The Origins of the Ptolemaic Tradition and its Adoption and Replacement in Colonial America*

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Abstract
This monograph addresses the vital impact of ancient Greek thought on Colonial American cosmography, through an analysis of the ways Colonial Americans interpreted and applied Greek ideas. The conflict between the Ptolemaic tradition and the heliocentric model of Copernicus provides a focal point for this study. To highlight this cosmographic reformation, I examine the influence of Greek democratic culture, in particular the tolerance of open discussion, as well as attitudes of scientific objectivity, mathematical reasoning and religious openness. In turn, this cultural inheritance inspired and enabled leading Colonial American cosmographers associated with Harvard and Puritanism to view scientific truth as God's truth. Thus, religiosity and the understanding of God's created universe in Colonial America embraced an ongoing journey of discovery shaped by scientific inquiry and an openness to changing received wisdom concerning the cosmos.

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Introduction

The mapping of the universe and the attempt to understand the cosmos and one's place within it has been a constant intellectual quest of the human race since ancient times. This systematic scholarly investigation is known as cosmography. In this Big History monograph, I analyze how early Colonial American scholars made sense of ancient Greek understandings of cosmography. In particular, I will focus on the way these Greek ideas shaped American thinking not only about the cosmos itself, but also about the way cosmographic understanding became intertwined with views about God and theology.

When they first arrived in North America, Colonial Americans generally subscribed to a cosmography that was based on the Ptolemaic tradition. But, once they became established in the new world, and especially after the founding of Harvard University, a cosmographic revolution taking place in Europe began to resonate in the so-called New World. Some Colonial American scholars willingly engaged in contemplation of the new outlook and proved receptive to the heliocentric theory of Nicolas Copernicus. Not surprisingly, in a land where scientific and religious thought overlapped so extensively, heated scholarly debate ensued over the topic and even resulted in student protests at Harvard University. The record of these debates can be traced back to the 17th-century writings of Colonial America, as illustrated by several astronomical almanacs that since have been preserved as vitally significant artifacts of intellectual life in the colonies. These almanacs were at the heart of published debate between the Ptolemaic tradition and the ideas of Copernicus.

In order to organize this topic most effectively, I use Big History methodology, to break up my analysis into distinctive phases to draw connections, bridging the period between the Colonial Americans and the ancient Greeks. These phases, each centered on three distinct threads of intellectual development, illuminate the reception of ancient Greek astronomical knowledge and reasoning by the Colonial Americans. The first phase, represented in chapter II, titled "Origins of the Ptolemaic Tradition," examines the origins of

Alexandrian scientific and philosophical tradition and attempts to reconstruct its development. This analysis will be driven by three major points, which I have identified to be crucial to the evolution of the Ptolemaic tradition. 1. The Greek tradition of freedom of thought, stemming from Athenian democracy. 2. The objective, empirical approach of Claudius Ptolemy when conducting his research. 3. The mathematics of Ptolemy on which his theory rests. To avoid any confusion, discussion of the mathematics concerns the theoretical implications of his quantitative study, rather than the specific mathematical calculations themselves.

In the next phase in chapter III, called "Reception of the Ptolemaic Tradition in Colonial America," addresses how Colonial Americans received the Ptolemaic tradition. Here it is important to identify the way the Ptolemaic understanding became established in America and the evidence of its influence on Colonial American cosmography. Taking into account important primary and secondary sources, discussion revolves around three points: 1. The Ptolemaic tradition in Europe prior to the founding of Colonial America. 2. Popular Colonial American ideas about astrology. 3. The Colonial American belief in the Geocentric theory advanced by Ptolemy. Based on this contextual discussion, I concentrate on the primary source writings left by the Colonial American scholar and professor at Harvard, Charles Morton, who wrote the first Harvard University textbook on Astronomy.

In my third phase, I inspect the Colonial American movement towards the ideas of Nicholas Copernicus and evaluate the causes of the corresponding drift away from the Ptolemaic tradition. In chapter IV, titled "The Shift Towards the Copernican Tradition," The causes are reducible to following three main lines of discussion: 1. The Puritan use of ancient Greek thought. 2. The Puritan's religious openness towards new ideas. 3. The scientific support the Puritans received from England. Because this chapter represents the heart of my research, the claims of several important scholars receive especially close scrutiny and help establish the foundation of my historical explanation. Most prominent among the primary sources are the writings of Zechariah Brigden, the groundbreaking Colonial American scholar who analyzed the relationship between science and the Copernican tradition, as well as why the Copernican tradition was superior to its Ptolemaic predecessor. Related pro-Copernican essays by Colonial Americans such as Samuel Cheever, Thomas Brattle, and John Foster bolster the case. A concluding assessment of Claudius Ptolemy's own statements about the complementary relationship between science and theology actually reinforces the claims of Colonial American writers.

To be sure, it is important to note that this research should serve as an introduction to the exploration of the origins of Colonial American cosmography in relation to the Ptolemaic tradition. There is more research to be done to fully grasp this topic, given the enormity of the subject. Still, I hope my work serves to acquaint readers with an intriguing matter that has to my knowledge not previously been explored in this way, entailing across such a large timescale between the founding of the Ptolemaic tradition and the intellectual awakening of Colonial Americans. Upon founding their new lives in North America, colonial thinkers were in some respects enjoying an opportunity to reconsider received wisdom about the world and the cosmos. In the midst of building a new society, they reflected on the journey of cosmographic wisdom across centuries and how ancient Greek influence persisted across historical eras. Therefore, I hope this investigation will shed light on the major connection between the cosmography of the Greek world and Colonial America that has largely been unrecognized until now.

Ultimately, through this methodological approach, I will answer the following three main questions I pose. Why and how did the Ptolemaic tradition develop in the Greek world? Why and how did the Ptolemaic tradition influence Colonial Americans? And lastly, why and how did Colonial Americans replace the Ptolemaic tradition, with the Copernican tradition?

The Ptolemaic tradition originated in Alexandria, as opposed to somewhere else, due to a convergence

of historical circumstances. Prominent among them was a cultural outlook transmitted directly from democratic Athens to Alexandria that promoted the freedom of scholarly thought. The scholarly objectivity and empirical approach of Claudius Ptolemy clearly owe much to the influence of the Athenian philosophers, as does Ptolemy's emphasis on the usefulness of mathematics. These factors would in turn lay the foundations of the Ptolemaic tradition in the Western world. The views of Colonial Americans reflect this enduring tradition, as seen in their belief in astrology and the geocentric theory, a direct inheritance from England. Subsequent replacement of the Ptolemaic tradition in Colonial America was possible due to a combination of religious openness and intellectual vitality that reflected the long-term influence of the Greek outlook. Also significant were timely contributions by English astronomers. Colonial Americans believed the search for truth to be an active enterprise, an idea that itself stemmed from Greek traditions and would make questioning the Ptolemaic tradition a natural rather than heretical act.

II: Origins of the Ptolemaic Tradition

The origins of what would become the Ptolemaic tradition trace to the ancient Greek philosopher Anaximander of Miletus, who was born in 610 B.C.[1] He argued that the Earth was at rest and in the center of our cosmos.[2] Building on the work of Anaximander, Plato, who was born in about 427 B.C., took this idea a step further, depicting the Earth at the center of a massive rotating sphere, which contained the stars, planets, and the sun.[3] Next, this idea would be expanded on by Eudoxus of Cnidus who was born around 390 B.C.[4] Eudoxus of Cnidus tried to explain the reason for the daily orbit of these fixed stars around the Earth, arguing that it occurs due to what is called "uniform motion."[5] Thus, Eudoxus believed that the sphere would turn on a fixed axis once a day covering an equal distance at equal intervals of time. For Eudoxus, this explained why the stars returned every night in the same position, because unfortunately Eudoxus did not have the tools to notice that the stars can actually move. Eudoxus' successors, Aristotle and Ptolemy, would both come to this conclusion as well.

