Scientific transformations: a philosophical and historical analysis of cosmology from Copernicus to Newton

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SCIENTIFIC TRANSFORMATIONS: A PHILOSOPHICAL AND HISTORICAL ANALYSIS OF COSMOLOGY FROM COPERNICUS TO NEWTON

by

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ABSTRACT

The purpose of this thesis is to show a transformation around the scientific revolution from the sixteenth to seventeenth centuries against a Whig approach in which it still lingers in the history of science. I find the transformations of modern science through the cosmological models of Nicholas Copernicus, Johannes Kepler, Galileo Galilei and Isaac Newton. Since of the enormous content, I shall only pay particular attention to Copernicus and Newton in which the emerging sciences transformed the cosmos on what Alexandre Koyré calls from a "closed world to infinite universe".

As an interdisciplinary approach, I used the methods and inquiries from philosophy and history to explain the cosmological transformation in the sciences. The first part deals on the philosophic content of Michel Foucault and Thomas Kuhn which help to provide insight though their systematic thoughts are incompatible. The second part deals in the historic contents from Copernicus' doctrine, *De revolutionibus*, to Newton's mechanics, *Principia*. My ultimate outcome is to demonstrate the multi-perspective dimension of knowledge in which interdisciplinary studies shows transformation of the sciences and its effects on history.

Keywords: transformation, mechanomorphism, history of science, epistemic breaks, paradigm shifts, Copernican doctrine, Newtonian mechanics, effects on history.

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CHAPTER ONE: INTRODUCTION

In the history and philosophy of science, one knows of Thomas Kuhn's essential writing, or essay, *The Structure of Scientific Revolutions*. A work he planned for 15 years before initial publication in 1962[1]. The work itself stands in the pivotal point discussing the nature of history pertaining to the scientific revolution and the sociology of knowledge that emerges between the standard scientific models, method and community. According to his preface, that was not his initial goal[2].

Kuhn's corpus in the history of science became apparent that the sociology of science was the unintended consequence of his developing thoughts changing professions from physics, to history of science then philosophy; he wasn't trained as either historian or philosopher. He was outside the fields and that inspired him in his multi-lingual use of paradigm shifts: the changing knowledge in different professions like the sociologist, anthropologist and psychologist versus the biologist, physicist, astronomer, mathematician, and chemist[3]. Kuhn encountered this folly of dichotomies early in his years at Harvard[4]: in the 50's as a young fellow, he's environment of learning surrounded the president James B. Conant who revised Harvard's educational system of an interdisciplinary model that combines the humanities (e.g. arts, history, and philosophy) into science to help elaborate the core concepts that transformed the sciences in western history.

Kuhn's *The Copernican Revolution* was an early synthesized work of history, science and philosophy on the emerging disciplines that natural philosophers were conceptualizing in a change of the cosmos around Copernicus' time[5]. What interests me is the philosophical and

historical implications that can help illustrate the rigorous methods in the mathematics and physics and emphasize the strong relation between history and philosophy. According to the medieval historian Ibn Khaldun, in the *Muqaddimah*, history "is a discipline widely cultivated among nations and races. It is eagerly sought after. The men in the street, the ordinary people, aspire to know it. Kings and leaders vie for it"[6]. Within the essence of history, through Khaldun's thought, lies an inner meaning which

> involves speculation and an attempt to get at the truth, subtle explanation of the causes and origins of existing things, and deep knowledge of how and why events. History, therefore, is firmly rooted in philosophy. It deserves to be accounted a branch of it[7].

In a sense, history and philosophy provide the tools in nations or civilizations as a theoretical and practical matter that balances the disciplines of human knowledge.

According to William Durant's *Story of Civilization Part I*, the elements of civilization and their knowledge constitute the disciplines through the inter-connected links related to economics, politics, religion, morality, arts, and sciences[8]. If one area is heavily concentrated or misplaced to the others, then the whole working parts as an inter-connected link tumbles down and one will see the decline of a civilization[9]. This interdisciplinary ideology not only applied fifty to a thousand years ago with Durant, Khaldun, and Kuhn, rather it still applies now in our modern civilization.

Given the disciplines and their knowledge are very interdisciplinary and integrated as a self-governing entity, my speculations are particularly centering the arts and sciences within the history and philosophy of the emerging cosmos that came out of Copernicus and Newton as a

"closed world to infinite universe"[10]. The emerging, or origins, of modern science stems around the sixteenth and seventeenth centuries of the west which modern sciences throw off the superstitious elements that cloaked human ingenuity over a thousand years or coming out of the Middle Ages. This notion on the origins of modern science and its cosmology illustrates a Whig approach/interpretation in the history and history of science which I disagree as the whole concept in interdisciplinary studies through history and philosophy.

The history of science is not a one-sided approach rather an interdisciplinary outlook that natural philosophers/scientists create the cosmos through this transformation that, according to Webster's *Seventh New Collegiate Dictionary*, is defined as "the operation of changing…one configuration or expression into another in accordance with a mathematical rule"[11]. Hence this rule succeeds through an epistemological thought operation shown in mathematics, physics, and the sciences on a geometrical level of analysis. The transformative elements in the geometrization of space in cosmology and its perceptions produced a transformation in the history of science.

This paper is outline into two parts in the philosophical and historical investigation on the cosmos. The first is to elaborate the philosophies not only to Thomas Kuhn with other historians and philosophers but as well the French philosopher Michel Foucault in Foucault and Kuhn's approaches on epistemic changes and paradigm shifts. After tackling their philosophies, I would transition within the contents surrounding Copernicus, Kepler, Galileo, and Newton to see how this transformation occurred. To start off, I would like to counteract the notion of Whig history as one of the few models in the nature of history and its effects.

Whig history

Before going into Whig history, there is a difference in meaning following "nature" in the context of the nature of history. According to C.S. Lewis in his *Discarded Image*, he divides nature in two types[12]: the personification of nature as Mother Nature versus speaking in abstraction of Nature like the pre-Socratics discussed on metaphysics. Of the two types, the latter furthers in the history of science with how certain individuals were able to reconfigure the new universe from Copernicus to Newton where the former sees the events as personified forms through a literary context. I would think that transformations in history and history of science follow the two types of nature where it provides a multiple perspective rather than one-sidedness from the Whig perspective.

The term Whig history is one of many interpretations of history, especially in historiography, which I shall address the concept used by the historian Herbert Butterfield. In Butterfield's book *The Whig Interpretation of History*, he provides on what he terms – beyond political ideologies of eighteenth century Whigs and Tories and religious ideologies in Catholics and Protestants – in Whig history as a victor/winner in history and the account of its past as present. The first concept demonstrates, in Whig history, that the historian's role must be taken as an "avenger" to justify the means of a committed "wrong" that imbalances the nature of history. To Butterfield, the historian stands as "a judge between the parties and rivalries and causes of bygone generations"[13] which the parties, in appearance, must stand to liberate the individual in history. For example: Protestants must win over Catholics as English people who affiliate themselves as Whigs must win over to the Tories.

In Butterfield's concept of history, he view these victories as an assumption which the "verdicts of history" says something about the individual or group[14]. The point of departure is classifying, or better yet defining, to whom these certain individuals are considered as the victor. However, the ethnographic political display indentifies the victors of history as the historian in writing "their" account or experience. Though the Whigs and Protestants were victorious at one point against their opponents, at another period in history they may become the subjugation of their opponents, the Tories and Catholics. The conundrum furthers in Butterfield's second concept of Whig history: the view of time.

The view of time is especially critical in account on what makes history *history*. History is the study of the past but of what kind? Not every historian can fully calculate every significant event or phenomenon, natural or human, in narration. Like the poets from ancient Greece and Rome, the historians give a personified interpretation of all natural and human events yet cannot fully account all such phenomenon down to its micro-proponents[15]. Instead, the historian, like the poet, regulates a medium in narration to the reader beginning at *medias res*, in the middle of things. The middle of things in narration then furthers the etiological function which may have caused disruptions, declinations or reverberations in history. The issue that Butterfield defines in Whig history is I inspect as one-sidedness in history.

This one-sidedness in the history of any specific inquiry, moral, scientific or political, follows characteristics that may leave significant and insignificant details or ulterior motives in usurping the "losers". To understand the transformation of such knowledge or intellect that was considered anachronistic, one must view all anachronistic tendencies which fall out of line in and

failure develops out of its mistakes; this is to say anachronistic tendencies still play a role in history. This role in nature, both description as personification and abstraction, resembles the balances of order and cosmos as seen through cosmogony stories which tell of events before the appearance of humanity. One-sidedness in history fails to account the speculation of time and location beyond Newton's or Einstein's mechanics. To illustrate this point, Olaf Stapledon's narration in *Last and First Men* calls in question of the narrator or historian in telling the story of mankind in the future which Whigs can postulate on liberations. In his introduction, Stapledon states that the narrator maybe "one contemporary with its readers, [or] the other inhabitant of an age which they would call the distant future"[16].

The Whig historian must take in attempt, where this one-sidedness to liberation against the confinements and cyclicality, the point in casting two narrators: one from the past and one from the present. The "author" in Stapledon's narration plays both as an historian and literary personnel. However, which is the authentic historian? If the author from the future is our historian, then the "present" author's narration is valuable only to the extent of what the futuristic individual can hold through one's available knowledge in events occurring in time. If the present author is our historian, then one is committing a fallacy in foretelling events that have not happened; yet something can be said that such events in prediction can occurs if such the nature is repetitive.

Though based on science-fiction about mind embodiment or out of body experience, such speculation calls to the inquiring mind whether as historian, philosopher or scientist. In inquiring specific histories, Butterfield makes note of importance that

> the greatest of all lessons of history is this demonstration of the complexity of human change and the unpredictable character of the ultimate character of the ultimate consequence of any given act or decision of men; and of the face of it this is a lesson that can only be learned in detail[17].

The lessons of history are a difficult task in covering an enormous content in history for which my investigation rely on an interdisciplinary approach that can illuminate trivialites when looking at the sciences. From understanding his notion on Whig interpretation and faults, Butterfield expands from a general history to a specific history on its philosophy in the history of science known in *The Origins of Modern Science*.

Notes

[1] Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: Chicago University Press, 1962), pg. xxxiv

[2] Ibid, pgs. xliv-xlvi

[3] Ibid, pg.xlii

[4] See Conant's foreword in Kuhn's *The Copernican Revolution* (Cambridge, MA: Harvard University Press, 1957) and *Structure*, pg. xl

[5] Kuhn (1957), preface, pgs. vii-viii

[6] Ibn Khaldun, *The Muqaddimah* (New York: Princeton University Press, 1967), pg.6

[7] ibid.

[8] William Durant, *The Story of Civilization Part I* (New York: Simon and Schuster, Inc., 1935), pg.1

[9] ibid, pg. 3

[10] I like this philosophic concept from Koyre's overall perspective in the history of science dealing on cosmology; this comes from his title *From the Closed World to Open Universe* (Baltimore: John Hopkins Press, 1957).

[11] See Webster's *Seventh New Collegiate Dictionary* (G&C. Merriam Company Publishers, 1967), pg.940

[12] C.S. Lewis, *The Discarded Image* (Cambridge: The University of Cambridge Press, 1964), pgs.37-38

[13] Herbert Butterfield, *The Whig Interpretation of History* (New York: W.W. Norton & Company, 1965), pg.1

[14] Ibid., pg.2

[15] In historiography, this is called bottom-up and micro history

[16] Olaf Stapledon, *Last and First Men* (New York: Dover Publications, Inc., 2008), pg.13

[17] Butterfield, pg.21

CHAPTER TWO: THE FOUCAULT-KUHN SHIFT

What I detect is the early philosophy in the history of science and its transformation from Butterfield's work in *The Origins of Modern Science* and Alexandre Koyré's *From the Closed World to Infinite Universe*; the first address the historic aspect while the latter deals the philosophic aspect in the history of science. Butterfield advises the general historian to pay particular attentions in the shifts of human interactions when *The Origins of Modern Science* looks to a teleological function affirming successes that the lessons of history have been learned. Unfortunately, Butterfield leaves traces of Whig tendencies that historians and historians of science find inevitable when investigating individuals like Galileo, Descartes or Newton who conquer over superstition with geometry.

What does provide *The Origins of Modern Science* its efficiency is the period examined from 1300 to 1800. Whether the scientific revolution began either in the fourteenth or seventeenth century[1], the theory of impetus from the nominalist school, like Ockham and Orseme, laid importance on a theory of motion from Aristotelian doctrine concerning falling bodies. Without the theory set in motion, whether right or wrong, there wouldn't be a "switch" in the mind-set on Galileo's dynamics of inertia from the swing pendulum to parabolic curve. Butterfield clarifies the medieval sciences in terms that,

> the modern world is in certain sense a continuation of the medieval one [;]…some historians of science have been disposed seriously to qualify the traditional concept of the "Renaissance" and to see, from the eleventh or twelfth century at least, a continuous development of western thought[2].

This continuous trend from medieval to modern science approaches the transformation from medieval sciences, similar if not different, to the modern sciences developed under Copernicus, Kepler, Galileo, Descartes, and Newton.

Koyré's *From the Closed World to Infinite Universe* is an expanded work on philosophy were cosmology follows the concept of infinity. In his introduction, he writes the change of the cosmos comes around the seventeenth century which is described as

> bring forth the destruction of the Cosmos, that is, the disappearance…of the conception of the world as a finite, closed and hierarchically ordered whole…and its replacement by an indefinite and even infinite universe which is bound together by the identity of its fundamental components and laws, and in which all these components are placed on the same level of being[3].

The philosophic component in the history of science deals this transforming model of a closed to infinite world in Koyré's investigations that speculates from a scientific to religious stance to the individual's perception in nature and environment.

Butterfield's and Koyré's canons initiate the philosophy in the history of science as one sees a transformation of old to new science. From a traditional framework to innovative study, one can see emerging works in the history of science discipline around the 50s to 80s in which the sciences take a different stance than the philosophies of Kant or Whewell[4]. In connection to Butterfield and Koyré, I find the philosophy in the history of science and its transformation in the philosophies of Michel Foucault and Thomas Kuhn through epistemological changes.

Both philosopher and historian Foucault and Kuhn focus the epistemological changes of the sciences, their transformations, when they investigate the modernity of science around the

sixteenth to seventeenth centuries. They share similar notions of epistemological changes with epistemic breaks and paradigm shifts; however, their investigations take different approaches in a biological and physical stance in science. In Kuhn's *The Structure of Scientific Revolutions,* he states in his preface, "my decision to deal here exclusively with the latter [, physical,] was made partly to increase this essay's coherence and partly on grounds of present competence"[5]. He could have written the biological inclusion but its context would not fit coherently as a whole within the structure of scientific revolutions. Where Kuhn tackles the physical sciences, Foucault demonstrates the historical transformation of ideas within a biological framework pertaining in the realms of psychiatry and clinical medicine in his earlier works. For Foucault, he delves further into the sciences and their "transformation" of another science.

I would see to it that Foucault's and Kuhn's philosophy in the history of science have compatibile properties in epistemological changes when understanding the transformation of the sciences. Though Foucault mentions slightly the physical sciences, his philosophy stems on a "humanistic" picture of the sciences through techniques and knowledge investigated from his earlier works to build a model of what the history of science constitutes.

Foucault's medium

Ian Hacking, in his *Historical Ontology*, stipulated Foucault's ideology of science, in terms that can relate to Kuhn, on the matter that he calls "maturity" in the science. Like an adolescence maturing into adult hood, organic maturity in the science is thrown into light of progressive traits. Hacking's view between the philosophies in the history of science with Foucault and Kuhn, in terms of maturity, which Kuhn understands science as "nonobservable

and theoretical"[6]. Unlike Kuhn, Hacking models Foucault's understanding of the sciences as immature in his philosophy what Hacking calls as the "history of the present". Foucault's model in the "history of the present" illustrates his articulated views on the theories of philosophy into a practical form of technique. Due to the amount of content and little room to elaborate, I will solely concentrate a representative debate on human nature that illustrates Foucault's philosophy in the history of science and where he lies in the "debate".

