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The World as a Gift: Scientific Change and Intelligibility for a Theology of Science

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Abstract: "Truth" and "cause" are essential issues in theology. Truths of faith are meant to remain solid and fundamental and can be traced back to the unique truth of God. The same God is conceived of as the Creator who brought everything into existence before every other cause. Recent discussions about scientific rationality and causality have engaged with the same ideas of "truth" and "cause", even though they have done so according to different methodologies and from different points of view. Can those discussions stimulate theology, and if so, in what manner? In this paper, we begin by considering the subject of scientific change and rationality, arguing that scientific change leads to the recognition of the connection between any scientific theory and what remains intelligible in nature. Next, we show some of the outcomes from new mechanistic philosophy, focusing on the idea of cause, which unveils a strong correspondence between epistemology and ontology and provides a unique way of speaking about causality. Finally, we conclude that science can support theology through new approaches to nature and that a theology of science is required today as an intertwined perspective between science and theology. The main virtue that guides this approach is humility.

Keywords: science; scientific change; transdisciplinarity; intelligibility; epistemology; theology of science

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1. Introduction

Does "scientific truth" exist if scientific theories change over time? If it does, then why does our aspiration continue to be a "definitive" understanding of reality? What has the history of science taught us about every aspiration to knowledge, and, in turn, what has theology learned from that lesson? All these questions are only marginally investigated in the framework of science and religion studies. However, the quantum and relativity revolutions that took place at the beginning of the twentieth century, as well as the following development of the natural sciences and the so-called complexity sciences, amply demonstrated that a new approach to sciences had arisen from a crisis of the fundaments of science. New epistemological perspectives integrated the old ways of understanding nature or replaced them with more articulate and efficient ones that are capable of shaping new phenomena unknown in the past. At the same time, the perception that it was impossible to arrive at complete and conclusive forms of knowledge became more salient thanks to discussions about the historical development and change of scientific theories. The same idea of God First Cause has to be discussed in a new approach, since the topic of cause has been approached in a new way from the inside of the scientific world. Interestingly, this happened while the development of technology—as an expression of science—affected society. Against that background and in that context, every theological reflection and every argumentation addressed to a believing consciousness must consider the fact that the cultural and educational context cannot easily be separated from science.

Hence, it is essential to establish what science is today before making any attempt to establish a dialogue or integration between science and theology and before developing any

argumentation about how science and theology challenge each other. Generally, by theology, we understand an attempt to intellectually make comprehensible what are considered the truths of faith of a certain religion. In our further analysis, we will concentrate on the Christian religion and mainly on Catholic theology. As the science of faith, theology seeks to understand what is believed, why it is believed, and what can be known concerning God (*sub ratione Dei*). More specifically, we will focus on a theology of science conceived of as a theological subdiscipline concerned with the very existence of science, with the conditions of scientific knowledge, and with science as a value.

In this paper, we will examine the impact of scientific change on the idea of "scientific truth" and point out how scientific change makes evident the way in which reality and knowledge are dynamically intertwined. This sort of dynamicity is particularly expressed in the historical change of theories, although it does not cause a relativism of knowledge. On the contrary, it allows us to recognize that dynamic interweaving is a fundamental feature of the scientific enterprise. In any case, what remains beyond any change is the experience of intelligibility of the world, or at least part of it. In Section 2, against the background of the fact that scientific explanations change through time, we will briefly focus on changes in the concept of causality in science and then ask how theological argumentation can assume God as Creator today. Thus, we will further explore the possibility of developing theological perspectives about causation by assuming scientific pluralism, and we will defend the idea of a theology of science and its urgency, based on what science is today. In Section 3, we will show how the most crucial lesson from scientific change is humility and, consequently, how science helps us recognize that the world is a *gift* because it is *intelligible*. Finally, we will conclude with a brief reflection on the need for the development of a theology of science so that theology in general can engage productively with the current culture.

2. Where Is the (Scientific) Truth? Science Has Many Faces

For a scientist, science is a path towards the best understanding of the natural world. Causes, forces, elements, and every other material or conceptual component of theoriesare all essential for having correct explanations and, consequently, manipulating nature for practical purposes. Scientific truth should be the outcome of scientific knowledge, which is considered a specific kind of knowledge. In the twentieth century, the very idea of scientific truth gave way to a more nuanced approach that sometimes embraced certain forms of irrationalism. In addition to this, especially after World War II, science and technology became increasingly pervasive in daily life, and society at large became permeable to various forms of rationality, increasingly shaped by scientific and technological knowledge. The question of truth—and epistemological questions in general—had to account for science.

2.1. Truth, Revolutions, Certainties

Truth, method, and empirical statements: these keywords can synthesize what happened to the scientific enterprise at the beginning of the twentieth century. From the Vienna Circle's Manifest onwards, the physicalist approach proposed by philosophers such as Rudolph Carnap, Hans Hanh, and Otto Neurath (Hahn et al. [1929] 1973) contributed to reinforcing the idea—rooted in the Positivist age—that science aims to understand the natural world in its entirety because of its method, based on logical integration between sense data and reasoning. A unique knowledge and physical foundation with a unified method and approach to the natural world yielded the premise that unifying sciences was the best way towards growth in scientific inquiry. Nevertheless, against such a severe form of reductionism, there evidently appeared inhomogeneities and dissimilarities among different branches of sciences (Ruphy 2017). Two significant new theories in physics—the Special and General Theory of Relativity and Quantum Mechanics—as well as the discovery of digital computation and complexity in computer science were not unique injections from science in the first half of the twentieth century. Something was also happening in natural sciences: the creation of a synthesis between the rediscovery of Mendel's laws and the Darwinian

theory, between genetic and natural history, was urgently needed. Thomas H. Morgan, Ronald A. Fisher, Theodosius Dobzhansky, Ernst Mayr, and other biologists searched for it, and it became clear that science would have to admit the existence of complex systems and elucidate a methodological way to understand them. New approaches to evolutionary theories became popular, known as the "New Modern Synthesis" (Huxley 1942).

In the meantime, historians were exploring the processes involved in the development of modern science in more depth, and exactly at the mid-century point, the myth of the unity of science was consolidated by a seminal book: *The Structure of Scientific Revolutions* by Thomas S. Kuhn (1962). Social agreement within the scientific community and cultural conditions determine the unity of science during an epoch. The state of *normal science* is based on what scientists accept as *normal*, agreeing about laws and explanations of certain natural phenomena. When some anomalies appear, the scientific community falls into crisis, attempts to solve the conundrum, and, if necessary, implements a paradigm shift. On the one hand, while Kuhn's program was sophisticated from a philosophical point of view, it was appropriated and revised by sociologists (Wray 2021). On the other hand, Kuhn's interpretation of the rise of modern science was fundamentally dependent on his earlier studies (Kuhn 1957), and historians have subsequently refined that overview (Westfall 1971; Shea 1988; Gaukroger 2006; Westman 2011; Marcacci 2018, pp. 23–56). As a result, the awareness of the manifold approaches to understanding and explaining science, its structures, and its developments grew. Scientific knowledge appears as "situated", and the understanding of science as a phenomenon "in relation to" social conditions, semantic contextualism, metaphysical commitments, contingent and technical ability to perform discoveries, etc., led to the "relativistic question" in science (Kusch 2021). In the case of science, a typical way to intend relativism is from a methodological point of view: the inquiry of the historical and cultural situatedness of science does not entail an evaluate stance, but it only must explain what happened in the affirmation or rejection of a theory. Such a form of relativism in science has been supposed to be against absolutism, rationalism, and realism. This is to say that scientific knowledge cannot engage with absolute, rational, or nominalist knowledge. These positions still raise lively debates, even hooked into the relativistic question (Chang 2020). However, what we can hold as an acquisition of the last decades of discussions in the philosophy of science is the realization that one cannot talk about science while leaving out the details of its practices and singular case-study. Moreover, science must interact with other forms of knowledge, insofar as the philosophy of science must interact with other branches of philosophy.