Now, planets were a bit trickier for these astronomers, because the planets did not actually behave according to this theory and the Greeks studying these astronomical phenomena knew it. This led to the Greeks calling celestial bodies like the sun, moon, and planets "wanderers", because they could not understand why their movement did not follow the theory behind the "fixed axis", as the stars did.[6] To solve this mystery, Eudoxus assumed there must be more fixed spheres in order to accommodate the movements of all seven identified planets. In all, he came up with 26 spheres. Then came Aristotle, born in 384 B.C.; he added more spheres bringing the count to 56.[7] There were so many different trajectories of the planetary orbits that ancient Greeks, desperately trying to make their system fit what they were observing, were unable to reconcile empirical observation with theory.

Not all of the ancient Greek astronomers agreed with the hypothesis of Geocentric theory, though. Considering that cosmography was still in its infancy, this is not surprising. For example, one

1. Alban Dewes Winspear. *The Genesis of Plato's Thought*. (London: Transaction Publishers, 2011), 112.

2. Dirk L. Couprie, Robert Hahn, and Gerard Naddaf. *Anaximander in Context: New Studies in the Origins of Greek Philosophy*. (Albany: State University of New York Press, 2003), 31.

3. Stephen Blake, *Astronomy and Astrology in the Islamic World*. (Edinburgh: Edinburgh University Press Ltd., 2016), 7.

4. Leonid Zhmud. *The Origin of the History of Science in Classical Antiquity*. (Berlin: Hubert & Co., 2006), 232.

5. Edwin Hung. *Philosophy of Science: A Text on Traditional Problems and Schools of Thought*. (Wadsworth: Wadsworth Cengage Learning, 2014), 452.

6. Hung, *Philosophy of Science: A Text on Traditional Problems and Schools of Thought*, 452.

7. Hung, *Philosophy of Science: A Text on Traditional Problems and Schools of Thought*, 453; Norriss Hetherington. *Planetary Motions: A Historical Perspective*. (Westport: Greenwood Press, 2006), 27.

alternative view came from Aristarchus of Samos who was born around 310 B.C. and spent most of is life living in Alexandria.[8] Aristarchus stands out because he actually suggested that the Earth orbited the Sun in a circular motion.[9] Using basic geometry, he calculated the spatial relationship between the Earth, sun and moon.[10] Combined with careful, but imperfect observations, he reached what at the time were novel conclusions. Aristarchus concluded that the universe was expansive and believed that the Sun and the stars were stationary.[11] Unfortunately, this was an unpopular astronomical belief among the ancient Greeks and was even stigmatizing for Aristarchus, as it led some to question his piety.[12] Mostly, however, other astronomers just did not think it was scientifically accurate enough to be true, based on what they could observe.[13]

The other notable Alexandrian astronomers from the 3nd century B.C. include Eratosthenes, who was influential in the field of mathematics and was famous for measuring the Earth's circumference.[14] We also have the astronomer Hipparchus, who had substantial influence on the astronomer Claudius Ptolemy, because of his mathematical insights in astronomy, which paved the way for Ptolemy to fully transform Greek astronomy into a mathematical science. Hipparchus was also able to predict the precession of the equinoxes.[15] Next, Archimedes worked on methods for determining areas and volumes, which would later become the basis of calculus.[16] Lastly, there were the astronomers Timocharis and his student Aristyllus who recorded the movements of the stars.[17] Clearly, Ptolemy had many great predecessors in Alexandria.

Next, we will examine what the scholarly scene was like in Alexandria, Egypt before and at the time of Claudius Ptolemy. The city of Alexandria was famous for having the Library of Alexandria, founded by a former general of Alexander the Great, Ptolemy Soter. This library held the collections of Babylonian, Greek, Jewish, and Egyptian intellectual thought and science.[18] [19] The library's most prominent feature was its extensive collection of Greek literature and the numerous translations of non-Greek works into Greek.[20] The first nucleus of the libraries' collection was built by a student of Aristotle's named Demetrius of Pharlem, with the goal of mimicking the model of Aristotle.[21] As a result, this Alexandrian thirst for knowledge made Alexandria the center of science in the ancient world, where new explorations in the

8. Marcelo Gleiser. *The Dancing Universe: From Creation Myths to the Big Bang*. (Hanover: Dartmouth College Press, 2005), 50-54.

9. Rosen Edwards. *Copernicus and his Successors*. (London: Hambledon Press, 1995), 5.

10. Morris Kline. *Mathematical Thought From Ancient to Modern Times: Volume 1*. (Oxford: Oxford University Press, 1972), 156-157.

11. Edwards, *Copernicus and his Successors*, 5.

12. Thomas Heath. *Aristarchus of Samos, the Ancient Copernicus: A History of Greek Astronomy to Aristarchus, Together with Aristarchus' Treatise on the Sizes and Distances on the Sun and Moon*. (Cambridge: Cambridge University Press, 2013), 304.

13. Jean-Claude Pecker. *Understanding the Heavens: Thirty Centuries of Astronomical Ideas from Ancient Thinking to Modern Cosmology*. (Berlin: Springer, 2001), 88.

14. Kline, *Mathematical Thought From Ancient to Modern Times: Volume 1*, 160.

15. Kline, *Mathematical Thought From Ancient to Modern Times: Volume 1*, 158.

16. Rory MacLeod. *The Library of Alexandria: Centre of Learning in the Ancient World*. (London: I.B. Tauris Publishers, 2000), 6.

17. MacLeod, *The Library of Alexandria: Centre of Learning in the Ancient World*, 6.

18. MacLeod, *The Library of Alexandria: Centre of Learning in the Ancient World*, 8.

19. Robert Barnes. "Cloistered Bookworms in the Chicken-Coop of the Muses: The Ancient Library of Alexandria." in *The Library of Alexandria: Centre of Learning in the Ancient World*. (London: I.B. Tauris Publishers, 2000), 61.

20. MacLeod, *The Library of Alexandria: Centre of Learning in the Ancient World*, 7.

21. Enrico Berti and Virgilio Costa. "The Ancient Library of Alexandria. A Model for Classical Scholarship in the Age of Million Book Libraries." *CLIR Proceedings of the international symposium on the scaife digital library*, (2009), 14. http://www.perseus.tufts.edu/~ababeu/Berti-Costa_Alexandria_Kentucky.pdf; MacLeod, *The Library of Alexandria: Centre of Learning in the Ancient World*, 2.

sciences were conducted.[22] The secret to this success was that Alexandria based its learning on the model set by the Athenian Aristotle, where scientists, poets, historians, and grammarians worked together and this collaborative environment produced tremendous knowledge as a result in the fields of mathematics, engineering, and astronomy.[23]

On top of this, another example of Athenian influence in Alexandria comes from their use of Platonic thought, which was quite popular Alexandria.[24] In fact, the first edition of Plato's works as a collection was produced in Alexandria by Aristophanes of Byzantium in the 2nd century B.C. and was divided into a trilogy.[25] Other Alexandrian scholars like Erastothenes and Eudorus were serious students of Platonism. Erastothenes studied Platonism's mathematics and Eudorus was influential in its revival in Alexandria.[26] Platonism, of course, stems from Plato and people who subscribed to Platonism were attempting to understand the master's ideas and teachings. This was to a certain degree subjective, and much of Plato's thought left room for interpretation. Thus, although there are various views of what Platonism is, generally speaking, it embraces the following ideas: The universe has systematic unity, it is hierarchical, God is essential to the explanation of this hierarchy, the soul is the main principle of life and a person's soul is immortal, and lastly there are various ways of acquiring knowledge, which are hierarchical and based on varying levels of correlation to objective reality.[27] Hence, it appears Alexandrian academia was greatly influenced by the Athenian Socratic thinkers Plato and Aristotle, the same two thinkers who thrived in the democratic intellectual atmosphere that predominated in Athens.