I would agree on terms to Hacking stating in Foucault's formation of his philosophy, during the 1960s, which "phenomenology was detested and despised by figures such as Levi-Strauss"[7]. Foucault may have aligned himself as a thinker of structuralism but, in the Foreword to the English edition *The Order of Things*, he stated,

> in France, certain half-witted 'commentators' persist in labeling me a "structuralist". I have been unable to get it into their tiny minds that I have used none of the methods, concepts, or key terms that characterize structural analysis[8].

In line of reasoning, there were some concepts and terms used but Foucault's structuralism was on a different level comparing to the anthropologist Claude Levi-Strauss and existentialist Jean-Paul Sartre. Where Foucault's philosophy lies come from an archeology of knowledge/science between the crux on Sartre's freedom in existentialism and Levi-Strauss's structural anthropology. Examining slightly to what their philosophies exemplified can help further elaborate Foucault's defense on his "structuralism".

Sartre's freedom

Sartre and Levi-Strauss did not have a face-to-face debate similar to Foucault and Noam Chomsky's debate in 1971 on human nature. The differences in Sartre and Levi-Strauss' philosophies were pointed out by Levi-Strauss in his last chapter, *The Savage Mind*. To understand what Levi-Strauss disregarded in Sartre's system, I will elaborate the headings of Sartre's philosophy concerning the individual's place within the world, environment, and history.

The concern is the individual's place in history and what needs were to be fulfilled and justified as beauteous in nature. Sartre's philosophy is founded through his existentialism concerning the maxim, like Kant's categorical imperative, "existence precedes essence". Kant's question in attribution to God's position was Sartre's solution through his existentialism away from Kierkegaard's and Jasper's notion of essence and angst. To Sartre, an individual's existence, overcoming angst and despair, was liberated against humanity's definition on what makes a person a person. Sartre's philosophy was to define the individual through one's liberation in everyday life-activity to thinking, working, talking and to the extent on living by passing the inevitable despair and then to suicide. This marked one phase of Sartre's philosophy from his work in *Being and Nothingness* and would proceed to his next phase in modern French philosophy.

The extent of Marxist thought influenced Sartre's thinking in contribution of the individual's place in society when alienation settles in existentialism and what it meant for him. Like *Being and Nothingness*, Sartre saw the *Critique of Dialectical Reasoning* as his superb formation of French thought setting in the 1960s. The purpose was to combine Sartre's notion of

freedom, the individual's place, to Marxist interpretation to the Hegelian notion of history, the nature of the dialectic; the dialectic as whole-part symbiosis or the thesis-antithesis-synthesis matrix. Sartre defines the nature of history with the dialectics, as representatives, in totality and totalization. To the former, Sartre defines totality as

> as a being which, while radically distinct from the sum of its parts, is present in its entirety, in one form or another, in each of these parts, and which relates to itself either through its relation to one or more of its parts or through its relation to the relations between all or some of them[9].

The notion of totality is constructed within the being or individual itself. To the latter, totalization adds the practico-inert self of doing which "relates the whole to itself through the mediation of its parts"[10]. Totalization, to Sartre, is the major concern to the individual's place in history. Sartre views the problem that history, practically nature at some point, alienates the individual which the individual disappears from historical categorization on practicality, groups and communities[11]. Philosophically, the problem centralizes on consciousness.

From Butterfield's construction of Whig history, history contains within its system of the past viewed as present that links to the perceptions of the individual's consciousness. For Sartre, the totalization of history makes the individual, in-itself as a person, as a remnant past or fading memory[12]. Sartre's concern may seem too absurd or drastic but it serves a lining within the debate on human nature in accordance to Levi-Strauss' means.

Levi-Strauss' structural anthropology

Unlike Sartre's concerns through the ends of philosophy, Levi-Strauss turns away French philosophy and cross into the domains of anthropology. In Levi-Strauss' *The Savage Mind*, he argues against Sartre's notion of the individual through the means by cultural context of the barbaric individual. This notion imposes Sartre' philosophy of man preceding "civilized" man in Parisian culture versus the barbaric man in indigenous culture. The whole work is to equalize human beings as companions sharing the globe as well sharing the same consciousness within different cultures. Though geographic location, ecology, and hygiene are regionally different through the temporal plane of the individual's mind, Levi-Strauss argues in accordance with the concept of kinship.

Like in Western culture stemming from Sophocles' *Oedipus Rex* and finally into Freud's psychoanalysis, barbaric individuals show similar signs and system to take the prerogatives in avoiding crimes of incest. There are totems to illustrate accuracy in the barbaric mindset however Levi-Strauss disapproves the conventional classification within modern anthropology and takes the comparison of the western mind set in the emerging fields of botany and zoology. Levi-Strauss' concept on the barbaric consciousness calls into order a civilized mind where natural philosophy distinguishes magic from science. To Levi-Strauss, magic "postulates a complete and all-embracing determinism" and science is, "based on a distinction between levels: only some of these forms admit determinism; on others the same forms of determinism are not to apply"[13].

The forms of knowledge imbedded on barbaric individuals are just the same as individuals in civilized societies and are just different in comparison of methodologies that are practice. Levi-Strauss further this idea into the types of individuals who practice like an engineer does or what individuals practice as bricolage; the latter has no definitive equivalence in English only the meaning in which compares to "do-it-yourselves" motto. Civilized individuals postulate theorems or axioms like Euclid's *Elements* in geometry and implements them in practicality while barbaric individuals work in accordance to what nature designates itself interpretive to fellow individuals; not a calling or shamanic practice in pursuits of knowledge but classification to distinguish nature as an ordered or chaotic entity.

To Levi-Strauss, the bricolage individual "does not subordinate each of them [, things,] to the availability of raw materials and tools conceived and procured for the purpose of things project"[14]. This elimination of a project would have bothered Sartre's philosophy concerning totalities and totalization. In chapter eight, "History and Dialectic", Levi-Strauss borrows Sartre's terminology to point the ridiculousness that Sartre himself allowed in his systematic thought concerning the individual's place in history. To Sartre, he uses the terms diachronic, human-depth of existentialism in history, and synchrony, the ensemble of the present[15], to elaborate the totalization of history that can erase the individual's place in history. For Sartre, the dialectic "is not the culmination of history; it can only exist as the original movement of totalisation"[16]. Synchrony is only brought through the praxis, the inherent practice-inert force, which constitutes and reconstitutes itself in history; this in itself forms dialectic and analytic reason.

Along Sartre's lines, Levi-Strauss found it hard to believe in what Sartre's dialectic of history produces the dialectic and analytic reason. Levi-Strauss states, "the work entitled *Critique de la raison dialectique* is the result of the author's exercise of his own analytical reason: he defines, distinguishes, classifies and opposes"[17] as well to the difficulty presented that both dialectic and analytic reason are "defined by mutually exclusive characteristics"[18]. Levi-Strauss finds his contradiction with the matter to save Sartre's method in combining existentialism to Marxist-Hegelian nature of history. Levi-Strauss imposes his method into the nature of the individual and history on human nature as sharing a structure. Levi-Strauss' anthropological structuralism differs from Saussure's structuralism, in signs and signifiers, and Boas' anthropology to solidify an ideology on human nature in constituting familiar structures across the globe, culture and habit of fellow human beings. Levi-Strauss does not concentrate on freedom and its liberation but the similitude of human beings sharing the same origins or mythologies in civilized and barbaric societies. There is no liberation but a communal understanding of humans sharing the same consciousness but different standards.

Foucault's philosophy in the history of science

Like a political spectrum between Sartre and Levi-Strauss, the former represents the left and the latter as the right: Sartre's philosophy represents freedom while Levi-Strauss' represents equality. Obviously putting these perspectives into practice presents issues as impratical in political context. Give for instance on the matters that political ideologies do not suit their political parties for political ideologies vary on the spectrum pertaining to the individual's or community's interest in practice.

What Butterfield seeks is for the historian, through this political spectrum, as a medium between liberation (Sartre) and equality (Levi-Strauss); the medium would be Foucault. Foucault, I would like to believe, is the medium between the philosophies of Sartre and Levi-Strauss on the nature of human beings and their place within history. Foucault's philosophy in the history of science distributes evenly yet perplexingly in writing between Sartre and Levi-Strauss.

Foucault's biological sciences

As stated before, Foucault's view of the sciences rely on a biological or humanistic level of analysis which created his system of philosophy. Convoluted on what Foucault argues in his philosophy, his thoughts can easily be divided in two such categories: archeology and genealogy. The former category tracks on his monographs from *Madness & Civilization* to *The Order of Things* while the latter tracks *Discipline & Punishment* and *The History of Sexuality*. The analysis of Foucault's history of sciences imbeds itself with the history of madness, psychology, psychiatry, clinical medicine and the human sciences.

Hacking points to Foucault's immature science stemming from a focal point in his career surrounding what Foucault concentrated on, particularly to Hacking's historical ontology, the three axes[19]: knowledge, power and ethics. For simplicity sake, Foucault's philosophy of knowledge, in relation to power and ethics, was first conceived through his investigations on madness in the western world. In *Madness & Civilization,* Foucault investigated institutional reforms, techniques and confinement centralizing the identified subjects as "insane". Whether one was indeed insane or not, there was no implication to physicians or neurologist in ethical

standards but only the dire consequences in the medical train of thought which ebbed easily in "practicing" treatment. Of course Foucault identified power in confinement and social boundaries where so-called reason was attributed in society yet the underlying assumption settles through the usage of knowledge.

In chapter six of *Madness & Civilization*, Foucault devotes philosophic analysis through the ground work of medical treatment and techniques which at first became the standard deviation to "good" practice but unfortunately became abused within the system or model as time progresses from the initial standpoint. In curing madness, Foucault elaborates the moral therapeutics as consolidation, immersion, purification and regulation of movement. In regulation of movement, madness is identified as not only the obstruction of the bodily humors but as well as "the irregular agitation of the spirits, the disordered movements of fibers and ideas"[20]. The cure of madness in this technique is a simple regiment, prescribed from the physician, in walking, running, horse riding or voyaging across plains, mountains, valleys, meadows, etc. The purpose of this technique is liberation of the patient to exercise the will in regulation onto the body within itself.

However, Foucault "twists" the perception to demonstrate in which one form of knowledge can sustain that ideology then another ideology can "transcend" or replace it. The physician's surrounding of the asylum produces what is contributed as a mechanistic form in the regulation of movement without the patient moving: the rotary machine. This mechanism was to leave the patient in bed without every moving in which nature as a scenic portrayal was "viewed" in an artificial screening where the bed rotates on its axis like a merry-go-round. There

indeed was a transition for the better in one form but not to the individual's sake; Sartre would take consideration in the moral therapeutic of regulation. Foucault's archeology phase began in psychological evaluation of the patient continuing through *The Birth of the Clinic*.

A sequel in his history of science, Foucault's extends psychiatric medical analysis to clinical medical analysis between doctor and patient. The relation of doctor and patient emphasizes the importance of communication grounding the archeological story which was about "the creation of a self-constituting class of experts located within a new knowledge"[21]. This new knowledge was the creation of the professional physician in the eighteenth and nineteenth centuries centering the pathological anatomy of patients and the nosological scheme on diagnosing pathogens. What constitutes these dramatic changes is termed by Foucault as the "medical gaze" where the physician "plunges into the space that it has given itself to the task traversing"[22]. By space, Foucault details the analysis of the physician's mind which sees the patient's body spreading

> before it, horizontally and vertically in graded depth, as it penetrates into the body;…disease…is a set of forms and deformations, figures, and accidents and of displaced, destroyed, or modified elements bound together in sequence according to a geography that can be followed step by step. It is no longer a pathological species inserting itself into the body wherever possible; it is the body itself that has become ill[23].

What constitutes the medical gazes observes the patient as a set of organs rather than a being suffering pathological disorders.

To Hacking, Foucault "does not aim at such a history of who said what and why, but a story about the web of specific sentences that were uttered, and a theory… of what made it

possible for those sentences to be uttered"[24]. Foucault's genius with developing his philosophy in the history of science can be extrapolated on the context of discourse with words, meanings and "things" that detail the forms of knowledge from nature in context to man; this proceeds to his next major work in *The Order of Things*.

The Order of Things

What Foucault followed in procedure through his philosophy comes from the thoughts earlier illustrated in Sartre's and Levi-Strauss' philosophy in human nature and their place in history. Foucault's earlier work in archeology stratifies concepts and themes prevailing in his philosophy concerned in the medical/biological form of knowledge and try to condense them down into a reliable form in which the sciences form into the human sciences. What gave Foucault a fascination into the philosophical and historical interests was the fact that "he was adept at reorganizing past events in order to rethink the past"[25]. Sustainable forms of knowledge to Foucault were reliable to those who can utilize them in everyday activity from communication, work and basic living.

Foucault's philosophy in the history of science traces epistemological breaks what he refers to the classical age of knowledge from the sixteenth to eighteen centuries that articulate the sciences emerging in biology, economics and linguistics. Foucault's concept in life, labor and language are formed from these sciences after the nineteenth century reconstituting the knowledge that can perplex the historians of science on how these sciences transformed through history. The inquiry expounded is not easily at first grasped due to the content in which Hacking states, "these sciences have objects that don't correspond with or map onto their predecessors of

natural history, the theory of wealth, or general grammar"[26]. In order to preserve the transitional elements in the sciences, there must be predecessors in which knowledge had a limitation to what can be stated in matters relating to its specialized form.

Foucault analyzes biology, economics and linguistic to form bridges but as well gaps from the earlier concepts of natural history, analysis of wealth and general grammar. Though complex, Foucault maps these occurrences within the classical domain which provides a visual representation[27] to his readers on what occurred in that specific point in history. The representation occurs through two diagrams one in seventeenth and eighteenth centuries and the other in the nineteenth century. The former illustrates the four corners situating the elements of articulation, attribution, designation and derivation into a geometric plane, supposing Euclidean projection, onto two activities networking out into continuity of beings and representability of beings. What occurs in the nineteenth century model of knowledge keeps the same structure however a spastic influx occurs where continuity and representation disappears and what emerges through its inverses are the philosophical and epistemological fields. Fields that once never existed now existed due to a transition from the empty gaps from the previous model of the seventeenth and eighteenth centuries. What results into the nineteenth century is an assumption of philosophy in formalization and interpretation versus epistemology as actual forms.

This is not to say that philosophy is useless rather it is a self-reflection on itself which once systematize can reconfigure itself without causal explanation through nature. To picture Foucault's epistemic breaks is to imagine a continuous series on broken lines in which the whole model represents non-continuity. These gaps between broken lines and their aberrations can be

interpreted through the medium of the individual or the individual's place in history in which the notion of power disrupts but as well creates new knowledge; however, the notion of power is not significantly identified as human interactions. To Foucault, history may have no place in the human sciences in which "it may well be that it maintains with them all a relation that is strange, undefined, ineffaceable, and more fundamental than any relation of adjacency in a common space would be"[28]. History first occurred in human memory in primitive times before the creation of the human sciences yet it is the human sciences of anthropology, sociology, and psychology that traverse the web of knowledge giving a purpose. There is inference that history did not need human sciences but inversely the human sciences needed history.

The so-called nature of history in relation back to Sartre's conception relies solely on the individual's place in history however Foucault thinks otherwise. In Foucault's endless transformations, or immature sciences, the individual does have a place in Sartre's model however Foucault emphasis of the individual can be summed up as,

> Man did not exist – anymore than the potency of life, the fecundity of labour, or the historical density of language. He is a recent creature, which the demiurge of knowledge fabricated with its own hands less than two hundred years ago[29].

Such a pronouncement incurs Nietzsche's cry in "God is dead" and becomes a prodigy to Foucault crying "Man is dead". Obviously the two are highly different in humans and gods but what occurs to the mind of Foucault is the interrelated model of human beings within the context of history.

This model installed in his philosophy can be analyzed in the context that through the transformation of the sciences are transitory to the individual's place where knowledge is constantly created just as human beings. There is a slight deviation in which Hacking points out with the correlation between individuals and the totality of knowledge through a question: What are the relations between power and knowledge?[30] Hacking provides two bad answers, (1) knowledge is instrumental to gain ends of power and (2) a new body of knowledge brings new institutions in power. Why they were considered bad gave two contradictions in the ideologies themselves like Russell's paradox in sets and classes: "(1) a ruling class generates an ideology that suits its own interests; and (2) a new ideology, with new values, creates a niche for a new ruling class"[31]. Hence we find, in political and scientific terminologies, a revolution.