In fact, a deeper historical analysis demonstrates that no method was the essential cause of the birth of modern science; consequently, the defense of scientific rationality called into question many philosophical claims, and the notion of what science is became an issue to be investigated rather than a model to be exported to other fields of knowledge. In addition, understanding science by means of multiple points of view—a sort of *pluralism shift*—has been replacing the ambition of the *paradigm shift*.

It is beyond the aim of this paper to assess the whole debate on pluralism (Mitchell 2003; Kellert et al. 2006; Ruphy 2017); however, we would like to hint at a variety of pluralisms present in the current philosophical literature (Van Bouwel 2014). If these stances are to be placed on a continuum going from monism to anything-goes pluralism, then we can identify monism, moderate/temporary pluralism, integrative pluralism, interactive pluralism, isolationist pluralism, and anything-goes pluralism. These positions can be characterized briefly in the following way: Monism—viewed as explanatory reductionism—generally equates science with a single language, one true scientific method, one privileged standard for all explanations. Moderate/temporary pluralism promotes a temporary plurality of competing theories as a step towards achieving the unity of science in the long run. This form of pluralism acknowledges the monist goal and the possibility of resolving the character of plurality. Integrative pluralism, in turn, takes into account highly specialized disciplinary research on the one hand and the need for integrating the findings concerning explananda on the other. As for interactive pluralism, "on the one

hand, it claims that satisfactory explanations can also be obtained without integrating of multiple levels, so there is no integration imperative, and . . . on the other hand, it does not discourage interaction as, in some instances, interaction and integration do lead to better explanations" (Van Bouwel 2014, p. 109). Isolationist pluralism presupposes some sort of explanatory closure and maintains a narrowness in the scope of scientific investigation that excludes interaction between scientific disciplines. And finally, anything-goes pluralism holds that all the possibly inconsistent theories that emerge from the scientific endeavor are equally acceptable. This list clearly evidences a sort of *pluralism shift*, since each version offers a different answer to the question of whether the plurality needs to be resolved and how it should be understood.

On the other hand, in more recent years, the confidence in the so-called complex sciences and the proliferation of sociological studies about science have demonstrated that there is an abundance of factors which influence the scientific enterprise and actually participate in establishing insight into scientific explanation. The recent collective experience of the pandemic has brought to the fore how science—and disciplines such as epidemiology—must cope with social organizations, human habits, and networks. While the context of the prevailing risk and the urgency of making decisions rendered the traditional review processes ineffective, more people became cooperative and interested in science. However, there have also been people taking an opposite stance, which was equally crucial for determining the effectiveness of medical procedures such as a vaccine. Science stepped out of the laboratory, and the scientific community was no longer the sole determinant of the success of science (Marcacci and Oleksowicz 2022). Risk, uncertainty, and interaction between scientific and political initiatives as well as between science and other kinds of knowledge are now relevant to understanding how science works and can work. It is impossible to eliminate uncertainty, and more so than in the past, collective actions jeopardize collective survival. In fact, some have spoken of post-normal science (Funtowicz and Ravetz 1993), while others—more recently—have spoken of the triumph of uncertainty (Tauber 2022).

Be that as it may, the search for certainty and truth has changed its approach, method, and perspective. The tools of objectivity against subjectivity, of neutrality against perspectivism, and of foundationalism against relativism manage to justify and explain only a limited set of problems confined to the specific rules of a specific scientific discipline. Objectivity, neutrality, and the foundation of science are not easy goals to define or achieve (Snow 2022).

The consequence is not a renouncement of certainty, for without the aspiration to certainty, no science would exist (Tauber 2022, pp. 5, 39). Instead, the consequence is that certainty must be commensurate with uncertainty, that truth must be commensurate with partial truths, depending on the assumptions of a given reference theory, and that partial truths must be commensurate with plural truths—moving from the scientific context to the philosophical context and, finally, to the theological context. Let us now dwell on the latter perspective. Considering that according to the Christian theology, basically, there are two modes of knowing God, one through the natural order, and the second through Revelation, the order of the created world identifies an implicit harmony between creation and redemption. The divine truth of creation—whether this is conceptualized as God Creator, Wisdom, Providence, First Cause, Mind of God, etc.—must be thought of as being embedded in the created world and in Jesus Christ. The same truth concerning the world which the sciences discern with their proper but changing methods is at the same time to be identified with the unchanging truth of Jesus Christ. On the one hand, that there is an independent ordered world, the structure of which can be investigated and explained scientifically, is a very "peaceful claim"; on the other hand, as we suggested beforehand, it is clear that to base the interaction of theology and the sciences on the basis of "the alleged 'certain findings' of the natural sciences will therefore find itself outdated with every advance in scientific understanding" (McGrath 2001, p. 48). The inevitable result of this would be to offer a very provisional and superficial theological project; thus, in what follows, we will try to avoid such a risk.

2.2. Scientific Change, Forms of Rationality, and Intelligibility

The idea of being able to arrange the world within an orderly system of propositions is very old, as is the idea of coordinating this system of propositions with experiments and demonstrations. Mathematics and physics are the most sophisticated versions of this ideal, which has moved from a philosophical backdrop to a technical and formal one after the rise of modern science. Nowadays, the plurality of scientific explanations and the coexistence of various kinds of knowledge make it difficult to speak of science in terms of those ideal compact systems. Does this mean that science has lost its rationality? As said before, that is, of course, not the case. Multiple models of theory development have been proposed around the central problem of determining what remains and what changes during the succession of the scientific theories. Scientific rationality has changed its shape throughout the ages, and styles of reasoning have changed (Hacking 1992). However, at least the success in explaining and modifying the natural in pursuit of practical ends is a reliable indicator that not "anything goes" (Feyerabend [1975] 1993; Nickles 2017). Something must go well so as to avoid every good explanation becoming a miracle, according to the so-called "no miracle argument" (Putnam 1981). Without dwelling on sophisticated epistemological implications, the aspiration to scientific endeavor depends not only on knowledge itself but also on facilitating human life. In other words, the expected goal of science is to have an adequate way of describing the world for living in it, independently of the ethical aspects of the matter. Thus, truth comes to terms with certainty, and the degree of certainty that a scientific theory can provide depends on the foundations on which that theory is built and on the success of empirical applications. Lastly, both of these aspects change over time.

The history of science demonstrates that every conception of science has changed over time. Age by age, something true would be discovered by scientists and later abandoned on account of being too partial (or even "false", Laudan 1981). At the same time, something has been maintained because it has a supra-historical value (Marcacci 2015). Criteria for congruence of triangles, integral calculus, concepts such as species or epigenetics, and ideas such as atom and power or measure and measurement are only a few examples of the issues and tools that have been taken up, developed, and interpreted in various ways at many historical junctures. Other narratives and theories had long been held to be valid, and when the set of axioms on which they had been based fell apart, those narratives and theories were reinterpreted and retained their validity, albeit with the new interpretation, as was the case, for instance, with the non-Euclidean geometries. The supra-historical value of such ideas is not divine but totally human.