Some scholars, though, argue that Alexandrian and Athenian science really did not have much in common. For instance, H. Floris Cohen, in his book *How Modern Science Came into the World* argues "In Athens the central operation was explanation through the positing of first principles; in Alexandria, description in mathematical terms. First principles of various kinds were put forward by a range of Athenian thinkers; what these first principles had in common was, indeed, their being *posited*, with a blend of inner self-evidence and external, empirical illustration serving to underwrite their validity. Validity was held in each case to be warranted by the very nature of the principles – but for the level of details, knowledge was not just probable but established once and for all. Alexandrian thought had no use for any such first principles. Practitioners took the basics for granted. Their sole aim was to establish mathematical regularities without explanatory pretensions or underlying ontology. Still, they also laid claim to indubitably certain knowledge, albeit attained quite another way, by means of mathematical proof for each successive theorem."[28] Essentially, Cohen says that Alexandrian science was based on mathematics, while Athenian science was more based around natural philosophy. Cohen reiterates this opinion "The argument so far has concerned Athenian natural philosophy and Alexandrian mathematical science as two distinct, largely separate entities." In short, "despite some overlaps (notably, a shared intellectualism and a commonly held conviction of a centrally fixed Earth),

22. Berti and Costa. "The Ancient Library of Alexandria. A Model for Classical Scholarship in the Age of Million Book Libraries.", 17.

23. Berti and Costa. "The Ancient Library of Alexandria. A Model for Classical Scholarship in the Age of Million Book Libraries.", 18.

24. Tanner. "Aristotle's Works: The Possible Origins of the Alexandria Collection.", 144.

25. Maren R. Niehoff. "Philo's Role as a Platonist in Alexandria." *Etudes platoniciennes*, Vol. 7, (2010), 35. https://www.academia.edu/26405975/Philo_s_Role_as_a_Platonist_in_Alexandria?auto=download.

26. Niehoff. "Philo's Role as a Platonist in Alexandria.", 35.

27. Lloyd P. Gerson "What is Platonism?" *Journal of the History of Philosophy*, Vol. 43, No. 3. (2005), 258-260. http://individual.utoronto.ca/lpgerson/What_Is_Platonism.pdf.

28. H. Floris Cohen. *How Modern Science Came into the World: Four Civilizations, One 17th-Century Breakthrough*. (Amsterdam: Amsterdam University Press, 2010), 16-17.

overall they stood far apart."[29] Still, this paper contends that there are three fundamental points of congruence. How can the contrast be so stark given how influential it seems the Athenian philosophers Plato and Aristotle were in shaping Alexandria's intellectual foundations?

Cohen makes an important point about Alexandrian and Athenian academia, but it appears he is not focused on the early origins of education in Alexandria or the impact of the "shared intellectualism" between the two cities. Rather, he appears more interested in what academia would eventually become in Alexandria. However, it seems based on the evidence provided above that Alexandria in at least its early stages was heavily influenced by Athenian academia, especially by the model created by Aristotle. However, I do think Cohen makes a good point about the subsequent role of mathematics in Alexandrian education.

What does Cohen's argument mean for Claudius Ptolemy though? Before we examine this question, first, I think it will be important to describe who Ptolemy was and what he did. Claudius Ptolemy was born in 100 A.D.[30] His name Ptolemy shows Greek ethnic origins and his name Claudius shows that he was a Roman citizen and that an ancestor of his was granted citizenship by the Emperor Claudius.[31] Ptolemy lived around Alexandria in the Greco-Roman world and created astronomical models, which would serve as the western world's guide to astronomy up to the Scientific Revolution.[32] Ptolemy is known for attempting to create a model of the entire universe that was known to him.[33] In this model called the Ptolemaic system, Ptolemy placed the Earth in the center, being orbited by the following celestial bodies in order of closeness: the moon, Mercury, Venus, the sun, followed by the rest of the planets, and then the sphere of fixed stars.[34] As pointed out earlier, these were all ideas, which came from astronomers prior to Ptolemy. Ptolemy's biggest contribution to the field of astronomy were the mathematical models Ptolemy developed in his works, like the *Almagest* and the *Planetary Hypotheses*, where he detailed the motions of the celestial bodies or what he called "the heavenly motions."[35] [36]

This leads us to ask the question, what exactly in the field of mathematics did Ptolemy do that led to his strong support of the subject? To start, Ptolemy was a pioneer on a number of fronts when it came to his mathematically based astronomy. For instance, his planetary models and parameters were grounded in geometric techniques, based on very specific and dated observations.[37] He was the first person to ever produce such work.[38] This was special because Ptolemy was using a new and improved scientific method to mathematically describe why and how the moon,

29. Cohen, *How Modern Science Came into the World: Four Civilizations, One 17th-Century Breakthrough*, 27.

30. Pecker, *Understanding the Heavens: Thirty Centuries of Astronomical Ideas from Ancient Thinking to Modern Cosmology*, 93.

31. Blake, *Astronomy and Astrology in the Islamic World*, 9.

32. Jaqueline Feke. *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*. (Toronto: Institute for the History and Philosophy of Science and Technology University of Toronto, 2009), 1.

33. Robert R. Newton. "Astronomy, Astrology, Ptolemy, and US." *Johns Hopkins APL Technical Digest*, Vol. 3, No. 1 (1982), 79. http://www.jhuapl.edu/techdigest/views/pdfs/V03_N1_1982/V3_N1_1982_Newton.pdf.

34. Newton, "Astronomy, Astrology, Ptolemy, and US.", 79.

35. A. Murschel "The structure and function of Ptolemy's Physical Hypotheses of Planetary Motion." *Journal for the History of Astronomy*, Vol. 26. (1995), 33. http://adsbit.harvard.edu//full/1995JHA....26...33M/0000057.000.html.

36. Elizabeth Anne Hamm. *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*. (Toronto: Institute for the History and Philosophy of Science and Technology, University of Toronto, 2011), 2.

37. Bernard R. Goldstein. "Saving the Phenomena: The Background to Ptolemy's Planetary Theory." *Journal for the History of Astronomy*, Vol. 28, No. 1. (1997), 1. http://www.pitt.edu/~brg/pdfs/brg_i_3.pdf.

38. Goldstein, "Saving the Phenomena: The Background to Ptolemy's Planetary Theory.", 1.

planets, sun, and fixed stars orbit the Earth.[39] On top of this, Ptolemy set out to calculate the distances between these celestial objects, as well as their sizes.[40] These calculations were used by Ptolemy to come up with conclusions that were the most sophisticated ones up to date at the time.[41] Ptolemy was insistent that to have a legitimate astronomical model of the universe, such a model must have a uniform and circular motion, be simple, accurate, and based on empirical data.[42]

Therefore, based on his research, he maintained the belief of his predecessors Eudoxus and especially Aristotle that the celestial bodies have a uniform and circular motion, the heavens are endless, and at the center of all of this, is planet Earth.[43] His exception, though, was how he described the motion of the planets around the Earth, which stumped all his predecessors. Ptolemy describes this problem his predecessors faced in this passage "Now it is our purpose to demonstrate for the five planets, just as we did for the sun and moon, that all their apparent anomalies can be represented by uniform circular motions, since these are proper to the nature of divine beings, while disorder and nonuniformity are alien [to such beings]. Then it is right that we should think success in such a purpose a great thing, and truly the proper end of the mathematical part of theoretical philosophy. But, on many grounds, we must think that it is difficult, and that there is good reason why no-one before us has yet succeeded in it. For, [firstly], in investigations of the periodic motions of a planet, the possible [inaccuracy] resulting from comparison of [two] observations (at each of which the observer may have committed a small observational error) will, when accumulated over a continuous period, produce a noticeable difference [from the true state] sooner when the interval [between the observations] over which the examination is made is shorter, and less soon when it is longer."[44] As one can tell, Ptolemy is quite aware of the difficulties that have historically existed when tracking the planetary motions, because data has been inconsistent between various observers. This of course is because geocentric theory is wrong, but how Ptolemy tries to make sense of these motions based on the supposed truth of geocentric theory being true is quite ingenious.

Ptolemy then goes on to describe the main issue when identifying the motions of the five planets stating "In investigation of the anomalies, considerable confusion stems from the fact that it is apparent that each planet exhibits two anomalies which are moreover unequal both in their amount and in the periods of their return: one [return] is observed to be related to the sun, the other to the position in the ecliptic; but both anomalies are continuously combined, whence it is difficult to distinguish the characteristics."[45] Ptolemy here describes why many astronomers have struggled to accurately calculate the motions of the planets because of what he calls their "anomalies", which were strange motions the planets were observed to make that didn't make sense according to astronomical models prior to Ptolemy. Ptolemy explains his solution to solving the anomalies of planetary motion this way: "There are, as we said, two types of motion which are simplest and at the same time sufficient for our purpose, [namely] that produced by circles eccentric to [the centre of] the ecliptic, and that produced by circles concentric with the ecliptic but carrying epicycles around. There are likewise two apparent anomalies for each planet: [1] that anomaly which varies according to its position in

39. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 65.

40. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 5.

41. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 21.

42. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 39.

43. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 21.

44. Claudius Ptolemy. *Ptolemy's Almagest*. G.J. Toomer trans. and Annot. (London: Gerald Duckworth & Co. Ltd., 1984), 420.

45. Ptolemy, *Ptolemy's Almagest*, 420.

the ecliptic, and [2] that which varies according to its position relative to the sun of each individually."[46] In turn, Ptolemy came to the conclusion that the planets moved on a small sphere called an epicycle, which was connected to a bigger sphere, like the one's described by Eudoxus and Aristotle as mentioned earlier.[47] Because of this theory, he was the first person to be able to determine the location of these planets based on a geometrical theory and solved the mystery of their movement improving the geocentric theory.[48]

Therefore, the *Almagest* and the *Planetary Hypotheses* are considered to be some of the greatest works of science ever and they were the first to incorporate complex mathematical principles to create a solution to solve the mystery of the planetary motions, which Ptolemy's predecessors failed to do.[49] Elizabeth Anne Hamm describes the legacy of Ptolemy in her work *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary* in the following statement: "The second-century A.D. natural philosopher Claudius Ptolemy is arguably the most important author whose works exist on Greco-Roman science. His works of science encapsulated and exceeded the work of his predecessors…While he owes much of his success to his predecessors, it is Ptolemy's own contributions – namely his ingenuity, his thoroughness, and his ability to coalesce theories – that made him an authority in so many fields."[50] In fact, Ptolemy built off of the texts representing Aristotle's geocentric theory to construct the best astronomical model the world had seen until this of Nicholas Copernicus in the 16th century, which would not gain widespread favor until the 18th century.[51] [52]

Mathematics was the Ptolemy's specialty and clearly a major factor in why his work was tremendously influential. However, does this mean that no other factors played a role in his research? No, as Cohen points out "Ptolemy provides the one and only case of a mathematical scientist expertly and more than fleetingly concerned to construct the very kind of specific linkages between Alexandrian and Athenian approaches that I have demonstrated were by and large absent from Greek nature-knowledge…With *heavenly bodies* Ptolemy sought in three different ways to enlarge upon the geometric two-dimensional models presented in the *Almagest*. At the head of that book he placed six 'hypotheses' (points of departure), for example, 'that the Earth makes no motion involving change of place'. He drew support for these hypotheses from empirical phenomena if he could and from natural philosophy (Aristotelian or stoic) if he had nothing else to draw on."[53] At the same time though, I believe Cohen downplays the role of Athenian influence, by describing Athenian philosophy as more of a last resort option, rather than a complementary method.

To challenge Cohen, we must examine scholar Jacqueline Feke's work *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology.* Feke notes the following about Ptolemy "His philosophy, his motivation and method for studying mathematics and natural philosophy, remains relatively unstudied."[54] This is a very important idea, because when we focus on the philosophy behind his work, Ptolemy's research appears littered with philosophical reasoning stemming from the Socratic philosophers of Athens. Evidence of this statement comes from Ptolemy's engagement

46. Ptolemy, *Ptolemy's Almagest*, 442.

47. Thomas Kuhn. *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*. (Cambridge: Harvard University Press, 1957), 69-70.

48. Stephanie Lynn Budin. *The Ancient Greeks: New Perspectives*. (Santa Barbara: ABC-CLIO, Inc., 2004), 383.

49. Ptolemy, *Ptolemy's Almagest*, 1.

50. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 1.

51. Ptolemy, *Ptolemy's Almagest*, 3.

52. MacLeod, *The Library of Alexandria: Centre of Learning in the Ancient World*, 8.

53. Cohen, *How Modern Science Came into the World: Four Civilizations, One 17th-Century Breakthrough*, 24.

54. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 9.

with Aristotle, when it comes to determining the write method of astronomical inquiry. For instance, Ptolemy lays out Aristotle's three theoretical sciences in this quote: "For Aristotle divides theoretical philosophy too, very fittingly, into three primary categories, physics, mathematics and theology. For everything that exists is composed of matter, form and motion; none of these [three] can be observed in its substratum by itself, without the others: they can only be imagined." Here Ptolemy acknowledged the importance of the Aristotelian tradition. Ptolemy then goes on to deem mathematics as the only legitimate method of inquiry.[55]

Even more eye catching yet, is Ptolemy's relationship with the philosophy of the Athenian Plato. Ptolemy seems to be quite familiar with many philosophies ranging from the Socratic philosophy to the Stoic and the Epicurean. Despite his diverse interest in these philosophies, the one that stands out is what Feke calls "Platonic Empiricism."[56] As Feke observes, "At the foundation of Ptolemy's scientific method is his criterion of truth, grounded in what later came to be labeled empiricism and designed to differentiate opinion from knowledge, a distinction which he expresses in Platonic terms. This criterion serves as the means by which Ptolemy categorizes every object in the cosmos, determines the epistemic success of the theoretical sciences, and establishes a scientific method aimed at producing knowledge."[57] Consequently, Ptolemy appears to use Plato's theory of knowledge versus opinion, when it comes to determining that mathematics is the only true source of knowledge out of Aristotle's three theoretical sciences.[58] Thus, this sheds light on the influence of the Athenian philosophers Plato and Aristotle on Ptolemy and also shows how critical Athens was to the future development of knowledge in the Greek world. In turn, not only were Athenian philosophers influential when it came to the foundations of the scholarly climate of Alexandria, regardless of what it would later become, they also affect Ptolemy's research when it came to seeking knowledge.

To put this another way, it is hard to imagine the intellectual flowering of Alexandria had it not been stimulated by a democratic intellectual impulse from Athens. Without it, perhaps Plato and Aristotle would not have been as influential on the academic world of Alexandria and consequently Ptolemy too. This then begs the question, what was it about democratic Athens that was so critical to the development of the philosophies of Aristotle and Plato? To understand this connection, we must go back to the Greek freedom of thought found in Athenian democracy. The legacy of ancient Greek democracy is well known and the influence of these democratic ways was critical to the future development of Greek science. This is because under Athenian democracy the freedom of thought reached its apex in Greece. As scholar Enrico Berti argues, "freedom of speech was an essential aspect of Athenian democracy."[59] In fact, the Athenian Plato, who was critical of democracy as a political system, realized Athens was friendlier to free speech than any other place in Greece. According to Berti, Plato even called Athens "in love with speech" and the city of "many speeches."[60] How then does this relate to Ptolemy, who lived hundreds of years later under the more authoritarian Roman Empire? To answer this, it is important to note that Greek democracy may have died in Athens, but it bequeathed sophisticated systems of thought for the cultures which descended from it. Though not sufficient by itself to explain subsequent intellectual life, Athens' democratic culture was an invaluable contributor. Viewed through

55. Ptolemy, *Ptolemy's Almagest*, 35.

56. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 221.

57. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 221-222.

58. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 43.

59. Enrico Berti. "Ancient Greek Dialectic as Expression of Freedom of Thought." *Journal of the History of Ideas*, Vol. 39, No. 3 (1978), 348. http://www.jstor.org/stable/2709382.

60. Berti. "Ancient Greek Dialectic as Expression of Freedom of Thought.", 348.

another lens, Athenian philosophers were not brilliant due to a genetic predisposition, but rather because of an environment that allowed bold ideas to flourish. Obviously, there were very intelligent Greeks before the Socratic thinkers, but Athenian democracy created a more favorable atmosphere for intellectual thought to develop in ways not seen before.