What Hacking extends to Foucault's immature science is the notion which the sciences are constantly transforming but has no structure at first and if so, like the origins of the universe, there is no focal point of origin. Foucault's philosophy in the history of sciences is an eternal recurrence in which the human sciences "captures" the knowledge of nature and boxes in a corporal or material being in which continuity exists in "that" temporal plane versus an idealized form. It is because of this idealized form does Foucault structure a geometrical plane of knowledge as well as the planes intersecting in formation. To Foucault, the modern episteme, form of knowledge, begins in the first plane of mathematization to the empirical sciences, then converse to the second plane of the human sciences. With Foucault,

> the first two dimensions together define a common plane: that which can appear, according to the direction in which one traverses it, as a field of application of

> mathematics to these empirical sciences, or as a domain of the mathematicizable [, or geometrization,] in linguistics, biology and economics[32].

Once these two planes are solely combined then can the third geometrical plane of knowledge intercedes with philosophical reflection. When philosophical reflection institutes itself in this geometrical plane of knowledge can one then say that "those regional ontologies which attempt to define what life, labour, and language are in their own being" and "the mathematical disciplines combine to define another common plane: that of the formalization of thought"[33]. This now completes a model that is founded by mathematical-physical spaces that when converged through geometric planes transcends to the human sciences in connection to geometrical reasoning or philosophical reflection.

Foucault's philosophy in the history of science is at the pivotal point to say in conjunction to Kuhn's philosophy in the history of science in which compatibility is at hand. Though they are two different in context of their sciences it is rather a necessity to impose the obligation which the two philosophers have more in common in what method of philosophy describes "these" sciences.

Kuhn's philosophy in the history of science

Though Hacking does not find compatibility in their sciences, I would like to view the contrary that there can be something in their philosophies. Previously described, what makes them incompatible, according to Hacking, demonstrates the accuracy on the maturity level exemplified through their philosophical systems: Foucault's science is immature while Kuhn's science is mature. For Foucault, *The Order of Things* is "philosophical because it portrays a

theory of knowledge, in both theoretical and practical terms" while Kuhn's *The Structure of Scientific Revolutions* "tended to be nonobservable and theoretical"[34].

Kuhn's philosophy opposes Foucault's in non-observation which the physical sciences have taken yet there is the second half on doing science through experimentation or its practicality; this maintains his view with the philosophy of the history of science. Kuhn's notion on the sciences is based on the scientific revolution in which he dealt with earlier in his *Copernican Revolution. The Structure of Scientific Revolutions* examines not one particular science that Copernicus innovated but a series of revolutions with a set of disciplines, scientists and "rules" that play in dealing the stature of what he calls "normal" science. On the nature of "normal science", there is the overall structure in which it starts and "end":

> "Normal" science is the rule, and this comes down to the quiet and successive resolution of remaining puzzles after the revolution has led to the establishment of a fresh "paradigm" – a set of principles and modus operandi accepted as valid, for the time being, by the community of scientists organized around the paradigm[35].

Cataclysmically, what fail in his philosophy in the history of science is his notions on paradigms and their shifts.

Paradigms and paradigm shifts

In the introductory essay to the fiftieth anniversary edition, Hacking points that Kuhn himself and the popular usage misappropriated the meaning to an entirely different concept of paradigms in them. Before Kuhn's usage, ancient antiquity verbalized paradigms as deductive or analogical[36]. Hacking illustrates Aristotle's notion in the situation with Athens and Sparta:

"Should Athens go to war with its neighbor Thebes? No. It was evil of Thebes to make war on its neighbor Phocis. Any Athenian audience would agree; [hence] it is a paradigm"[37]. Paradigms meant in this context as contradictory meanings which form an argumentative substance that points to one who should not do what one proposes in its significance; ancient politicians and statesmen have used paradigms to further their context that does not control the populace by mere rhetorical skills but the shift in meaning that can either take a good or bad turn.

In relation to Kuhn, he does not take paradigms as a set of self-evident rules when applying them to practice science. To Kuhn, practical science delineates away from theoretical or non-observable science in his notion of normal science. Normal science is divided by two components in a scientific community[38]: the previous competing models and the problems to be rectified within the community. Normal science is a way of doing science within the norm and its social contexts pertaining to those who practice science or know about them. To Kuhn, these scientific models and their problems are like players trying to solve a puzzle: there is an *a priori* of the model but the individual has to piece it together to make the picture work out to their advantage. In this case, the advantage relies solely on the scientist in their particular community or specialization.

Through training and rigorous application can the scientist figure or reconfigure past models in conjunction to "new" models to explain their paradigm shifts. What Kuhn uses as these paradigm shifts can be explained like "rules" in language or psychological association. To the former, the scientist reconfigures inherently on the "rules" of doing science which systematizes, like Foucault's order, an order pertaining to these paradigms that Kuhn associates

with Wittgenstein's usage on words. Kuhn examines Wittgenstein's philosophy on words and their associations to meaning through ostentation like: what applies to "terms like 'chair', or 'leaf', or 'game' unequivocally and without provoking argument"? [39] In other words, what gives meaning by association? Kuhn answers that "we must…grasp some set of attributions that all games and that only games have in common"[40]. There must be correspondence on what must be spoken to retain meaning behind something as real as the sun is the center of our solar system, 2+2=4, or the earth is spherical in shape through a vacuum of empty space. Kuhn points, in Wittgenstein's idea, that there are no "set of characteristics" rather one sees a "family resemblance"[41]; there are such resemblances that overlap one another on what primarily constituted.

The second sets on psychological terms used from the first used in rules on communal or professional aspects to the scientist; this becomes Kuhn's gestalt switch theory on doing science. Kuhn utilized the *weltanschauung* philosophy concerning the individual's place in the world while perceiving certain objects in nature. In normal science,

> the transition from a paradigm in crisis to a new one from which a new tradition of normal science can emerge is far from a cumulate process…; During the transition period there will be a large but never complete overlap between problems that can be solved by the old and by the new paradigm[42].

Unlike Foucault's broken lines, there are no gaps but impositions of gaps during this transitional phase from old to new models of paradigms.

This shift from the scientist or anthropological view now becomes Kuhn's gestalt switch when he agreed to Butterfield's thought that reorientation is like "picking up the other end of the

stick" and "handling the same bundle of data as before, but placing them in a new system of relation with one another by giving them a different framework"[43]. Kuhn attributes this different framework to the scientist practicing normal science as "a change in visual gestalt: the marks on paper that were first seen as a bird are now seen as an antelope, or vice versa. That parallel can be misleading. Scientist do not see something as something else; instead, they simply see it"[44]. Scientist simply sees and observes to what nature has provided in accordance pre-established to the individual and its place in history. The gestalt switch of a bird to antelope or duck to rabbit, exemplifies a significant transition of the psychological profile of the scientist investigating nature as biological or sociological forces occurring.

Kuhn's paradigms point to two divergences from the rules of language and gestalt switch in the sciences as well as the practicality within the scientific community and possibly the global community. With Kuhn, there are the natural and social sciences that delineate from the initial purpose on what create these scientific revolutions and there structures. Kuhn's normal science through paradigms cross examines in itself within and without these sciences that produces these "revolutions". In practicality of rules in the sciences, "paradigms could determine normal science *without the intervention* of discoverable rules"[45] [my italics]; this in thought turns back onto to the scientist and further in which the human sciences, with complex rules and direction, infiltrates the natural sciences.

How these non-interventions of discoverable rules apply can only be met when Kuhn states, "one is at liberty to suppose that somewhere along the way the scientist has intuitively abstracted rules of the game himself"[46]. This possible line of reasoning in paradigms and the

sciences echoes a shadowing of the individual and one's place in history within Foucault's philosophy in the history of science.

The Foucault-Kuhn shift

Kuhn's evaluations on the sciences and their revolutions relies on the idea of paradigms that fortify within the system that automatically fills the gaps where Foucault's immature science would never resolve rather transform an endless cycle of knowledge. The complexity hidden with Kuhn's paradigm shifts involve the individual and their place in history where the science community retains the individual scale and the paradigm shifts them as nature within itself in history. The complexity implies that "normal science is a single monolithic and unified enterprise" in that solely history determines the sciences as one-sided and, to some extent of the historian, as Whig in nature. Conclusively, Kuhn does not use a Whig approach like Butterfield's determination against Whig history in *The Origins of Modern Science*.

What makes Foucault and Kuhn different becomes apparent like the two-faced Janus and the gestalt switch model the *weltanschauung* through juxtaposing philosophy in the history of science. One never matures yet becomes continuous while the other mature yet could break to an entirely different model. In Hacking's conclusive examination of the two philosophers, there are indeed incompatible forces that drive a wedge between the two and their sciences. However, one system of thought could enhance the epistemic breaks by filling the gaps of Kuhn's paradigm shifts as a line of continuity in the history of science. Transformation, a change of conceptual models that configures geometrical knowledge, spreads in history and philosophy into the

mathematical-physical realm that moves the cosmos from a closed world to infinite universe with Copernicus' to Newton's cosmos.

Notes

[1] See Cohen's *The Scientific Revolution: A Historiographical Inquiry* (Chicago: Chicago University, 1994), pgs. 21-22 and his sections on the Duhem Thesis & Shaping the scientific revolution pgs. 45-88.

[2] Herbert Butterfield, *Origins of Modern Science* (New York: Macmillan, 1957, revised edition), pg.28

[3] Alexandre Koyré, *From the Closed World to Infinite Universe*, pg. 4

[4] Cohen, pgs. 24-39

[5] Thomas Kuhn, *The Structure of Scientific Revolutions*, pg. xliii

[6] Ian Hacking, *Historical Ontology* (Cambridge, MA: Harvard University Press, 2002), pg.87

[7] ibid, pg.78

[8] Michel Foucault, *The Order of Things* (New York: Vintage Books, 1970), pg.xiv

[9] Jean-Paul Sartre, *The Critique of Dialectical Reason* (Paris: Editions Gallimard, 1960), pg.45

[10] ibid, pg.46

[11] ibid, pg.51

[12] ibid, pg.53

[13] Claude Levi-Strauss, *The Savage Mind* (Chicago: The University of Chicago, 1966), pg.11

[14] ibid, pg.17

[15] ibid, pg.55

[16] ibid, pg.56

[17] ibid, pg.345

[18] ibid, pg. 246

[19] Hacking, pg.2

[20] Michel Foucault, *Madness & Civilization* (New York: Vintage Books, 1965), pg.172

[21] Hacking, pg.77

[22] Michel Foucault, *The Birth of the Clinic* (New York: Pantheon Book, 1973), pg.136

[23] ibid.

[24] Hacking, pg.77

[25] ibid, pg.73

[26] ibid, pg.78

[27] Foucault, *The Order of Things*, see diagram pg.201

[28] ibid, pg.367

[29] ibid, pg.308

[30] Hacking, pg.73

[31] ibid.

[32] Foucault, pg.347

[33] ibid.

[34] Hacking, pg.88

[35] Cohen, pg. 124

[36] Kuhn, pg.xix

[37] ibid.

[38] ibid, pg.10

[39] ibid, pg.45

[40] ibid.

[41] ibid.

[42] ibid, pg.85

[43] ibid.

[44] ibid.

[45] ibid, pg.46

[46] ibid, pg.47

CHAPTER THREE: COPERNICUS' INNOVATION

What I call the Foucault-Kuhn shift presents the philosophy in the history of science as a model to illustrate a philosophic concept on transformation. The historical and philosophical concept in this paper is to show an interdisciplinary approach from what I would like to transition from the Foucault's and Kuhn's philosophic concept to the historic content. Their epistemological changes occurs as a result on a transformation from consciousness and environment that Owen Barfield, in his *Saving the Appearances*, approaches the history of science that the "culmination in a system of thought only interests itself in phenomena to the extent that they can be grasped as *independent* of consciousness"[1] [my italics]. Nature and its ideas are grasped by independent variables but some of these ideas are inter-related, historically and philosophically speaking, with one another that forms Koyré's philosophic outlook in the transforming cosmos.

The big picture in investigating the history of science from Copernicus to Newton is the model pertaining to cosmology affecting instrumental means by astronomy, mathematics, and physics. According to Bertrand Russell's *A History of Western Philosophy*, he identifies four prominent scientists[2] who emerged the new picture of modern science and its cosmology from the old picture with Nicholas Copernicus, Johannes Kepler, Galileo Galilei and Isaac Newton. Though I cannot cover all four, two are the main stage while the other two are supporters. The emergence of this cosmological model from a closed world to infinite universe allows a transformation in which all disciplines of science connect each other during this period of

scientific advancement. What makes them intriguing comes with Copernicus' innovation and Newton's synthesis of the cosmos.

The scientific revolution

In the second edition of *The Critique of Pure Reason*, Immanuel Kant styles his transcendental philosophy as a "revolution" in the sciences concerning the matter in which Copernicus took it upon himself. Kant's philosophy was in intuition that would resemble Copernicus' revolution in the sciences; however, Copernicus "assumed that the entire celestial host revolves around the observer, [and] tried to see if he might not have greater success if he made the observer revolve and left the stars at rest"[3]. Kant's initial emphasis of Copernicus begins the awareness on historians of science[4] that *something* did occur through historic evaluations in the scientific revolution from Copernicus' to Newton's time.

The significance that came from their time transitioned into the sciences of Einstein, Bohr, Schrodinger, Planck and Heisenberg which builds a continuous foundation from antiquity to modernity. I start with Copernicus' revolution not a confusion of series to other sciences rather a "plurality…[which] offers an ideal opportunity to discover how and with what effects the concepts of many different fields are woven into a single fabric of thought"[5]. In Kuhn's *Copernican Revolution*, Copernicus' revolutionary text was a matter that "the book gave rise to a revolution that it had scarcely enunciated. It is a revolution-making rather than a revolutionary text"[6]. The text in itself was bent on 'saving the phenomena' through reforming Ptolemy's *Almagest* in Kuhn's emphasis that the "Ptolemaic planetary theory had turned into a 'monster'"[7].

Before Copernicus' cannon, there constitute transformative elements that appear or influence the transformation of cosmology in Copernicus particularly switching from a geo-centric to heliocentric model. Such elements to be investigated are efficient to give a transitional picture into Copernicus' innovation following the ideas coming out of occult science, humanism, scholasticism and cosmology.

Occult science

Edward Rosen raised the question in his article "Was Copernicus a hermeticist?" which divides Copernicus' innovation into two phases: "the first phase consisting of an animistic universe operated by magic, the second phase of a mathematical universe operated by mechanic"[8]. This line of inquiry can be such stated in the matters that Copernicus' influence may have been derived through the hermetic tradition in which he states in chapter 10 of *De revolutionibus*, introduction,

> …the middle of everything is the sun. For in this most beautiful temple, who would place this lamp in another or better position than that from which it can light up the whole thing at the same time? For, the sun is not inappropriately called by some people the lantern of the universe, its mind by others, and its ruler by still others. [Hermes] the Thrice Greatest labels it a visible god, and Sophocles' Electra, the all-seeing[9].

Where did this innovation of a sun-centered universe come from? In Alexandrian times, Aristarchus of Samos first postulated the sun-centered universe however mathematical explanation fell to deaf ears. Copernicus cites, "I found in Cicero that Hicetas supposed the earth to move. Later I also discovered in Plutarch that certain others were of this opinion"[10]. There was also of mention of Pythagoras and his pupil Philolaus into the nature of the cosmos and its

harmonious order. This train of thought comes from the hermetic tradition that significantly influenced, in some way, the transformation of modern science.

This line of questioning first arose through Francis Yates' *Giordano Bruno and the Hermetic Tradition*; most intrinsic around Copernicus' times. The hermetic tradition comes from a corpus account written by the designated yet fictional figure named Hermes Trismegistus; the former named after Hermes, the Greek god of delivery, and the latter named Thoth, "the scribe of the gods and the divinity of wisdom"[11]. The hermetic tradition came into focus that occurred in year before Christ but later historians have shown that the hermetic corpus came after Christ in the fourth century[12].