Gila Sher (2017) has recently spoken about "dynamic correspondence" within ideas and about their efficacy in the world. She considers truth to be "the sense of requiring a substantial and systematic connection between would-be units of knowledge and their targets in the world" (Sher 2017, p. 381). This "broad" sense of correspondence between human cognitive acquisition and the world (or, more specifically, natural phenomena as objects of science) is affected by historical practices, constituted by cultural frameworks and instrumental prowess. Nevertheless, "the precise form (pattern) correspondence takes depends on, and changes with, the complexity of the target facets of the world, their accessibility to human cognition, and our resourcefulness in forging cognitive routes to them" (Sher 2017, p. 381). According to Sher, dynamic correspondence is demanding because it must take into consideration variations from culture to culture, from person to person, and from norms of truth to norms of truth. It is also flexible, because the pattern of correspondence between knowledge and the world is not decided in advance. However, it is not a form of relativism, because objective facts which are external to us are not denied. Of course, the pattern of correspondence varies from field to field, being simpler in some and more complex in others. The dynamic theory of truth focuses on the world. The first and fundamental question which a dynamic correspondence theorist answers is "what facets of the world does a scientific theory seek to study?" The issues of how language allows some inquiry to be formulated or how abstract objects are to be addressed become secondary considerations in the analysis. Sher uses mathematical truth as an example:

neither in a Platonist nor in a radically empiricist view but in a dynamic approach, what is needed is the understanding of the correspondence relation between abstract entities and the world as it in fact is. Thus, mathematical theories such as arithmetic or set theory can be correct or incorrect about the formal features of objects and about the laws by which we describe those objects. Where (in what *world* and with what kind of cognitive access) abstract entities are and whether only individuals exist are questions which lie outside the scope of interest of a dynamic correspondence theorist.

Sher defines her proposal as an Aristotelian approach (2017, p. 383). Indeed, this approach evokes Aristotle and his rejection of Plato's account of nature. Roughly speaking, what Aristotle tended to explain as *physis*, Plato tended to explain as *psyche*. Also, with regard to mathematical entities, Aristotle promoted relating objects to their principles before relating them to an ultimate ground of intelligibility; he claimed that the world had both an intelligible order and a physical order, whereas categories had an ontological level and an epistemological level of meaning. Beyond the complexity of Aristotelian philosophy, one can say that Aristotle—and the ancient thinkers in general—were comfortable with the idea that "there was something about the world which rendered it capable of being understood" (McGrath 2001, p. 92). The correspondence between *rei et intellectus* took the expression of *adequatio* in the work of Thomas Aquinas. The *ens* and the intellect mutually adjust each other, and knowledge is the consequence of that "adjustment". The notion of truth is based on the essence of the *ens* being known, not on some form of consciousness as the fundamental ground of knowledge (Basti 2011). The source of the *adequatio* is reality, but the way to understand reality can be modified and amplified. Thus, every demonstration proceeds from first principles and axioms, and first principles and axioms are drawn from reality by an inference called induction (or, more precisely, syllogism by epagoge, Aristotle 1976, Post. An. II, c. 23). To acquire a first principle, a number of references to reality are needed. It has been debated for a long time whether this procedure of Aristotle was fallacious because it was based on an infinite enumeration. Thomas Aquinas, who was one of the best interpreters of Aristotle with regard to the idea of induction (Aquinas 1964, In Post. An. I, xxvii, 317), read the Aristotelian induction as if it meant no infinite enumeration, that is, as a procedure where it was enough to count a sufficient number of useful cases to consider an axiom's content valid. This content, however, remains open, and new cases may force a new version to be formulated. In other words, those axioms are "opened" depending on the manner of understanding (Marcacci 2008, pp. 215–41). This indefiniteness, or openness, allows for changes in demonstrative systems.

Similarly, scientific change shows many different forms of scientific rationality and theories that have succeeded one another, even though, beyond those forms and theories, some regularities remain. Science has always given sense to the world by dealing with categories and ideas. We refer to this feature of the world, this disposition to be understood, as *intelligibility*, properly a philosophical term that evokes the bond between natural philosophy and science. As Dear (2006) notes, "the natural-philosophical component of science is the one that has, perhaps, the most profound role in shaping our views of ourselves. The universe in which we live, the bodies that we experience as part of ourselves, and the sense we have of our immediate environments are all shaped by our acceptance of the images of reality that we owe to science in its guise as natural philosophy" (p. 11). The intelligible texture of reality persists, and the scientific theories produced by the epistemic capacity of human beings change. If the God of science was the God of causes, what remains of the God of causes today?

Potentially the main contribution of this paper would be to promote the ongoing discussion around a "theology of science" from a Catholic perspective, but before we enter into details, it might be useful to briefly name other approaches, e.g., that of A. McGrath's scientific theology, in order to highlight the distinctive contributions of the former. While some argue that theological engagement with the sciences rests merely upon a free decision or arbitrary preferences, we agree with McGrath, that it is rather "*demanded by the Christian understanding of the nature of reality itself*—an understanding

which is grounded in the doctrine of creation. The Christian doctrine of creation demands a unitary approach to knowledge, while being responsive to diversity" (McGrath 2001, p. 21). Moreover, we find as pertinent three basic claims underlying his realist perspective: (1) ontologically, reality awaits our discovery or response and is independent of the human mind; (2) epistemologically, there can be gained at least some degree of epistemic access to reality, while the manner in which it is apprehended is limited; (3) semantically, this reality may be explained or represented inadequately or provisionally, as approximating to the truth. We think that these basic claims are good points of convergence with his theological project. However, in our proposal, the position set out in this paper may be regarded as an exposition of a theology of science, representing a sympathetic yet critical response to the claim that theology and the sciences share a common commitment to a realist perspective. If so, as we agree, this answer imposes and stimulates further questions:

- What can theology contribute to an understanding of science, given its fragmentation and pluralization?
- What can science contribute to a theological understanding of reality, given that our understanding of reality is theory-laden?
- What role can ideas such as truth and causality play in this?
- What are the advantages of the development of a theology of science as a way of augmenting our understanding of the natural world?

We think that it is not enough to state that theology and the sciences share a common commitment to reality. Philosophical or theological commitment to the world is deeply mediated by scientific worldview. On the one hand, theology should not be constructed on the base of provisional science; on the other hand, the theological commitment to the natural world is scientifically laden. The theology of science is needed in order to address this dilemma.

3. Where Is the Cause? Or, Whether a Theology of Science Is Possible

During the 19th century, the topic of scientific progress was developed by the contemplation of the roots and progress of modern science. Certain facets of this discussion will be used here. For example, the category of causality was useful in explaining the regularities of natural phenomena. At the same time, it was discussed in its metaphysical side to clarify the relationship between the First Cause and second causes. We will focus on the discontinuity with the original understanding of this issue.

For a theologian, there is no doubt that God can cause things to happen, but there has been and still is a great deal of controversy about the precise explanation of God's causal activity in the world. Essentially, the biblical and theological account is straightforward; that is, God is the Creator of the world, and everything depends upon Him. There is, however, a theological disagreement when one begins to ask, for example, whether God is the sole active agent in the universe, whether God delegates various causal powers to the other causes, how God's omnipotence or omniscience can be reconciled with the free or causal action of other causes, or whether there is some room in nature left for His own direct intervention. Although various answers have been offered to the above questions over the centuries, our primary aim is to describe briefly the crucial theological views on causation and mention the recent principal strategies while addressing the problem of divine causation in light of modern science. This background will help us deal with the issue of causality within a theology of science.

