remarkably the Aristotelian Thomistic logic and metaphysics, even if rewritten in the symbolic language of our contemporary sciences, appear to be strongly adequate to assume the very role of such a *Theory of foundations*. Some foreseeing texts of the Catholic Magisterium on science are also examined. What is offered in the present paper has been developed along the last thirty years of collaboration with Prof. Giuseppe Tanzella-Nitti in the *Centro di Documentazione Interdisciplinare di Scienza e Fede* (disf.org).

KEYWORDS: Thomas Aquinas, Albert the Great, Epistemology, Computer Science, Logic, Metaphysics, Foundations of Sciences, Analogy, Abstraction, Magisterium, Natural Law.

RIASSUNTO: Il lavoro intende offrire inizialmente un'introduzione alla personalità eminente dell'Aquinate e alla sua originale visione della cognizione umana e dell'epistemologia, che comprende anche la teologia tra le scienze. Viene poi presentato uno schema dei risultati più rilevanti di alcune scienze recenti volti ad indagare una ormai necessaria *Teoria dei fondamenti* comune a tutte loro. Sorprendentemente, la logica e la metafisica aristotelico-tomista, riscritte nel linguaggio simbolico delle nostre scienze contemporanee, sembrano essere decisamente adeguate ad assumere il ruolo di tale *Teoria dei fondamenti.* Vengono inoltre esaminate alcune prospettive precorritrici del Magistero cattolico sulla scienza. Quello che viene proposto nel presente articolo è stato maturato in circa trent'anni di collaborazione con il Prof. Giuseppe Tanzella-Nitti presso il *Centro di Documentazione Interdisciplinare di Scienza e Fede* (disf.org).

PAROLE CHIAVE: Tommaso d'Aquino, Alberto Magno, Epistemologia, Informatica, Logica, Metafisica, Fondamenti delle Scienze, Analogia, Astrazione, Magistero, Legge Naturale.

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In the present contribution I will try to show how throughout my career as a physicist and teacher of philosophy of science and theology I realized what contemporary sciences owe to the powerful synthesis of St. Thomas Aquinas and how they are rediscovering his results in a new fashion.

The paper will be organized as follows. In §I, I offer a sort of sketch of my "cultural journey". In §II an example of the recent queries and results of computer science is viewed in the light of a sentence of Aquinas. §III offers a view on the human personality of Thomas and the providential context he lived in. §IV addresses the crisis of realism. §V and VI are concerned with his epistemology and its emergence in current scientific problematics. §VII deals with the sapiential view in the Magisterium of St. John Paul II and Benedict XVI concerning science and reason.

## I. A sort of "Autobiographical" Introduction

When I met Prof. Giuseppe Tanzella-Nitti, for the first time in the late nineties of the 20th century, he showed me his project of a wide "interdisciplinary" dictionary of science and faith. The plan of the work would have involved about one hundred authors each of one provided, at the same time, of a specific scientific competence on his own discipline, and a philosophical and theological background. The project soon appeared to me so fascinating that I accepted to be engaged as a co-editor and as author of some of the entries.

In the *Introduction* of the *Dizionario Interdisciplinare di Scienza e Fede*[1] we explained what would be intended by the word "interdisciplinarity" according to the perspective of the job.

[1] The Dictionary was printed in Italian by Urbaniana University Press, Rome 2002; on line disf.org and partially translated into English, on line, on inters.org.

> Let us clarify that, in this work, "interdisciplinarity" does not simply mean the mere comparison of what different disciplines immediately say about a common object, nor does it mean the mechanical "addition" of the respective contents of the various sciences regarding the same object. Dealing with an "interdisciplinarity" intentionally addressed within the framework of the relationship between science and religion (specifically a Catholic *weltanschauung*), we have tried to position ourselves in the perspective of the unity of knowledge. A unity which is based on a sapiential organization of thought, in which the different disciplines find, on one hand, a common reflection on the foundations of their own knowledge. […]
> This approach seems particularly favored, in our days, by the new issues arising from the sciences, increasingly working towards developing a *Theory of foundations*, a theory which, in a modern key, approaches as if for the first time, questions that are also classical in Greek and medieval logic and metaphysics. At the same time, philosophical and theological disciplines increasingly need to consider that more systematic, communicable, and universal approach, which certainly finds a powerful and significant exemplification in the sciences.[2]

On developing the job, it more and more appeared clear to us that the medieval logic and metaphysics, especially according to the synthesis elaborated by St. Thomas Aquinas, and if suitably rewritten in today's scientific language and formalism, could be a true candidate for preparing a *Theory of foundations* of contemporary sciences. After thirty years of intensive research, developed in the environment grown around the *DISF* (disf.org), the *INTERS* (inters.org) and the *SISRI* (sisri.it),[3] I am now convinced that the former intuition was right.

## II. A meaningful example

Before entering the core of my article, I want to offer a meaningful example confirming my former idea. Recently a book of mine devoted to physical mathematical topics (not philosophy or theology!) – which just begins reporting a quotation of a text by St. Thomas – was accepted for publication by an international scientific publisher having

[2] *Introduction*, 9. Translations into English of Italian texts in this article are mine.

[3] The *SISRI* (sisri.it) is a school for young graduates and researchers who are interested in an interdisciplinary approach to the sciences concerning their own jobs, according to the perspective of the *DISF*.

passed the approval of three independent referees.[4] Only a few years ago a similar quotation would have been surely rejected as not suitable in a scientific book!

I want to detail here that Thomas' quotation, followed by some of my comments, seems to emerge in the most recent acquisitions in computer science, as testified by two of the chief actors of the debate in information science.

Here is the quotation: «There is no science on singulars (*scientia non est de singularibus*)».[5]

In fact, human science is *a knowledge through universals*. Since human intellect acquires its knowledge abstracting from matter the universal "form" organizing each singular "matter" body. So, our mind, being "immaterial", does not know singulars, while our senses do, being "material" as part of our material body.

Surprisingly the latter principle, together with the notion of *information*[6] – beside the notions of *whole* and *parts, chance, order* and *finality* and some other ones – seems to be attained in some way, at least in some of its aspects, by our contemporary logicians, mathematicians and experts of *information theory*. Therefore, a genuine interest in Aristotle's and Aquinas' works has arisen within the most advanced scientific research fields.

In terms of today's informational logic, knowing universally appears to mean the capability to find a *law* or an *algorithm*,[7] the string code of the latter being shorter than the list of all individual entities

[4] A. Strumia, *From Fractals and Cellular Automata to Biology. Information as Order Hidden within Chance*, World Scientific, Singapore 2020 (www.worldscientific.com/worldscibooks/10.1142/11743). The following in the present section refers to the *Introduction* of the book (1-4).

[5] Thomas Aquinas, *In Metaphys.*, Lib. 2, lec. 4, n. 8 in *Index Thomisticus* (www.corpusthomisticum.org), [All the following quotations of St. Thomas are from *Index Thomisticus* online; the English translations from Latin text are mine].

[6] The notion of *information* was somehow perceived by Aristotle and Medieval authors like Thomas Aquinas and their followers and it is recognizable by us in what they called "form (*forma*)".

[7] «An *algorithm* is a sequence of operations capable of bringing about the solution to a problem in a finite number of steps» (E. Sarti, *Information, notion of* [cfr. *https://inters.org/information*], §V).

when they are singularly collected into a *set*. So modern science seems to have rediscovered, in some sense, the ancient Aristotelian-Thomistic principle according to which not all the entities may be "described" (logic, cognition, science) or "built" (ontology, metaphysics, physics) by an *algorithm* (a string shorter than the list of individuals). In fact, there are entities, the string describing which cannot be other than the list of each single element (*incompressible* string). Or, in terms of propositions, not any proposition (string) is "decidable" (by means of a theorem) within an axiomatic system, since it cannot be reduced to the string of the axioms, according to the well-known Gödel's undecidability theorem.[8]

Only a divine mind can know all singular details characterizing an individual entity. While human mind knows through universals, so it cannot find an algorithm describing all entities (*Whole Theory* or *Theory of Everything*) and all their features. Only divine mind which knows/creates each single entity, both according to a universal form and to each individualizing matter, is able to catch all singular details.

Aquinas offered a logical-metaphysical explanation of such a difference between human and divine science.

