Analogies and Models in Science and Theology

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A Study of Mary Hesse

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PREFACE

Pluralism of religious and moral beliefs is a fact in our modern-day world. The majority consider them as having more or less value to social progress and wellbeing. But to the question of the rational justification of such beliefs, there is no consensus on whether or not any of such belief systems qualifies as true. However, this is not obtained through scientific beliefs. The perceived view of science from the seventeenth century to the first-half of the twentieth century, in the English speaking philosophical tradition, is that there is a radical difference between science and religion. Science was canonized as the reliable route to the search for knowledge and truth, since its linguistic tools are atomistic, naked, literal and empirical. Religion, on the contrary, is heavily ladened with metaphors which is undeniably a vehicle of subjective world model and as such is incapable of attaining knowledge status. The scientific *credo* – that scientific method is the only reliable method in the search for truth, its statements are isomorphic with the ways things *really* are – has been made credible by the success of natural science. The onus is on those who argue that such a conclusion is *non sequitur* to demonstrate how else to speak of the *real* if not by the almighty scientific method. Thus, scientific naturalism has turned to scientific imperialism. This is a very big challenge to those who believe in reality beyond the natural and the scientific; to those who are passionate about commending religion to a world deeply immersed in scientific worldviews. Mary Brenda Hesse (1924- 2016) belongs to this class – those who presume that reality is beyond the natural world of science. She came into the scene with her notion of Models, Analogies and Metaphors as instruments not only in use in theological discussions but at the heart of scientific enterprise itself. This unexpected attention is due to the backlashes against scientific presuppositions about knowledge and truth. First, it was found out that the scientific appeal to correspondence theory of truth is no longer tenable and science has to recourse to weaving up metaphoric world-models. More so, the excitement about the 'progressive' movement of science to cumulative truth has been revealed to be success in prediction, and has nothing to do with the deep structure of reality. Finally, after subjecting the pretensions of scientific realism to damaging criticisms, the deep epistemological difficulty about making inference from observation to theories was revealed. It was shown that scientific inferences are logically inconclusive because of the theory of 'underdetermination' proposed by Quine and Duhem. All this shows that there is more to knowledge and truth than the progressive discovery of new facts using scientific methods. Thus, Hesse proposes her Network Model of theory otherwise known as Hesse-net as the more comprehensive approach to the search for knowledge and truth. The implication of this theory ranges from cognitive significance of theological values to the truth validity of belief systems which entail complimentary interaction of correspondence, coherence and consensus notions of truth. This book is a scholarly evaluation of the claims of Hesse-net. It originated in my doctoral dissertation which was presented to the Philosophy faculty of Gregorian University, Rome. As such, a debt is due to my first moderator, Prof Louis Caruana, who read and commented upon the chapters of the book. He fed me with valuable ideas and resources that helped me to rethink and clarify my thoughts. Thanks is also due to my second moderator, Prof. Johanes Stoffers, who read through the chapters offering corrections and endorsing it. I am thankful to my bishop, Most Rev. C.V.C. Onaga for his generous support and encouragement. I am also appreciative of the assistance rendered to me by my friends and colleagues in Rome, Germany and U.S.A. If I started to tick off your names, the list will be endless. I think it is sufficient to say that you know who you are and I am grateful. A final note of thanks is in order to Adam Rummens and the formidable team at Cambridge Scholars Publishing for being generous with their time and expertise without which this book would probably remain in the *Limbo* of unpublished books. This book does neither claim to be the final word on Mary Hesse nor on the values of models and analogies in science and theology. All I did was to scratch the surface hoping that interested scholars will be invigorated and inspired to investigate deeper on Hesse-net and science and theology.

INTRODUCTION

In the first chapter of his *Categories*, Aristotle distinguishes three different kinds of relationships between names, concepts and things[1]. He uses 'homonyms'(latin: aequivoca) to refer to things with common names but different concepts (ratio) of the essence corresponding to that name (think of the term 'bank', which can be for money bank and river bank); he uses 'synonyms' (latin: univoca) to refer to things that have both the name and concept corresponding to that name in common (think of the term 'animal' used for both man and donkey) and 'denominatives' to refer to things that derive theirs from some others but differ from it in termination (think of 'grammarian' deriving its name from grammar). This remained acceptable until the period of the schoolmen, who did not find the division sufficient enough for the debate on being and relations. Thus, this tripartite division by Aristotle was replaced by the thirteenth century thinkers with another triadic scheme[2]. They replaced the third type, 'denominatives', with the medieval invention of 'analogy' while retaining univocity and equivocity. Predication in analogical fashion is said of many things neither according to wholly diverse meanings nor according to one and the same *ratio* but according to an order of priority and posterity. This invention was in response to problems in three areas which Jennifer Ashworth summarized thus:

> Medieval theories of analogy were a response to problems in three areas: logic, theology, and metaphysics. Logicians were concerned with the use of words having more than one sense, whether completely different, or related in some way. Theologians were concerned with language about God. How can we speak about a transcendent, totally simple spiritual being without altering the sense of the words we use? Metaphysicians were concerned with talk about reality. How can we say that both substances (e.g., Socrates) and accidents (e.g., the beardedness of Socrates) exist when one is dependent on the other; how can we say that both God and creatures exist, when one is created by the other? Medieval thinkers reacted to these three problems by

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[1] ARISTOTLE, *Categories*, c1,1a 1-15. Boethius Latin translation Aristoteles Latinos Vol.1/1-5, *Categoria vel Praedicamenta,* ed. L. Minio Paluello.Bru, Paris, 1961, 5; See also J. AERSTEN, *Medieval philosophy as transcendental thoughts*, Boston, 2012, 9.