In the sixteenth century, what scholasticism called natural philosophy had an extended meaning other than theology in which alchemy, astrology, magic and cabalism where imbedded in the studies. Magic was highly sensitive to persecution if used incorrectly but designated as a private practice which only a few knew of its hidden secrets, hence "occult". Heinrich Cornelius Agrippa, a pupil of Johannes Trithemius, composed an account of magic in his youth entitled *Three Books Concerning Occult Philosophy*. To his readers, he addresses the purpose on elucidating the notion of magic against the devilish usage which "a magician doth not amongst leaned men signifie a sorcerer, or one that is superstitious or [devilish]; but a wise man, a priest [and] a prophet"[13]. What is highly sensitive undergoes the matter to take the distinction between what he considers good magic versus evil. The evil classified the practices of charlatans who create the "philosopher's stone" in healing all disease with the thought to transmute any object to

gold and matters of conjuring evil spirits, necromancy, to harm others; the good relates to natural philosophy, or some sense science.

Through the hermetic tradition, Yates investigates leading influences of magic that later transferred into Bruno's thought process on memory, theology and magic. She traces his precursors from Pico, Ficino, Pseudo-Dionysius and Agrippa that demonstrates the Renaissance tradition of its sciences leading into the modernization of the sciences. Yates describes the survey of Agrippa that rely magic in the world through three realms[14]: natural, celestial and ceremonial magic. She states that all three divisions "correspond to the divisions of philosophy into physics, mathematics and theology. Magic alone includes all three"[15]. Mathematics, in a way, resembles magic from a tradition of Pythagoras that accumulates the strata of nature through mathematical means in which gives harmony to the universe. Yates points out, during Agrippa's time, the marvelous constructions of ancient works like columns and pyramids through the sciences of arithmetic, music, geometry, optics, astronomy and mechanics[16].

Through these marvelous inventions and constructions to human civilization, can one say that Copernicus' genius merited directly from the hermetic tradition? According to Yates and Rosen, they answer to the negative. To Rosen, Copernicus' innovation retained "no hermetic-cabalist tradition was dominant in his mind. It was the opposition of Aristotelians and theologians that he feared"[17]. Copernicus had no revolutionary means to overthrow the geocentric view of the earth or enrage the theologians protecting Aristotelian physics in alliance with Catholic doctrine. What became controversy was Bruno's incitement of Copernican doctrine in relation that ties to the hermetic mind in which Yates argues that Bruno was "taking

the Copernican sun as a portent in the sky of the imminent return"[18]. Copernicus is seen more a mathematican's role rather than the hermetic in pre-dating modern science. Copernicus chose simply the heliocentric model that harmonizes the world's system in relation to man in which humanism was a leading factor in this transformation of modern science.

Humanism

When Copernicus cited Cicero and Plutarch inversely they cited the Greeks astronomers and mathematicians, there was an authority of Greco-Roman literature which came into tradition to the Europeans around the Renaissance, circa fifteenth century. The authority of the Greeks and Romans was to "return" back into a golden age, before Europe's bubonic plague, leading to its recovery simultaneously as Constantinople fell to the Turks in 1453. Marie Boas, in *The Scientific Renaissance*, stated that "one of the strangely persistent myth of history is that the humanist study of Greek works began with the arrival in Italy in 1453 of learned refugees from Constantinople…laden with rare manuscripts"[19]. There is some accuracy to her statement on translation and transmission of Greek texts but it will show later that there were phases of transmission that came in Europe dating back to medieval times. The purpose is to evaluate the idea of humanism and what it stands for.

George Sarton was influenced[20] by this ideology of the Renaissance humanism in which he tried to combine with the emerging field in the history of science. With that in mind, what is humanism and what did it mean in Copernicus' time? Yates illustrates two definitive definitions to what constitutes humanism: Latin humanism and Pico's humanism. The former runs as the initial point in which Cicero's letters were re-discovered by Petrarch. The rediscovery of the

Roman politician "reached a stage of sophistication *before* the next great experience of the Renaissance"[21] than the Greek texts of Constantinople. After the Crusades and bubonic plague, Europe needed to re-establish Roman identity throughout Italy, Petrarch's domain, in which Cicero became the model of a "gentleman" figure to Europeans. Humanism was a response into recreating Cicero's ideal of a "republic", predominately in Italy, and the literary and historical studies which Cicero wrote to produce the elegant language of Latin[22]; hence the "humanist" tradition in Latin.

The latter version of humanism stems from Pico's mixture of cabalism and magic in the natural world surrounding the individual. Pico's version of humanism, in *The Oration and Dignity of Man*, relies that the individual is the center of the universe and is "the intermediary between creatures, which he is familiar of the gods above him as he is lord of the things beneath him"[23]. His reasoning came from cabalistic interpretation of nature that used the sacred language of the Hebrews rather than the ancestors of the Romans. Pico's humanism co-inflicted to Petrarch's and Erasmus' humanism which creates the tradition of humanism of Christian Europe that shadows the universe in an orderly fashion of the individual and one's place in history.

The idea of order in both a magic-religious and political-religious tradition can be explained in psychological terms on why humanist tradition went against itself through the magical qualities. In psychological terms, Kuhn dates the mystical meaning of man's place in the universe as a two-centered universe to the primitive mind. The two centered universe is the micro and macro cosmic orders that re-align cosmology as a theater in which the stage surrounds

man's daily activities and those activities by the Gods[24]. In relation to astronomy and cosmology, he states,

> by explaining the physical relationship between man's habitat and the rest of nature, they integrate the universe for man and make him feel at home in it. Man does not exist for long without inventing a cosmology because a cosmology can provide him a world-view which permeates and gives meaning to his action, practical and spiritual[25].

In Humanism, the author of the text, spiritual or mathematical, was to confirm back to man's place "without scribal errors and the restoration of doubtful passage"[26]. This line of confirmation to the humanist holds similar yet different boundaries concerning the scholastic tradition.

Scholasticism

Scholasticism was the practical boundaries to theologians on interpretation of God's agency and the world in which God created. Stated before, Scholastics had three trends, with the translations, that created the antagonism of Aristotelian authority. The transition[27] of knowledge starts from Boethius' and Macrobius' translations of Greek and Roman texts; the high Middle Ages admitting Arabic commentators and translations of Aristotle; finally, there are the translations re-interpreting and organizing the Greek authorities of Archimedes' mechanics, Galen's anatomy and Ptolemy's mathematics in the Renaissance.

Forming Copernicus' and Newton's background of late Scholasticism[28], there were a change of institutional standards through the education on monasteries. After the Byzantine emperor Justinian closed the doors of Plato's academy, there ended the "pagan" teaching to Christians; however, the transmission of knowledge like wealth never ends. Before the formation

of the universities in the high middles, monasteries structured the teachings of Christ and the natural world that human beings inhabited. An exemplar found in monasteries was the teachings and experiences of St. Anthony and his temptations from the devil in which he received salvation living the life of a hermit. The purpose was to rejuvenate a new order of saintly hood which continued with St. Benedict's firm rule of monastic life and the retrieval of lost information before the Roman Empire broke away from the barbarian invasion.

Russell demonstrates the matter that "in later centuries, monks served many purposes: they were skilled agriculturists, and some of them kept alive or revived learning"[29]. However, in the beginning, "most monks did not work, never read anything except what religion prescribed, and conceived virtue in an entirely negative manner, as abstention from sin, especially the sins of the flesh"[30]. In some way was Petrarch right in describing those times as the "dark" ages yet there had to be some light in that darkness to transpire. During the Crusades, a defense of Catholic faith or identity leads the revival of western learning but with the support of their enemies. Regardless of war, there are constant cycles of trades that not only dealt in monetary but knowledge factors in crisis.

What created Scholasticism were, ironically, the three faiths that went against spiritual doctrine: Judaism, Christianity and Islam. Each faith represented were the philosophers Maimonides, Thomas Aquinas and Averroes in which tried to combine Aristotelian philosophy, reason, into the sacred scripture, faith. Averroes strenuously built the works, Maimonides found compatibility of such harmony on religion and philosophy, and Aquinas succeeded after the tribulations formed around the Parisian decree of 1277 which discredited Averroes influence and

the pagan Aristotle. Around the late Middle Ages, Aquinas system of faith and philosophy helped Dante support the Thomistic picture through his adventures in *The Divine Comedy*. Dante's illustrated how close the celestial and "deadly" realms closed into man's material view in the intermediary planes that separates them. The individual is composed within one's realm as material and spiritual like Aristotle's philosophy. On the matter of the individual's place, Kuhn, describes Dante's allegory that,

> Man lives in squalor and uncertainty, and he is very close to hell. But his central location is strategic, for he is everywhere under the eye of God. Both man's double nature and his intermediate position enforce the choice from which the drama of Christianity is compounded. He may follow his corporeal, earthly nature down to its natural place at the corrupt center, or he may follow his soul upward through the successively more spiritual spheres until he reaches God[31].

The Scholastic picture of theology painted the universe as synchronic from Aristotelian-Ptolemaic universe to matters of faith and philosophy where the individual resides in a geocentric model of the world instead of questioning matter of 'appearances'.

Cosmology in Copernicus

In the forward to Copernicus' *De revolutionibus orbium coelestium,* Osiander writes the following on behalf of Copernicus to illustrate his "hypothesis" concerning the heavens in due not to contradict sacred scripture. Osiander furthers in his opinion when he states the matter on the astronomer's part:

> For it is the duty of an astronomer to compose the history of the celestial motions through careful and expert study. Then he must conceive and devise the causes of these motions

> or hypotheses about them. Since he cannot in any way attain to the true causes, he will adopt whatever suppositions enable the motions to be computed correctly from the principles of geometry for the future as well as for the past[32].

Osiander concludes that Copernicus only held the heliocentric system of the universe as a hypothesis least "he accept as the truth ideas conceived for another purpose, and depart from this study a greater fool than when he entered it"[33]. The problem that would later fall in line in Copernican doctrine continued a tradition in the study of cosmology with "saving the appearances/phenomena".

In Plato's *Timaeus* and Aristotle's *De caelo,* both philosophers painted an opposing theory and practice to the physicist/astronomer concerning the nature of the two-sphere universe or heavens. C.S. Lewis regards this situation when concerning the sciences from antiquity in conformity to modernity that "a scientific theory must 'save' or 'preserve' the appearances, the phenomena…"[34]. What concerns the cosmos could be for example,

> your phenomena are luminous points in the night sky which exhibit such and such movements in relation to one another and in relation to an observer at a particular point, or various chosen points, on the surface of the earth[35].

By "your phenomena", there resides on the traditional cosmos in which the individual resides in the universe where the earth is the center of all creation in relation to individual faith concerning the importance. Opposite to physical phenomena, "your astronomical theory will be a supposal such that, if it were true, the apparent motions from the point or points of observation would be those you have actually observed. The theory will then have 'got in' or 'saved' the appearances"[36]. Lewis' contemporary, Barfield, pointed that Plato made distinction to knowledge

of the heavenly universe in which geometry, the individual's instrument, is the bastard between pure-intelligence and sense knowledge[37]. The astronomical level intermingles with observation, calculation of celestial objects and the divine truth in all the cosmos[38] which early humanity have relied through the millennia in religious ceremonies, navigation and speculation.

Copernicus worked within an ancient/medieval tradition of the cosmos that defined the earth as the center of all virtues and actions in which the individuals resided within God's creation of the universe. Such philosophers like Plato, Aristotle, Simplicus, Pseudo-Dionysius and St. Thomas Aquinas built the frame or model of the cosmos where the planets are align in accordance from the furthest heavens, fixed stars, Saturn, Jupiter, Mars, the Sun, Venus, Mercury, and the moon, to earth. The celestial sphere are aligned in regards to the common individuals that views the sun rising from the east and setting in the west. Those who perturb further can unveil the "secrets" of the universe in which such occurrences happens to the Earth's seasons, equinoxes, lunar and solar eclipses, and the orbits of Mercury and Venus.

Astronomical inquiries do observes a physical phenomenon in place as well as mathematical calculations observant to the viewer. The earlier mathematicians Philolaus, Eudoxus, Hipparchus, and Apollonius, structured the heaven through mathematical formulas that operated the mechanics in homocentric circles, epicycles, deferent and eccentrics. Like Newton, Ptolemy synthesized through his *Mathematical Syntax*, or *Almagest*, the operative functions of the planets in appearances and mathematical precisions. The "saving appearances" issued accumulated Ptolemaic astronomy when Ptolemy explained the retrograde motion of planets like

Mars in which regression is apparent to the observer and implement a rigorous model of epicycles that later turned into a “monster” venture where the Cosmos is in discord.

One section of Foucault’s *The Order of Things* views the world Copernicus’ time from the notion of resemblance in four axes: convention, emulation, analogy and sympathy versus antipathy. The forces that bind the world also bind the axis in which,

> the whole volume of the world, all the adjacencies of 'convenience', all the echoes of emulation, all the linkages of analogy, are supported, maintained, and doubled by this space governed by sympathy and antipathy, which are ceaselessly drawing things together and holding them apart[39].

The sixteenth century knowledge, or episteme, of Copernicus was at an ends and what came after would transform into a “new” area of discipline and knowledge gathering from the gaps from the previous generation. However said, Copernicus’ innovation was not an ends to means rather a means to an end on a notorious debate in cosmology, mathematics, theology and physical sciences.

De revolutionibus

Copernicus model of heliocentricity was discussed prior to the compilation on *De revolutionibus* in a small treaty passed to his peers written in the *Commentariolus* in which he states the significance of the heavens and their misrepresentation that,

> I have often considered whether there could perhaps be found a more reasonable arrangement of circles, from which every apparent inequality would be derived and in which everything would move uniformly about its proper center, as a rule of absolute motion requires[40].

After identifying the problem, Copernicus lists six assumptions on proposing a heliocentric model in replacement of Ptolemy's geocentric model. Three of the seven listed[41], to give a sense on what he thought, Copernicus examines that (1) there is no one center of all of the celestial circles or spheres; (2) The center of the earth is not the center of the universe, but only of gravity and of the lunar sphere; and (3) All the spheres (planets) revolve about the sun as their midpoint, and therefore the sun is the center of the universe. Copernicus treated these assumptions as axioms that Euclid authorized in his *Elements* and wouldn't consider the plausibility of self-evident truths in nature which supposes what Osiander considers them merely hypothesis; however, Copernicus structured the heavens based on these axioms to calculate the mathematical precisions concerning epicycles and eccentrics.

Though Copernicus' innovation came into context with a heliocentric model, he calculated the heavens through geometric and trigonometric methods on epicycles and eccentric. Much of Copernicus' mathematics relies on Ptolemaic methods in which "it [*De revolutionibus*] was mathematical planetary astronomy, not cosmology or philosophy, that Copernicus found monstrous, and it was the reform of mathematical astronomy that alone compelled him to move the earth"[42]. Accordingly Copernicus' continued an improved tradition of Ptolemaic mathematics which leads to his creative accounts of heliocentricity. The fabrications of his perfectly circulated spheres were reasons, like his ancient Greek predecessors, based on Earth's position. Copernicus, in chapter one, exclaims the spherical universe

> …is spherical. The reason is either that, of all forms, the sphere is the most perfect, needing no joint and being a complete whole, which can be neither increased nor diminished; or that it is the most capacious of figures, best suited to enclose and retain all

> things; or even that all the separate parts of the universe, I mean the sun, moon, planets and stars, are seen to be of this shape; or that wholes strive to be circumscribed by this boundary, as is apparent in drops of water and other fluid bodies when they seek to be self-contained[43].

In relation to bodies of water, Copernicus included the pre-supposition of Earth being spherical. Through determination of the physical universe Copernicus conclude the relation of macro-micro perspective harmoniously mathematical to the observer.

His model is such that "the major irregularities of the planetary motions are only apparent"[44]. The appearances in this case relies the problems of retrograde motion which Copernicus task is to not only "save the appearances" but as well reduced the intricate system built up through numerous mathematical calculation after Ptolemy. The view that Copernicus reduced "the total number or circles (deferents and epicycles) to thirty-four instead of the seventy-seven required in the geocentric theory"[45] is highly probable when pointed out by Koestler. In *The Sleepwalkers*, Koestler argued that the *Commentary* had less than forty (approximately 34) compared[46] to Ptolemy's original calculation and that Copernicus in fact had 48. Koestler stated that "contrary to popular and even academic belief, Copernicus did not reduce the number of circles, but increased them"[47]. Why was this mistaken? He pointed that mathematicians and astronomers did not take Copernicus work seriously even Galileo did not read it, yet used Copernican doctrine to justify his theory on tides and the making of Copernican doctrine.