> The reason for this will be clear if we consider the difference between the relation to the thing had by its likeness in our intellect and that had by its likeness in the divine intellect. For the likeness in our intellect is received from a thing in so far as the thing acts upon our intellect by previously acting upon our senses. Now, matter, because of the feebleness of its existence (for it is being only potentially), cannot be a principle of action; hence, a thing which acts upon our soul acts only through its form; consequently, the likeness of a thing which is impressed upon our sense and purified by several stages until it reaches the intellect is a likeness only of the form. […]
>
> On the other hand, the likeness of things in the divine intellect is one which causes things; for, whether a thing has a vigorous or a feeble share in the act of being, it has this from God alone; and because each thing participates in an act of existence given by God, the likeness of each is found in Him. Consequently, the immaterial likeness in God is a likeness, not only of the form, but also of the matter. Now, in order that a thing be known, its likeness must be in the knower, though it need not be in him in the same manner as it is in reality. Hence, our intellect does not know singulars, because the knowledge of these depends upon matter, and the likeness of matter is not in our intellect. It is not

[8] See K. Gödel, *On formally undecidable propositions of Principia Mathematica and related systems I*, in *Collected Works*, vol. 1, edited by S. Feferman, J.W. Dawson, W. Goldfarb, C. Parsons, and W. Sieg, Oxford University Press, New York 2001, 144-195.

> because a likeness of the singular is in our intellect in an immaterial way. The divine intellect, however, can know singulars, since it possesses a likeness of matter, although in an immaterial way.[9]

The sequence of such singular elements in a whole appears to us as completely random, since we cannot – *in principle* and not just because of technical difficulties – deduce by a rule (*algorithm*) any of the next element starting from the knowledge of the previous ones. But the datum of the incompressibility of a string, which we perceive as randomness, does not mean non-sense of that string, but simply that it is self-explained being the reason to itself; hence, being a fundamental law, though a rather complex one, it needs no further explanation. As Gregory Chaitin has observed:

> for example, a regular string of 1s and 0s describing some data such as 0101010101… which continues for 1000 digits can be encapsulated in a shorter instruction "repeat 01 500 times". A completely random string of digits cannot be reduced to a shorter program at all. It is said to be algorithmically incompressible.[10]

That notwithstanding, in some relevant and not so rare circumstance, the whole may reveal an order and an organized structure capable to perform special activities (*operations*) as it happens in living systems, or in some physical and chemical complex systems. At present it seems that we do not know any compressed string (*law* or *algorithm*) capable to generate the whole of the actual sequence of the genetic code of a living being and we are compelled to list its individual elements one after the other as if they were provided randomly by nature. Something similar happens in the context of arithmetic when we deal with *prime numbers*, the sequence of which appears randomly distributed into the *ordered set* of natural numbers.

An intensive discussion, somehow similar to a medieval dispute, is animating the scientific world about the logical consistency of the idea of a *Theory of Everything*.

[9] Thomas Aquinas, *De veritate*, q. 2, a. 5co.

[10] G. Chaitin, *Information theoretic incompleteness*, World Scientific, Singapore 1992, 141.

A relevant example of different opinions about the matter is offered by the contemporary debate between Stephen Wolfram and Gregory Chaitin. Wolfram is convinced that

> in the end it will turn out that every detail of our universe does indeed follow rules that can be represented by a very simple program – and that everything we see will ultimately emerge just from running this program.[11]

Wolfram's conviction seems to arise by his deep experience with *cellular automata*, which may evolve into very complex structures, even being governed by very simple algorithmic rules.

> In the existing sciences whenever a phenomenon is encountered that seems complex it is taken almost for granted that the phenomenon must be the result of some underlying mechanism that is itself complex. But my discovery that simple programs can produce great complexity makes it clear that this is not in fact correct. And indeed in the later parts of this book I will show that even remarkably simple programs seem to capture the essential mechanisms responsible for all sorts of important phenomena that in the past have always seemed far too complex to allow any simple explanation.
>
> It is not uncommon in the history of science that new ways of thinking are what finally allow longstanding issues to be addressed. But I have been amazed at just how many issues central to the foundations of the existing sciences I have been able to address by using the idea of thinking in terms of simple programs.[12]

While on the contrary Chaitin considers random strings (*incompressibile* strings) as admissible in nature as undecidable propositions exist in an axiomatic system.

> Wolfram has a very different view of complexity from mine. […] Wolfram's view is that simple laws, simple combinatorial structures can produce very complicated unpredictable behavior. $\pi$ is a good example. If you didn't know where they come from its digits would look completely random. In fact, Wolfram says, maybe the universe contains non randomness, maybe everything is actually deterministic, maybe it's only pseudo-randomness. And how could you tell the difference? The illusion of free will is because the future is too hard to predict but it's not really unpredictable.[13]

[11] S. Wolfram, *A new kind of science*, Wolfram Media Inc., Champaign 2002, 545.

[12] *Ibidem*, 4.

[13] G. Chaitin, *The unknowable*, Springer-Verlag, Singapore 1999, 113.

I performed a deeper investigation on these and related topics in some previous books and papers.[14] In the following of the present contribution I will freely pick up from my previous writings.

Now, after the latter, almost "autobiographical" preface, in the next §III, I will approach the personality of St. Thomas Aquinas as a man of science can do nowadays following the suggestions of the most recent researches.[15]

## III. St. Thomas Aquinas: the Saint, the Doctor, the Genius

The extraordinary scientific-philosophical-theological synthesis of St. Thomas Aquinas has a unique value in itself, not only for the Catholic Church, of which he is the *doctor communis,* but for culture, philosophy and science of all humanity in all times. This is not an excessive evaluation. In fact, the Thomistic synthesis cannot be considered simply the fruit of the work of a man who was at the same time a genius, a learned man – even a doctor of the Church – capable of *thinking big* and a saint – the which in itself would be enough to consider him an extraordinary man – but it must also be recognized as the work carried out by the *right man* at the *right time* in the *right place*. The occurrence of this coincidence of favorable conditions can only be traced back to the provisions of divine Providence.

Some men may be geniuses, more or less recognized, but endowed with too specialized knowledge – as has normally happened in the world closest to us to the characters we consider geniuses – to be able to *think big* so as to be capable of a synthesis between science and philosophy.

[14] Cfr. Strumia, *From Fractals*; Idem, *Complexity Seems to Open a Way towards a New Aristotelian-Thomistic Ontology*, «Acta Biomedica» 78 suppl. 1 (2007), 32-38; Idem, *The Problem of Foundations. An Adventurous Navigation from Sets to Entities From Gödel to Thomas Aquinas*, Createspace, Charleston 2012; Idem, *Information as Order Hidden within Chance: An Application to Biology*, «Physical Science & Biophysics Journal» 3 (2019) 000126-000140; Idem, *Information Drives Chance to Order and Organization: Applications to Mathematics, Physics and Biology*, «Newest Updates in Physical Science Research» 10 (2021) 116-154; *Complexity: the Role of Information in Organizing Chance*, in *Organisms*, «Special Issue: Where is Science Going?» 5 Nr. 2 (2021) 77-85; Idem, *Keywords in Contemporary Science. Information, Self-Organization, Chance, Intelligence, Self-Awareness*, Generis Publishing, Wilington 2022.

[15] Cfr. as an Italian source for some of the next sections, my *Prefazione* a Tommaso d'Aquino, *Commento a il Cielo e il Mondo*, Edizioni Studio Domenicano, Bologna 2022.

And in many cases, they may also be devoid of that Christian faith, fully Catholic, which allows them to also involve theology in their own vision, and sometimes even to understand it as saints do. It should then be noted that the fragmentation of knowledge cannot be compensated only by forming a team or a working group: synthesis is always achieved by one person and not by a group. A group of people, however, can usefully collaborate in the diffusion and application of the method of a master who has the synthesis.

Others may be great saints, but not be men or women of study, neither geniuses nor scholars. Others, again, may indeed be geniuses, and even capable of *thinking big* and saints, being in a certain sense the *right man* (a very rare circumstance in any case!), but not having found themselves in the *right place* at *right time*.

Thomas was blessed – in addition to his extraordinary human qualities, his sanctity – with the favorable historical condition of being in the *right place* at the *right time*, belonging to a movement of religious life as the Order of Friars Preachers, founded by St. Dominic – within which at that precise time he was received and valorized. And the wonderful fruit of his mind and his life, was assimilated and acquired, over time, by the universal Church, since he was found in the *right place* at the *right time*. More he met the *right master*, St. Albert the Great, scientist, philosopher and theologian who provided him the right background of the Aristotelian thought.

It seems possible to rightly say that such a *fullness of time* (adapting by analogy the Paul's expression of *Gal* 4,4) can hardly be repeated in history, and also for this reason St. Thomas has always been proposed by the Church as an irreplaceable master of thought and not just as a great man from the past who is no longer current.

## IV. The Philosophical Crisis of Realism and Metaphysics

But what did it happen so that modern philosophical thought could turn so fiercely against realism and metaphysics, or rather against Thomism, so that theology often abandoned St. Thomas as a leading guide?

If it is not an exaggeration to say that a good part of modern philosophical thought has developed by progressively distancing itself from

Christian Revelation, to the point of reaching explicit contrasts,[16] due to a deliberate cultural choice, as a sort of philosophical "original sin", it must be said that such a *choice against* has its roots in a reductive, and therefore inadequate, way of addressing at least two major questions which are strictly philosophical.