[2] Ibid.

> developing a theory which divided words into three sorts, independently of context[3].

Thus, the term analogy became a term used to refer to the relation of being. Metaphor at this time was simply understood as the transference of characteristics of an object to another object, different but analogous to it. There is no extant text of this time on 'model' as a subject of philosophic discourse. In all, the medieval thinkers invented the use of the word 'analogy' as well as established the link between metaphor and analogy but they did not make clear if natural science and theology could appeal to analogical relationship to produce probabilistic rather than demonstrative arguments[4]. Hence, Sergio Cremeschi[5] noted that the medieval doctrines of *Analogia Entis* have been a kind of prologue in heaven to contemporary philosophy of science. This is to say that a quick view of the medieval thoughts on analogy with its emphasis on transcendental realities, that is God, would be a good point of departure in discussions about models, metaphors and analogies.

A purely academic discussion on the nature and functions of models, analogies and metaphors in science could be traced back to the study worked out by Logical Empiricism in the nineteen fifties. By the first decade of the twentieth century, the discussion was not only on analogy but had extended to models. Mary B. Hesse articulates the central concern of the time thus:

> If a scientific theory is to give an 'explanation' of experimental data, is it necessary for the theory to be understood in terms of some model or some analogy with events or objects already familiar? Does 'explanation' imply an account of the new and unfamiliar in terms of the familiar and intelligible, or does it involve only a correlation of data according to some other criteria, such as mathematical economy or elegance? [6]

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[3] J.E. ASHWORTH, «Medieval theories of analogy», *The Stanford Encyclopedia of Philosophy* (Fall 2017 Edition), Zalta, E. N. ed., URL = <https://plato.stanford.edu/archives/fall2017/entries/analogy-medieval/>. Accessed 14/11/2019, 17.39.; F. J. WIPPEL, *The Metaphysical thought of Thomas Aquinas: From finite being to uncreated being*, Washington, 2000.: See also J. AERSTEN, *Medieval philosophy as transcendental thoughts*, Boston, 2012,

[4] Ibid.

[5] S. CREMASCHI, «Models and Metaphors» Accessed in www.Academia.edu on 10/11/2019 8.30. Translation of S. CREMASCHI, «Metafore, modelli, linguaggio scientifico: il dibattito postempirista», in V. Melchiorre ed., *Simbolo e conoscenza*, Milano 1988. 31-102.

[6] M. B. HESSE, *Models and Analogies in Science*, Notre Dame 1966, 1.

Pierre Duhem[7] in 1914 made a contrast of two kinds of scientific minds in which he saw the contrast between the continental and English temperaments in relation to the importance placed on models. The fact is that Duhem admits that models may be, although rarely, useful psychological aids for proposing theories but he objects to their use because they are incoherent and superficial and have the tendency to distract the mind from logical search for order. Duhem's view was challenged by Norman Campbell[8], whose view is that models are not mere aids to theory construction and, they do not lose their relevance once the theory has been developed. Here, Campbell acknowledges the essential role of models and analogies to scientific theories.

However, it was precisely the position of Duhem that gave rise to the rigorously formalistic program of the logical empiricism. The logical empiricists were worried about the excessive disorder in the scientists' use of the word 'model' hence the need for the discipline. They came up with their correspondence theory of meaning. This is used to describe the similarity that should exist between a thing and its model. The technical term for it is isomorphism. Primarily, this has to do with one-to-one correspondence between the elements of the model and the elements of the thing of which it is a model[9]. Its effect, which was anything but bracing on metaphysics, theology and ethics, could be summarized thus,

> … a revolutionary force in philosophy, for it stigmatized metaphysical, theological and ethical pronouncements as devoid of cognitive meaning and advocated a radical reconstruction of philosophical thinking which should give pride of place to the methods of physical science and mathematical logic[10].

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[7] P. DUHEM, *The Aim and Structure of Physical Theory*, Princeton 1954. cited in M.B. HESSE, *Models and analogies in science*, ibid.
[8] N.R. CAMPBELL, *Physics, the Elements*, Cambridge, 1920, Chapter VI. (Now in Dover edition entitled Foundations of Science).
[9] M. BRODBECK, «Models, Meanings and Theories» in L. Gross (ed.) *Symposium on Sociological Theory, Evanston* (Ill): Harper & Row, 1959, 580; see also C. G. Hempel, *Aspects of Scientific Explanation*, New York 1970, 439.
[10] P. ACHINSTEIN, S. BAKER eds. *The Legacy of Logical Positivism*. Studies in the Philosophy of Science, Baltimore, 1969.