Not only innovations began accurate as seen by Copernicus model of the universe. He worked within a closed circuit of the ancient world where astronomers, mathematicians and

physicists have not seen or believed the physical ultimate truth rather a metaphysical one. Copernicus still believed an invisible geocentric model of mathematical hypothesis and inserted it with a heliocentric approach. With reason, is the probable cause to increase the epicycles from 40 to 48 which Koestler argued Copernicus had to compensate the abolition of equants, imaginary fluctuations, the constant angle of Earth's axis and the rectilinear oscillations[48]. Copernicus not only stumble mathematical precision but as well physical theories of heavenly motions concerning stellar parallax and the infinitesimal corporeal atoms resonating beyond the planets motions around the sun; he recognized the fixed stars but only in the harmonious medieval framework. Mathematical precision would be taken by Johannes Kepler in his transformative fixture of the cosmos both "physical and metaphysical" truth.

Copernican doctrine and its effects

Previously stated, Copernicus' major corpus was only a revolution-making influence rather revolutionary text in which barely anyone significantly read. Copernicus text is only revolutionary in context like that in the book of Ecclesiastes which he was under the same impression that there was "nothing new under the sun". Copernicus's paradox in keeping tradition allowed a "system…which had profound revolutionary implications were to become apparent"[49]. Another tribute to Copernicus tells that,

> never…has such a conservative and quiet thinker had such an upsetting effect upon men's minds and souls; but seldom has such a conservative thinker been, even inadvertently, so bold in accepting the improbable[50].

Mathematics was the key to unlock one portion of the heaven that Copernicus calculated to Newton's complete system underlying Copernicus' innovation. Newton's "mechanical" system of mathematics in natural philosophy is just the top of the totem pole in the sciences where Copernicus represents the foundations in which the highest doesn't without the lowest.

Though Copernican became fundamental in building modern sciences was he also controversial in expounding unorthodox beliefs that undermined ancient tradition from Aristotelian philosophy influenced in Christian doctrine. To challenge Aristotle was to challenge the Church; in no way were Copernicus and Galileo set to challenge Ecclesial authority rather the physical foundations. There was not such matters as faith versus reason in the sciences for it became coincidentally aligned to matters that the Church faced during the Protestant reformation and the lands becoming usurped by the Protestant Lords; this follows later in the Thirty Years war.

The Copernican doctrine underhanded Aristotelian physics, in scholastic tradition, which explained man's position as the center within the universe and the attack of Catholic doctrine in one passage stated that Joshua commanded the sun to stand still. This divided two groups: those who follow Copernicus and Aristotle. In one sense, those who regarded themselves as Copernicans were "seeking escape from what they regarded as the trammels of scholastic Aristotelianism [which] they turned eagerly to any theory supporting their desire for innovation"[51]. The astronomer and mathematician Johannes Kepler held Copernicus as a desire for innovation in his celestial/religious approach.

Kepler: celestial and "mystical" calculations

On the point as innovators through Copernicus, the historians of science, like Boas, viewed the matter that not all astronomers or mathematicians were invited to Copernican doctrine[52]. Kepler's boss, Tycho Brahe, did not hold the Copernican doctrine lightly. Since the appearance of the new star in the constellation Cassiopeia in 1572, Brahe practiced astronomy, aside from alchemy and astrology, through his equipment at Uraniborg which observed the phenomena[53] of the great comet of 1577. This is not the controversial figure that the heavens displayed in modernity which other societies, China, India, Persia, the Polynesians and Americas, observed the Crab nebulae in 1054 while Christendom Europe was debating the West-East Schism. In the debate on the Copernican doctrine, Brahe rejected the mathematical-physical explanations and tried to reconcile Ptolemaic epicycles to Copernicus system like the Egyptian model with Venus and Mercury's fast orbital acceleration in comparison to mars: the sun's orbit (Copernican model) intersected to the geocentric model (Ptolemaic model)[54]. This approach did not come to fruition.

Bruno's conception on Copernican doctrine was a return of hermetic tradition with Lucretian cosmology of infinitesimal atoms. The speculation was earlier called by Copernicus' inquiry of beyond Saturn's orbit and the distance and size of the immobile sphere. Copernicus observed that atoms are "imperceptible, they do not immediately constitute a visible body when they are taken two or a few at a time. But they can be multiplied to such an extent that in the end there are enough of them to combine in a perceptible magnitude"[55]. This section of Copernicus' inquiry transitioned to Bruno's argument upon the infinity of worlds that Copernicus should have

gone further. Accordingly, Yates argued no incontrovertible evidence in Copernicus' esoteric beliefs but there was a matter of leeway on why Bruno found compatibly with his doctrine.

What really transformed the cosmological model from a closed to infinite universe was argued in conformation to Koestler's view in the history of ideas with Johannes Kepler and his creativity to bring two opposing forces in conjunction. This conjunction of ideas starts on Pythagoras with cross-disciplinary ideas of mysticism, geometry, morality, arithmetic, and music, and ended with the separation on faith and reason domain with Plato and Aristotle[56]. Though there was an interlude on scientific transformation through political, social, and religious mentalities in the Middle Ages, Kepler re-integrated the old cosmology from Pythagoras to mathematicians, astronomers, and physicists in his time. Kepler first began his innovation with his *Mysterium Cosmographicum* which attributed a physical/metaphysical speculation of the cosmos through the geometrization on the planets. In his model[57], Kepler places the Copernican system through the intervals of space filled with the five Pythagorean/Platonic solids on the planets orbits. From outer to inner distance: cube, tetrahedron (triangular pyramid), dodecahedron (twelve pentagons), icosahedrons (twenty equilateral triangles), and the octahedron (eight equilateral triangles). In all would make the mathematic-physical universe of Copernicus' model. However it was not the correct scheme to imagine actual solids between orbits but prompted Kepler's imagination to go further in calculation.

Kepler's view, against Bruno's cosmology, is shown as a religious symbol of the holy trinity[58] within the mathematical order of Copernicus' model; a mystical property in the number three in extension to cubes. Kepler saw order and harmony not found "in the infinite and

therefore perfectly formless – or uniform – universe of Bruno"[59]. His later works *Astronomia Nova* and *Harmonices mundi* produced his famous three laws of celestial motion within the Copernican model. His three laws of motion worked under strenuous and tiresome efforts along his calculations as assistant to Brahe before rigorous frustration on social changes (Thirty Years War and Persecution of mother as a witch). The first two laws dealt on the matters that Copernicus's model was inaccurate of perfect circles instead on its elliptical shapes and mathematical demonstration on the velocity of planetary objects orbiting around the sun. The second law pertains to a creative element found earlier in William Gilbert's *De magnete*. Gilbert's treatise dealt on the properties of loadstone and their occult-like properties of attraction; this gave influence in Kepler's model. In Gilbert's form, there are forces that attract planetary objects coming closer and repelling when going further; this also demonstrates geometric proportions that planetary velocity covers the equal distance of surface area from the stationary sun. However Gilbert's form was concerned with "an animate mysticism which endows the Earth with a living forces, and accounts for physical rotation, and for eternal living perfection"[60]; Kepler was to make the Earth move.

When Kepler made the Earth move by some mystic force, was "the existence of magnetic forces within each planet…explained the mysterious property of gravity"[61]. Now to apply this motion was difficult in itself with other celestial rotation like Mercury, Venus and especially the devil himself: Mars. What makes Kepler seen as the new Pythagoras, in Koestler's eyes, was the innovation found within the third law. The third law was later known to Galileo and Newton's time as the inverse square law that states the mathematical equation that if T, period of revolution of any planet, and D, mean distance from the sun, then the formula is $T^2=kD^3$; where *k*

represents the constant[62]. Such calculation would have been later put together by Newton to solve the puzzle of God's universe seen through mathematical properties able to physicists, astronomers and mathematicians. Kepler's third did not only explain the scientific approach but as well the mystic approach through concept of music. Kepler's belief in the trinity also transpired, in Kepler's life, the Pythagorean purge on what numbers display in nature. In the ancient cosmology, each celestial object resonated a certain sound or oscillated tone as one would pluck the chord, ½, ¼… etc., the vibrations transcend the frequency into a slower to faster speed.

"Living" and "moving" forces

Indeed were Copernicus and Kepler "achieved mathematical simplification and a more harmonious and aesthetically superior theory"[63] however there are merely innovative minds in spectrum of ideas. Koestler writes that

> inside these minds, we find no abrupt break with the past, but a gradual transformation of the symbols of their cosmic experience - from *anima motrix* into *vis motrix*, moving spirit into moving force, mythological imagery into mathematical hieroglyphics - a transformation which never was, and, one hopes, never will be entirely completed[64].

This transformation in the cosmology was not a shaking off of superstition rather a switch in perception and thinking that one sees as a moving spirit and then a moving force in the geometrization of space.

What gave this moving force, in itself a transformation can be seen through the side of *weltanschauung* in mathematics: geometry. Barfield accounts that geometry, when applied to

motion, produces the modern outlook of the machine[65], or the mechanomorphic outlook. This machine is seen through geometry in motion in which "bodies can go on moving indefinitely without an animate or psychic 'mover'"[66]. This line of reasoning now shifts the focus of a closed universe from Copernicus to now the possible infinite world with Newtonian mechanic and the innovations found with experimental philosophy, mechanic spirit itself, and terrestrial motion.

Notes

[1] Owen Barfield, *Saving the Appearances* (Connecticut: Wesleyan University Press, 1965), pg.43

[2] Bertrand Russell, *A History of Western Philosophy* (New York: Simon & Schuster, 1945), pg.535

[3] Immanuel Kant, *Critique of Pure Reason*, pg.110

[4] See Cohen, pg.21, Steven Shapin's *The Scientific Revolution* (Chicago: University of Chicago, 1996) pgs. 1-4 and John Henry's *Scientific Revolution and the Origins of Modern Science* (New York: St. Martin's Press, 1997) pgs. 2-8.

[5] Kuhn, *The Copernican Revolution*, pg.vii

[6] ibid, pg.135

[7] Cohen, pg.269

[8] Edward Rosen, "Was Copernican a hermeticist?" (1970), pg.164

[9] Nicholas Copernicus, *On the Revolutions of the Celestial Spheres*, pg.25

[10] ibid, pg.6

[11] Frances Yates, *Giordano Bruno and the Hermetic Tradition* (Chicago: University of Chicago, 1964), pg.2

[12] ibid.

[13] Heinrich Cornelius Agrippa, *The Occult Philosophy in Three Books*, to the reader

[14] Yates, pg.131

[15] ibid.

[16] ibid, pg.134

[17] Rosen, pg.171

[18] Yates, pg.155

[19] Marie Boas, *The Scientific Renaissance 1450-1620* (New York: Harper & Row Publishers, 1962), pg.24

[20] See his article, "The New Humanism". *Isis*, Vol. 6, No. 1 (1924), pgs. 9-42.

[21] Yates, pg.159

[22] ibid, pg.160

[23] See the first five paragraphs of Pico's treatise

[24] Kuhn, pg.6

[25] ibid.

[26] Boas, pg.25

[27] Cohen, pg.271

[28] See Benjamin Franklin's article "Science by Conceptual Analysis: The Genius of the Late Scholastics*". Studia Neoaristotelica: A Journal of Analytical Scholasticism*. Vol. 9, no. 1, (2012), pgs. 3-24

[29] Russell, pg.377

[30] ibid.

[31] Kuhn, pg.113

[32] Copernicus, pg.3

[33] ibid.

[34] Lewis, pg.14

[35] ibid, pgs.14-15

[36] ibid, pg.15

[37] Barfield, pg.46

[38] ibid, pg.47

[39] Foucault (1966), pg.25

[40] Edward Rosen, *Three Copernican Treatises* (New York: Dover Publication, 1959), pgs.57-58

[41] ibid, pg.58

[42] Kuhn, pg.143

[43] Copernicus, pgs. 9-10

[44] Kuhn, pg.150

[45] Morris Kline, *The Loss of Certainty* (New York: Oxford University Press, 1980), pg. 36

[46] Arthur Koestler, *The Sleepwalkers* (New York: The Macmillan Company, 1959), pgs.579-580; see Appendix

[47] ibid, pg.195

[48] ibid, pg.580

[49] Boas, pg.69

[50] ibid, pgs.69-70

[51] ibid, pg.96

[52] ibid, pg.91

[53] ibid, pgs.110 & 113

[54] See Koestler, pgs. 47-50

[55] Copernicus, pg.16

[56] See Koestler section “Part One: The Heroic Age” and “Part Two: Dark Interlude”, pgs. 19-117

[57] Koestler, pgs.252-253

[58] Koyré, pg.58

[59] ibid.

[60] Boas, pg.121

[61] ibid, pg.302

[62] Kline, pg.38

[63] ibid, pg. 40

[64] Koestler, pg.261-262

[65] Barfield, pg.51

[66] ibid.

CHAPTER FOUR: NEWTON'S SYNTHESIS

What became an innovation to Copernicus through the *De revolutionibus,* also became a primary factor through the rise of modern science in the seventeenth century through a process of mechanomorphic transformation; a transformation moving from a "living" to "moving" force in application to mathematics. From ancient Rome, Caesar reformed the calendar with Sosigenes of Alexandria in accordance to Greek mathematics. The result was the Julian calendar, a calendar whose purpose was to "correctly" align ceremonial, political and religious dates to the Roman people. The error that accumulated, after the fall of the Roman Empire, were mathematic precisions of the earth's alignment in the system by the moon's and sun's orbits.

There also included a transformation of not only to "save the appearance", in a physical sense, but as well the instrumental usage pertaining to numbers. In Latin Christendom, Europeans used the Roman numeral symbols I, V, X, L, C, and M, to designate the meaning of calculations and it changed, during the Crusades, when Italian merchants had an interest of trade with the Islamic empire at the time[1]. The offshoot was Leonardo of Pisa's contribution on the Hindu-Arabic numerals[2]. This system of algorithms combated the traditional abacus which Durant stated that,

> only a few mathematicians realized that the new symbols, the zero, and the decimal alignment of units, tens, hundreds ... opened the way to such developments of mathematics as were almost impossible with the old letter numerals of Greeks, Romans, and Jews[3].

In the end, algorithms of the Hindu-Arabic numeral won out against the abacus[4]; however, mathematicians still relied on abacus systems like calculation charts from the heavens.

Johannes of Sacroboso used Hindu-Arabic numerals within his calculations of the heaven in *On the Sphere of the World*. Along with this treatise and Copernicus' work did the Catholic Church and mathematicians revised the calendar from Julian to Gregorian calendar in 1582; from the Alfonsine to Putenic tables, Kepler revised further with the Rudolphine tables[5]. Come the seventeenth century, mathematics had evolved in a different spectrum yet relied on old ideas still founded by Euclid, Archimedes and Ptolemy. Mathematicians, physicists and astronomers like Galileo and Newton relied on the refurbished mathematics into new ideas of a mechanomorphic world where mystic forces can now be explained by experimental and cognitive factors in epistemology that followed.

Experimental and empirical philosophy

Agrippa recounted that "good" magic alone interacted through all its realms through natural, celestial and ceremonial magic. In his days, magic was used often to not only construct pyramids or civic building but as well talking statues and flying swans. Magic had a play in developing modern science through its invigoration of theoretical knowledge to applicable areas; however, magic was a hidden element and, in the turn of the seventeenth century, its properties either had to be assimilated or vanquished to develop the conception of "modern" science.

The new experimental philosophy was brought in by Francis Bacon in introduction, *The New Organon*, to his method of logics: induction. To Bacon, his new method was to support a humanitarian vision of reason where "scientist ought to take up an intermediate position, like that of bees, which extracted matter from the flowers and then re-fashioned it by their own efforts"[6]. The scientist was to look fondly on empirical facts on the world, like bees collecting honey to its

colony. Bacon's plan on empirical means was to purpose practicality amongst individuals in society that "the inquiry into nature is not well founded and properly constructed" and both the arts and sciences have "innumerable repetitions of the same thing, different in manner of treatment"[7].