The former consists in the loss of the ability to formulate a solid logical-metaphysical theory of *analogy*, progressively reducing the latter to a pure linguistic metaphor.

The latter concerns what we today call the *cognitive sciences* and consists in the disappearance of the cognitive doctrine of *abstraction*.

Both terms (*analogy* and *abstraction*) have a *strong* technical meaning in Thomism which no longer corresponds to the *weak* one that modern language attributes to them.

*The loss of analogy*, not only of language (analogy of names), but also of the being itself (analogy of entity), has ancient roots in the *univocal logic* of nominalism of the Oxford School (prepared by Roger Bacon and Scotus,[17] and implemented by Ockham) who saw the demonstrative power in the univocality of mathematics[18] and prepared the birth of modern Galilean science and modern mathematical physics.

[16] Cfr. John Paul II, Encyclical Letter *Fides et Ratio*, September 14, 1998, n. 46.

[17] In a particularly hermetic passage, Scotus declares that «being is univocal to all, but to concepts that are not simply simple, it is univocal in terms of *quidditas*, while to simply simple concepts it is univocal in the sense that it is determinable or nameable, and not in the sense that it is predicated of them quidditatively, because this includes contradiction» (G. Duns Scotus, *Ordinatio I*, d. 3: quotation in *ibidem*, 1374).

[18] On the univocity of mathematics R. Bacon wrote: «Now in mathematics, it is possible for us to arrive at a complete truth without error and a universal certainty without shadow of doubt, since it is proper to proceed with *a priori* proofs, for proper and necessary causes. And proof, as we know, leads to truth. […] Only in mathematics are there proofs in the true sense of the word for proper causes; and therefore, only within the field and by virtue of mathematics can man arrive at truth. […] Thus, in mathematics alone is full certainty achieved. Therefore, it follows that if we wish, as is our duty, to arrive at a certainty that excludes all doubt and at a truth that excludes all error in the other sciences, it is necessary that mathematics becomes the foundation of our knowledge, from which we can achieve complete certainty and truth even in the other sciences» (R. Bacon, *Opus Maius*, quoted in Italian in AA.VV., *Grande antologia filosofica*, vol. IV, Marzorati, Settimo Milanese 1989, 1299-1300).

More, the misunderstanding of the cognitive theory of abstraction has introduced the doubling between "reality" and its "representation" at the level of the mind which is at the basis of all the epistemological dualisms of modern philosophy, from Descartes, Locke, Berkeley and Hume, up to the present day. On the contrary, the Thomistic approach recognizes in a same "form" (*forma*) actualizing real entities' "matter" the ability to actualize also the "possible intellect" (*intellectus possibilis*) – almost as if it were a sort of "matter" suitable for knowledge of the universal, once the form has been "abstracted" from the physical matter of things by the "active intellect".

Epistemological dualism makes cognitive realism inconceivable and leads inevitably to today's relativism, fading any notion of truth. In such a perspective, there is no place, except in the history of philosophy, for Thomas Aquinas, who is thus inevitably placed among the "naive realists" and the "outdated geniuses".

## V. The Epistemology of St. Thomas Aquinas

Let us now consider the ancient science in the Aristotelian-Thomistic conception.[19]

### a) Definition

According to the Greek conception (mainly Aristotle's one) and then the medieval one (specifically, St. Thomas Aquinas'), science is *cognitio certa per causas, i.e.*, knowledge by demonstration (in other words, mediately evident) and explicative knowledge.

### b) The subdivisions of science

The sciences, adopting our modern terminology, were divided fundamentally into two categories:

> i) the *deductive sciences* or the sciences of explanation, such as metaphysics and mathematics, whose deductive instrument was logic; today we call them "formal sciences";

[19] For the subdivision of medieval sciences and a comparison with modern ones see, *e.g.*, J. Maritain, *An Introduction to Philosophy*, Continuum International Publishing Group Ltd., London 2005; Idem, *Distinguish to Unite, or The Degrees of Knowledge*, Geoffrey Bles: The Centenary Press, London 1937, Part I, chap. 2.

ii) the *inductive sciences* or the sciences of verification, such as the empirical natural sciences; today we call them "experimental sciences".

But science, in the full sense of the term, is only that of the first type because it is linked to known principles.

c) The *foundations* of science

In addition, for both the ancients and the moderns, a science requires *foundations*, that is, points of departure that cannot be demonstrated by that science itself; such foundations must remain undemonstrated because:

– *either* they are demonstrated as true within the sphere of a more universal, science,

– *or* they are accepted as true without a demonstration, as hypotheses (by convention or because they are indispensable).

In the first case, we have sciences that lead to *necessary truths*; in the second, only *hypothetical* (*ex suppositione*) sciences, which are formally correct, but not necessarily true: they are pure instruments of calculation or prediction, or at most, sciences of verisimilitude.

It should be fairly clear that contemporary sciences fall into this second category. Therefore, the ancient concept of science encompasses, *in principio*, also the modern sciences, even if modern science has been *de facto* developed *after* ancient science.

d) The organic structure of epistemology

In the philosophical framework, from the epistemological viewpoint, the sciences were organized hierarchically, according to the different levels of *abstraction*.

i) On the *first level* were the *physical* sciences, which disregard individuality of bodies, and study their motion (evolution over time in a wide sense) in general.

ii) on the *second level* were the *mathematical* sciences, which disregard the real matter stuff of the bodies and the motion, and study their ideal quantitative relations (numerical, extensive, etc.).

> iii) on the *third level* were the *metaphysical* sciences, which disregard also from the quantitative and relational characteristics of the bodies, and study the *principles of being as being*.

According to this organic and hierarchical epistemology, each discipline serves as the *foundation* for a dependent one.

> Every higher discipline forms a principle of regulations for those inferior to it. Metaphysics, since it deals with the supreme reasons of being, should be the regulative science par excellence: *scientia rectrix*. But mathematics is also a deductive science, a science of the *propter quid*. It therefore also tends to regulate the lower ranges of knowledge, if not to usurp the position of metaphysics itself.[20]

The sciences of the highest level, then, do not have foundations demonstrated by other sciences, but are founded upon evident principles, in the sense that they are indispensable principles, because without them it is not possible to elaborate any form of knowledge.

e) The placement of Galilean science

In the modern vision of science, and according to the present terminology, the distinction between formal and experimental sciences, continues to be valuable. But while the epistemological status of the logical-formal disciplines (like mathematics) has passed nearly unharmed – indeed, it has become ever more accentuated (apart from the significant empowerment of its formalism and the enormous enrichment of its results) throughout the centuries –, what occurred in the sphere of the observational sciences has had a special emphasis.

We have now placed the epistemological status of Galilean science within the epistemological picture of the medieval sciences. The Galilean science is characterized by its assumption of mathematics, and no longer metaphysics, as *scientia rectrix* (*foundational science*), that is, as a deductive science through which we may formulate the definitions and deduce the explanations of observation data.

According to an Aristotelian-Thomistic perspective, we may highlight how reality, as it is approached by the Galilean science, is known mainly under the two aspects (*accidents*) of "quantity" and "relation".

[20] Maritain, *Distinguish to Unite*, 51.

These aspects are relevant, but accidental, with respect to "substance", and non-exhaustive of its being.

When one considers Galilean science as the only kind of possible types of sciences, he or she is led to attribute to quantity and relation a sort of "substantial consistency" as if the object were exhausted by what mathematical science can know. One thus tends to make mathematics a substitute for metaphysics, so reducing the being itself only to quantity and relation.

The main character of Galilean and modern science consisted in the *mathematization of the experiments* and of the explicative hypotheses. A mathematization that at Galileo's times was carried out above all as a *geometricization of science*.[21]

Surprisingly, however – but not too much, since human reason has its own irrepressible nature, its irreducible logic, and the reality that surrounds us has a metaphysical objectivity that tends to re-emerge sooner or later – current sciences, more than philosophy (and therefore even more than theology!) seem to rediscover Aristotle and Thomas, even if in a largely unaware way. The symptomatic example I referred to in §I is only a first suggestion. And it is at this point that the Thomistic synthesis becomes interesting for those who work in the scientific fields. Its logic, physics and metaphysics no longer appear as something belonging only to the past, or as an optional spiritual supply for those who want to save realism at all costs. On the contrary, Thomas presents himself as the one who suggests the way to develop today's *Theory of Foundations* of the sciences. Even if the details of his physical or cosmological theories are no longer relevant – being dependent on a qualitative description of nature and the cosmos, which nowadays are outdated – the *foundational* aspects (logical and metaphysical) of his theoretical reflection exhibit an extremely significant relevance today.