This position was not immune to reaction and criticisms. Among many reactions were observations made by Karl Popper[11], Max Black[12], Willard Van Orman Quine[13], Thomas S. Kuhn Kuhn[14] and Paul K. Feyerabend[15]. They tried to show from different perspectives that whatever would entail knowledge cannot be confined to mere observations but would entail the theoretical as well.

Consequently, there emerged various reactions with regard to scientific models, analogies and metaphors in relation to scientific theories and observation statements. Different approaches were assumed, but it was Dudley Shapere, Peter Achinstein[16], and Mary B. Hesse who made the more significant contributions to the topic under discussion. Hesse (1924-2016) provided a contribution deserving more attention than others. All her publications have been characterized by the topic of models and analogies in the first phase, and by the topic of metaphor and of the extension of meanings of terms in the later phase. She has five books to her name, the fifth of which she co-authored with Michael A. Arbib. She came up with the Network Model of theory (NMT), as a synthesis of the debate on scientific models, analogies and metaphors in relation to what knowledge, truth and meaning entail. The Network Model of theory is used to underline the fact that our descriptions of phenomena do not depend only on their empirically detectable features but also on network of other unverbalized assumptions and pre-acquired knowledge. This network *conditions* the observation statement in a reasonably significant way. The observation statements, on the other hand, *constrain* the network. Thus, the observation statements remain acceptable in as much as they are in coherence with the laws of the network. Both the observation statement and the network can correct each other by way of extension and contraction of meanings. The change in the laws of the network is determined not by *a priori* conditions but by what is considered coherent, comprehensive and convenient to a given community. Thus, it is this Network Model of theory that formed the

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[11] S. GATTEI, *Thomas Kuhn's 'Linguistic turn' and the legacy of Logical empiricism.* England, 2008, 7.
[12] M. BLACK, «Metaphor», *Proceedings of the Aristotelian Society* 55 1954, 273-294, reprinted as ch. 3 of *Models and Metaphors*, New York 1962, 41.
[13] W.V. O. QUINE, «Two dogmas of empiricism» in *From a Logical Point of View*, Cambridge, Mass., 1953, 20.
[14] T.S. KUHN, *The structure of Scientific revolutions*, 2nd ed, Chicago, 1970.
[15] P. K. FEYERABEND, «Problems of empiricism», *University of Pittsburgh Series in Philosophy of Science*, ed. R. G. COLODNY, E. CLIFFS, N.J., 2, 1965, and 4, 1970.
[16] P. ACHINSTEIN, *Concepts of Science*, chs. 7 and 8.

background of our investigation into the role which the notion of model, analogy and metaphor could play in science, society and theological discussions.

The NMT is the synthesis of Hesse's position on the perennial debate on what constitutes knowledge, truth and meaning from the point of view of scientific models, analogies and metaphors. The NMT is used to underline the fact that knowledge, truth and meaning are based not just on what is observed but are also significantly determined by other web or system of connections of informed assumptions and pre-possessed knowledge that are not verbalized. The observable is described in terms that are not only in coherence with the network of laws but are more *entrenched* in a given linguistic community. The change in the network is not determined *a priori* but by what the community considers comprehensive, convenient and coherent. This is to say that whatever would qualify as knowledge, properly so called, would be *constrained* by facts but is not *determined* by facts alone. The determining factors are significantly theoretical which are based on informed background assumptions. These assumptions or hypotheses are based on what the interested community considers acceptable and pragmatic at the time. Thus, this underlines the importance of such sociological factors as politics, economics, religious beliefs and so on, on scientific inferences and by extension knowledge, truth and meaning.

Since the NMT of Hesse underlines the significant role of the sociological factors in determining what we know, one of such important sociological factors is religious beliefs. This means that religious beliefs can have an important role to play in determining what would be accepted as knowledge. In presenting the background of the study, I noted that as a result of the scientific revolution of the seventeenth century, metaphysics, theology and ethics were stigmatized and relegated to the background as meaningless and lacking cognitive value. But the NMT argues otherwise. Therefore, the originality of this book lies in the attempted careful, critical, and evaluative investigation into the question: How does the NMT of Mary Hesse apply to the Christian theological discussions? In trying to argue for the meaningfulness of Christian theological discourse, I seek to apply the notions and nature of scientific models, analogies and metaphors as understood by Hesse. It is important to quickly note that my focus is on the God-hypothesis-debate aspect of theological discourse. This debate upholds the existence of God as a transcendent being and seeks evidence for its support. Thus, the God-hypothesis is the heart of every theological discourse. I believe that when it is properly situated and understood from the perspective of NMT every other dimensions of theological discourse can be easily implied.