Instead of artificial settings like the Royal Society to develop modern notation of experiments, ancient authority of Aristotle augmented a natural approach by the senses through the individual from the world. Like Bacon, Margaret Cavendish of Newcastle formed a philosophy based on sensation and reason in her *Observations upon Experimental Philosophy* and took a different approach on experimental philosophy. Where Bacon portrays Aristotle's authority as wrong, Cavendish writes that Aristotle

> was a very subtle philosopher, and an ingenious man; It is true, he was subject to errors, as well as other men are…but if all that err should be accounted fools, and destitute of regular reason, then those deserve it the most , who think, themselves wiser than they are…[8].

Aristotle was no fool as compared to Bacon involvement on the new sciences. What Cavendish illustrates are the simultaneous forces where modern science was emerging and the old science retained authority. To Cavendish, the emerging science from Descartes, Galileo and Newton took on an eclectic form which no system of thought was better or worse than the other yet emerged scientific innovations as a transitive outlook.

Scientific ideas in cosmology did not only change but as well social-political factions to finance natural speculation. The early seventeenth century was an emerging world in modern Europe after Elizabeth's foreign policies in maritime law[9], a demand of land, power, and wealth,

were the exact methods to achieve such goals. Court science was the traditional manner in acquiring expediency on numerous projects but became reduced when independents sought organizations like the Royal Society or Academy in Paris[10]. In experimental philosophy one views a social-political outlook emerging conjunctively from the cosmological transformation.

Cartesian philosophy and mechanics

Opposed to empiricism and experimental philosophy, Descartes contributed the method of doing science through the mind, or cogito, of the world. In his first discourse in the *Discourse on Method*, Descartes reminisced on previous experience through his own training of scholastic training and various ways to get information of the world surrounding him. He later declares that nothing has shown him anything which he did not previously known or, to some extent, others (e,g, Cicero, St. Augustine and Al-Ghazali). Before his eureka of *cogito ergo sum*, Descartes list a series of self-evident doubts concerning when to proceed as plan: 1) never to accept anything true, 2) consider many possibilities, 3) conduct one's thoughts to any easiest explanation, and 4) finally to enumerate all possibilities to eliminate[11].

Such a method echoes on modern day scientific methodology without empirical reasoning from internal or external sense. Much of Descartes methodology was to profoundly change the ways of doing philosophy, in relation to natural philosophy, from a point of view specifically to the individual or in this case the individual's cognition. An individual, historian, and natural philosopher can doubt all causal explanation surrounding the cosmos and the agent's design of interpretation but not the existence or mode of thinking that reflects within the inner

sanctum of the human body which expresses Descartes' belief in God's omnipresence or omnipotence. To Descartes, "the God of a philosopher and his world are correlated"[12].

Descartes, like Galileo, sets his philosophy to expand the mathematical-physical sciences incorporated from mathematics into philosophy: geometrization in the natural world – this sets the stage in Newton's natural philosophy. In Alfred Rupert Hall's *From Galileo to Newton*, he remarks the "contest" of natural philosophy between Descartes' and Newton's system which "though Newton himself opposed Descartes directly on almost every issue, it would be absurd to deny Descartes' strong influence on him"[13]. Descartes and Newton had many similarities in their philosophy that Hall points out, by their titled works, "…it is the *Mathematical Principles of Natural Philosophy* as against the *Principles of Philosophy*…"[14]; the former deals mathematical principles within the bounds of nature while the latter deals of pure principles found in nature. Descartes' system was self-evidence to the individual where Newton's system instrumented mathematics within nature itself.

Descartes' system of philosophy differs on matters dealing with cosmological schemes found within the individual compared to Newton's, which will be dealt later. To Descartes system, he finds nature to be composed of corpuscular elements that are moved by the unmoved Agent from Aristotelian philosophy. The issue raised from previous generations was the issue of the void concept which Kuhn states,

> some doubted the void, but the aethereal fluid with which they filled all space was for most purposes as neutral and inactive as the void. And, most important, all agreed that the motions, interactions, and combinations of the various particles were governed by laws imposed by God upon the corpuscles at the Creation[15].

Whether particles were effective as a "living" force to explain such phenomenon, Descartes' philosophic investigation on corpuscles transitions the mechanomorphic frame of transformation as "moving" force in the laws imposed by Newton.

To the atomist view, like future space travel, there is no sense of direction by terrestrial observation that the inhabitants on earth characterizes as up, down, left, right, front and behind. Scholastic domination forbade the concept of void in nature that gives God's agency a complex picture in causing infinite motion without boundaries; in a system of nature, the picture of chaos. Descartes recognized that in nature do these particles continually change speed[16] in accordance to geometrical instrumentation. The continuous altered state of these particles moving are "caused by external pushes and pulls derived from other bodies"[17]. This resembles Newton's first law of motion when a body stays in rest until at constant speed or stationary status unless another body enacts a force dejecting its initial Euclidean right line path or the force enacted on the object. Such forces are explained through the agency of God but concerning the void makes the universe full. Descartes' cosmology takes a turn into the idea of vortexes where the plenum is recycled through a stream intertwined within the universe itself. This however only explains certain phenomena of physical appearance such as how comets move through the solar system and collecting debris.

Such vortexes made by Descartes entail a spiral universe constantly refurbishing corpuscular elements in accordance to God's domain. To note, Koyré states that

> the Cartesian God, that is, the world of Descartes, is by no means the colorful, multiform and qualitatively determined world of the Aristotelian, the world of our daily life and

> experience…but a strictly uniform mathematical world, a world of geometry made real about which our clear and distinct ideas give us a certain and evident knowledge[18].

The Cartesian universe and philosophy stem from what Descartes perceived of God yet Koyré points the critical moment that "*he* could really think that *his* inability to conceive, or even imagine, a finite world could be explained in this way"[19]. The ability of Descartes' God is the ability to detect infinite entities but, as opposed to the individual's cognition, there become indefinite entities unknown to the observer. Though Descartes set the Newtonian framework, it is partial to its fallacy concerning terrestrial motion in celestial mechanics that Galileo undertakes through his telescope.

Galileo's terrestrial observations

Descartes and Bacon founded scientific observations through empirical and rational means to the individual observing nature regardless if nature is observed by instrumental means through a microscope or telescope. However, there were there no such found experimentation until the Royal Society and Academy of Science emerged in the late seventeenth century. Such observations of celestial phenomena became fully observed to Galileo's dedication of Copernicus' system in argumentation of a sun-centered universe. The ulterior motive behind the Copernican module is to rebuke the Catholic Church's condemnation of Copernicus' model which went against Scriptural authority.

During the issue of the Copernican doctrine, the battle against Aristotelian followers, religious authority, reached a climax with Galileo's involvement that contradicts geo-centric

module of the universe and Holy Scripture. In a letter from Roberto Bellarmine, he writes on the issue of Galileo and the cosmos that

> it is perfectly proper…to say that all the appearances are saved more effectively by the hypothesis that the Earth moves and the Sun is fixed than by postulating eccentrics and epicycles; and this is as far as a mathematician can go[20].

The proper way that Bellarmine issued Copernican doctrine is solely as a means to a hypothesis that has no fruition to the mathematician's role. What about the astronomer as physicist?

In Pierre Duhem's essay *To Save the Phenomena,* he presents the dichotomies underlying the cosmological scheme of celestial objects through the observer's perspective as either a mathematician or physicist. The major concern was: did such epicycles or eccentrics exist that explained the phenomena of celestial movements? In Koestler's view, they were not essential for they did not exist[21]. However, mathematicians postulated a model that calculates the said phenomena as actual versus a physicist who by uses as instrumental in hypothetical exploration; this issue remained from antiquity and propelled Kuhn's justification that it became a monster which lead Copernicus to simplify.

According to Duhem, astronomical hypotheses, in mathematics, are "simply devices to save the phenomena"[22]. After Copernicus' publication, the period from the Gregorian calendar to Galileo's condemnation in 1633 made astronomical hypothesis, from the Greeks, "relegated to oblivion, or rather, it furiously attacked in the name of the prevailing realism"[23]. The issue occurred, again in scholastic debates, the philosophic discussion pertaining to ontology as either a conceptual, nominal, or realistic framework in the scheme of things that nature prevails and

distinguishes to the observer. The issue with Galileo was the decline of traditional/authoritative views of the heavens and a rise to the foundations of modern mathematical-physical sciences.

Much of Galileo's mechanomorphic cosmos comes from his defense of Copernican doctrine first played in his earlier recorded celestial phenomenon with *A Sidereal Message* that Aristotelian physics were inaccurate on the heavens being perfect in the sublunary sphere. According to Koyré, the invention of the perspicillum – the Dutch spy glass converted to the telescope – with his *Sidereal Message* "played a decisive part in the whole subsequent development of astronomical science" and "began…a new phase of its development, the phase that we might call the instrumental one"[24]. An instrumental phase that speculated further to the sun's dark spots, seen in his *Letters on Sunspot*, which are later, determined the cause of solar flares with the excess amount of hydrogen re-circulating through its nuclear fusion stages with star's mid-point life.

Galileo's firm defense of Copernican doctrine, with terrestrial observations, is supposedly expanded in his *Dialogues on the Two Chief World System*. A dialogue demonstrated by opposing views of Copernican and Aristotelian doctrine and later reconciled as the victor, Salviati, successfully rebuking Simplico, a double entendre of Simplicus – commentator of Aristotle's works – and the "simpleton" theologian. Though undermined and unfair to scholastic followers, the dialogue was to impose a positive change of direction in the sciences to "correct" the Aristotelian system of nature in Ptolemaic-Copernican cosmology with innovative insights that during Aristotle's time did not have the luxury.

Galileo's argumentation of a moving earth resides in his fourth day discussion on the issue of tides. There are diurnal, monthly and annual occurrences set forth by the tide which sea level rises and descends. Mathematics is situated in this discussion but arguable the preference retains the idea of the Copernican doctrine residing the Earth's motion in relation to its tide that proves it as the third planet revolving around the sun. Koestler points that both

> the earth's rotation and its annual revolution are inertial, that is self-perpetuating, and hence produce the same momentum in water and land; and a combination of the two motions still results in the same momentum[25].

The fallacy shown by the same momentum in relation to one other shows that "he refers the motion of the water to the earth's axis, but the motion of the land to the fixed star"; Galileo cheats his audience by subconsciously adding the stellar parallax absently in this argument[26].

A failure on one aspect in this transforming landscape of the cosmos is made up for mathematical innovation in dynamics and statics in Galileo's later years. From terrestrial observations, Galileo implements a mathematical demonstration, with Kepler's mathematics of ellipses[27], on falling objects by a parabolic curve in observation rather than a tangent curve[28] that the Aristotelians have been viewing on motion single-mindedly. The panoramic view of terrestrial motion became a mechanomorphic model in mathematical rigor which can calculate the projectile path of canons and the mind set of calculus before Newton and Leibniz.

Newton's synthesis

Through Galileo's achievements, Hall finds that neither "the logic of the mathematical physics he inaugurated nor its agreement with observable phenomena were quite adequate"[29].

Hall furthers that Galileo's innovation was immersed through the older sciences which delineated his "own new perception with sharp definition and entire rigour"[30]. Progress is made in accordance to old tradition to fill the gaps of errors that human ingenuity failed through investigations of the world around them. This is to say the human ingenuity in the sciences is built up to failure and their successors are more pruned to failure with no exact trail which leads "cloudy traces". Not only Galileo but Bacon's and Descartes' philosophy; this would incur an eclectic form that transformed the different scientific methods from the mid-seventeenth century to nineteenth century.

What constitutes through Bacon, Galileo and Descartes are transformative elements that are synthesized through Newton's ingenuity and the innovations of the mechanomorphic transformation established by Copernicus. Like Galileo, Newton would have to fail even though all intricate system has been solved mathematically in nature. Morris Kline, in *Mathematics: The Loss of Certainty*, argued that the flowering of mathematical truth from the mathematic-physical sciences declined and lost virtue after Newton's contribution that distorted mathematics in its diverse yet related branches: logics, non-Euclidean geometry, statics and dynamics, pure and applied mathematics. Kline stated the matter towards mathematicians with "the source of insight is hindsight, and it is with hindsight…that mathematicians finally saw what generations of their predecessors had failed to see or had seen…"[31]; this can also be illustrated with Koestler's recurring phrase: *reculer pour mieux sauter* ("to draw back in order to make better"). This frame of mind not only applied to Newton but as well his predecessors to make out what Newton investigated through the intricate system, for example, in calculus.

Newton's framework of the cosmos and its model was investigated through his *Principia*, and its successor *Opticks*, which created the Newtonian universe. Why it had to fail was in due process on the order to transform the sciences.

Principia

Prior to Newton's making of *Principia*, Newton had already made calculations learning from the trivialities of Copernicus' innovation, Kepler's celestial mechanics and Galileo's terrestrial bodies. Hall, editor to Newton's calculative papers, designated the findings of Newton circa 1666[32], around his early Cambridge years, dealing on the issue of falling bodies and the notion of gravity. Newton's mathematical endeavor was not the rigorous innovation that he and Leibniz gave to calculus but simple geometrical skills. Newton states,

> Geometry does not teach us to draw these lines, but requires them to be drawn; for it requires that the learner should first be taught to describe these accurately, before he enters upon geometry; then it shows how by these operations problems may be solved[33].

Geometry, the basic of scholastic teaching and fundamental arts in the quadrivum, gave Newton's entire finding through mathematical skills used by art.

The basic understanding to Newton's mathematics was viewed as empirical and practical means in the mechanics that nature finds itself to distinguish from physical phenomena. Prior to Newton, Descartes and Galileo would have divided the dividends of nature in this emerging science to one sect as minute particles roaming the physical domain or "science seeking mathematical description rather than physical explanation"[34]. What made Newton significant in contribution, according to Koyré's *Newtonian Studies*, was "not skill… [rather] his deep

philosophical mind"[35]. Creativity roamed around the minds from Copernicus, Kepler and Galileo to finally see the significance of all three natural philosophers become embedded through Newtonian mechanism on celestial and terrestrial boundaries.

This is by no means an entire progressive trend that Newton succeeded while others failed, but a transformation through ingenuity in distinctive stages that the scientist, philosopher and historian identifies. The idea prevalent in Newton's mind was mathematical puzzles to be solved in nature and its distinctions on why one entity moves from another or the inclination that holds the most heaviest objects in ration of the individual's place to beyond the celestial stars.

Digressing away from ingenuity, Newton's inquiry of gravity and falling bodies become encumbered from Cartesian mechanics that made no calculations of the universe[36]. The problem appeared to improve Kepler's third law, the inverse equation of elliptical orbits and their acceleration, in respect to forces keeping falling bodies intact. Such of taking Galileo's contribution, Newton had formulated in respect the equation that "the force of attraction, F, between any two bodies of masses m and M, respectively, separated by a distance of r…"[37]; such an equation is expressed as $F=G\ (mM/r^2)$, G representing the constant. Such a calculation is sufficient to help determine what mechanics are at work; however, it gives no physical explanation. Newton relied mathematical representation to give strenuous explanations on the matter of comets in which mathematically gives circulates as an ellipse but turns into a parabolic curve when "force" enacts an attraction further to a high-level mass in the solar system. This calculation was a collaboration of Edmund Halley's part which, Newton and him, described the accurate trajectory path of Halley's Comet every seventy-five years.

In Newton's *Principia,* he section his findings first through celestial calculations in book one and terrestrial, particularly on fluids from Galileo's innovation of tides, in book two. However trivial the mathematics are concerned on, there are far too rigorous for many philosophers and historians to speculate in the matter. The idea formulated through *Principia* is to announce publicly Newton's findings prior to publication in 1687 in the Latin vernacular. Tribulations occurs when the mathematic-physical science progresses through a public realm in distressing scientist, holding Cartesian physics, to Newton's defense on his investigation that concerns the nature of God. Newton's idea of mathematics is to describe nature through a series of actual formulations, expressed through numbers and equations, to be able to conduct in a mathematician's robe. The formation of the sciences from Copernicus now took a turn to professionalization in Newton's time that historians of science investigated through matters from other scientist opinions, those like Gassendi, Huygens, Hooke, Borelli and Leibniz.