However, we must also keep in mind the fact that Scholasticism, in Galileo's time, was rather decadent and deteriorated, and was no longer that of Thomas. While the latter's epistemology already envisaged a mathematical physics placed among the *middle sciences* (*scientiae mediae*). It was only necessary for the time to be ripe for it to be developed

[21] Cfr. A. Koyré, *Études d'Histoire de la pensée scientifique*, Gallimard, Paris 1971, 83 (English translation mine).

concretely, as indeed began to be done with Kepler, Galileo and above all Newton. Thomas himself had said, regarding Ptolemaic astronomy, precisely in the *Commentary on "De caelo"* (book II, lecture 17, n. 451):

> It is not necessary that those hypotheses that [the ancient astronomers] elaborated are true: in fact, although, having made these suppositions, they have saved the phenomena that appear, however it must not be said that these suppositions are true, because perhaps with another system not yet intuited by men, what appears regarding the stars is saved.

Thus, it must be recognized that if Thomas comments on Aristotle, indeed he sometimes corrects him and always interprets him appropriately in the light of reason and with the wisdom that comes from the faith in Revelation.

The rejection of a decadent Scholasticism was accompanied by the rejection of Aristotle in its entirety and a progressive distancing of modern science from Thomistic thought left the latter as relegated to theology. But today a certain Aristotelianism is reappearing in the most advanced scientific research.

Here I will limit myself to the two *keywords* I referred to before, namely *analogy* and *abstraction*, to document it with some examples.

More impressively one may realize as according to the epistemology of St. Thomas a *wider notion of science and rationality* was conceived by him, rather than the modern one. A frame within which the current mathematized observational sciences can be naturally hosted, together with logic and with the simply observational and taxonomic disciplines. A similar frame of sciences, analogically structured, allowed him to conceive also metaphysics in the role of what today we call a *Theory of Foundations* of all sciences.

In the commentary to Aristotle's *Second Analytics* Thomas offers a more synthetical picture of his epistemological frame, which he has widely exposed in his Commentary to *Boethii de Trinitate* at quaest. 5, artic. 3, ad 6um.

> Some sciences are purely mathematical: these abstract by reason from sensible material, such as geometry and arithmetic; others are intermediary sciences: these apply the mathematical principles to sensible material, as optical geometry applies the principles of geometry to the visual ray and music applies the principles of arithmetic to sensible sounds. [22]

[22] Thomas Aquinas, *In post. Anal.*, Lib. I, lec. 41.

As James A. Weisheipl observed:

> Thomas admits that there are forms of mathematical knowledge that study matter and motion, such as astronomy, mechanics, optics and even musicology. These sciences he calls *mediae*, inasmuch as they depend upon pure mathematics for the principles they need and upon the natural sciences for the data upon which to work. Thomas, it seems, is the only medieval philosopher to have used the expression *scientiae mediae* in this sense. […]
> He understood very well the nature of applied mathematics, at least for what concerns its philosophical structure.[23]

Two central questions arise, upon which the development of modern thought in relation to Aristotelian-Thomistic thought depends: i) the question on *analogy*; ii) the question on *universals*.

The mathematization furthermore will favor the abandonment (and thus, the lack of understanding) of *analogy* in favor of *univocity*, with the consequent reductionism of the method of the sciences.

## VI. Today's Sciences in front of St. Thomas. The Search for a Foundation Theory as a Metaphysical Quest

### *1. The Sciences Seem to Rediscover Analogy*

#### a) Analogy emerging from mathematical logic

Mathematical language and thought are *universal* and have always been characterized by a rigorous *univocity*, and their strength seems to lie in this: the same symbol (*name*) in the context of the same theory must correspond to one and only one definition that identifies an abstract universal notion: *e.g.*, number, triangle, relationship, function, etc. This seems to have always been the case until the 19th century, when mathematics expanded and redefined its object of investigation, aspiring to become something close to what scholars today call *formal ontology*.

This began to be achieved with the *Set Theory* of Georg Cantor[24] who had posed the problem of how to treat *infinity*, both as a multiplicity

[23] J.A. Weisheipl, *Friar Thomas d'Aquino: His Life, Thought and Works*, The Catholic University of America Press, Washington 1983, 136.

[24] G. Cantor, *Gesammelte Abhandlungen Mathematischen und Philosophischen Inhalts*, ed. by E. Zermelo, Springer, Berlin 1932. For a review on Cantor's studies on sets and infinity problem one can see J.W. Dauben, *Georg Cantor, his mathematics and philosophy of the infinite*, Harvard University Press, Cambridge, Mass. and London 1979.

and as an entity with its own overall unity. He will arrive at his *Theory of transfinite numbers* starting from the examination of collections of objects (*sets*) in their various ways of being implemented. This transition from numbers to collections of objects of any nature has completely redefined mathematics, which from *Theory of numbers*, with all its applications (arithmetic, algebra, mathematical analysis, analytical and differential geometry, etc.), has become a *Theory of collections*. The notion of *collection* is much closer to the universal notion of *being* (*ens*) in the sense of Aristotelian-Thomistic logic and metaphysics than *numbers* and their applications. And it is just enough to bring out, from within mathematics, the paradox that Aristotle and Thomas knew quite well, even in a different formulation, as a consequence of the contradiction that arises from believing the notion of *entity* (*ens*) as a genre (*genus*), with the consequent need to recognize that *being is said in many ways* (*analogia entis*).

Cantor already realized that the notion of *universal set,* or *collection of all collections*, could not be treated as a *set* in the *same sense* in which the sets within his theory were considered, because this entailed contradiction. These results, as well as other new paradoxes of logic and mathematics, were also obtained later by Bertrand Russell and by other mathematicians and logicians. As Jósef Bochenski observed the impossibility, noted by Aristotle, of speaking of being as a univocally defined universal *genus* (*set*), without incurring a contradiction, is linked precisely to what today's mathematicians know it as

> the problem of the universal class. He solved it with brilliant intuition, though, as we now know, with the help of a faulty proof. The relevant passage occurs in the third book of the *Metaphysics*: "It is not possible that either unity or being should be a single genus of things; for the *differentiae* of any genus must each of them both have being and be one, but it is not possible for the genus taken apart from its species (any more than for the species of the *genus*) to be predicated of its proper *differentiae*; so that if unity or being is a genus, no *differentia* will either have being or be one" [B3, 998b 22-27].[25]

Russell solved another paradox, which today bears his name, by hypothesizing that a set can be implemented in several different ways, which were called "types" (*Theory of types*). Kurt Gödel introduced two distinct

[25] J.M. Bochenski, *A History of Formal Logic*, University of Notre Dame Press, Notre Dame 1961, 54.

definitions to characterize two different ways of implementing a collection and eliminate the contradiction, that of *proper class*, which we can correlate, to a certain extent (*quodammodo*), to the Thomistic notion of *transcendental* (such as *ens*), and that of *improper class*, which we can connect to the univocal notion of *universal genre*.

Having reached this point, Gödel even recognized the indispensable need to arrive at unconventional, but true and objective, foundations of mathematics itself. Here are some of his considerations.

> Research in the foundations of mathematics during the past few decades has produced some results which seem to me of interest, not only in themselves, but also with regard to their implications for the traditional philosophical problems about the nature of mathematics. […]
> This fact is encountered in its simplest form when the axiomatic method is applied, not to some hypothetico-deductive system such as geometry (where the mathematician can assert only the conditional truth of the theorems), but to *mathematics proper*, that is, to the body of those mathematical propositions which hold in an absolute sense, without any further hypothesis. There must exist propositions of this kind, because otherwise there could not exist any hypothetical theorems. […] For example, some implications of the form: "If such and such axioms are assumed, then such and such *a* theorem holds" must necessarily be true in an absolute sense. Similarly, any theorem of finitistic number theory, such as 2 +2 =4, is, no doubt, of this kind. Of course, the task of axiomatizing *mathematics proper* differs from the usual conception of axiomatics insofar as the axioms are not arbitrary, but must be correct mathematical propositions, and moreover, evident without proof.[26]

He could hardly have encountered contemporary philosophy starting from such an explicit demand for realism. While he could have found an adequate interlocutor in St. Thomas. All this tells us how urgent and fascinating it is to open an interdisciplinary research work that connects two cultural worlds: the scientific one and the Aristotelian-Thomistic one, which still know little about each other. It is a question of understanding interdisciplinarity not just as an extrinsic comparison between parallel disciplines, but as an investigation into their *common foundations*. After *Set Theory*, the possibility of taking the further step of developing a *Theory of Entities*, expanding mathematics until it becomes a *Formal*

[26] K. Gödel, *Some basic theorems on the foundations of mathematics and their implications (1951)*, in Idem, *Collected Works*, vol. III, edited by S. Feferman, J.W. Dawson Jr., W. Goldfarb, C. Parsons, R. Solovay, Oxford University Press, New York-Oxford 1995, 304-305.