As Berti writes: "Naturally I do not intend to maintain that a philosophical and cultural movement as complex as that of the Sophists, or also a succession of philosophies as profound as those of Socrates, Plato, and Aristotle should be derived entirely from the freedom of speech allowed by Athenian democracy. It is well known that the major Sophists had their own particular conception of arete…Nevertheless it seems to me undeniable that the freedom of speech assured by Athenian democracy was one of the causes which contributed to the rise of such philosophies."[61] Ergo, though there is always an eclectic mix of factors which shape various cultural phenomena, Athenian democracy was surely a fundamental part of the process and one that stands out as the most influential of all factors other than an individual's talent, intellect, or ambition. There is no question that ancient Greek philosophers were immensely talented and intelligent, but without being in the right circumstances at the right time, it is certainly more difficult for such characteristics to reach their full potential. As a result, living in a democracy can give a talented person an edge over someone born in a less freethinking society. Nevertheless, Athenian philosophy and science occurred due to the freedom of thought, which allowed it to develop. In turn, its legacy lived on specifically through the intellectual products it left behind in the fields of philosophy and science. As Ober details in his chapter titled "Conditions for Athenian Democracy" in the book *The Making and Unmaking of Democracy: Lessons From History and World Politics*, "Because the new democratic state proved wildly successful on the international scene and spectacularly productive of literary, artistic, and philosophical culture, the Athenian model was highly influential and never forgotten."[62]

The evidence of the freed inquiry in Ptolemy's research, emerges from the debates he engaged in over various astronomical concepts. Ptolemy was not at all shy about criticizing his predecessors, even if they were of the likes of the great Aristotle or Plato. This fact alone reveals the importance of openness in Athenian intellectual life. He criticized Aristotle specifically, in regard to his work on celestial spheres.[63] As Hamm states, "Ptolemy argued that the arrangement proposed by Aristotle would not be physically feasible and he produced reasons as to why the concentric spheres proposed by Eudoxus and Aristotle did not provide a realistic description of the cosmos." This is because for Ptolemy, the movement of the celestial spheres could be caused by themselves and did not have to be driven by something else.[64]

In turn, one can clearly see that the climate of academia in the Greek world at the time was not restrictive of the opinions, whether favorable or opposed, of scholars towards the works of others, though there are a few exceptions. For the most part, the ancient Greeks were not being forced to follow some state sponsored ideas of the universe, but were instead challenging mainstream concepts and brainstorming new ones. As scholar James Evans points out "The second point to bear in mind in assessing the importance of Aristotle's physics is that the astronomers were capable of abandoning it whenever it seemed expedient…The Greek astronomers simply never were blind slaves to Aristotle's system that they sometimes have been made out to be."[65] This is a very important

61. Berti. "Ancient Greek Dialectic as Expression of Freedom of Thought.", 349.

62. Josiah Ober. "Conditions for Athenian Democracy." in *The Making and Unmaking of Democracy: Lessons From History and World Politics* edited by Theodore K. Rabb and Ezran N. Suleiman. (London: Routledge, 2003), 18.

63. Murschel "The structure and function of Ptolemy's Physical Hypotheses of Planetary Motion.", 38.

64. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 220.

65. James Evans. *The History and Practice of Ancient Astronomy*. (Oxford: Oxford University Press, 1998), 20.

point, because if the ancient Greeks were not allowed to question those like Aristotle, then who knows how harmful it would have been to the development of Greek astronomy. Therefore, the freedom of thought stemming from democratic Athens allowed for the development of Athenian Greek philosophy, which would influence the construction of the Ptolemaic tradition in Alexandria, due to the influence of Plato and Aristotle on the origins of Alexandrian academia.

Hence, thanks to the influence of Athenian philosophers like Plato, Ptolemy's research was also highly successful, by virtue of his ability to be objective via his empirical reasoning, rather than plaguing his research with his own biases. As Ptolemy detailing his thought process himself, asserted: "Since we observe, examine, and come to understand reality by sense perception, reasoning, and by discourse either in our own minds or with other people, it would be not unreasonable to match sense perception with the instrument with which the subject under judgment is judged, intellect with the agent of judgment, and *logos* with the means by which the agent judges." Essentially, he is saying that we obtain knowledge by using reason to judge our sense of perception.[66] This is a relevant idea for all of human history, because it is still so easy for people to come to unreasonable conclusions via illogical analysis and confirmation bias. The fact that Ptolemy was so aware of this speaks volumes about his intellect and the sophistication of intellectual thought in the Greco-Roman world.

Ptolemy was open to new ideas, but not afraid to criticize bad ones. As the scholar Andrew Barker expresses in his book *Scientific Method in Ptolemy's 'Harmonics'* "He shows himself to be well informed about the debate, and he offers sharp criticism of extreme views on either side. His own position is designed to incorporate promising insights from any doctrinal repertoire, while avoiding the faults they had carried with them, and to fuse them into a new methodological amalgam, more balanced and more adequate to its task."[67] Here Barker does a nice job of describing what makes Ptolemy so skilled as a scientist, because he is not cherry-picking facts, nor is he obsessed with his own ideas. In fact, Ptolemy even denounces such behavior as seen in the following quote: "For those who approach this science in a true spirit of inquiry and love of true thought to use any new methods they discover, which give more accurate results, to correct not merely the ancient theories, but their own too, if they need it. They should not think it disgraceful, when the goal they profess to pursue is so great and divine, even if their theories are corrected and made more accurate by others beside themselves."[68] Thus, it is evident that for Ptolemy his research is about seeking the best possible interpretation of nature, it is not about who is right or who is wrong. This is ultimately the characteristic of a great scientist and one who is a modest and an objective seeker of knowledge.

Now one can argue today that if Ptolemy was so reasonable and based on logic, why did he believe in astrology? After all, Ptolemy essentially wrote the "how-to" guide of astrology. If we keep to the historical context of his time, though, this is not so strange. Throughout history, people have had religious beliefs that seem to contradict the reasoning behind some of their scientific research, though. For example, only in the modern era is it common to have such a large number of scientists who are atheists, agnostic, non-believers, or people who simply believe in God, but don't have an opinion of who or what God is. Throughout history the majority of the greatest scientific minds, irrespective of culture, were people of religious faith. Therefore, Ptolemy is not so much a walking contradiction, but rather normal for his time. Just because someone is reasonable about one thing, does not mean they will be reasonable about another. As Feke states "It is true that Ptolemy also wrote a book on astrology, but then so did many of those to whom

66. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 55.

67. Andrew Barker, Andrew. *Scientific Method in Ptolemy's 'Harmonics'*. (Cambridge University Press: Cambridge, 2000), 14.

68. Hamm, *Ptolemy's Planetary Theory: An English Translation of Book One, Part A of the Planetary Hypotheses with Introduction and Commentary*, 28.

we attribute much of our modern…In the Almagest Ptolemy was at his scientific best. Whatever may have been his astrological views they do not seem to intrude anywhere in his astronomical work. This was certainly not the case in the work of Kepler."[69]

Ptolemy was not only an astronomer, which I detailed earlier, but also an astrologer. As a matter of fact, Ptolemy was so influential in the field of astrology that he wrote the handbook on it for the Greco-Roman world and western civilization. This book was known as the *Tetrabiblos*. In this work, Ptolemy defends astrology as a beneficial discipline, because he feels it helps people understand the power and influence of the celestial bodies. In fact, for Ptolemy astronomy and astrology went hand in hand. For him, the only differences between the two subjects were that astronomy explains and predicts the locations and movements of celestial bodies and astrology studies and predicts the influence of these celestial bodies on Earth.[70] Thus, in the *Tetrabiblos* Ptolemy was concerned with the influence of the planets on human beings. Supposedly, because the planets' rays affect the development of human beings in regard to their bodies and souls. Ptolemy describes these assumption in the following passage from the *Tetrabiblos*: "In somewhat summary fashion it has been shown how prognostication by astronomical means is possible, and that it can go no further than what happens in the ambient and the consequences to man from such causes—that is, it concerns the original endowments of faculties and activities of soul and body, their occasional diseases, their endurance for a long or a short time, and, besides, all external circumstances that have a directive and natural connection with the original gifts of nature, such as property and marriage in the case of the body and honor and dignities in that of the soul, and finally what befalls them from time to time."[71] The reasoning behind this was that Ptolemy felt that if the sun and the moon have physical effects on the Earth, then the planets must as well; in turn the planet's rays must affect people, because a person's soul and body are all made of matter just like a planet's rays.[72] [73]

This is not at all surprising, given the fact that Ptolemy also believed the planets to be divine. As Ptolemy states, "Now it is our purpose to demonstrate for the five planets, just as we did for the sun and moon, that all their apparent anomalies can be represented by uniform circular motions, since these are proper to the nature of divine beings."[74] That being said, Ptolemy still viewed astrology as conjectural, whereas astronomy due to mathematics, as mentioned earlier, was considered truth.[75] Ultimately, Ptolemy's views were quite common in the Greco-Roman world, originally stemming from the Babylonians.[76] In addition, astrology and astronomy were often considered to go hand in hand for much of history. The lack of clear distinction between astrology and astronomy was something that lasted in Europe until around the time of the Renaissance.[77] By about 1600 educated Europeans began rejecting astrology.[78] Also, all studies of Ptolemy's research deem it scientific, based on reason, and unhindered by his astrological beliefs. It was not the scientific method that was lacking in Ptolemy's work, but more the tools necessary to see the universe for what it is.[79] For example, when one looks at the night sky, it appears that the planets are

69. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 18.

70. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 4-5.

71. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 169.

72. Newton. "Astronomy, Astrology, Ptolemy, and US.", 79.

73. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 170.

74. Ptolemy, *Ptolemy's Almagest*, 420.

75. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 157.

76. Evans, *The History and Practice of Ancient Astronomy*, 343.

77. Newton. "Astronomy, Astrology, Ptolemy, and US.", 77.

78. Newton. "Astronomy, Astrology, Ptolemy, and US.", 79.

79. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 18.

moving, but not the Earth. As a result, we are only as good as the tools we have at our disposal when it comes to astronomy.

In turn, this objectivity was what led to the development of mathematics and how Ptolemy used it to change the history of astronomy. You see, Ptolemy had a unique philosophy of mathematics. As mentioned earlier, Ptolemy was one of the few Greeks to see mathematics as the only true source of knowledge and criticized other fields popular with the Greeks like physics and theology, considering them as nothing more than mere speculations.[80] As Ptolemy himself argues in the *Almagest*, "From all this we concluded: that the first two divisions of theoretical philosophy should rather be called guesswork than knowledge, theology because of its completely invisible and ungraspable nature, physics because of the unstable and unclear nature of matter; hence there is no hope that philosophers will ever be agreed about them; and that only mathematics can provide sure and unshakeable knowledge to its devotees, provided one approaches it rigorously. For this kind of proof proceeds by indisputable methods, namely arithmetic and geometry."[81] Feke nicely summarizes just how powerful this statement by Ptolemy is stating, "According to Ptolemy, physics and theology are conjectural, and mathematics alone yields knowledge. This claim is unprecedented in the history of ancient Greek philosophy."[82] The reason for this is that in the Greco-Roman world prior to Ptolemy, science was more of a philosophical field and not as much a scientific one in the modern sense and thanks to Ptolemy science would be greatly improved.[83] Therefore, Greek astronomy was focused solely on physical explanations of the universe, instead of numerical ones.[84] Ptolemy would change this and rewrite the book so to speak on how science should be conducted.

Ptolemy understood that observation alone could not answer every question and he realized that mathematics played a very large role in the understanding of the universe as well.[85] Ptolemy recognized that observation is limited by interpretation and imprecision, while mathematics is not subjective. The evidence Ptolemy gives to support his theory of mathematics, when it comes to understanding astronomy can be seen by Feke in this statement "Ptolemy explains in Almagest 1.1 that astronomy studies mathematical objects that are divine, eternal, and unchanging. It is because these objects are eternal and unchanging that the mathematical knowledge associated with them is itself eternal and unchanging."[86] As one can tell, Ptolemy clearly sees mathematics as some sort of language of the Gods in a way, because he considers it to be the only way of discovering truth in the universe. Therefore, mathematics is the only method of acquiring knowledge about the heavens and the divine objects such as the planets. Overall, mathematics was orderly, consistent, aesthetically perfect, and useful in explaining phenomena in the real world. This is similar to how the Puritans in Colonial America saw it as well, which will be described in a later chapter.

Next, besides the divinity of the subject of mathematics for Ptolemy, from a methodological standpoint, he believed mathematics was based on reason, because mathematics is not someone's opinion, it is based on mathematical models and formulas, which are perceptible and testable.[87] As Ptolemy describes "These things belong to the loftiest and loveliest of intellectual pursuits, namely to exhibit to human understanding through mathematics [both] the heavens themselves in their physical nature (since they can be seen in their revolution about us), and

80. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, II.

81. Ptolemy, *Ptolemy's Almagest*, 36.

82. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, II.

83. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 1.

84. Evans, *The History and Practice of Ancient Astronomy*, 217.

85. Evans, *The History and Practice of Ancient Astronomy*, 392.

86. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 60.

87. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 61.

[the nature of] the Earth through a portrait (since the real [Earth], being enormous and not surrounding us, cannot be inspected by any one person either as a whole or part by part." Thus, according to Ptolemy mathematics allows us to see the nature of the universe.[88]

III: Reception of the Ptolemaic Tradition in Colonial America

Now, before we delve into the Ptolemaic tradition in Colonial America, it is important first to understand where the tradition was prior to the British colonization of the new world. For instance, in Europe. The Ptolemaic tradition was dominant in Europe up until the Renaissance. The first person to challenge this theory in Europe was the Polish astronomer Nicholas Copernicus. According to scholars, Nicholas Copernicus, who was born in 1473 was concerned with Ptolemy's claim that the celestial bodies were on a small sphere, connected to a bigger sphere orbiting the Earth. This is known as Ptolemy's "Equant."[89] For Copernicus, this theory did not match up with Aristotle's claim of the necessity of a uniform and circular motion. As a result, Copernicus began exploring other potential celestial arrangements, which would fit Aristotle's theory of planetary motion.[90] Copernicus then came up with another idea, arguing that the motion of the sun and the planetary motions that Ptolemy described are flawed, because they are based on observations from Earth, which is also in motion.[91] Therefore, in an attempt to return astronomy back to Aristotle's theory of uniform motion, Copernicus made the bold claim in his work *On Revolutions* in 1543 that the Sun was the center of the universe and was orbited according to uniform motion by Earth and the other planets.[92] Unfortunately, Copernicus' work was not widely accepted.[93] In fact, before 1600 scholars estimate that there were only 10 supporters in Europe of Copernicus' ideas.[94] Despite common myth, however, this was not due to the church, but rather just due to the fact that scholars disagreed with his ideas, because they did not quite match the observational data available.[95] Interestingly enough, though, Copernicus' astronomical work spread all over Europe and a second edition came out in 1566.[96] Many scholars even regarded his criticisms of Ptolemy's "equant" legitimate.[97] Despite this, as mentioned earlier the heliocentric theory was still not accepted much among astronomers. The 16th century scholars mostly just used some of Copernicus' findings in an attempt to improve the Ptolemaic tradition.[98] Some scholars rejected it on scientific grounds, while other scholars believed it just went against the Bible and thus

88. Feke, *Ptolemy in Philosophical Context: A Study of the Relationships Between Physics, Mathematics, and Theology*, 62.

89. Evans, *The History and Practice of Ancient Astronomy*, 420.

90. Moritz Hutten. "A new Cosmos-a novel Physics: The Scientific reception of the heliocentric world view in the Renaissance." *Max Planck Institute for the History of Science*, (2013), 3. http://www.haus-der astronomie.de/3440709/01Huetten_HelioCentricCosmos_korrigiert.pdf.

91. Jerry Dobrycki. "Nicolaus Copernicus-His Life and Work," in *The Scientific World of Copernicus: On the Occasion of the 500th Anniversary of his Birth 1473-1973* edited by Barbara Bienkowska. (Dordrecht: D. Reidel Publishing Company, 1973), 20.

92. Sun Kwok. *Our Place in the Universe: Understanding Fundamental Astronomy from Ancient Discoveries*. (Berlin: Springer, 2017), 194.