Opticks

Like the *Principia, Opticks* was another magnanimous treatise concerning the physical and calculative phenomena in the property of light. As prior to his publication, Newton worked earlier on light and its predilection to the nature on reflection and refraction. Alhazen theorized a mathematical treatise that predates geometric composition that rays of light react upon until that formulation became apparent through Snell's Law, concerning refraction through passable mediums. The opponents of physical explanation took Cartesian mechanics that theorized

> the particles of the matter of light…pressed outwards from the center of the vortex, or a flame, must spin as well as travel, a fast spin being perceived as red, a moderate spin as yellow, [and] a slow spin as blue[38].

Cartesian mechanics explained the emanation of light as corpuscular figures spiraling through a medium of the vortex. The Aristotelian term aether was still reliant in the modern sciences; both Huygens and Hook implemented this theory in their experiments.

Newton by contrast did not only experiment through the prism of light and its physical properties but as well geometrized nature like Al-Hazen's method through mathematical means. Newton's idea of light passes as a spectrum where light is refracted in frequencies attributed to its wavelength where the human eye perceives the visibility – in a short spectrum between infrared and ultraviolet – to the cornea. In astronomical methods, Newton's system prioritizes the observations of the heavens through light luminosity that details certain objects on mass, density, volume, heat, distance, acceleration and chemical compositions in the celestial realm.

At the end of *Opticks*, Newton list queries after his mathematical demonstration into nature concerning light. Durant, in *The Story of Civilization Part VIII*, foretells[39] Newton's demise with Einstein's relativity when Newton wrote in Query I, "Do not bodies act upon light at a distance, and by their action bend its rays, and is it not this action strongest at the least distance?" and Query XXX, "Why may not Nature change bodies into light, and light into bodies?". The mathematics and physical sciences do diverge after quantum mechanics sets precedent into modern physics, mathematics and astronomy but the scheme, or model, set by the sciences with Copernicus and Newton was to harmonize the universe. This model formulated by Copernicus and Newton does indeed continue from antiquity to modernity.

The Newtonian world and its effects

After Newton's *Optics* and revised editions of *Principia*, one views a general picture of Newton's world in synthesizing all the emerging sciences at the end of the seventeenth to beginning eighteenth century. Newtonian mechanics can be described such that from mathematic-physical investigations can one ascertain the unity of light and matter, corpuscle-like atoms as indivisible and the non-material attractive and repulsive forces[40]. Such a system can be derived from Newtonian mechanics stated further when a Being is put into place as a governing lord or in its minute roles in nature governing like the shepherd tending his herd of sheep or the engineer's mechanistic tinkering on a clock or watch.

A Being that illustrates the theistic attitude in the emerging of modern science, Newton's Lord of all calculated the celestial bodies acting on harmonious intervals between the sun, moon and five planets orbiting the sun and the terrestrial observations on falling with an un-identifiable force holding these bodies. What could these forces come from? From the *General Scholium*, he states: "I have not been able to discover the cause of those properties of gravity from phaenomena, and I frame no hypotheses". A conclusion in which Newton himself cannot go beyond nature with the emerging sciences. What is left is Newton's conception of such a force is described through theological discussions like those who from the eleventh to thirteenth centuries of scholasticism.

Debate: God, Newton, Berkeley, and Leibniz

Newton's defense of mathematical-physical mechanics implements, after his celestial observations, that this "most beautiful system of the sun, planets, and comets, could only proceed

from the counsel and dominion of an intelligent and powerful Being"[41]. This powerful being is in place the order and presence of a Lord that rules dominion of all things within and without God's realm. To Newton, this being is an unperceivable entity in which substitutes its attributes, whatever they maybe, upon the world. This description of God is only Newton's interpretation of God; this creates problems like Descartes' cosmology through God.

Bishop Berkeley pointed the issue towards absolute space which Newton's God claims dominion of all natural things. To Berkeley, he does not accept the notion of absolute space in which an unperceivable reality is unthinkable[42]. How can one claim absolute space without the essential attributes of perception? This line of questioning disrupts not only the underlying scientific investigations but theological perceptions of a divine entity. To Newton, God is like a clock-maker in which, after created, the world participates without God's intervention only when necessary; causing such phenomenon to the religious individual as miracles. To Berkeley, God's essence in a mechanic world is without due when he acclaims to words *esse est pricipi* ("to be is to be perceived") and not "occasionally perceived".

The German polymath Leibniz added in the Newtonian debate on the scheme of time with his concept of pre-established harmony. Somewhat esoteric in meaning, Leibniz illustrated a different mode in expressing Newton's world on differential space-time structure whether it is compact on what he called monads or space & time entities. A philosophical follow up into his notion of theodicy and God's eternal position that does not make God a watch-maker or shepard but a part of the cosmos and sufficient reason; this becomes ridiculed in Voltaire's *Candide* questioning such sufficient reasoning from the 1755 earthquake in Lisbon[43].

A "closed world to infinite universe"?

What Berkeley and Leibniz pointed in Newton's absolute space & time universe as infinite, is perfectly summed up by Koyré last words on the subject:

> The infinite Universe of the New Cosmology, infinite in Duration as well as in Extension, in which eternal matter in accordance with eternal and necessary laws moves endlessly and aimlessly in eternal space, inherited all ontological attributes of Divinity. Yet only those – all the others the departed God took away with Him[44].

The inherited attributions of the universe relied on Newton's model of God and the universe. A model similarly conjectured to Descartes' model; the one he went against on vortexes and motion.

What one sees in Newton's synthesis of the cosmos transforms Copernicus closed world of finite space to Newton's infinite universe. The question becomes now: was there a transformation of the cosmos from a "closed world to infinite universe"? Shockingly to say, the answer is both yes and no. Yes because Copernicus' heliocentric model paved skepticism in the cosmology beyond the Earth's place as a moving unit through space rather a stationary figure. With Kepler and Galileo, the mechanomorphic figuration transfers the epistemological changes through the mathematical-physical sciences to help explain the motion of the universe. From there, Newton synthesized a coherent structure that kept order in space, time, motion, and extension in place different from Copernicus' time.

Yet, the answer was no because Copernicus had doubts on a closed world and investigated further beyond the fixed stars, an invigoration before Newton came into picture. The

surprisingly strange the notion on “saving the appearance”, though ridden from Kepler’s ellipses, still held a different but subtle meaning as a coherent picture that infinity was not all-pervading through atoms or corpuscles but the agency of God. The idea of God’s agency is as old as Aristotle concerning the First Mover which, according to Cavendish[45], still held some authority in the emerging new science. Such anachronism continues, from Scholasticism, into Newton’s universe.

Notes

[1] William Durant, *The Story of Civilization Part IV* (New York: Simon and Schuster, Inc., 1950), pg. 586

[2] See Durant, pg. 989 and George Joseph’s *The Crest of the Peacock* (New York: Princeton University, 2011) chapter eight: Ancient Indian Mathematics, pgs.338-349

[3] Durant, pg.990

[4] See Willard E. Stone’s article “Abacists Versus Algorists”. *Journal of Accounting Research*, Vol. 10, No. 2 (Autumn, 1972), pgs. 345-350)

[5] Boas, pgs. 92-93

[6] Butterfield, pg.112

[7] Francis Bacon, *The New Organon*, pg.6

[8] Margaret Cavendish, *Observations upon Experimental Philosophy*, pg.195

[9] See A.C. Grayling’s *The Age of Genius: The Seventeenth Century and the Birth of the Modern Mind* (New York: Bloomsbury Press, 2016), chapter 8: War and Science

[10] See chapter 5: “Florence, London, Paris” in Alfred Rupert Hall’s *From Galileo to Newton 1630-1720* (New York: Harper & Row Publishers, 1963)

[11] Descartes’ Second Discourse

[12] Koyré, pg.100

[13] Hall, pg.108

[14] ibid.

[15] Kuhn, pg.238

[16] ibid, pg.239

[17] ibid.

[18] Koyré, pgs.100-101

[19] ibid, pg.108

[20] Mark Davie and William Shea, *Galileo: Selected Writings* (New York: Oxford University Press, 2012), pg.94

[21] See Koestler, pgs. 69-72

[22] Pierre Duhem, *To Save the Phenomena* (Chicago: The University of Chicago Press, 1969), pg.92

[23] ibid.

[24] Koyré, pg. 90

[25] Koestler, pg.472

[26] ibid, pgs. 472-473

[27] Kuhn, pg. 213. Apollonius conic sections into circles, ellipses, parabolas and hyperbolas which Kepler used ellipses and Galileo with parabolas.

[28] See Hall, chapter III: "Nature's Language", pgs. 79-86 and 95-99. Galileo pre-figuring Newton's and Leibniz's contribution in calculus (derivatives and integral forms).

[29] Hall, pg.73

[30] ibid.

[31] Kline, pg.101

[32] Hall, pgs. 280-284

[33] See Newton's preface in *Principia*

[34] ibid, pg.51

[35] Alexandre Koyré, *Newtonian Studies* (Harvard University Press, 1965), pg.3

[36] Hall, pg.280

[37] Kline, pgs.52-53

[38] Hall, pg.259

[39] Will and Ariel Durant, *Story of Civilization Part VIII* (New York: Simon and Schuster, 1963), pg.536

[40] Koyré (1957), pg.207

[41] Also found in the *General Scholium*

[42] Koyré, pg.222

[43] Before Voltaire's publication of *Candide* (1759), he became outraged of Leibniz's positive reasoning with Dr. Pangloss repetitively speaking: "the best of possible worlds". After the Lisbon earthquake of 1755, he wrote a *Poem on the Lisbon disaster* (1756) recounting the emotion distress of an orderly universe by Newton and what theological implication it suggests. Voltaire illustrated, satirically, Candide's misfortunes throughout the novel, in Leibniz's philosophy, only to end by saying, "cultivate your garden"; a world of possibilities reduced down to a microbial structure of a garden which can represent the universe.

[44] Koyré, pg. 276

[45] Look back in experimental and empirical philosophy section

CHAPTER FIVE: CONCLUSION

To summarize, inquires used to investigate cosmology, from a "closed world to infinite universe" developed by Koyré, were the disciplines in history and philosophy. I used historical and philosophical investigations because they had an interconnected realm of knowledge, stated by Durant, Ibn Khaldun, and Kuhn, which I thinks applies to an interdisciplinary approach. My line of argumentation was to clarify that the history of science[1] was not a one-sided approach in Whig history, like stimulus and response in behaviorist psychology[2], rather a multi-approach in the transformation of the sciences. Rather than viewing superstitious or anachronistic elements cloaking human ingenuity, these elements act as transformative insights into the overall transformation of sciences.

After examining Butterfield's interpretation on Whig history, I later examined his and Koyre's early developmental philosophy in the history of science. To expand their notions, I furthered into Michel Foucault's and Thomas Kuhn's philosophies when both examine the epistemological changes in history[3]. Between the French philosophers Sartre and Levi-Strauss, I wedged Foucault's philosophy between opposing sides on human nature in its freedom and similarity found within culture. Foucault's philosophy was found dominantly in the *Order of Things* which the human sciences, anthropology, sociology, and psychology, transformed from a different order in philology, biology and economics. Foucault's insight was the geometrization of the sciences within the planes from epistemic breaks in history to where one discipline ends and one emerges; his reversal back within mathematical and physical science can relate to Kuhn's level of science.

Illustrated by Hacking, their differences become the maturity of science: Foucault's approach was immature and Kuhn's was mature. Foucault's philosophy in the history of science was never maturing due to epistemic breaks caused by power relations on both an individual and natural aspect. Foucault's picture was a line of non-continuity, yet continuous, which the gaps are created with no big picture of geometrical knowledge versus Kuhn line of continuity in the history of science as a line of filled gaps in geometrical knowledge. These so-called gaps are his notion of paradigm shifts caused by normal science within a community of divergent scientists and their perceptions, within themselves reflecting the change from old to new models. Kuhn implicated a gestalt theory of psychology when perceiving certain phenomena through a *weltanschauung* approach as the paradigms switches from one point of view simultaneous to another instantly as though two opposing forces appear apparent to the observer. Though both philosophies in the history of science are different, I view the concept of transformation that Kuhn's picture completes Foucault's picture in history.

From the philosophic point of view, I transitioned to a historic view in the scientific revolution. Whether the scientific revolution occurred or not, *something* happened between Copernicus' to Newton's time through the re-configuring cosmology instrumental with the mathematics and physics. The first half dealt in Copernicus' influence from hermetic, humanist and scholastic background in which Copernicus model the geocentric to heliocentric model of cosmology in *De revolutionibus*. Though inaccurate, its main inspiration transpired to fellow mathematicians, scholars, philosophers and astronomers of the heliocentric model and its "saving appearance" phenomena. Kepler took the model of the cosmos to correct its malformation through his mystic-mathematic approach of celestial objects first worked in his *Mysterium*

Cosmographicum. From there, his development of his three laws implemented a mechanomorphic outlook that emphasized mathematics/geometry as a "moving" versus "living" force.

The second half dealt with the transitioning mechanomorphic view of the cosmos with Galileo and Newton. Still inherent of traditional mathematics and sciences, the philosophers Bacon and Descartes viewed the sciences as experimental and cognitive matters when perceiving phenomena of nature. The missing half of Newton's synthesis was Galileo's terrestrial motion in part with Kepler's celestial motion. Galileo's s defense of Ptolemaic-Copernican cosmos, in his *Dialogue of Two Systems*, failed against the explanation of the earth as a moving object. Through failure, one sees his geometrization of space with terrestrial observations from his earlier investigation on the telescope. Following Galileo, Newton synthesized Copernicus' model with Kepler's celestial and Galileo's terrestrial motion into a mathematical rigor in his *Principia* and mathematics measured in natural philosophy. The surprising element in Newtonian mechanics still relied on the medieval model of God's intervention of the infinite world. This allows within the boundaries as either Copernicus looking ahead while Newton was looking back. Yet, simultaneously, Copernicus was working within the tradition of the "closed world" through Ptolemaic astronomy and Newton expanding Galileo's and Kepler's mechanics to open an "infinite universe".

Transformation and its effects on history

How can Copernicus be looking backward yet forward and Newton is looking forward yet backwards? A play of actions characterizes external (environment) and internal

(consciousness) forces throughout the investigations in the history of science and its transformations. What these actions entail are not exact to my specific inquiries since it relies on a lessons of history approach. By lessons on history, what role does transformation, particularly on the sciences investigated, affect the outcomes or results in history? Receiving this answer entails a point in discussion that involves the models of history and it cosmology of how things occur. Earlier, I mention one model that I denied heavily on the Whig model of history that showed its one-sidedness and its liberating factor. I propose on three models of history in this transforming landscape of knowledge, science and philosophy.

Progressive. Unlike Whig history, a progressive outlook does not entirely show its one-sidedness as things accumulate within each successive step in human history or its creativity. Nothing is victorious or liberated in a sense for things become well than their preceding successors. An image on progress can be seen through a totem pole where certain spirits and ancestor are depicted on success and improvements from past successions. The only key figure to highly pay attention in progresses is its roots or foundations in which a totem pole was first erected from a mound; one can say "the highest does not stand without the lowest"[4] or "standing on the shoulders of giants".

Cyclical. Opposite in progressive, a cyclical outlook never becomes better or worse than its successors. Liberation as a whole is not the key rather for minute details that need to be learning if one needs not repeat history[5]. Two such illustrations can represent cyclical history as Russian dressing dolls and LP records. The former model shows the similarity of dolls encapsulating one another through structure and shapes but a difference emerges through designs that one views the

intricate lines and symbols beautifying the dolls; the viewer of history must pay attention of details. Though minute details can be picked easy in repetitiveness, the latter illustration shows the repetitive disruptions through the circular disc of harmony by mechanical interventions of the needle.

Reflective/Refractive. Similar in cyclical but different in structure as the refraction of lights to dispersing its rays of different colors; its intensity and quaintness is shown through a morphed version of cyclicality. Like Leibniz's theodicy and Voltaire's reaction on the best of possible worlds, there is a differentiation of forces acting simultaneous to its similarities; a simpler way to illustrate is Indra's Net[6]. In this analogy, all gems represent a world in which inter-connections occurs through the refraction or reflections of light emitting from the source and within the gemstone themselves or on to others. In one instance, progress happens while another action causes decline through a different world or civilization.

Through the models of history, transformation occurs through the Whig, progressive, cyclical and reflective/refractive approach. The lessons sought in history and its model can be seen on what I think on the reflective /refractive approach since transformation has its multiplicity in history from one local point to another. In last remarks on transformations, what can be observed through the intermediary local point is the notion found through creativity and education.