*Ontology*, seems to be now ripe. An operation that reverses the direction of Cartesian reductionism, which instead tended to restrict metaphysics by bringing it back to mathematics.[27]

b) Analogy emerging from the sciences of complexity

i) Structure of matter: information and material support

Another emergence of the analogy of being was found at a more experimental than at theoretical level, in physics, chemistry, biology, etc., when it began to be taken into consideration what – since the sixties of the twentieth century – it was called, in scientific and popular literature, "*complexity*". By *complexity* we can mean, approximately, the irreducibility of a system (physical, chemical, biological or other), considered as a *whole*, to the *sum of the parts* from which it can be constituted and into which it can be decomposed. We call such irreducibility a *structural complexity*. This irreducibility has led to the rediscovery of the ancient metaphysical question of the *whole-parts relationship* in an entity. Hierarchical levels of organization of a system have been discovered which require some *information* that orients (*finalism*) the organization of their structure and of their temporal evolution. In the latter teleonomic sense we speak also of a *dynamical complexity*.

The notion of *information* which has been gradually developed – by physicists, for complex systems of a mechanical and thermodynamic nature interacting with the environment (*dissipative systems*); and by biologists, for systems capable of self-organization, growing and reproducing themselves (*living organisms*) – is compared with the Aristotelian-Thomistic notion of *form*. The form is understood as an immaterial principle that is responsible for the properties of a complex system in its totality, which are not deducible from the properties of its separate parts. In this case, the analogy of the entity is manifested in the fact that a single principle (*e.g.*, matter) is not enough to account for experimental observations. So a second principle (form, information), which is of a different nature, is required. What we observe is the result of the action of a form acting on its individual matter support. Information, being

[27] I made a first attempt of a transition from *Set Theory* to a *Theory of Entities* in my book *The Problem of Foundations. An Adventurous Navigation*.

immaterial is, by definition, not reducible to matter; the matter support being unorganized and purely potential is irreducible to pure information; the observed object is irreducible either to pure matter or to pure information.

Therefore, there has been talk of a *crisis of reductionism*, or the impossibility of a scientific explanation that reduces everything to a single one explanatory principle.

The fact that a whole (*complex system*) cannot be broken down into its parts without being destroyed as a whole – which is particularly evident in a living organism, but already present in mechanical, thermodynamical and chemical systems – has a reason that today it is also understandable from the point of view of mathematics, thanks to the fact that the function that describes it is a solution of a system of *non-linear equations*. For the latter, in fact, it is known that the sum of several solutions is generally not a solution and *vice versa*.

### ii) The "whole-parts" relationship and the distinction between "potency" and "act"

The problem of the "whole-parts relationship", from another point of view – which presents itself, for example, once again, in *Set Theory* – also reopens the way to the consideration of the Aristotelian-Thomistic theory of the distinction between "potency" and "act". In *Set Theory*, in fact, a primitive relation is considered, from a logical point of view, which is that of belonging (denoted with the symbol $\in$) of an entity to a collection, which identifies an integral part that is "in act" in the collection, and that of inclusion of a set in another set (denoted by $\subset$), which indicates a "potential" part in the collection, as it is not actually separated from the other parts, but can become so if it is cut out by isolating it from the starting collection.

In today's theories of the physical world we have not yet come to terms with the notions of "act" and "potency", and the use of these words still has a rather different meaning from the Thomistic one, even if sometimes some attempts at comparison have been made, such as that of seeing in the quantum vacuum a sort of matter "in potency" or even "prime matter", but until now it has been a matter of what is often called a "spontaneous philosophy of scientists". However, we must point out that Werner Heisenberg already glimpsed in the wave function of quan-

tum mechanics a sort of rediscovery of the Aristotelian concept of "potency"; an idea that was practically forgotten until recent years in which several authors have seriously taken it back into consideration.[28]

iii) The dynamics of matter and analogy in causality

"Complexity", in the sense we give to this word today in the scientific field, seems also to suggest the re-emergence of the doctrine of the four Aristotelian causes, since it is no longer enough to reduce causality in the sciences to the "efficient cause" alone.

- The "material cause" emerges through scientific investigation into the "structure" of matter, in the search for elementary components, no longer conceivable as juxtaposed "elementary" bricks ("parts") – which, when added together, create a system ("whole") – but as "states" of a "unified field" (the knowledge of which we are approaching step by step, although we have not yet completed the task).
- The "formal cause" is appearing precisely through the notion of "information", understood in a sense that, especially in biology, is increasingly approaching the Aristotelian-Thomistic sense of "form".
- The "final" cause, today – as well as the fact that the important principles of physics can be formulated mathematically through *variational principles*, which are interpreted in a finalistic key (something, moreover, that has been well known for more than a century) – , makes its appearance, above all, in the experimental data, which highlights how complex systems tend to organize their structure in view of operations that they must be able to perform. Such functions are oriented to reach *attractors* which are more and more organized complex systems, up to living organisms. And it is the "information" itself, the "form", that orients them teleonomically, even if the initial conditions are assigned in a completely random way.[29]

[28] On the "potency-act" interpretation of quantum mechanics one may see, *e.g*, my paper *A "Potency-Act" Interpretation of Quantum Physics*, «Journal of Modern Physics» 12 (2021) 959.

[29] For examples and details, one may see my previously referenced book *From Fractals*.

*2. Cognitive Sciences and the Aristotelian-Thomistic Theory of Abstraction*

The side of "cognitive" sciences directly calls into question the *Theory of Abstraction*, which offers a model that is surprisingly well fitting the results of today's research in the fields of logic, psychology, physiology and biology with regards the "mind-brain relationship" and more generally "mind-body". At the same time, with the engineering research regarding what is, more or less appropriately called "artificial intelligence", with applications to computers and robotics. Once again both "information" and its "material supports" come into play. It is notable to have acknowledged that information, despite needing a material support that conveys it, is to a certain extent independent of the support itself, in the sense that the same information can be transferred from a support to another one without thereby modify its informational content: the information appears to be in a certain way "immaterial".

The research to understand what intelligence is, capable of managing immaterial universal information that is "abstracted" (*i.e.*, "extracted") from physical matter, reopens the question of what the "mind" is: whether this is something that emerges from matter when a high level of complexity is reached, or is it something that may sometimes also have an existence autonomous from matter. In the latter case, whether this independence can be detected by studying the operations that the mind is capable of carrying out, such as *abstraction of universal information extracted from matter* itself.

The sciences, in this field of research, have even been temporarily misled by modern philosophical theories which have proven inadequate and have therefore been abandoned by researchers and engineers. Just think of the fact that, initially, by resorting to the philosophy of Hume who considers "universals" as "fading singulars", computers were instructed to search for the common ("universal") characteristics of objects of the same kind, allowing a certain margin of error to be tolerated in carrying out the optical recognition of their topological structures. But in this way completely poor and technologically unusable results were obtained. And, therefore, the engineering strategies had to change.

Today there are still two schools of thought debating on which "principle" should be considered as "primary".[30]

i) For some researchers it is matter to be primary and information would emerge as a secondary one from it more or less spontaneously (randomly).

ii) Others believe, on the contrary, that information should precede matter as a principle capable of structuring and organizing it.

We have certainly not yet reached the point of conceiving the possibility of some kind of form/information capable of existing independently of matter (*spirit*) as it is able to carry out activities that are independent of matter, such as the formation of "abstract universals" and "consciousness", as Saint Thomas Aquinas argued. However, the scientific path towards this result is more open today than in the past times, at least from a theoretical point of view. Intellectual and scientific honesty will be necessary to achieve it.

*3. Some Remarks on Artificial Intelligence*

To conclude the present section, I would like to add some considerations on the so-called *Artificial Intelligence* (*AI*), so present in public opinion and discussion through the media.

*AI* was conceived as an idea as early as 1950-55 (by Alan Turing and others). The problem that made it practically unrealizable at that time was the slowness of the first electronic computing machines (*computers*). Today, however, we have: a) very fast machines; and b) a global network (*Internet*) of computers operating together.

This has made Artificial Intelligence possible. It is capable of performing many, if not all, those "processes" of human thought that follow mechanical rules, such as *reasoning*, which is reducible to *calculation* (*logical calculation*), and those *sentences* (*iudicia*) that can be reduced to a comparison between signals produced by some sensors that connect the machine to the external world (*peripherals*) and single pieces of information already stored (object, voice, writing, image recognitions, etc.). But *AI* cannot go beyond those "processes".

[30] See, *e.g.*, R.J. Marks II and Oth. (eds.), *Biological information. New perspectives, Proceedings of a Symposium held May 31 through June 3, 2011 at Cornell University*, World Scientific, Singapore 2014.