3.1. Main Theological Views on Causation

The most important views on divine causation that have emerged in theological thinking can be labeled as conservationism, occasionalism, and concurrentism (Freddoso 1994, pp. 132–34). According to mere conservationism, God contributes to the ordinary course of nature solely by creating and conserving natural active and passive causal powers. Since God's sovereignty is radically diminished under this concept, we can include it in the category of deism, which undermines God's agency in the world. Occasionalism, in turn,

claims that since God alone brings about effects in nature, natural substances make no genuine causal contribution at all. This approach defends God's agency but at a very high cost, that is, by diminishing natural causal agency. The last view, concurrentism, occupies a middle ground between the two approaches. According to it, a natural effect is produced immediately by both God and created beings, so that, contrary to occasionalism, natural agents make a genuine causal contribution to the effect, whereas, contrary to mere conservationism, they only do so if God cooperates with them as an immediate cause in a very general way. Thus, the theory of divine concurrentism (with God as the primary cause and creatures as secondary causes engaged in causal processes) has fostered a middle way for theology between deism and occasionalism. For instance, Thomas Aquinas's theory of divine action may be classified as divine concurrentism since it essentially assumes that natural events are caused by God and creatures, both directly and fully involved (or concurring) in bringing an effect, with proper awareness that divine causation and natural causation are of different metaphysical orders such that there is no question of them "interfering" with each other (*Summa Contra Gentiles*, III, 69).

Since the advent of modern sciences, theologians have tried to develop various approaches while addressing the problem of divine action in light of the scientific method and its demands (e.g., Russell 1988; Bartholomew 2008; Dodds 2012; Tabaczek 2013). On the one hand, approaches have been proposed such as divine interventionism (where God is a "lawbreaker", since He breaks the laws of nature), liberal theology (where divine action is limited to the realm of personal, existential encounter), process theology (where God acts in each event but only as a persuader who invites the world to progress), or divine limitation (where God's omniscience and omnipotence are self-limited by the nature of what He has made). On the other hand, more recently, the notion of divine causation has been investigated in the context of the following scientific theories and their philosophical problems: the realm of emergence (causal influence of an emergent whole on its parts analogical to the causal influence of God on the natural world), quantum indeterminism and probability (the probabilistic character of natural events seen as the room for divine noninterventionist action), and the origins of the universe and of known forms of life, which show a very delicate balance of initial conditions and physical constants for their evolution (opening the way back for divine goal-oriented causation, the so-called "argument from design").

We do not go into the details of the above-mentioned contemporary interpretations of divine action, but for our purposes, we would like to emphasize that all of them raise many questions and doubts. First of all, they are based on certain philosophical interpretations of scientific theories. Such interpretations are often chosen by authors in order to offer an interpretation of natural phenomena which may leave some "metaphysical space" for God's action. This methodological choice seems to be very problematic in some cases since the theological view is not built upon a proper philosophical analysis of ontological and epistemological problems raised within certain theories but rather upon metaphysical issues raised beforehand. Moreover, some of the above concepts of divine action seem to assume a univocal predication of God's action in the world; that is, they place or attempt to place God as an entity acting among other entities. Finally, we agree with Dominique Lambert (1999) that the theology–science dialogue should respect methodological differences between the two and, at the same time, seek mediation at three levels—metaphysical, epistemological, and axiological—rather than just at the metaphysical one, as many of those proposals suggest.

3.2. Causality and Theology of Science

In view of the above, how can theology address the issue of causation in a more scientifically informed manner? First of all, theology must inevitably have recourse to a plurality of disciplines and methods, according to the nature of the object being studied (International Theological Commission 2011, n. 77). In the case of causation, this would mean that science indicates a way of doing research on causality as such that can be as

a stimulus to theological reflection. Science works from very general and well-known theories to develop new hypotheses, and the verification of these new hypotheses allows one to choose the most valid solutions to the problems posed. There are a number of different approaches to causation (e.g., Oleksowicz 2021), and the latter can be analyzed within different scientific theories and explanatory contexts. Theology as such should not neglect this fact from the outset.

The second step is then to reflect upon the above proliferation of causal approaches within the contemporary philosophy of science and particular sciences. This point, we think, is to be scrutinized by a theology of science as such, which seems to be able to take advantage of what many theologians and metaphysicians are prompt to call methodological naturalism (reductionism). The latter assumes—with regard to the method of science—that science explains the world by evoking it (Peters 2017). The theology of science as a theological subdiscipline that we refer to was proposed by Michał Heller (1996) and should be concerned with the very existence of science, the conditions of scientific knowledge, and science as a value (Oleksowicz 2019, 2020; Polak and Rodzeń 2022; Trombik and Polak 2022). As a consequence and as we have said above, the relationship between humans and the world has become mediated by scientific knowledge, with the subject and the scientific communities playing a decisive role, although exposed to doubt and uncertainty. Therefore, science—if we focus on causation—becomes the bearer of a new way of looking at the causal processes in the world. This new way is deeply bound by our theories, models, and scientific concepts.

In this context, a more articulated theological survey of the problem of causality can be made. The interaction between knowledge and the world, between epistemology and ontology (which is not about what actually exists but about what is assumed according to certain theories or models), is something typical of the contemporary philosophy of science. If, for example, the causal process is the explanandum, the explanation is built on the domain of conceptual (philosophical) issues and on that of theory-laden empirical data. The proper task for a theologian of science is neither to explain causality as such nor to introduce divine intervention into physical and biological processes among entities and activities. Nevertheless, the existence of an intelligible causality in the world in itself needs an explanation (which does not have to be restricted to chains of natural causes). The intelligibility of causality in the world is not the result of scientists' efforts but a condition offered to them to enable them to discover how the causal machina mundi is working.

At this point, we would like to formulate a brief inquiry into causation that a theologian of science might undertake. As we have emphasized, God is the Creator of the entire universe in its fullness, and not just of some of its aspects. The exponential growth of scientific knowledge about causal processes does not invalidate the search for a theological understanding of the universe as such. On the contrary, theology may see in this growth a further need to understand "why" and "how" we may address the question of causality. There are different ways of being a causal pluralist (Campaner and Galavotti 2007; Cartwright 2004; Godfrey-Smith 2009; Hall 2004; Hitchcock 2007). In what follows, we will briefly refer to just two approaches to causation (i.e., the activity-based approach and the difference-making approach) and point out the theoretical aspects that a theology of science may address.

In the case of the activity-based view (Anscombe [1971] 1993), which focuses on interacting entities and causal productive relations, theologians may note that the theoretical language of causal powers or dispositions resembles the Aristotelian metaphysical distinction between act and potency. For instance, the activity-based view was appropriated into the new mechanistic approach to causation proposed by Stuart Glennan (2017). When speaking about the metaphysical structure of the world, Glennan insists that causal mechanisms constitute the causal structure of the world. Basically, he understands "production" as being synonymous with causation, denoting the capacity of mechanisms to act. Causal production is not one thing but many, since there are different kinds of activities. In this approach, we believe that theologians of science may find various inspiring stimuli. First

of all, activity-based mechanistic causation proves to be highly compatible with causal realism, which can be defined according to two basic assumptions, namely that causation is something real and that it involves some sort of necessity with respect to the connection between causes and effects (Chakravartty 2005). This conclusion is not trivial for theologians, who have very often tried to defend the realist view of causation in order to speak about real divine causation. Secondly, for a theologian, God is the first giver of what exists, and it is from Him, as from the first act, that every act proceeds, both of being and of operating (Aquinas 1967, *S. Th.*, I, q. 4, a. 2; Aquinas 1953, *De Potentia*, q. 7, a. 2). Thus, the activity means that the act is assumed as the foundation of causality. Finally, Glennan's approach clearly evidences that the complexity of causal phenomena is something that makes good causal explanations very elusive (Glennan 1996, 2005). In other words, although the realism of causal activities can be assumed with confidence, it is not a straightforward task to explain causal activities in the case of complex systems.