93. Kuhn, *The Copernican Revolution: Planetary Astronomy in the Development of Western Thought*, 185.

94. Martin V. Curd. "The Rationality of the Copernican Revolution." *Proceedings of the Biennial Meeting of the Philosophy of Science Association*, Vol. 1 (1982), 3. http://www.jstor.org.proxy.uba.uva.nl:2048/stable/ pdf/192651.pdf?refreqid=excelsior%3A5e3cfe33be6579619121acd834fe2391.

95. Nicholas P. Leveillee. "Copernicus, Galileo, and the Church: Science in a Religious World." *Inquiries Journal/Student Pulse*, Vol. 3 No. 5, (2011), 1. http://www.inquiriesjournal.com/articles/1675/copernicus-galileo-and-the-church-science-in-a-religious-world.

96. Pietro Daniel Omodeo. *Copernicus in the Cultural Debates of the Renaissance: Reception, Legacy, Transformation*. (Leiden: Brill, 2014), 63.

97. Evans, *The History and Practice of Ancient Astronomy*, 420.

98. Jean-Pierre Luminet. "The Provençal Humanists and Copernicus." *Inference*, Vol. 2 No. 4 (2017), 5. https://arxiv.org/ftp/arxiv/papers/1701/1701.02930.pdf.

valued some of his observations, but considered his conclusion anti-Christian.[99] It also must be pointed out that Copernican astronomy also had its flaws. For instance, J.B. Brackenridge in his work titled "Kuhn, Paradigms and Astronomy" explains in a very useful way two important points. First, there were a lot of flaws in Copernicus' work, which is one reason for its slow acceptance. To some degree, Copernicus reached the right conclusion about a heliocentric universe, even though his work was not really objectively much better than that of Ptolemy. A subsequent study by Kepler and Newton was necessary to consolidate a real "scientific revolution." To this point, Brackenridge cites the words of another scholar, Thomas Kuhn: "Modern historians, making ample use of the advantage of hindsight, stress the revolutionary significance of the heliocentric system and the simplification it had introduced. In fact, the actual computation of planetary position was exactly the ancient pattern and the results are the same. The Copernican solar theory is definitely a step in the wrong direction for the actual computation as well as for the underlying cinematic concepts…Had it not been for Tycho Brahe and Kepler, the Copernican system would have contributed to the perpetuation of the Ptolemaic system in a slightly more complicated form but more pleasing to philosophical minds."[100] Kuhn then continues arguing, "Thus the astronomical revolution that provides the transition from the Aristotelian world view, as reflected in the Almagest, to the Newtonian world view, as reflected in the Principia, takes place over an extended period of nearly one hundred and fifty years."[101] However, Copernicus' work was still critical in breaking the stranglehold that Ptolemy's vision of the universe had over the astronomical views held by most scholars at the time. The fact that subsequent proofs were necessary to prove the point does not diminish this fact. Still, this also helps explain why some scientists were reluctant to latch onto Copernicus' view. He had solved one problem, but not others that were associated with it.

Now turning towards Colonial America, which began to forge a common culture in the early 17th century, one can see based on the earlier historical outline of the 16th century in Europe that the Ptolemaic tradition was still enshrined throughout European academia, except for a few individual scholars. This being said, in order to fully understand the Colonial Americans, we must first understand who these people were. For this, we need to start with the Puritan movement in England, which was one of the results of the Protestant Reformation in Europe spawned by Martin Luther. The Puritans were very much influenced by Calvinism and developed a very strict interpretation of Christianity, which led them on a quest to purify the Church of England. For the Puritans, they believed that the church was still plagued by remnants of Catholicism and they wanted to purge it of all things they believed were not found in scripture like idolatry, which was the worship of images and symbols. Their strong religious ideas and their outspokenness about them did not mesh well with the other Christians in England and caused many conflicts. Because of this, Puritans in England suffered from persecution and decided to move to the new world to create the society they desired.[102] Not all Puritans came directly to the new world, however. One particular Puritan minister by the name of John Davenport, who was educated at Oxford University, moved to Amsterdam in 1633.[103] There, Davenport was the co-minister of the Church of England. Unfortunately, this position would not last long, because Davenport was too extreme in his religious beliefs for the church there in Amsterdam

99. Luminet, "The Provençal Humanists and Copernicus.", 5; Omodeo, *Copernicus in the Cultural Debates of the Renaissance: Reception, Legacy, Transformation*, 19.

100. Bruce J. Brackenridge. "Kuhn, Paradigms, and Astronomy: Astronomy as a Case Study of Khunian Paradigms." *Proceedings of the American Philosophical Society*, Vol. 129, No. 4 (1985), 446. https://www.jstor.org/stable/986938.

101. Brackenridge. "Kuhn, Paradigms, and Astronomy: Astronomy as a Case Study of Khunian Paradigms.", 447.

102. Murrell. *Essential Church History: And the Doctrinal Significance of the Past*, 131-132.

103. Samuel Eliot Morison. *The Founding of Harvard College*. (Cambridge: Harvard University Press, 1995), 374.

and had many disagreements with other members of the church. Thus, in 1637, Davenport set off for the new world to join his fellow Puritans.[104] Later, Davenport will be an important figure when it comes to understanding the mentality of the Puritans towards new scientific ideas.

In the new world, the Puritans founded the Massachusetts Bay Colony in 1630. In this colony, the Puritans were the drivers of science in Colonial America and the founders of Harvard University. Before we delve into the science of the Puritans, though, we must understand that the Puritans were an extremely religious group of people. The colonists were motivated by religion and lived by their faith.[105] Thus, for the Puritans living in the Massachusetts Bay Colony it was a religious utopia, where all people worked together for the greater good of the colony through their various talents, which according to the Puritans, were God given.[106] For example, in the Puritan Dedham community in Massachusetts, their lives were lived according to a covenant, based on the following points: "the fear of God," the practice of "everlasting love," and lastly the idea that one should let all disputes among men be settled by a third party.[107] This was an agreement sworn by all Puritans in Dedham. This oath represents the Puritan goals of having societal peace and order.[108] Citizens also would regularly gather together to take part in town meetings and participated in the decision-making progress by expressing their opinions.[109] The main decision makers were the elected selectmen chosen by the people. These selectmen were rarely questioned or rejected once elected. Nevertheless, though, the Puritan communities used these social gatherings to come up with compromises to solve communal disagreements.[110] Over time, as generations passed these communal decisions would become less and less based on the selectmen and more based on popular support.[111]

On top of these beliefs, Puritans believed in predestination, for example, they believed they were already predestined by God to go to heaven or hell from birth. They also believed in a personal covenant relationship with God, which they felt was crucial for an individual to escape their sins.[112] The scholar Elizabeth Patton describes in her article "The Excellency of Theology: A Critique of Robert K. Merton's 'Puritan Thesis,'" these aspects of Puritanism: "Ascertaining these marks of grace was central to Puritan theology, for it linked directly with the doctrine of Election, the idea that some were predestined for salvation, while others were damned. Only God truly knew who was assured and who was not, but individuals could gain assurance by finding the signs of grace in their own lives. Thus, the hope and desire for [election], the awareness of it, and the assurance of it, were fundamental to the Puritan religion."[113] As one can discern from Patton's statement the Puritans were quite dedicated to their faith and this would play an influential role on their astronomy as well.

When it came to science, the Puritans were quite interested in astronomy, due to the strong connection

104. Morison, *The Founding of Harvard College*, 374.

105. Morison, *The Founding of Harvard College*, 350.

106. Abram C. Van Engen. *Sympathetic Puritans: Calvinist Fellow Feeling in Early New England*. (Oxford: Oxford University Press, 2015), 41, 50.

107. Francis J. Bremer. *The Puritan Experiment: New England Society from Bradford to Edwards*. (Lebanon: University Press of New England, 1995), 104.

108. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 104-105.

109. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 103-105.

110. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 103-105.

111. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 103-105.

112. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 18.