Therefore, *AI* cannot perform the operations of abstraction of universal information of a new concept, nor those specific to self-consciousness. This is explicitly stated by *AI* experts themselves.[31]

*AI* is made up of algorithms (learning, expert systems, use of probability, fuzzy logic based on true/false established with probability *P*).

Manifestly, together with evident advantages which may improve the quality of life, *e.g.* in medical applications, *AI* improperly used without reference to correct moral rules implicates also serious dangers, the severity of which increases with its power and efficiency. Among these, the following should be considered.

i) The power to decide the destiny of the world is increasingly concentrated in the hands of a few individuals.
ii) The unreliability of many contents (*fake news*) present on the *Internet*, which the system assumes to be true and allows for the production of new ones.
iii) The psycho-emotional dependence on *avatars* (a phenomenon already present even among experts).
iv) The unpredictability of a *complex system* like the *network* and *AI* (this is a consequence of results demonstrated in mathematics in the 20th century for *complex non-linear systems*).
v) The danger that people use their intelligence by limiting themselves to reasoning like a computer, like *AI,* without understanding what they are doing, delegating decisions to automatisms.

It is clear that the problems cannot be solved by simply *plugging the holes*! The problem of the livability of a society, the problem of man, of re-educating consciousness, goes much deeper. We need a remedy that fundamentally solves the problem of man, a *Salvation*. Thus, the word *Salvation* regains all its anthropological and social significance and is not relegated as an optional and private choice for the devout.

The response of Faith offered by Revelation to the *question on Salvation* becomes irrevocable because it is indispensable, since it is demand-

[31] See, *e.g.*, D.K.W. Modrak, *Aristotle the first cognitivist?*, «Apeiron» 23 1 (1990) 65; F. Faggin, *Silicon. From the Invention of Microprocessor to the New Science of Consciousness*, Waterside Productions, Oxford 2020, Appendices IV and V; E. Fewser, *Aristotle Revenge. The Metaphysical Fondations of Physical and Bilogical Science*, Editiones Scholasticae, Neunkirchen-Seelscheid 2019.

ed by reason itself, under penalty of losing all rationality, of losing everything and everyone. Of losing the right to exist. *Salvation* is accepted as a reparation (*Redemption*) of the justice between man and God the Creator (of the sin against God the Creator!), of the right relationship of man with God ("You shall love the Lord your God", Mt 22,37) and with other human beings ("You shall love your neighbor as yourself", Mt 22,39). More of man's relationship with himself ("as yourself").

## VII. A Sort of Sapiential Conclusion from the Magisterium

I dedicate the last section to some texts of the Magisterium[32] as a suitable conclusion of my contribution.

The purpose of the Magisterium is not so much to develop a detailed theory regarding the argument it treats;[33] rather, it is to "indicate", and in some cases "define", those principles of comprehension of reality (both natural and supernatural) that must be considered indispensable for a correct understanding of the questions under examination whether from the viewpoint of the faith or of reason. In particular, the Magisterium:

> does more than point out the misperceptions and the mistakes of philosophical theories. With no less concern it has sought to stress the basic principles of a genuine renewal of philosophical enquiry, indicating as well particular paths to be taken.[34]

Our purpose in reading passages of the Magisterium is to point out some of these indispensable principles, such that to pose correctly the problem of the rationality and the scientific character of a cognitive method. Then, the task of research comes, the task of identifying a way to develop a proper epistemology emerging from the very scientific issues at hand. Such epistemology, while keeping in mind the indispensable principles, must be capable of giving an answer to the questions posed today by the *Theory of foundations* of the sciences themselves.

[32] A wider exposition of the subject examined in the present section can be found in my book *The Sciences and the Fullness of Rationality*, Davies Group, Aurora 2010.

[33] «The Church has no philosophy of her own nor does she canonize any one particular philosophy in preference to others» (John Paul II, *Fides et Ratio*, n. 49).

[34] *Ibidem*, n. 57.

*1. Something from the Teaching of John Paul II*

In particular, we will turn our former attention to the Magisterium of *John Paul II*, who has opened and travelled along a path that permits us to read correctly the path of the modern sciences and the epistemological and sociological reflection on the same. Given his philosophical formation (Aristotelian-Thomistic in its foundations and phenomenological in his approach to man's experience), his method consists in keeping present at the same time the "external" as well as the "internal" aspects of the sciences, and their reciprocal connection. His teaching on such themes:

> a) *from without* departs from the *data of experience*, whether on the personal or social level and manages to outline the theoretical issues of the contradictions found in experience.
> If the acceptance of certain principles has led to a society that is contradictory and nearly unlivable (for the individual and the community), one has a clear indication that at least some of these principles were erroneous from the beginning. Therefore, it is necessary to change them, or even substitute them, reconsidering the fundamental choices that are at the basis of culture and the concept of science currently in place. If at the basis there has been a multi-secular, anti-metaphysical prejudice, is it not correct to assume that this has been one of the principle causes of the contradiction?
>
> b) From *within* he suggests identifying those problems on the logical and foundational order that obstruct the very development of scientific theories, indicating the intrinsic limits of the model of rationality that has been, until now, considered valid, and searching for a way that would be constructive of a rationality both "widened"[35] and open to a dimension that can transcend it, such as faith.
> If the journey that departs *from without* is in a certain sense a *via negativa*, and only offers the symptoms of a state of disease, which

[35] The "widened rationality" will be a recurrent theme also in the Magisterium of Benedict XVI. See, *e.g.* the speech *At the Sixth European Symposium of University Professors*, June 7, 2008.

> it does not manage to heal, the journey that departs *from within* is instead a *positive way*. It is not a way that merely points out what does not work; it proposes itself as a way that can help to construct this "new rationality".

With regard to science, the *way* is laid out in the *Speech of John Paul II to Scientists and Students*, given at Cologne on November 15th, 1980. It constitutes a point of reference for many of the later speeches of his pontificate on this topic.

The *internal way* begins to appear more explicitly in some passages of the more recent speeches, since probably because only in the last these years an epistemological reflection arose which shows more evident signs of openness in this sense. It seems that lately, the anti-metaphysical prejudice has begun to diminish and even to yield, due to the scientific method's internal necessities of development. This constitutes a novelty of no little importance, even if for the moment it poses questions only in the most innovative sectors of scientific research, and does not seem to touch the more traditional sectors, which live off the gains of the old methodologies according to a reductionistic and closed epistemology. This diminishing of the anti-metaphysical prejudice is taken into account even less by the world of subjectivist and relativistic philosophy, which has condemned itself to a future without a future. However, it is only a matter of time before it reaches these fields as well: the problem of foundations is inevitable.

The speech at Cologne inserts itself into the period of celebrations for the Seventh Centenary of the death of St. Albert the Great (c.1200-1280) and takes its point of departure from the figure and work of the great medieval scientist, who is a Doctor of the Church and the patron of scientists, besides being the master of St. Thomas Aquinas. It offers an analysis of the situation in which contemporary science finds itself, and proposes the lines for posing the epistemological problem correctly.[36]

After the usual greetings (no. 1), the speech is structured around three themes:

[36] Original text in German online at www.vatican.va/content/john-paul-ii/de/speeches/1980/november/documents/hf_jp_ii_spe_19801115_scienziati-studenti-colonia.html. Here, the English translation is from my book *The Sciences and the Fullness*.

– the problem of dialogue between science and faith (nos. 2-3);

– the problem of technology with regard to "applied" science (nos. 3-4);

– the problem of science as "theory" and "form of knowledge" (nos. 4-5),

and also indicates the logical steps joining them.
Our attention will be focused above all on the second and third themes, which will bring us to a more properly epistemological study, even if the speech touches on other extremely important aspects, such as that of *meanings* and of the *freedom* and *autonomy* of science with respect to power.

> Scientific knowledge has led to a radical transformation of human technical ability. As a result, the conditions of human life on earth have changed in an enormous way and have also improved considerably. The progress of scientific knowledge has become the motor of a general cultural progress. […]
> This interrogation acquires particular weight before the duty of scientific thought in relation to man. The so-called human sciences have surely furnished important and progressive knowledge regarding human activity and behavior. These, however, incur the danger, in a culture driven by technology, of being utilized to manipulate man, for purposes of economic and political domination (n. 3).

The encyclical *Redemptor Hominis*[37] at n. 15 had already conducted a lucid analysis on the crisis of "livableness" of the scientific-technological civilization. The speech of Cologne applies this analysis in detail to science and technology.

a) The Problem of Technology as "Applied" Science

First of all, we must make a distinction regarding the principle between pure science and applied science (technology), in opposition to much contemporary epistemology that, on the path of relativism, has denied science a cognitive value. It has reduced even the most abstract science to a theoretical technology for the manipulation of data and numbers that are useful only to make predictions and to build machines, but not to know in the sense of explaining and understanding the universe in

[37] Cfr. John Paul II, Encyclical Letter *Redemptor Hominis*, March 4, 1979.

its causes.