In the case of the difference-making view (Woodward 2003), its main premise is that causes make a difference (e.g., if *c* had not happened, then *e* would not have happened). We analyze cause–effect relations by focusing on the manipulability of causal conditions. Briefly put, causal relationships are potentially exploitable for purposes of manipulation and control. Theologians may note here the theoretical parallelism between this view and the conundrum of how to reconcile human freedom with God's action. For instance, one of the attempts to preserve divine providence and foreknowledge, a theory known as "God's middle knowledge", was based on the assumption that God knows, prior to his own free decrees, how any possible rational agent would freely act in any possible situation. This means that God possesses the knowledge of all counterfactual propositions, including counterfactuals of freedom (conditional future contingents). In fact, the manipulationist or difference-making approaches to causation are based on the knowledge of the counterfactuals, that is, of the possible states of affairs. This causal knowledge, in contrast to metaphysical debates on possible worlds or divine foreknowledge, does not imply knowledge of what will actually happen. Different manipulative techniques and formal frameworks of counterfactuals are properly devised in order to understand the organization of complex causal systems and their possible states: i.e., what depends on what under changing conditions. Our causal reasoning is often based on both "evidence of difference-making" (associations, correlations, counterfactual dependencies) and "evidence of underlying causal relations". In this context, the functional dependence of variables (i.e., what would happen if one were to intervene and fix the value of a variable to the antecedent of the counterfactual) is a tool employed in order to determine which causal facts are truth-makers for causal claims. Hence, we are dealing with an epistemological interpretation of counterfactual claims which is, nevertheless, intertwined with an ontological commitment about what actually makes something into the cause of an effect. In other words, causal descriptions and counterfactuals are often two faces of the same problem, that is, deciphering causal relations. In fact, they work together within certain models or theories because we seek answers to two fundamental questions: "what" questions (concerning what is causally relevant) and "why" questions (concerning how relevant entities perform their productive activities and for what purpose). In light of the above, it may be the case that theological models of God's omniscience and will, framed within the evidence conditions, have often projected our limited way of acquiring causal knowledge about God.

The differences in how we build or choose among causal approaches do not stem from reality alone. They should also be attributed to our explanatory aims, since we are not impartial observers of reality. In fact, we actively provide explanations of intelligible reality. On the one hand, we have a variety of explanatory aims and use diverse epistemic tools, and on the other, we are confronted with the complexity of the phenomena. So far, we have at least indicated a path which—although it certainly needs to be articulated in more detail—may guide the contemplated theology of science to address some important issues regarding causation and, as a next step, offer an up-to-date theological perspective

for looking at the world and science from both a metaphysical and an epistemological point of view. The real challenge, however, is to replace the scientifically outdated reductionistic views of causation still present in theology, which block the path towards theological accounts of nature and science. How this can be done?

The metaphysical dimension of causation means that one is committed to the mind-independent existence of the causal world. Causal realists, on the one hand, do not exclude the possibility that causation has a deep metaphysical nature, although they may argue that there are many signs of it and many ways to identify its presence. On the other hand, if causation is rather treated as a loose condition—as the sort of metaphysical posit providing a very general and idealized account of the causal structure of the world—such a perspective would not rule out the possibility that we can know some causal truths, but it shifts the issue from metaphysics to the epistemology of causation. In fact, a vast quantity of philosophical literature on causation is dedicated to the question of acquiring causal knowledge and offering good causal explanations. Such an approach is not necessarily causal anti-realism tout court, but its thrust may be that "causal truths have a plurality of truth-makers that do not share anything deep in common" (Psillos 2009, p. 149).

The epistemological aspect of causation would reflect the conviction that we can, although usually in a conjectural way, build causal knowledge, identify cases of causation, and, often but not always, discriminate them from cases of non-causation. Our causal knowledge can, to an extent, be adequate (in relation to what the explainer expects from the explanation), accurate (i.e., precise in describing reality), or efficient (in terms of the amount of work needed to obtain a given explanation) in representing the phenomenon. Such knowledge can be traced by means of various relations: productive, regular, difference-making, probability-raising, invariance under intervention, and the like.

These metaphysical and epistemological aspects of causation show that it is not a literal interpretation of scientific or philosophical claims about the world that is in agreement with reality. Although the source of the *adequatio* is reality, the way to understand causality can be modified and amplified. It is then not the literal interpretation of theoretical claims about the causal world but the interaction of epistemological and metaphysical perspectives that acts as a vehicle for developing satisfactory causal explanations. The focus on the pluralism shift and epistemological aspects of causal knowledge does not exclude the role of a metaphysical analysis but reflects the variety of points of view on the causality itself. The interaction of different causal accounts does not have to do with some provisional feature of our construction of causal knowledge that is to be overcome by capturing a deep, single theory or metaphysics of causation. It seems that an explicit endorsement of the multiplicity of epistemological and metaphysical approaches to causation offers an added value. Such a pluralism, instead of committing us to the progressively pursued integration towards some sort of most comprehensive understanding or single correct metaphysical theory of causation, leaves the space to think that the value of causal concepts and theories is determined not only by whether they are true and provide genuine explanations but also by the extent to which they are useful and understandable for us. There is, however, a concept of intelligibility that, if undertaken by the theology of science, may grasp both the metaphysical and epistemological aspects of causation.

4. Science, Intelligibility, Humility

According to Dear (2006, p. 173), "the hallmark of natural philosophy is its stress on intelligibility: it takes natural phenomena and tries to account for them in ways that not only hold together logically, but also rest on ideas and assumptions that seem right, that make sense; ideas that seem natural". What Dear says in reference to natural philosophy is also applicable to science. He shows how the transition from natural philosophy to science showed continuity in the ambition to grasp intelligible content, albeit with different goals and methods. Faced with non-naive historical restitutions of the achievements and developments of science along this line of continuity, a theology of science must both

provide for examining theoretical issues and identify existential attitudes that give vitality to the practice of research.

Sher (2017) notes that "the tale of scientific change is both hopeful and cautionary. It cautions us against the existence of undiscovered errors, and it gives us hope of discovering and correcting these errors, as well as of expanding our knowledge to hitherto unknown regions of the world" (p. 392). We can paraphrase by saying that the tale of scientific rationality is made cautious by the history of science. If it is quite difficult to understand the difference between rationality and intelligibility from a speculative point of view, science can help somehow in the consideration of the passage from the medieval to the modern context for the philosophy of nature. According to Bonaventure, the world is given as a certain image of the Eternal Wisdom, and from the sign to the thing signified. Humans are guided through sensible objects to the intelligible world. The metaphor of the book of nature that refers back to God the Creator is crucial here. As Harrison (2015, p. 60) recognized, "for the early Middle Ages the intelligibility of nature lay primarily in its moral and theological meanings, rather than in sets of causal relations". The bond between the material and the spiritual world can be found in the Aristotelian postulate, according to which nothing in the intellect is not first in the senses. Humans have evident symbolic capacities, and they provide a way "to understanding God as the causal source of their being, since to some degree effects resemble their causes. This is a presupposition of Aquinas's famous 'analogy of being'" (Harrison 2015, p. 68). Thus, a long process of abstraction underlies the transition from sensitive experience to knowledge. Modern philosophers of nature particularly insisted on understanding causal relationships in nature as fundamental in grasping the repeatable mechanisms underlying natural phenomena experienced by the senses.