This book adopts a method that would be described as multiple and in stages. First, there is the cataloguing of the sources necessary for successful research in my area of interest. These sources are divided into the primary and secondary sources. The primary sources include the five books and many articles of Hesse, and other books and articles on the cognitive status of theological discourse. These are studied with maximum evaluative and critical interest. The secondary sources are other books and articles that supported or rejected both the ideas of Hesse and my hypothesis. Secondly, there is a draft of the structure of the book in terms of what comes first and what comes later or last in relation to the NMT. This should not be misconstrued to mean that the book has adopted a totally chronological approach. It means that the methodology adopted by the book incorporates elements of both synchronic and diachronic approaches. All these approaches are aimed at showing the relevance of Hesse's NMT to our quest for truth and knowledge. Thirdly, there is the organization of the bibliography. I took cognizance of the fact that the draft of the bibliography at any stage was not comprehensive and remained modifiable till the end of the research. Finally, comes the writing of the book with maximum commitment to originality, intellectual honesty, and critical, evaluative and qualitative contribution to scholarship.

The body of this book is divided into four parts. Each part has two chapters. Part I is an analysis of the situation in the philosophy of science that gave rise to the NMT of Hesse. In chapter one, I analyze and evaluate the debate on the roles of models to scientific theories[17]. The notion of model that is of interest to this book is that developed from the second-half of twentieth century. Models in the first-half of twentieth century had poor reputation and were of little or no interest to scholars in philosophy of science. They were considered as inferior tools in the hands of those improperly trained on how to do science. Suffice it to say that while there was bias toward theory by scientists and scholars in philosophy of science, there was conversely proportionate bias against model among the same circle. This disregard for models was not to last forever. By the second-half of twentieth century, there was a revival of interest and one can say without ambiguity that the table seemed to have turned in favor of models. Today there are

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[17] Here we rely on Hesse's *Models and Analogies* in Science, London, 1963; «Reasons and evaluation in the history of science» in *Revolution and reconstruction in the philosophy of science*, London, 1980.

proliferation of articles analyzing the roles of models in various fields of knowledge. In fact, its reputation and relevance go beyond scientific enterprise. The chapter four parts. In the first part, there is a thorough investigation into the early notion of model. It presents the roles of such scientists as James Clerk Maxwell, William Thomson and Ludwig Boltzmann in bringing the notion of model to unprecedented height. The second part is an evaluative inquiry into the notion and nature of analogy. The third part is a scholarly exploration into the notion of scientific theory. The final part is a synthesis which articulates the different shifts in the development of models from inattention to cognitive function.

In the second chapter, I examine the storm of protest that rose against empiricist epistemology beginning from its own members and its principles. Thus, I trace the shift from verificationist account to model-based account of scientific method. This chapter is divided into four major parts. In the first part, I explore the emergence of logical positivism. The second part is an examination of the advanced form of logical positivism otherwise known as mature positivism or logical empiricism. The three main themes that will guide the study in this part include: criterion of cognitive significance; status, structure and functions of theories and theoretical terms; and the nature of scientific explanations[18]. The third part is a critical review of the positivists program which resulted in the classification of metaphysics and theology as meaningless at best and false at worst. Furthermore, I present the paradoxes entailed in such program together with the attacks of Karl Popper on both their cognitive criterion of confirmability and induction. Additionally, there are criticisms from other philosophers of science who maintained that the positivist program is so very restrictive and leaves out the methods of such social sciences as psychology, sociology and so on, hence the advocacy for a broader approach. It is this advocacy for broader approach that will result in the emergence of the attention given to models and analogies in science[19]. In the last part, there is an overview of the

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[18] For philosophical reactions on the verifiability principle see: B.J. CALDWELL, *Beyond Positivism,* 21; K. POPPER, *The Logic of Scientific Discovery* (first published 1934), translated ed. K. POPPER, J. FREED & L. FREED New York, 1959, 36; A.J. AYER, «Editor's Introduction» in A.J. AYER ed., *Logical Positivism*, Glencoe, 1959, 14; A.J. AYER, *Language, Truth and Logic*, New York, (1936) 1946, 39; C. HEMPEL, «The Empiricist Criterion of Meaning» in A.J. AYER ed., *Logical Positivism*, 115 and so on.

[19] For further readings on this, references could be made to: K. POPPER, «Conjectural Knowledge: My Solution to the Problem of Induction», in *Objective Knowledge: An Evolutionary Approach*, Oxford, 1972, see also his *The Logic of Scientific Discovery* (Eng. transl., 1959), 2nd edn., New York. (1934) 1968, sections 4–6; 'Science…,'

perspectives of the British proponents such as Richard Braithwaite and Ernst Hutten on scientific model. Moreover, Mary Hesse who is one of the British proponents is given a more elaborate overview. This book explores her Network Model of theory in relation with models, analogies and metaphors in science, society and religion. Thus, in the last part of chapter two I introduced her under such headings as: background and career, intellectual currents and debates at her time: sources of influence and inspiration and finally her view that models and analogy have a central role in scientific discovery and creative imagination[20].