The *speech* then identifies two levels of crisis: one regarding science as technology and the other regarding science as theory, and establishes a precise connection between them.

> The transformation of the world on the technical level has appeared to many as the meaning and purpose of science. In the meantime it has happened that the progress of civilization does not always indicate an improvement in the quality of life. There are involuntary and unforeseen consequences, which can become dangerous and harmful. I recall here only the ecological problem, which arose following the progress of technical-scientific industrialization. In this way, serious doubts arise regarding the capacity of progress, in its entirety, to serve man. Such doubts have repercussions on science, understood in the technical sense. Its meaning, its objective, its human significance are put into doubt (n. 3).

The present crisis of legitimization of science originates in having judged technology the one and only purpose of science. There are two positions implicit in this utilitarian decision: one ethical, the other epistemological.

On the *ethical plane* «If science is understood essentially as a "technical fact", then it can be conceived of as the search for those processes that lead to success of a technical type» (n. 3) and, choosing a logic that identifies technical success with the value of man, one is lead to identify the "good" as "that which is technically possible".

On the *epistemological level*, it is assumed that:

> what has value as knowledge, therefore, is that which leads to success. The world, on the level of scientific data, becomes a simple complex of phenomena that can be manipulated; the object of science becomes a functional connection that is analyzed only in reference to its functionality. Such a science can only conceive of itself as pure function. The concept of truth thus becomes superfluous; indeed, sometimes it is even explicitly rejected. Finally, reason itself is seen as a simple function, or the instrument of a being that finds the meaning of its existence outside of knowledge and science, in the best of cases, in life alone (n. 3)

in a dimension that is described as instinctive, sentimental, and at any rate, irrational. It is precisely in this irrational dimension that the most important questions are placed, such as the question of the "meaning" and the "purpose" of things and of life, and of the "foundation" of knowledge, and so on.

As a consequence, one finds that not only science, but also all «our culture, in all its sectors, is imbued with a science that proceeds in a

largely functionalistic manner» (n. 3).

At this point in the *speech*, the link is established between the ethical aspect concerning the purpose of science and the epistemological aspect concerning its cognitive value. This is the central issue to be resolved. In such a way, one passes from the problem of technology, as "applied" science, to the consideration of the problem of science as "theory" and "form of knowledge".

b) The Problem of Science as "Theory"

The key issue linking the analysis of science as technology with the question of the epistemological assumptions of science as theory, lies in the inevitability of the nexus between the conventionalist and utilitarian position, which denies the classical notion of objective truth, and the ethic of success as the final purpose of science, according to which the good is everything that is technically possible.

The first ends up denying science the possibility of reaching any form of knowledge of truth and, as a result, also denies its autonomy and freedom with respect to power. The second, in its most extreme consequences, tramples on the dignity of man and makes society progressively more unlivable.

> Until now we have spoken mainly of the science that is at the service of culture and in consequence, of man. Still, it would be too little to limit ourselves to this aspect. Precisely in front of the crisis we must remind ourselves that science is not just a service for other ends. The knowledge of the truth has meaning in itself. It is fulfillment, of a human and personal nature, a human good of the first order. Pure "theory" is itself a modality of human "praxis", and the believer is awaiting a supreme "praxis" that will unite him forever to God: that "praxis" that is vision, and therefore also "theory".
>
> We have spoken of a "crisis of legitimacy in science".
>
> To be sure, science has its own meaning and its own justification when it is recognized as capable of knowing the truth and when the truth is recognized as a human good. Then even the demand for the freedom of science is justified; indeed, how could a human good be realized, if not through freedom? Science must be free also in the sense that its actualization must not be determined by immediate ends, social needs or economic interests. This does not mean, however, that it must, in principle, be separated from "praxis". Only that, to be able to influence praxis effectively, it must receive its first determination from truth, and thus be free for the truth. A free science devoted only to the truth does not allow itself to be reduced to the model of functionalism or to other kinds of models, which limit the cognitive sphere of scientific rationality (n. 5).

In a positive sense, reference is made to the "organic" model of the unity of knowledge and to an open rationality such as the medieval rationality at the time of St. Albert the Great and especially of St. Thomas Aquinas.

> Science must be open, and furthermore multi-form, without however having to fear the loss of a unitary orientation. This is given by the triple reality of personal reason, freedom and truth, in which the multiplicity of concrete implementations is founded and confirmed. I do not hesitate to place even the science of faith within the horizon of a rationality understood in this way. The Church hopes for an autonomous theological research, that does not identify itself with ecclesiastical Magisterium, but which knows itself to be committed to work before the Magisterium in common service of the truth of the faith and to the people of God (n. 5).

*From the "external" way to the "internal" way* the word "truth" is proposed once again. With this journey from outside science, one is not yet able to construct demonstratively an epistemology (and more generally, a philosophy) in which the notion of truth, in the classical and full sense of the word, finds a space, and therefore a meaning. However, through this way, one is suggested, or almost forced to see, through factual clues, the necessity of developing a *Theory of Science* in which the word "truth" has a *non-conventional* value.

The reference to the medieval conception of the sciences – especially the one of Thomas – and of the unity of knowledge, at this point, takes on particular significance, since in such a synthesis the word "truth" is given its true and proper place. It is necessary, however, to integrate this *external method* with the attentive *internal analysis* of the methodology of modern science in the search for its *logical* and *ontological foundations*.

It is worthwhile at this point to cite a passage of a more recent text:

> Today "we face a great challenge […] to move from *phenomenon* to *foundation,* a step as necessary as it is urgent. We cannot stop short at experience alone; […] speculative thinking must penetrate to the spiritual core and the ground from which it rises" (Encyclical *Fides et ratio*, n. 83). Scientific research is also based on the capacity of the human mind to discover what is universal. This openness to knowledge leads to the ultimate and fundamental meaning of the human person in the world (cf. *ibid.*, n. 81).[38]

It is also worthwhile citing another passage from *Fides et Ratio* that allows us to foresee how the problem of foundations might constitute a true

[38] John Paul II, *Jubilee of Scientists. Address of the Holy Father John Paul II*, May 25, 2000.

and proper link with the most profound philosophical and theological questions, which have full rational dignity and cannot be done away with as psychological or irrational.

> Finally, I cannot fail to address a word to scientists, whose research offers an ever greater knowledge of the universe as a whole and of the incredibly rich array of its component parts, animate and inanimate, with their complex atomic and molecular structures. Science has come so far, especially in this century, that its achievements never cease to amaze us. In expressing my admiration and in offering encouragement to these brave pioneers of scientific research, to whom humanity owes so much of its current development, I would urge them to continue their efforts without ever abandoning the sapiential horizon within which scientific and technological achievements are wedded to the philosophical and ethical values which are the distinctive and indelible mark of the human person. Scientists are well aware that "the search for truth, even when it concerns a finite reality of the world or of man, is never-ending, but always points beyond to something higher than the immediate object of study, to the questions which give access to Mystery".[39]

What is new and interesting for the scientific mentality is that at present, this openness is no longer simply the object of an exhortation proposed from outside science, but begins to show itself as an internal necessity, indispensable for the foundation of scientific knowledge, which is no longer able to demonstrate from within its own self-sufficiency. Nor can it show this self-sufficiency to be complete or coherent.

This referral of scientific theory to its own foundation constitutes a type of joining element between the modern problem of the *Theory of Foundations* in the field of mathematical logic and the ancient medieval concept of science, which required every science to be founded on knowledge of a superior level that acted as a meta-science, until they reached indemonstrable first principles, recognized as indispensable for constructing the whole edifice of knowledge.

> Scientific affirmations are always in the particular. They are justified only in consideration of a determined point of departure, they are situated in a process of development and within that they can be corrected and surpassed. But above all: how can something constitute the result of a scientific point of departure which first justifies this point of departure and therefore must already be presupposed by it?[40]

[39] John Paul II, *Fides et ratio*, n. 106.

[40] John Paul II, *Speech of Cologne*, n. 3.

A science needs a point of departure, a series of affirmations, not demonstrated and non-demonstrable from within its (axiomatic) system: these constitute its foundations (definitions, rules, principles). If one accepts a univocal model of science, in which only one type of science is offered (univocal epistemological model), such presuppositions necessarily come to be found outside that science and are therefore unscientific, irrational, based on convention or ideology. This is the paradox of the "closed" conception of science: the impossibility of founding itself on completely rational bases, just when it needs the maximum of scientific rationality.

Today we find ourselves in front of a bipolar model of science, where the two poles are constituted by mathematics on one side and by the experimental sciences on the other. Mathematics furnishes some foundations for the physical sciences, and more in general for the experimental sciences, but it itself, in turn, is not founded on a superior science nor is able, on its own, to found itself on indispensable and true first principles, but only on conventional principles.