Nowadays, thanks to a greater historical awareness about developments in science (see Section 2 in this paper), we know that scientific rationality is "situated" and, therefore, susceptible to change. The comprehension of what "causal mechanisms" meant has been moving along new paths (see Section 3.2). Forms of scientific rationality change, but something intelligible remains. The reciprocal adequacy between human cognitive resources and the world is made manifest in scientific change, which not only makes it possible to understand how science actually works, but also, and above all, reinforces our awareness of the complexity of the human epistemic position. That position is not always fallible; it can sometimes be successful. Over the centuries, human reason has grasped things from nature and given them a scientific form, taking contextual elements and shaping insights. Scientific rationality has evolved; at the same time, something intelligible has remained, and the awareness of our complex and fragile epistemic situation has grown. After all, strength is manifested in weakness, as St. Paul said (2 Cor 12:9).

Considering the above, has theology incorporated and absorbed reflections on scientific change? Has theology formulated its questions in a new way, having learned the lesson from the history of science? Nowadays, when one practices theology, theology must refer to a scientific context. Giuseppe Tanzella-Nitti places theology in the context of scientific rationality (Tanzella-Nitti 2015, pp. 50–60). Contents and categories of scientific knowledge not only provide a context for defining the relationship between faith and reason but also act as assumptions for the development of theology itself. The quests for truth and cause are only two examples of the many aspects of a theology of science.

Human reason is an expression of historical ages, and theology must integrate the ratio temporis and the interpretation of Revelation. Such integration is all the more relevant when one considers the last few decades, especially the turn of the first decade of the twenty-first century. The complexity of the social landscape, the intertwining of culture and science, and the pervasiveness of technology in every sphere of existence invite open-minded thinking in order to interact with continuous change. From *Fides et ratio* (1998) by Pope John Paul II to *Veritatis Gaudium* (2018) by Pope Francis, the call for dialogue, for interdisciplinarity, for knowledge conceived of as a process that enhances each proposal has been constant. There are numerous signs of our time which confirm that the path

of knowledge cannot end and that knowledge itself is collective and invites cooperation, reflecting the humility and tenacity of "the thinking reed" shaken by the winds of time (Marcacci 2019).

Precisely by starting from an ongoing and not too casual interest in the history of science, the theologian Thomas Torrance captured certain aspects closely related to those discussed in this article:

A scientific theory or model of this kind is a sort of lens through which we allow nature in its intrinsic patterns to reveal itself to our apprehension. In the process of refining the lens or the theory, our basic images and concepts undergo radical change; otherwise, they would be opaque and not transparent media. Moreover, in this refining process, as our theories or models advance from level to level in a deeper grasp of reality, we find operating the analogical or cross-level references in which images are made to refer beyond themselves to imageless objective structures by which they themselves are controlled in our knowledge (Torrance 1980, pp. 125–26).

Torrance compared this openness of science to what takes place in theology. After remarking on the value of analogy as a method for theology, he compared the analysis of the understanding accomplished by science in the face of nature and the world with the analysis of the revealed knowledge with which theology is confronted. The result is a methodological structure that is in many ways similar. As he argued, "true theological knowledge and statement are in this respect not dissimilar to scientific knowledge and statement. Although they are grounded in the intelligibility of God through his self-revelation and are not arbitrary inventions on our part, they have to do with God in his unlimited reality and are therefore also correlated to open possibilities—but as such they cannot be theoretic constructs logically deduced by us" (Torrance 1980, p. 137).

According to Torrance, the Christian doctrine of creation cannot yield to a "created intelligibility": the human mind can (and perhaps *must*) discern the best way to understand and manipulate reality in order to improve the human condition. Hence, humility is seen as a virtue proper to a scientific approach to inquiry about the world: "There is no doubt that what must predominate is a spirit of respectful humility before the astonishing intelligibility of nature and a childlike readiness to open our understanding to whatever nature may reveal of itself" (Torrance 1980, p. 153).

In fact, the reason for including the issue of humility in science by theologians stems from the abundance of human limitations. Science undoubtedly has developed accurate knowledge of many aspects of the world and fostered very useful applications in many human and social settings (e.g., economy, health, education, nutrition, or climate changes). However, an exaggerated trust in the power of the scientific method applied to all areas of knowledge or even to all other areas of human life is an ideology, often called "scientism". Science has its systemic limits since it cannot discover or address everything. Apart from such limits, one can also point out the epistemic ones, linked with the fact that while our human cognitive capacities are well fitting for many functions (e.g., daily life, providing scientific explanations, formulating philosophical problems), they are less adapted to understanding reality in its entirety. Not only does science not encompass the entirety of the world, but first and foremost, human beings do not (Lumbreras et al. 2023).

Another reason for humility can be considered in the aforementioned pluralism of sciences. The pluralism shift, on the one hand, stems from the underdetermination of the scientific data, which is the theoretical locus classicus of history and philosophy of science; on the other hand, the confidence in the so-called complex sciences and the proliferation of sociological studies about science have demonstrated not only the complexity of reality itself (at the physical, living, mental, or social level), but at the same time the complexity of sciences (many methods and interpretations at all levels of analysis and the abundance of factors which influence the scientific enterprise). The great and irreducible complexity of investigated reality and employed sciences revealed the impossibility of building unique models able to account for that complexity in both cases.

If we look deeper at the personal and interpersonal levels, we may note the presence of intrinsic and extrinsic limitations. The first ones are features of our cognitive character. "These include limitations of our intellectual character (e.g., intellectual laziness), our individual cognitive capacities (e.g., lack of aptitude for quantitative reasoning), our general cognitive capacity as humans (e.g., our inability to know the future), or our evidence base for particular beliefs (e.g., lack of conclusive evidence)" (Baehr 2022, p. 77). These limitations are to be found not only in the lack of rational objectivity in individuals, but also at the interpersonal level in groups. We are not only intrinsically limited, but also extrinsically limited as a function of factors outside of a person's cognitive ability, which include limitations such as a person's dependence on members of their epistemic community or their ignorance relative to another person's cognitive ability. Although the issue of the so-called cognitive biases (e.g., following the opinion of the majority, confirmation bias, selective bias, authority bias, overconfidence bias) has been well studied for many decades, these biases influence and dampen scientific practice. We continuously and unconsciously deviate from the ideals of rationality both at the personal and social levels. However, accepting the reality of our epistemic limitations, at the individual or group level, is not easy. It requires humility.

5. Conclusions

When a scientist is a believer, he or she needs to integrate his or her commitment to scientific research with his or her faith. Every theological concept accepted by a religious sensitivity will often have implications or consequences that may or may not resonate with one's way of understanding the world. The combination of epistemological and ontological aspects recognized in the philosophy of science in the second half of the twentieth century shows that rationality is always expressed contextually. The idea of scientific change challenged the conception that science could work out absolute certainties. The ensuing broad debate, hinted at in Section 2, destroyed the ambition of scientific rationality, concluding in radical forms of skepticism and relativism. However, skepticism and relativism are not the only possible outcomes. The defense of scientific rationality can, in fact, take place on the level of understanding the assumptions of any scientific theory. On the one hand, these presuppositions concern empirical achievements and formal analysis about certain (classes of) phenomena. On the other hand, the socio-political, philosophical, and even theological elements that influence the development of a theory are also important. Although there remains the aspiration for knowledge, the attitude towards this aspiration becomes humbler. The insight is that knowledge is a process always in progress, never concluded, but within reach of human beings.