Part II focuses on two interests: first, it is an evaluative analysis of the background to Hesse's NMT – from Duhem to Quine and finally to Hesse. Second, it does an in-depth investigation of the structure of scientific theory from the perspective of NMT. Chapter three is a critical review of the structure of scientific knowledge which has generated many debates among scientists and philosophers of science. The received view had been that a certain sort of test, the crucial experiment, is a reliable basis for distinguishing between acceptable and unacceptable theories. This position was common up till nineteenth century. By twentieth century there emerged significant opposition to it. Rather than talk about crucial experiment, there were references to holism or what Mary Hesse refers to as the NMT. This chapter has three parts. The first part is a critical examination of the background to NMT. I will show how the notion was drafted by Pierre Duhem and adopted by W.v.O. Quine culminating in what is known today

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Ibid., 40–1; «The Demarcation between Science and Metaphysics», in *Conjectures and Refutations*, 253–92; Caldwell, B. J. *Beyond Positivism,* Ibid.; F. SUPPE, «Afterword» in F. SUPPE ed., *The Structure of Scientific Theories*, 29–36; the introduction and articles by J.J.C. SMART and M. GROVER in R. GRANDY (ed.), *Theories and Observation in Science*, New Jersey. 1973; and E. NAGEL, *Structure of Science*, 129–52 and so on.

[20] Further reference could be made to such scholarly works as : R. BRAITHWAITE, *Scientific Explanation: A Study of the function of theory, probability, and law in science*, Cambridge, [1953] 1968; E. H. HUTTEN, «The role of models in physics», *British Journal for the Philosophy of Science*, 1954; M. HESSE, «Models in physics», *British Journal for the Philosophy of Science,* 1953, See also her « Positivism and the logic of scientific theories», in P. ACHINSTEIN and S. BARKER eds., *The Legacy of Logical Positivism for the Philosophy of Science*, Baltimore,1969; also *Revolution and reconstruction*, 1980.; M. HALLBERG, «Hesse, Mary Brenda», in S. BROWN, ed., *Dictionary of Twentieth-Century British Philosophers*, vol. 1, Bristol, 2005, 406–9; M. HALLBERG, «Revolutions and reconstructions in the philosophy of science: Mary Hesse (1924–2016) », *Journal for General Philosophy of Science*, 48 2017, 161–71.

as the Duhem-Quine thesis[21]. The second part is an evaluative analysis of Hesse's NMT showing her arguments in support of theory-observation continuity against the received view of theory-observation dichotomy[22]. The final part is a critical exploration of Hesse's understanding of theoretical explanation as metaphoric redescription[23]. This is based on the analogy drawn from Max Black's interaction view in which there is interdependence between the primary and the secondary referents. This helps to properly situate the notion of NMT for the rest of the book.

Chapter four is divided into two major parts. The first part undertakes a critical evaluation of Hesse's argument for 'variant theory-observation statements'[24]. I x-ray Hesse's view that theoretical and observational sentences are subject to change but we cannot tell with certainty *which* will be changed and *which* will not. The second part is a critical evaluation of the notion of truth in science[25]. The scientific claims for truth and sovereignty of knowledge is subjected to critical evaluation.

The general goal of part III is exploration and critical evaluation of Hesse-Habermas search for sociology of knowledge. This is a follow up to the damaging criticism dealt on the positivist insistence that the conformity of human science to the logic and methodology of natural science is a *conditio sine qua non* for its recognition as objective knowledge. Chapter five is an attempt to use Hesse's NMT to cross-examine the question of truth and objectivity in human sciences. In the first part I present the background to the issue under consideration by tracing through an entirely different route how the enlightenment project characterized by enchantment for truth as correspondence was found to lead to disenchantment of the human person

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[21] M.B. HESSE, «Duhem, Quine and a new empiricism» in *Can theories be refuted?,* Boston, 1976.

[22] M.B. HESSE, *The structure of scientific inference*, London, 1974, see also her *Revolutions and reconstructions in the philosophy of science*, London, 1980.

[23] M.B. HESSE, «The explanatory function of metaphor» in *Revolution and reconstruction in philosophy of science*, Ibid., «Models, metaphors and truth» in *Knowledge and language*, Ankersmit, F.R. and Mooij, J.J.A., eds., vol iii, 1993, 49-66; «Theories, family resemblances and analogy» in *Analogical reasoning*, Helman, David H. ed., 97, 1988, 316-340; «The cognitive claims of metaphor», in *The Journal of Speculative Philosophy*, New Series, Vol. 2, No. 1, 1988.

[24] M.B. HESSE, «Models of theory-change» in *Revolutions and reconstructions in the philosophy of science*, London, 1980.

[25] M.B. HESSE, «Truth and growth of scientific knowledge», in *Revolution and reconstruction in philosophy of science*, Ibid.

and the values she placed on herself[26]. The role of the members of the Frankfurt school of social research is carefully investigated. The second part shows that the advocacy for the abandonment of the enlightenment project by the Frankfurt school was not well received by all the members of the school. Habermas advocated for a reevaluation rather than abandonment[27].