In this situation, science manages neither to be a completely demonstrative system, nor to demonstrate its own truths or even its own internal coherence (Gödel). Because of this, the problem of foundations today is acquiring ever more ground, because it sets the conditions for the advancement of the scientific enterprise itself. Rather than give up skeptically as much of philosophy has done, science is realizing that there is a path to a solution: an open science, capable of organizing itself in hierarchically structured levels of sciences, in which each one offers the foundation for the next, linking back to principles that are true at least because they are indispensable for the logic of thought as such. We are speaking about an organic and analogical model of knowledge.

*2. Something from the Teaching of Benedict XVI*

Benedict XVI develops the premises, posed by John Paul II, in both directions:

– a *theoretical* one emphasizing the need of a *widened model of rationality*, as suggested by the medieval thought of St. Thomas and today as required even by the recent mathematical and cognitive sciences, and in order to overcome the philosophical relativism of contemporary thought;

– a *practical* one emphasizing the need of a universal *natural law* and a *natural right* as urgently required by the crisis of livability of the contemporary more advanced societies and states.

We will approach his challenge to contemporary *relativistic moral thought*, starting from some simple considerations.

He explicitly identifies the cause of the loss of livability in our society with the denial of these two universal references (*truth* and *natural law*) by founding on the re-proposition of these, at least as provisional hypotheses to be verified in the social and legislative laboratory. The thesis of "non-negotiable principles" just follows from these two pillars of culture and of social life:

– the need to admit some *universal objective truths*;
– the need to admit a *universal objective natural law*, the one also communicated by Revelation (*revelatum per accidens*) synthesizing it in the *Decalogue*.

A sort of re-proposition of St. Thomas epistemology and metaphysics, together with Augustine view of *the city of men* far from *the city of God*, suggested in a negative fashion through the consideration of the devastating consequences of the abandon of both ones.

The main thesis is that if we give up these two pillars (*truth* and *natural law*), or even theorize their denial, society becomes not only unlivable, but even impossible to govern, and democracy ends up paralyzing and ultimately self-destructing, the economy will be blocked, etc. And present-day facts do confirm the thesis.

As a *latter* positive way the development of cultural work on the first point (that of the search for theoretical, scientific foundations, of universal objective truths) is the main task of intellectuals, men of science, philosophers and theologians, as the latter can offer to the former those philosophical elements that are already contained also in Revelation, Scripture, Tradition, and in the Magisterium. The indication given to them by the Magisterium of Benedict XVI, on the path opened by John Paul II, has been to work towards a "widened rationality". A work that can fruitfully start from the *problem of the foundations* of our most advanced sciences. I only mention some passages in this regard.

> A correct understanding of the challenges posed by contemporary culture and the formulation of meaningful responses to these challenges must have a critical

> approach to the limited and ultimately irrational attempts to restrict the realm of reason. The concept of reason must instead be "expanded" to be able to explore and understand those aspects of reality that go beyond the merely empirical dimension. This will allow for a more fruitful and complementary approach to the relationship between faith and reason.[41]
>
> By asking questions about the truth, we actually widen the horizon of our rationality, we begin to free reason from those too narrow limits within which it is confined when only what can be the object of experiment and calculation is considered rational.[42]
>
> We Europeans must rethink our secular reason.[43]

But while waiting for this theoretical elaboration to be developed – an operation that normally requires a long period of time – it is necessary to implement practical solutions, provisional hypotheses that serve to unlock the social deadlock in which the world in general, and Europe in particular, Italy included, finds itself trapped. The challenge to decide to take a step in this direction has been launched by Pope Benedict also in the form of a sort of slogan. That is, the formula he suggested *to live as if God existed*, reversing the old formula attributed to Grotius *to live as if God did not exist*.

> The idea of living "as if God did not exist" has proved harmful: the world needs rather to live "as if God existed", even if there is no strength to believe, otherwise it produces only an inhuman humanism.[44]

A kind of "test to believe" (almost a Pascal-like challenge), while waiting to regain possession of a thought system that allows to recover demonstratively, philosophically, scientifically the theoretical validity, as well as practical, of those irrevocable principles, so that *truth can return to be scientific*.

In the Magisterium of Benedict XVI, the inseparable bond between truth and freedom, already highlighted by John Paul II, is further explicitly stated.

[41] Benedict XVI, *Address to the Participants in the First European Meeting of University Lecturers*, June 23, 2007.

[42] Benedict XVI, *Address to the Participants at the Ecclesial Convention of the Diocese of Rome*, June 5, 2006.

[43] Benedict XVI, *Address to the Journalists*, Fiumicino Airport, November 28, 2006.

[44] Benedict XVI, *Address to Participants in the Congress Organized by the Pontifical Council for Social Communications*, October 7, 2010.

On one hand, negatively, as a "diagnosis" of a historical philosophical-cultural error with epochal consequences on civilization that we see in the form of its unlivability.

On the other hand, positively, through the challenge to men of culture, governments, powers of all kinds, and individuals, formulated as a proposal for a "therapy": that of adopting as new principles of thought and lifestyle those theoretical and practical principles that the neo-gnostic world of modernity had sought to avoid, in order to not have to seriously confront Christianity, or rather Christ himself through the Church.

In this context lies the issue of the *non-negotiable principles* systematically re-launched by Pope Benedict, especially in the last years of his pontificate. And even before that, at the foundation of these, the proposal to take up again the question of *natural moral law* as the "practical" counterpart corresponding to the question of *truth* on the "theoretical" level.

This proposal is no longer dealt with solely as an ethical-disciplinary call directed to Catholics and people of good will (according to a style of Magisterium typical of the past and suitable for those times), but as necessary and irrevocable condition for society to be livable and to escape from the deadlock in which every political and economic system has found itself. And today, we have now come to a total blockade.

> Some believe that human reason is unable to grasp truth and, therefore, to pursue the good that corresponds to the dignity of the person. […] The social doctrine of the Catholic Church offers, in this regard, elements of useful reflection to promote security and justice, both at the national and international levels, starting from reason, *natural law*, and also from the Gospel, that is, from what is in accordance with the nature of every human being and also transcends it.[45]

He addresses the International Theological Commission, to which he asked to produce a working document on the theme of *natural law* (published in 2009), with these explanatory words.

> The Catechism of the Catholic Church summarizes well the central content of the doctrine on the *natural law*, highlighting that it "indicates the prime and essential norms that regulate moral life. It has as its pivot the aspiration and submission to God, source and judge of all good, as well as the sense of the other as equal to oneself. In its principal precepts, it is expressed in the *Decalogue*. This law is called natural not in relation to the nature of irrational beings, but because the reason

[45] Benedict XVI, *Address to the Participants in the Conference of the Executive Committee of Centric Democratic International*, Castel Gandolfo, September 21, 2007.

> that promulgates it is proper to human nature" (n. 1955). With this doctrine, two essential purposes are achieved: on the one hand, it is understood that the ethical content of the Christian faith is not an imposition dictated from outside the conscience of man, but a norm that has its foundation in human nature itself; on the other hand, starting from the *natural law* per se accessible to every rational creature, it lays down with it the basis for entering into dialogue with all men of good will and, more generally, with civil and secular society. [...] True rationality is not guaranteed by the consensus of a large number, but only by the transparency of human reason to the creative Reason and by the common listening to this Source of our rationality.[46]

The speech delivered to the German federal parliament on September 22, 2011 is a true masterful lesson on the need to found legislation, at any level (local, national, and international) on a rediscovered common basis of *natural law*, rather than solely on conventions resulting from agreements voted by majority.

> In many matters to be regulated by law, that of the majority may be a sufficient criterion. But it is evident that in the fundamental issues of law, where the dignity of man and humanity is at stake, the majority principle is not enough: in the process of law formation, every person with responsibility must seek the criteria of their own orientation.[47]

Benedict XVI is even stronger in the aforementioned speech, and shielded with the authority of St. Augustine, he clearly indicates where good intentions end up: "Remove justice – and what is the State but a great band of robbers?, Augustine once said".

More he said: "The idea of *natural law* is considered today a rather singular Catholic doctrine, not worth discussing outside the Catholic context, so much so that one almost feels ashamed to even mention the term", but the proof that this opinion is incorrect lies in the facts, in the loss of livability that it ultimately produces.

According to a mathematical language, it could be said that we are facing a *reductio ad absurdum*. If you cannot constructively prove a thesis, try to prove its negation: if what you get is a contradiction, then the thesis you wanted to deny is the true one. And on the social level, the contradiction is manifested by the increasing unlivability.

[46] Benedict XVI, *Address to Members of the International Theological Commission*, October 5, 2007.

[47] Benedict XVI, *Address to the Bundestag*, September 22, 2011.