What remains for a theology of science here? Theologians might not be interested in the specific way in which a causal phenomenon is described, explained, modeled, etc., but in the fact that nature is revealed to some degree as being intelligible. Both scientists and theologians can often acquire the ideas of truth and causality without philosophical training and, as a consequence, connect science and faith in a naive way. For this very reason, we insist on the urgency of a theology of science. Such a theology would be capable of directly engaging with the dominant forms of rationality present in contemporary culture, especially as they are embedded in scientific inquiry. Clearly, in the current panorama, a special place is held by the pluralism of sciences and scientific methods, expressing the contextuality of scientific rationality. Referring to the *pluralism shift*, one may intuit that the theology of science would be at odds with monism (favoring only one all-encompassing view on scientific explanation), moderate/temporary pluralism (promoting a temporary plurality of competing theories and the unity of science in the long run), isolationist pluralism (either excluding the interaction between scientific disciplines or presupposing some sort of explanatory closure), and anything-goes pluralism (holding that inconsistent theories that emerge from the scientific endeavor are to be equally acceptable). The theology of science would neither be guided by the integrative imperative nor discourage fruitful interaction between various approaches at hand. A theology of science would make an

effort to consider the place of theology in a culture strongly impregnated by the scientific mentality and would be responsible for explicitly proposing the issues to be addressed by, and forms of interaction with, other sciences. It would accomplish these tasks in a twofold way: by examining the current output of sciences and philosophy of science and by raising important epistemological questions regarding the formulation of theological knowledge (worldview).

It seems that a theology of science may have a lot to offer in the current discussions as part of the science–religion debate. The idea is based on an understanding of Christian Revelation perceived not only as a set of a priori answers but also as a principle of or key to the rediscovery of the intelligible world and the rationality of science. It is about providing a cognitive act within which theology is not an opponent of rationality but its most faithful ally. By attempting to provide such an integrated view of the often separated ontological or epistemological issues, a theology of science can fulfill its own mission to enable others to actively participate in the contemplation of the intelligible world and in the humble service of one to another.

The intelligible plot of the world persists beyond the shifting and changing scientific theories. It is a subtle plot that can be intercepted through the efforts of individual personalities and entire scientific communities, a subtle plot that is never revealed definitively but always moves new ideas and raises new issues. Human beings often feel insignificant in the face of this feat of understanding, but at the same time, they often overcome the challenges that nature poses to their knowledge. The intelligible texture of things seems to make the world appear as capable of being understood. However, scientists or philosophers will never be able to say this is so. A theologian of science could approach that question and justify a possible answer: the world's intelligibility is a gift given by the Creator to humanity.

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References

Anscombe, G. Elizabeth M. 1993. Causality and Determination. In *Causation*. Edited by Ernest Sosa and Michael Tooley. Oxford: Oxford University Press, pp. 88–104. First published 1971.

Aquinas, Thomas. 1953. De Potentia. In *Quaestiones Disputatae*. Edited by P. Bazzi, M. Calcaterra, T. S. Centi, E. Odetto and P. M. Pession. Turin: Marietti.

Aquinas, Thomas. 1964. In Aristotelis Libros Posteriorum Analyticorum Expositio. In *Aristotelis Libros Perì Hermeneias et Posteriorum Analyticorum Expositio*. Edited by Raimondo M. Spiazzi. Turin: Marietti.

Aquinas, Thomas. 1967. *Summa Contra Gentiles*. Edited by Ceslao Pera, Pietro Marc and Pietro Caramello. Turin: Marietti.

Aristotle. 1976. *Aristotle's Posterior Analytics*. Translated by Jonathan Barnes. Oxford: Clarendon Press.

Baehr, Jason. 2022. Limitations-Owning and the Interpersonal Dimensions of Intellectual Humility. *Scientia et Fides* 10: 69–82. [CrossRef]

Bartholomew, David J. 2008. *God, Chance and Purpose: Can God Have It Both Ways?* Cambridge: Cambridge University Press.

Basti, Gianfranco. 2011. Ontologia formale: Tommaso d'Aquino ed Edith Stein. In *Edith Stein—Hedwig Conrad-Martius—Gerda Walther. Fenomenologia della persona, della vita e della comunità*. Edited by Angela Ales Bello, Francesco Alfieri and Mobeen Shahid. Bari: Edizioni Giuseppe Laterza, pp. 107–388.

Campaner, Raffaella, and Maria C. Galavotti. 2007. Plurality in Causality. In *Thinking about Causes: From Greek Philosophy to Modern Physics*. Edited by Peter Machamer and Gereon Wolters. Pittsburgh: University of Pittsburgh Press, pp. 178–99.

Cartwright, Nancy. 2004. Causation: One Word, Many Things. *Philosophy of Science* 71: 805–19. [CrossRef]