Chapter six is a more in-depth evaluation of the search for sociology of knowledge based on Hesse's NMT. There are two major parts to this chapter. The first part – 'critique of objectivity' – is a critical scrutiny of the alleged distinction between natural and hermeneutic sciences[28]. The second part – 'in defense of sociology of knowledge' –argues robustly based on Hesse's NMT that rather than the advocacy for dichotomy between natural and hermeneutic sciences, continuum between them would be a more rational and justifiable approach[29].

Part IV is principally on the right of theology to make cognitive claims. Two chapters are dedicated to this purpose. Chapter seven is a critical analysis of the implications of Hesse-net[30] on theological doctrines. I evaluate the foregoing views of science on the continuing science-religion debate. This chapter is divided into three major parts. The first part, begins with a brief background to the dichotomy between science and theology. I moved further, relying on our already established position about value interests and the cognitive importance of social science, and argue that theological value interests could be one of the explicit ideologies that determine theoretical explanations[31]. The second part focuses on investigating into the alleged incompatibility between science and theology[32]. The last part is a critical

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[26] D. FATAH., «The history of the Frankfurt school from criticism to emancipation movement», in *international journal of history education*, vol. 13, 1,2012, see also N. CAPALDI, *The enlightenment project in the analytic conversation*, Dordrecht, 1998.

[27] M.B. HESSE, «Habermas consensus theory of truth», in *Revolutions and reconstructions in the philosophy of science,* London, 1980, 206-230.

[28] M.B. HESSE, «In defence of objectivity» in *Revolutions and reconstructions in the philosophy of science*, London, 1980.

[29] M.B. HESSE., «Theory and value in the social sciences», in *Revolutions and reconstructions in the philosophy of science*, ibid.

[30] This is another term synonymous with the Network model of theory proposed by Hesse. It was a common term used by her contemporaries to describe her theory.

[31] M.B. HESSE, «Criteria of truth in science and theology», in *Revolutions and reconstructions in the philosophy of science*, London, 1980, 235-55.

[32] M.B. HESSE, «On the alleged incompatibility between Christianity and science », in Montefiore, H., ed. *Man and nature*, London, 1975.

evaluation of the truth claims of scientific cosmology and the religious doctrine of creation[33].

Chapter eight is a continuation of chapter seven. It takes the argument further and deeper in line with Hesse-net. My objective is to drive home the fact that in the same way science relies on models, metaphors and analogies for the description of nature so does religion with reference to God. The investigation is organized to respond to such questions as, What is religion? What are the social functions of religion? How does moderate realism address the cognitive claims in 'Theory of Everything'? and what are the sources for the most efficient way of understanding or speaking about God: metaphysics or metaphors? Answers to these questions are meant to play some roles not only in our perception of theological discourse but more specifically in underlining the distinguishing role of religion in the search for knowledge, truth and meaning – first, they will help us have a clearer understanding of religion in its social and transcendental perspectives; second, they will make clearer the difficulties associated with the attempt to substitute the Christian notion of God almighty with the scientific notion of 'Theory of Everything'; finally they will lay bare the major philosophical challenges embedded in the attempt to describe the Christian notion of God in terms of scientific models and analogies. There are two major parts to the chapter: the first part focuses on tracing the attempts by cosmologists to institute natural science as new religion with physical laws having all the attributes of God from omniscient to omnipresent. It goes further to underline not only the epistemological difficulties associated with such approach but also how unsatisfactory it is to every religious believers' notion of God[34]. The second part begins by giving a cursory attention to the 'Theory of Everything' as developed by Paul Davies in his *The mind of God.* I identify in his theory the problems associated with received realism and go further to locate solutions to those problems in Hesse's advocacy for 'moderate realism'[35]. This will help to situate religion in both social and transcendental contexts. It concludes with a critical analysis and scholarly synthesis of the model for God relying on Aquinas' *Summa Theologica* as a springboard.

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[33] M.B. HESSE, «Cosmology as a myth» in *Cosmology and theology*, Tracy, D., and Lash, N., eds and Lefébure, M., English lang.ed., New York, 1983.
[34] M.B. HESSE, «Is science the new religion?», in *Science meets faith: theology and science in conversation*, Fraser Watts, ed., London, 1998, 120-135
[35] M.B. HESSE, «The sources of models for God: metaphysics or metaphors?» in *Physics and our view of the world*, Hilgevoord, J., ed., Cambridge, 1994.

PART ONE:

BEYOND A VERIFICATIONIST VIEW

CHAPTER 1

ON THE ROLES OF MODELS WITHIN SCIENTIFIC THEORIES

The notion of model that is of interest to this book is that developed from the second-half of twentieth century. Models in the first-half of twentieth century had poor reputation and were of little or no interest to scholars in philosophy of science. They were considered as inferior tools in the hands of those improperly trained on how to do science. Suffice it to say that while there was bias toward theory by scientists and scholars in philosophy of science, there was conversely proportionate bias against model among the same circle. This disregard for models was not to last forever. By the second-half of twentieth century, there was a revival of interest and one can say without ambiguity that the table seems to have turned in favor of models, and today there are proliferation of articles analyzing the roles of models in various fields of knowledge. In fact, its reputation and relevance go beyond scientific enterprise. This chapter is an attempt to explore the roles of scientific models within theories. There are four main parts of this chapter. The first part will be an attempt to analyze the early notion of model which was basically a mechanical notion. This mechanical notion of model was mathematized and this led to its being abstract and consequently disregarded in the first-half of twentieth-century. We will also explore briefly the roles played by the nineteenth century physicists in bringing the notion to an unprecedented height. The second part will be on analogies. Analogy is always associated with models in philosophy of science. In this part, therefore, we will consider the understanding and analyzes of nineteenth century philosophers and scientists on the roles of analogies. This would lead to the explanatory role ascribed to it in the 1960s by philosophers of science. One point that was very interesting at this time was that the early notion of analogy in science seemed to have confused or identified analogy with model. Thus, we will try to make a distinction between the two by making a distinction between attributes and relations as well as the use of analogy in science. There will also be the third part, which will have to do with theories. Our concern will be to show the factors responsible for the poor reputation of models in the first-half of twentieth century. This was due to primacy of position enjoyed by theories. We will give attention, also, to the emergence of models in the context of British philosophy of science. Finally, the last part will be on the different phases in the development of scientific models. This will help us put our understanding of the roles played by models within scientific theory in proper context. It will be a kind of synthesis.

1.1 Mechanical models

Some scholars[1] held that the second half of the nineteenth century ushered in the use of the concept of models in science. Although models were being used before that time[2], this section aims to give attention to the nineteenth-century concept of models. This is because, it was this concept of model that was also referred to by the twentieth-century philosophers of science, in their consideration of models in science. The early concept of models was mechanical. Gregor Schiemann[3] observed that being mechanical has a wider sense which depicts «matter in motion as the primal cause of all natural phenomena» and a narrower sense which refers to «those approaches in the philosophy of nature and the theory of science that establish their explanations on the principles of mechanics, as enunciated paradigmatically by Newton and Lagrange».

These two uses have different roots in philosophers and in time. The former was influenced by the atomistic philosophies of Leucippus (fifth century B.C.) and Democritus (around 460-370 B.C.) on one hand and by the seventeenth century mechanical philosophy of Pierre Gassendi (1592-1655), Rene Descartes (1596-1650), and Robert Boyle (1627-1691) on the other hand. Isaac Newton's (1642-1727) *Philosophiae Naturalis Principia Mathematica* (1687) was the root of the latter.

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[1] D.M. BAILER-JONES, *Scientific models in philosophy of science*, Pittburgh, 2009, 21. See also, Jammer, M., «Die Entwicklung des Modellbegriffes in den physikalischen Wissenschaften» (The development of the concept of model in the physical sciences), *Studium Generale*, 1965, 18: 166–173. This is a work in Deutsch language but was cited by Bailer-Jones.

[2] For instance, GALILEO GALILEI (1564–1642) not only used models extensively in his scientific work, he also used the term *modello* in the second day of his *Dialogue Concerning the Two Chief Systems of the World* of 1632.

[3] G. SCHIEMANN, *Wahrheitsgewissheitsverlust: Hermann von Helmholtz' Mechanismus im Anbruch der Moderne,* Darmstadt, 1997; C. Klohr, transl., *Herman von Helmholtz's mechanism: The loss of certainty*, 2009, 7.

This distinction between the two uses of "mechanical" is related to Thomas Kuhn's mathematical and experimental traditions of science[4]. The mathematical tradition focuses on principles and deductions and corresponds to the first sense of "mechanical" above. The experimental tradition or Baconian science relies on corpuscularian conception, that is, the impact of small and discreet particles such as photons and electrons, and corresponds to the second sense of "mechanical" above. The seventeenth century figures of the mathematical tradition were Galileo, Kepler, Descartes and Newtons. They had «little of consequence to do with experimentation and refined observation»[5]. The experimental tradition had their root in crafts without the theoretical back up of the mathematical tradition. Kuhn notes that Isaac Newton is an exception to this distinction because he participated and inspired both traditions: the mathematical tradition with the work of the *Principia* and the experimental, corpuscularian tradition, with the work of the *Opticks, or a Treatise of the Reflections, Refractions, Inflections, and Colours of Light* (first published in 1704)[6]. Consequently, the nineteenth-century was characterized by the diverging trends of the mathematization of the experimental science on one hand and the employment of mechanical models on the other hand. Due to the fact that the notion of model stood in stark contrast to the well accepted mathematical trend, there was need for the users to explicate more and defend or promote their position. In the following sections, we shall employ the second notion of "mechanical" in reference to model. The first sense of it will be referred to as "mechanics" or "classical mechanics" when making reference to it.