On creativity

Koestler's theory of creativity brings two geometrizing planes of knowledge interesting from tradition and innovation to spark creativity, like rubbing two sticks with flint to produce

fire. With the philosophy in history of science, Koestler's geometrization of intersecting planes with creativity[7] into Foucault's intersecting planes, along with Kuhn's fill-in with paradigm shifts, into the human sciences[8]. In terms to the general activity of creativity, Koestler states the act of creation "does not create something out of nothing; it uncovers, selects, re-shuffles, combines, synthesizes already existing facts, ideas, faculties, skills. The more familiar the parts, the more striking the new whole"[9].

Creativity as wholes and parts integrates a different sense in the history of science where he mentions the discoveries in science are not always clear. The path science takes often maps as zigzags where it

> often consists...in the uncovering of a truth buried under the rubble of traditional prejudice, in getting out of cultural-de-sacs into which formal reasoning divorced from reality leads; in liberating the mind trapped between the iron teeth of dogma[10].

This is to demonstrate that the transformation of the sciences has no clear understanding relating from past actions and learning them to create things.

The matter can be looked with Copernicus' treatment of his major publication on the *De revolutionibus.* Translated from a letter from Lysis to Hipparchus, one pivotal idea that Copernicus drew was the fact Lysis argued that

> certain imitators of his [Pythagoras] teaching, however, perform at great length and out loud. Their instruction of the young follows a confused and improper procedure, thereby making their auditors impertinent and brash. For they mix disorderly and tainted morals with philosophy's lofty precepts. The result is like pouring pure fresh water into a deep

> well full of muck, since the muck is stirred up and the water is wasted. This is what happens to those who teach and are taught in this manner…[11].

Koestler asks: "Why did Copernicus, after ten years spent in the bubble-bath of Renaissance Italy, adopt this arrogantly obscurantist and anti-humanistic attitude?"[12] The answer given because Copernicus saw his ingenuity of the cosmos subtle of par-excellence and the fear of ridicule from the public as prejudice builds off Ptolemaic tradition; hence *pure fresh water into a deep well full of muck, since the muck is stirred up and the water is wasted*. He considered his work of creative enterprise but would become a major concern of Ptolemaic tradition still used in society: individual's perceptions of the universe and academia/scholasticism use of tradition.

In Kepler's *Rudolphine Tables,* the font piece illustrates the glorious, or whiggish, attitude in building the sciences from Hipparchus, Ptolemy, Copernicus, and Brahe. Contrary, Kepler places himself melancholy at the base where the matter is viewed on the foundations as a pile of mud from ancient tradition. Kepler's investigations of the cosmos were idiosyncratic due to science as "physical and metaphysical" elements like Pythagoras' religious nature in mathematics. Though at the bottom, Kepler had to start on the foundations of science, whether he like them or not, in order to climb higher than shoulders of giants or totem pole of previous ancestors. Newton's work was described as "no other work in the whole history of science equals the *Principia* as either in originality and power of thought, or in the majesty of achievement"[13] but, as an individual, "he was moody, sometimes irritable, suspicious, secretive, always timid but proud" and as "high strung and morbidly sensitive, he bore criticism painfully, resented it sharply, and fought back stoutly in controversy"[14]. Newton's achievements are contradictory innovation from mathematical rigor and sour determination to achieve fame.

On education

In Kuhn's last chapter of *The Copernican Revolution*, Kuhn relates Copernicus' multiple yet single fabric of thought following Kepler's celestial mechanics, Galileo's terrestrial mechanics, and Newton's infinite universe, with interrelated connections of science. To Kuhn, he thought – the matter transitioning from nature (physics) to history and its different frameworks – nature does not

> display incompatible properties in different fields. If the physicist's electrons can leap path to path without crossing the intervening space, then the chemist's electron should have the same ability, and the philosopher's concept of matter and space demand reëxamination. *Every fundamental innovation in a scientific specialty inevitably transforms neighboring sciences and, more slowly, the worlds of the philosopher and the educated layman*[15] [my italics].

The neighboring science from astronomy, physics and mathematics transcends through biology, chemistry, and politics[16]. This web follows a line of continuous interest where "each new conceptual scheme embraces the phenomena explained by its predecessors and adds to them"[17].

This web of interest, particularly from history and philosophy, stems as a local point in transformation with the value of education. Education and the technique practice is the virtuoso in interdisciplinary knowledge across the board. The essence underlying education standardizes the equilibrium between contradictory rises, falls, and decays in civilizations seen throughout history being recorded. The knowledge accumulated from Copernicus to Newton is only one spectrum in part of civilization which it identifies itself as

> not something inborn or imperishable; it must be acquired anew by every generation, and any serious interruption in its financing or its transmission may bring it to an end. Man differs from the beast only by education, which may be defined as the technique of transmitting civilization[18].

The individual is between perplexing worlds when creating and transmitting knowledge. The matter pertains how valuable the spectrum of epistemoligcal changes occur and how they are picked up.

In its dogma and liberation of the sciences or any area of knowledge, the value of education finds the inner meaning when investigating philosophy and history. I think the lessons of history are theory and practice base that one continually must observe carefully regardless of things being anachronistic. Through the process in transmitting knowledge and its constitutions, there follows a transformation starting from cosmology and trickling down to its interdisciplinary areas of knowledge from civilization.

Notes

[1] The cosmology, astronomy, physics, and mathematics instrumental in the inquiry

[2] See Koestler's *The Act of Creation* (New York: The Macmillan Company, 1964). He notes the behaviorist model in discourse on Book II, Chapter IV, particularly pages 603-604.

[3] Foucault's analyzes history as epistemic breaks where Kuhn's analyzes history as paradigm shifts. Both write epistemological changes but in different contexts – Foucault looks in biology (biomedical sciences) and Kuhn in physics.

[4] C.S. Lewis, *The Four Loves* (New York: Hancourt, Brace, 1960), pg. 9

[5] Santayana: "Those who do not know from history are doomed to repeat"

[6] I found Indra's Net analogy illustrated in Timothy Brooks' *Vermeer's Hat: The Seventeenth Century and the Dawn of the Global World* (New York: Bloomsbury Press, 2008). Brook's describes Indra's Net (22) as

> mirrors reflecting the multiplicity of causes and effects that have produced the past and the present. Buddhism uses a similar image to describe the interconnectedness of all phenomena. It is called Indra's net. When Indra fashioned the world, he made it as a web, and at every knot in that

> web is tied a pearl. Everything that exists or has ever existed, every idea that can be thought about, every datum that is true every dharma, in the language of Indian philosophy is a pearl in Indra's net. Not only is every pearl tied to every other pearl by virtue of the web on which they hang, but on the surface of every pearl is reflected every other jewel in the net. Everything that exists in Indra's web implies all else that exists.

[7] See Arthur Koestler, *The Act of Creation* (New York: The Macmillan Company, 1964), pgs. 33-35, 37-38, and 85

[8] Look back in Chapter 2, pg. 23

[9] Koestler, pg.120

[10] Koestler (1959), pg. 214

[11] Copernicus, pg. 29

[12] Koestler, pg. 153

[13] Hall, pg. 301

[14] Durant (1963), pg. 545

[15] Kuhn, pg.230

[16] ibid, pg.263

[17] ibid, pg. 264

[18] Durant (1935), pg. 4

APPENDIX: KOESTLER'S TABLE

Planets	*De revolutionibus*	*Commentariolus*
Earth		
Diurnal rotation…	1	1
Motions in Longitude…	3	1
Conic motion of earth's axis to account for its fixed direction in space and for precision	1	1
Two rectilineal oscillations to account for (imaginary) fluccession and in the value of the obliquity; resolved into 2 circular motion	4	N/A
Moon		
Motions in longitude…	3	3
Motion in latitude…	1	1
Three Outer Planets		
Motions in longitude 3x3=	9	9
Oscillations in latitude resolved into 2 circular motions apiece, 3x2=…	6	6
Venus		
Motions in longitude…	3	3
3 oscillatory motions in latitude resolved into 6 circular motions…	6	2
Mercury		
Motions in longitude (including one oscillatory motion)	5	5
Motions in latitude (as Venus)	6	2
Total epicycles=	48	34

REFERENCES

Agrippa, Heinrich Cornelius. *The Occult Philosophy in Three Books*. Translated by J.F. in English. External Link: http://www.esotericarchives.com/agrippa/.

Bacon, Francis. *The New Organon*. Original Published in 1620, Latin. Edited by Lisa Jardine and Michael Silverthorne. Cambridge: Cambridge University Press, 2000.

Barfield, Owen. *Saving the Appearances: A Study in Idolatry*. Connecticut: Wesleyan University Press, 1965. Second Edition, 1988.

Boas, Marie. *The Scientific Renaissance 1450-1630*. New York: Harper & Row Publishers, 1962. First Harper Torchbook edition, 1966.

Brooks, Timothy. *Vermeer's Hat: The Seventeenth Century and the Dawn of the Global World*. New York: Bloomsbury Press, 2008.

Burns, William. *The Scientific Revolution in Global Perspective*. New York: Oxford University Press, 2015. Paperback edition, 2016.

Butterfield, Herbert. *The Whig Interpretation of History*. London, 1931. New York: W.W. Norton & Company, 1965.

———. *The Origins of Modern Science: 1300-1800.* London: 1949. New York: Macmillan, 1957, revised edition. First Collier Books Edition 1962.

Cohen, H. Floris. *The Scientific Revolution: A Historiographical Inquiry*. Chicago: The University of Chicago Press, 1994.

Copernicus, Nicholas. *On the Revolutions of the Celestial Spheres*. Translated by Edward Rosen. External Link: http://www.geo.utexas.edu/courses/302d/Fall_2011/Full%20text%20-%20Nicholas%20Copernicus,%20_De%20Revolutionibus%20(On%20the%20Revolutions),_%201.pdf.

Davie, Mark and Shea, William. *Galileo: Selected Writings*. Translated by William R. Shea and Mark Davie. New York: Oxford University Press, 2012.

Descartes, Renee. *Discourse on the Method of Rightly Conducting the Reason, and Seeking the Truth in the Sciences*. External Link: https://ebooks.adelaide.edu.au/d/descartes/rene/d44dm/.

Duhem, Pierre. *To Save the Phenomena: an essay on the idea of physical theory from Plato to Galileo*. Translated from the French by Edmund Doland and Chaninah Maschler. Chicago: The University of Chicago Press, 1969.

Durant, William. *The Story of Civilization Part I - Our Oriental Heritage: Being a history of civilization in Egypt and the Near East to the death of Alexander, and in India, China and Japan,*

from the beginning to our day; with an introduction, on the nature and foundations of civilization. New York: Simon and Schuster, Inc., 1935.

———. *The Story of Civilization Part IV - The Age of Faith: A History of Medieval Civilization – Christian, Islamic, and Judaic – from Constantine to Dante: A.D. 325-1300*. New York: Simon and Schuster, Inc., 1950.

———. *The Story of Civilization Part VI - The Reformation: A History of European Civilization from Wyclif to Calvin, 1300-1564*. New York: Simon and Schuster, Inc., 1957.

Durant, William and Ariel. *The Story of Civilization Part VII - The Age of Reason Begins: A History of European Civilization in the Period of Shakespeare, Bacon, Montaigne, Rembrandt, Galileo and Descartes, 1558-1648*. New York: Simon and Schuster, Inc., 1961.

———. *The Story of Civilization Part VIII - The Age of Louis XIV: A History of European Civilization in the Period of Pascal, Molière, Cromwell, Milton, Peter the Great, Newton, Spinoza, 1648-1715*. New York: Simon and Schuster, Inc., 1963.

Foucault, Michel. *Madness & Civilization: A History of Insanity in the age of Reason*. Translated from the French, *Historie de la Foie*, by Richard Howard. Librairie Plon, 1961. New York: Vintage Books, 1965.

———. *The Birth of the Clinic: An Archeology of Medical Perception*. Translated from the French, *Naissance de la Clinique*, by A.M. Sheridan Smith. Presses Universitaries de France, 1963. New York: Pantheon Book, 1973.

———. *The Order of Things: An Archaeology of the Human Sciences*. Translated from the French, *Les Mots et les choses*, by A.M. Sheridan Smith. Editions Gallimard, 1966. New York: Vintage Books, 1970.

Grayling, A.C. *The Age of Genius: The Seventeenth Century and the Birth of the Modern Mind*. New York: Bloomsbury Press, 2016.

Hacking, Ian. *Historical Ontology*. Cambridge, MA: Harvard University Press, 2002. First Harvard University Press paperback edition, 2004.

Hall, Alfred Rupert. *From Galileo to Newton, 1630-1720*. New York: Harper & Row Publishers, 1963.

Henry, John. *The Scientific Revolution and the Origins of Modern Science*. New York: St. Martin's Press, 1997.

Joseph, George. *The Crest of the Peacock: Non-European roots of Mathematics*. New York: Princeton University Press, 1991. Second edition, 2000. Third edition, 2011.

Kant, Immanuel. *The Critique of Pure Reason.* 3rd edition. External Link: http://strangebeautiful.com/other-texts/kant-first-critique-cambridge.pdf

Khaldun, Ibn. *The Muqaddimah: An Introduction to History*. Translated from the Arabic by Franz Rosenthal. New York: Princeton University Press, 1967. Abridged paperback version, 1989.

Kline, Morris. *Mathematics: The Loss of Certainty*. New York: Oxford University Press, 1980. Paperback edition, 1982.

Koestler, Arthur. *The Sleepwalkers: A History of man's changing vision of the Universe*. New York: The Macmillan Company, 1959. Reissued in Pelican Books, 1968. Reprinted in Arkana, 1989.

———. *The Act of Creation*. New York: The Macmillan Company, 1964.

Koyré, Alexandre. *From the Closed World to the Infinite Universe*. Baltimore: John Hopkins Press, 1957. Angelico Press, 2016.

———. *Newtonian Studies*. Harvard University Press, 1965.

Kuhn, Thomas. *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*. Cambridge, MA: Harvard University Press, 1957. Renewed 1985 by Thomas S. Kuhn.

———. *The Structure of Scientific Revolutions*. Chicago: University of Chicago, 1962. 50th anniversary edition, 2012.

———. *The Essential Tensions: selected studies in scientific tradition and change*. Chicago: University of Chicago Press, 1977.

Levi-Strauss, Claude. *The Savage Mind*. Translated from French, *La Pensée Sauvage*, to English. Chicago: The University of Chicago, 1966.

Lewis, C.S. *The Four Loves*. NewYork: Hancourt, Brace, 1960. Copyright renewed 1988 by Arthur Owen Barfield.

———*The Discarded Image: An Introduction to Medieval and Renaissance Literature*. Cambridge: The University of Cambridge Press, 1964. Canto edition, 1994.

Newton, Isaac. *The Mathematical Principles of Natural Philosophy*. Translated in English by Andrew Motte. External Link: https://ebooks.adelaide.edu.au/n/newton/isaac/mathematical-principles-of-natural-philosophy/.

Pico della Mirandola, Giovanni. *The Oration and Dignity of Man.* External Link: https://ebooks.adelaide.edu.au/p/pico_della_mirandola/giovanni/dignity/.

Rosen, Edward. *Three Copernican treatises: The Commentariolus of Copernicus, the Letter against Werner, the Narratio prima of Rheticus*. New York: Dover Publication, 1959.

Rosen, Edward. “Was Copernicus a Hermeticist?”. *Historical and Philosophical Perspectives of Science*, Vol. 5 (1970), pp 163-171.

Russell, Bertrand. *A History of Western Philosophy*. New York: Simon and Schuster, Inc., 1945.

Sartre, Jean-Paul. *Critique of Dialectical Reason*. Translated from the French, *Critique de la Raison Dialectique*, by Alan Sheridan-Smith. Paris: Editions Gallimard, 1960. New York: Verso, 2004.

Shapin, Steven. *The Scientific Revolution*. Chicago: The University of Chicago Press, 1996. Paperback edition, 1998.

Stapledon, Olaf. *Last and First Men*. London: Methuen & Co. Ltd, 1931. New York: Dover Publications, Inc., 2008.

Yates, Frances. *Giordano Bruno and the Hermetic Tradition*. Chicago: University of Chicago Press, 1964.