Chakravartty, Anjan. 2005. Causal Realism: Events and Processes. *Erkenntnis* 63: 7–31. [CrossRef]
Chang, Hasok. 2020. Relativism, Perspectivism and Pluralism. In *The Routledge Handbook of Philosophy of Relativism*. Edited by Martin Kusch. London and New York: Routledge.
Dear, Peter. 2006. *The Intelligibility of Nature: How Science Makes Sense of the World*. Chicago and London: University of Chicago Press.
Dodds, Michael J. 2012. *Unlocking Divine Action: Contemporary Science and Thomas Aquinas*. Washington, DC: Catholic University of America Press.
Feyerabend, Paul. 1993. *Against Method: Outline of an Anarchistic Theory of Knowledge*, 3rd ed. London: Verso Books. First published 1975.
Freddoso, Alfred. 1994. God's General Concurrence with Secondary Causes: Pitfalls and Prospects. *American Catholic Philosophical Quarterly* 68: 131–56. [CrossRef]
Funtowicz, Silvio O., and Jerome R. Ravetz. 1993. Science for the post-normal age. *Futures* 25: 739–55. [CrossRef]
Gaukroger, Stephen. 2006. *The Emergence of a Scientific Culture: Science and the Shaping of Modernity 1210–1685*. Oxford: Oxford University Press.
Glennan, Stuart. 1996. Mechanisms and the Nature of Causation. *Erkenntnis* 44: 49–71. [CrossRef]
Glennan, Stuart. 2005. Modeling Mechanisms. *Studies in History and Philosophy of Biological and Biomedical Sciences* 36: 443–64. [CrossRef]
Glennan, Stuart. 2017. *The New Mechanical Philosophy*. Oxford: Oxford University Press.
Godfrey-Smith, Peter. 2009. Causal Pluralism. In *The Oxford Handbook of Causation*. Edited by Helen Beebee, Christopher Hitchcock and Peter Menzies. Oxford: Oxford University Press, pp. 326–37.
Hacking, Ian. 1992. 'Style' for Historians and Philosophers. *Studies in History and Philosophy of Science* 23: 1–20. [CrossRef]
Hahn, Hans, Otto Neurath, and Rudolf Carnap. 1973. The Scientific Conception of the World: The Vienna Circle. In *Empiricism and Sociology*. Edited by Marie Neurath and Robert S. Cohen. Dordrecht: Reidel, pp. 299–318. First published 1929.
Hall, Ned. 2004. Two Concepts of Causation. In *Causation and Counterfactuals*. Edited by John Collins, Ned Hall and Laurie Paul. Cambridge and London: MIT Press, pp. 225–76.
Harrison, Peter. 2015. *The Territories of Science and Religion*. Chicago and London: The University of Chicago Press.
Heller, Michał. 1996. *The New Physics and a New Theology*. Vatican City: Vatican Observatory.
Hitchcock, Christopher. 2007. How to Be a Causal Pluralist. In *Thinking about Causes: From Greek Philosophy to Modern Physics*. Edited by Peter Machamer and Gereon Wolters. Pittsburgh: University of Pittsburgh Press, pp. 200–21.
Huxley, Julian. 1942. *Evolution: The Modern Synthesis*. London: George Allen & Unwin.
International Theological Commission. 2011. Theology Today: Perspectives, Principles and Criteria. Vatican Website. Available online: https://www.vatican.va/roman_curia/congregations/cfaith/cti_documents/rc_cti_doc_20111129_teologia-oggi_en.html (accessed on 31 March 2023).
Kellert, Stephen H., Helen E. Longino, and C. Kenneth Wathers, eds. 2006. *Scientific Pluralism. Minnesota Studies in the Philosophy of Science*. Minneapolis and London: University of Minnesota Press, vol. XIX.
Kuhn, Thomas S. 1957. *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*. Harvard: Harvard University Press.
Kuhn, Thomas S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.
Kusch, Martin. 2021. *Relativism in the Philosophy of Science*. Cambridge: Cambridge University Press.
Lambert, Dominique. 1999. *Sciences et théologie. Les figures d'un dialogue*. Namur: Presses Universitaires de Namur, Éditions Lessius.
Laudan, Larry. 1981. A Confutation of Convergent Realism. *Philosophy of Science* 48: 19–49. [CrossRef]
Lumbreras, Sara, Laura Gismera, and Lluis Oviedo. 2023. How a Humbler Science Becomes a Better Science. *Religions* 14: 64. [CrossRef]
Marcacci, Flavia. 2008. *Alle origini dell'assiomatica: Gli Eleati, Aristotele, Euclide*. Roma: Aracne.
Marcacci, Flavia. 2015. History, Science and Ontology. In *Science Between Truth and Ethical Responsibility: Evandro Agazzi in the Contemporary Scientific and Philosophical Debate*. Edited by Mario Alai, Marco Buzzoni and Gino Tarozzi. Dordrecht: Springer, pp. 231–41.
Marcacci, Flavia. 2019. Gaudium aude! *Fides et Ratio* venti anni dopo come metodo per la ricerca nelle università. *Lateranum* 85: 171–87.
Marcacci, Flavia. 2018. *Cieli in contraddizione: Giovanni Battista Riccioli e il terzo sistema del mondo*. Perugia and Modena: Aguaplano-Accademia Nazionale di Scienze Lettere e Arti.
Marcacci, Flavia, and Michał Oleksowicz. 2022. Scientia Petita, Theologia Manifesta: Scientific Rationality and Theological Proposals in the Pandemic. *European Journal of Science and Theology* 18: 133–47.
McGrath, Alister E. 2001. *A Scientific Theology. Vol. 1: Nature*. Grand Rapids: Eerdmans Publishing Company.
Mitchell, Sandra D. 2003. *Biological Complexity and Integrative Pluralism*. Cambridge: Cambridge University Press.
Nickles, Thomas. 2017. Historicist Theories of Scientific Rationality. In *Stanford Encyclopedia of Philosophy*. Edited by Edward N. Zalta. Stanford: Stanford University. Available online: https://plato.stanford.edu/entries/rationality-historicist/ (accessed on 31 March 2023).
Oleksowicz, Michał. 2019. Teologia della scienza. Lo *status quaestionis* e possibili sviluppi ulteriori. *Aisthema* 4: 203–27.
Oleksowicz, Michał. 2020. Do we need a theology of science? *Cauriensia* 15: 755–70. [CrossRef]
Oleksowicz, Michał. 2021. New Mechanism and Causality: The Case of Interactive Causal Pluralism. *Revista Portuguesa de Filosofia* 77: 1175–208. [CrossRef]
Peters, Ted. 2017. Naturalisms: Scientific? Religious? Theological? *Theology and Science* 15: 302–20. [CrossRef]

Polak, Paweł, and Jacek Rodzeń. 2022. The Theory of Relativity and Theology: The Neo-Thomist Science–Theology Separation vs. Michael Heller's Path to Dialogue. *Theology and Science* 21: 157–74. [CrossRef]
Psillos, Stathis. 2009. Causal Pluralism. In *Worldviews, Science, and Us: Studies of Analytical Metaphysics: A Selection of Topics from a Methodological Perspective*. Edited by Robrecht Vanderbeeken and Bart D'Hooghe. Singapore: World Scientific, pp. 131–51.
Putnam, Hilary. 1981. *Reason, Truth and History*. Cambridge: Cambridge University Press.
Ruphy, Stéphanie. 2017. *Scientific Pluralism Reconsidered: A New Approach to the (Dis)Unity of Science*. Pittsburgh: University of Pittsburgh Press.
Russell, Robert John. 1988. Quantum Physics in Philosophical and Theological Perspective. In *Physics, Philosophy, and Theology: A Common Quest for Understanding*. Edited by Robert J. Russell, William R. Stoeger and George V. Coyne. Vatican City: Vatican Observatory, pp. 343–74.
Shea, William R., ed. 1988. *Revolutions in Science: Their Meaning and Relevance*. Canton: Science History Publications.
Sher, Gila. 2017. Truth and Scientific Change. *Journal for General Philosophy of Science* 48: 371–94. [CrossRef]
Snow, Nancy. 2022. The Value of Open-Mindedness and Intellectual Humility for Interdisciplinary Research. *Scientia et Fides* 10: 51–67. [CrossRef]
Tabaczek, Mariusz. 2013. The Metaphysics of Downward Causation: Rediscovering the Formal Cause. *Zygon* 48: 380–404. [CrossRef]
Tanzella-Nitti, Giuseppe. 2015. *Teologia della credibilità in contesto scientifico. Vol. II: La credibilità del cristianesimo*. Rome: Città Nuova.
Tauber, Alfred I. 2022. Rethinking Science. In *The Triumph of Uncertainty: Science and Self in the Postmodern Age*. Budapest, Vienna and New York: Central European University Press, pp. 163–92. [CrossRef]
Torrance, Thomas F. 1980. *The Ground and Grammar of Theology*. Belfast: Christian Journals.
Trombik, Kamil, and Paweł Polak. 2022. Teologia nauki—Propozycja nowego otwarcia teologii na nauki. *Człowiek i Społeczeństwo* 54: 49–64. [CrossRef]
Van Bouwel, Jeroen. 2014. Pluralists About Pluralism? Different Versions of Explanatory Pluralism in Psychiatry. In *New Directions in the Philosophy of Science*. Edited by Maria C. Galavotti, Dennis Dieks, Wenceslao J. Gonzalez, Stephan Hartmann, Thomas Uebel and Marcel Weber. Cham and Heidelberg: Springer, pp. 105–19.
Westfall, Richard S. 1971. *The Construction of Modern Science*. New York: John Wiley and Sons.
Westman, Robert. 2011. *The Copernican Question: Prognostication, Skepticism, and Celestial Order*. Berkeley: University California Press.
Woodward, James. 2003. *Making Things Happen: A Theory of Causal Explanation*. Oxford: Oxford University Press.
Wray, K. Brad. 2021. *Interpreting Kuhn: Critical Essays*. Cambridge: Cambridge University Press.