1.1.1 The mathematization of the experimental science

Kuhn noted that the first quarter of nineteenth-century was characterized by the mathematization of remarkable numbers of Baconian sciences[7]. Let us quickly observe, for memories sake, that the Baconian science was originally craft and experiment oriented. There was no formal connection with principles of mathematics. The mathematization would mean giving Baconian science mathematical layout and description in accordance with the principles of Newtonian mechanics. The Newtonian mechanics had long

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[4] T.S. KUHN, *The Essential Tension*. Chicago, 1977.
[5] Ibid, 40.
[6] In the eighteenth century, Newton's work *Optics* exerted remarkable influence on experimentalists and was read widely, something that was no longer the case in the nineteenth century, when the *Principia* was perceived as Newton's prime achievement. See I.B. COHEN, *Franklin and Newton*, Philadelphia, 1956, 113ff.
[7] T.S. KUHN., *The Essential Tension*. Chicago, 1977, 61.

been considered the ideal of successful physics because of its mathematical layout and mathematical solution to a range of physical problems. Such phenomena as electricity, magnetism, and heat were interpreted as closely as possible in the spirit of Newtonian mechanics. For instance, Coulomb's law was interpreted and put in a form similar to that of the law of gravitational attraction. The expected outcome of this mathematization of phenomena was that the mathematical interpretation of phenomena became increasingly disjointed «from the observable physical and geometrical properties of phenomenon – that is, it became more and more abstract»[8].

A route toward the mechanical treatment of phenomenon could be exemplified by Jean Baptiste Joseph Fourier (1768 – 1830) mathematical treatment of heat[9]. Fourier's mathematical tools were successfully transferred to the theory of electrostatics, by William Thomson (1824 – 1907). The mathematical analogy between the treatment of heat and of electrostatics subsequently highlighted a physical analogy—that between thermal conduction and electrostatic attraction—where the distribution of electricity was represented by the flux of electrical force and the distribution of heat by the flux of heat[10]. This is a demonstration of mathematical treatment of phenomenon without querying much of its physical nature. Thus, mathematization and mechanization of physics are connected in the sense that a mechanical model of physics was described mathematically. There is also the example of Maxwell's (1831 – 1879) vortex model. This mechanical model was taken from Faraday's (1791 – 1867) ideas to devise a mathematical description of the electromagnetic field[11]. This approach is not without some difficulties. There was the mathematical description although the phenomenon to be considered (the magnetic fields) could not be expected to lend itself to the mathematical description of Newtonian mechanics. This is to say that the mechanical model could be used to obtain abstract mathematical interpretation but the increasingly abstract and less mechanical phenomena like electromagnetism seemed to be less and less suitable to being modeled mechanically. This will be made clearer in our discussion of the problem of the link between theoretical entities and observations.

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[8] D.M. BAILER-JONES, *Scientific models in philosophy of science*, Pittsburgh, 2009, 24.

[9] P.M. HARMAN, *Energy, Force, and Matter: The Conceptual Development of Nineteenth-Century Physics*, Cambridge, 1982, 27-30.

[10] Ibid, 29.

[11] N.J. NERSESSIAN, *Faraday to Einstein: Constructing meaning in scientific theories*, Dordrecht, 1984, 77.

1.1.2 Mechanical age and scientific Models

The nineteenth-century physicists played significant role in bringing the development of mechanical model to unprecedented heights. Although this study does not aim at giving a detailed account of such effort, but it is important to note that the concern of these physicists in mechanical model was not with the sole interest of mathematization. The attraction of models was for giving a mechanical explanation of phenomena. This would become clearer as we review the observations of some scientists such as James Clerk Maxwell, William Thomson (Lord Kelvin) (1824–1907), and Ludwig Boltzmann (1844–1906) about models.

It is not always easy to distinguish what is considered model today from that of the nineteenth century[12]. This is because some of these scientists were not very precise in the distinction in their use of models on one hand and analogy on the other. Sometimes they appear to be used interchangeably. For instance, both Maxwell's vortex model[13] and model of electrical field lines as incompressible fluids moving in tubes would today be referred to as model but it is interesting to note that Maxwell does not even mention the term "model" in his *On Faraday's Lines of Force,* Maxwell (1855) 1890, instead, he only addresses the issue of the use of analogy in science in that context. A sense of what a practicing scientist, at that time, took a "model" to be is seen in Boltzmann's published article on model for both the tenth and eleventh editions of *Encyclopedia Britannica*. In this article people take "model" to mean physical model: « a tangible representation, whether the size be equal, or greater, or smaller, of an object which is either in actual existence, or has to be constructed in fact or in thought »[14]. Thus, although what is modeled may or may not exist, the model of it physically exists. Boltzmann gives example with the model artists make before they produce a sculpture in an expensive or hard-to-manipulate material such as stone or metal.

It was not an uncommon practice, in the nineteenth-century, to build a physical mechanical model. In fact, Boltzmann portrays it as a kind of

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[12] D.M. BAILER-JONES, *Scientific models in philosophy of science,* ibid 27.
[13] In 1861, Maxwell derived two of his equations of electromagnetism by modelling a magnetic line of force as a `molecular vortex' in a fluid-like medium. This led to the introduction of the concept of electromagnetic field and the formulation of electromagnetic theory of light.
[14] L. BOLTZMANN, « Model» *Encyclopedia Britannica*, 11th ed., 18. Cambridge, 638–640, (1902) 1911.