113. Elizabeth Patton. "The Excellency of Theology: A Critique of Robert K. Merton's 'Puritan Thesis.'" with Reference to the Works of Robert Boyle," *Journal of Faith and Science Exchange*, (2012), 17.

between their religious and astrological beliefs.[114] Astronomy was often written about in the astronomical almanacs produced by the Puritans, which featured the latest astronomical research by colonial scholars.[115] In light of this, it is important to note that the idea behind these astronomical almanacs actually comes from Claudius Ptolemy.[116] Evidence of this comes from the year 150 A.D., when Ptolemy made a catalogue of the stars, tracking their movements in records, which would create the basis for which the colonial almanacs would be structured.[117] Now, these almanacs were fixated on religious matters until about the 18th century, when the amount of religiosity in them started to shrink.[118] Also, these 17th century almanacs were usually produced by Harvard graduates.[119] In fact, 41 out of 44 almanacs produced prior to 1687 were written by Harvard graduates.[120] Harvard University was founded by the Puritans in 1636 as a religious institution.[121] At Harvard University in the 17th century, there were only a few textbooks on astronomy, which came from the private collections of John Winthrop the Younger and the family of Cotton Mather.[122] John Winthrop the Younger is considered by Colonial American scholars to have been the first American astronomer and scientist who would help lay the foundation of American astronomy.[123] Following in the footsteps of Winthrop, there were Colonial Americans who were making an impact in astronomy on the global stage. One noteworthy example was Colonial American scholar Thomas Brattle, who contributed to Isaac Newton's research on gravity via his research on the elliptical orbit of the comet of 1680.[124] He was not the only Colonial American with a connection to Isaac Newton though. Colonial American astronomer Arthur Storer was even friends with Newton and regularly exchanged letters regarding astronomy with him.[125]

Upcoming, I will analyze the influence of the Ptolemaic tradition on the Puritans. I will do this by focusing on the thriving beliefs in astrology and the Geocentric theory in Colonial America. As stated previously, these two fields must be grouped together because from even before the time of Ptolemy to the beginning of Colonial America, astrology and astronomy were inseparable. As scholar Robert R. Newton argues "In Greek civilization, and also in European civilizations until about the time of the Renaissance, little distinction was made between astrology and astronomy. When a distinction was made, we can see in the very names which subject was considered more important: astrology means the science of the stars whereas astronomy means merely their arrangement."[126] Because of this, when the Colonial Americans inherited the Ptolemaic tradition, they not only inherited its astronomy, but also its astrology. Now, starting with astrology, it is

114. F. E. Brasch. "John Winthrop (1714-1779), America's First Astronomer, and the Science of His Period." *Publications of the Astronomical Society of the Pacific*, Vol. 28, No. 165 (1916), 154. http://adsabs.harvard.edu/full/1916PASP...28..153B.

115. Samuel Eliot Morison. "The Harvard School of Astronomy in the 17th Century." *The New England Quarterly*, Vol. 7, No. 1 (1934), 16.

116. Charles L. Nichols "Notes on the Almanacs of Massachusetts." *Almanacs of Massachusetts*, (1912), 15. http://www.americanantiquarian.org/proceedings/45647891.pdf.

117. Nichols "Notes on the Almanacs of Massachusetts." *Almanacs of Massachusetts*, 15.

118. Nichols "Notes on the Almanacs of Massachusetts." *Almanacs of Massachusetts*, 17.

119. Donald K. Yeomans "The Origin of North American Astronomy—Seventeenth Century." *Isis*, Vol. 68, No. 3 (1977), 423. http://www.jstor.org/stable/231317.

120. Nichols "Notes on the Almanacs of Massachusetts." *Almanacs of Massachusetts*, 18.

121. Brasch. "John Winthrop (1714-1779), America's First Astronomer, and the Science of His Period.", 154.

122. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 422.

123. Brasch. "John Winthrop (1714-1779), America's First Astronomer, and the Science of His Period.", 154, 170.

124. F. E. Brasch. "The Isaac Newton Collection." *Publications of the Astronomical Society of the Pacific*, Vol. 74, No. 440 (1962), 388. http://adsbit.harvard.edu//full/1962PASP...74..366B/0000368.000.html.

125. Roberta J.M. Olson and Jay M. Pasachoff. *Fire in the Sky: Comets and Meteors, the Decisive Centuries, in British Art and Science*. Cambridge: Cambridge University Press, 1998), 26.

126. Newton, "Astronomy, Astrology, Ptolemy, and US.", 77.

important to understand why Colonial Americans developed these beliefs from the Ptolemaic tradition. In the Colonial American almanacs, scholars always detailed the monthly celestial events of each year and their correlations with astrology. On top of this, these almanacs also contained various essays on astronomy and astrology. For a notable number of Colonial Americans, but not all, astrology was taken quite seriously. For example, an author of some of the colonial almanacs by the name of Samuel Danforth believed the following about comets: "Most commonly they are observed to precede if not portend great calamities."[127] This was a very common theme for astrological supporters throughout history going back to the ancient world and the idea of comets representing pending disasters was popular among the colonists. Another Colonial American by the name of Increase Mather who was a Puritan minister, believed that comets were God's warnings to the sinners of Earth and a sign that those who have sinned must repent or prepare for disaster. Mather took this so seriously his grave warnings were commonly incorporated into his sermons.[128] He also wrote a book about astrology and comets in 1683 in a book titled *Kometographia*, where he argued about how comets symbolized God's anger.[129]

Despite this though, he denied that astrological predictions based on celestial events were legitimate, even though he was still superstitious about them.[130] Mather explains his theory of astrology in the following statement from his book *Kometographia* "There are those who think, that inasmuch as comets may be supposed to proceed from natural causes there is no speaking voice of heaven in them, beyond what is to be said of all other works of God. But certain it is, that many things which may happen according to the course of nature, are portentous signs of divine anger...Thunder, Lightning, Hail, and Rain, are from natural causes, yet are they sometimes signs of God's holy displeasure." [131] In turn, for the Puritans, like the ancient Greeks and Greco-Romans nature represented God or the Gods.

When it comes to the colonial non-believers of astrology, they reacted quite differently to the field of astrology. For instance, though astrology was written about in the almanacs, it was consistently criticized in them as well. As early as 1653, Harvard University condemned astrology as false. By 1690 Harvard had less influence on the almanacs and more astrology began to appear in them. To illustrate this, colonist John Holwell wrote astrological predictions in the almanacs from 1689 to 1700.[132] Nonetheless, astrology was still on its way out among the educated, as explained by Colonial American scholar Charles Morton in 1687 in his textbook on astronomy titled *Compendium Physicae*, where he states "The End of Comets hath been Guessed by their supposed effects; to prognosticate some Great evills to Some particular Country; So that they have stricken Great terror into the Vulgar; But [wiser] men see no satisfactory reasons for these Supposed Omens. They see that which is Said in this business is Grounded on [44] falsehood, (or at least [uncertainty]) Namely that they are inflamed matter and that their smoke and Ashes pollute the Air."[133] It should also be noted that in the 17th century students and scholars at Harvard had access to the following works as well:

127. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 419.

128. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 419.

129. Clark A. Elliot. *Science at Harvard University: Historical Perspectives*. (Bethlehem: Lehigh University Press, 1992), 34.

130. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 421.

131. Increase Mather. *Kometographia. Or A discourse concerning comets; wherein the nature of blazing stars is enquired into: with an historical account of all the comets which have appeared from the beginning of the world unto this present year, M.DC.LXXXIII. : Expressing the place in the heavens, where they were seen, their motion, forms, duration; and the remarkable events which have followed in the world, so far as thay have been by learned men observed. : As also two sermons occasioned by the late blazing stars*. (Boston: S.G., 1683), 18. https://quod.lib.umich.edu/e/evans/N00277.0001.001?view=toc.

132. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 421.

133. Charles Morton. *Compendium Physicae*. (Boston: Colonial Society of Massachusetts, 1940), 93. https://www.colonialsociety.org/node/526.

Usefulness of Experimental Natural Philosophy (1663) by Robert Boyle and *Astronomia Instaurata* (1656) by Vincent Wing and Adrian Heereboord's *Parallelismus Aristoteliscae et Cartesianae Philosophiae Naturalis* (1643). These works would provide the research of the great scholars around the world like Descartes, Galileo, Gassendi, Kepler, Newton, and Halley.[134] [135] Nonetheless, Colonial American astrology would start to fade away, after the Copernican tradition became ingrained in society.[136] Based on my research it is not clear why it lasted so long in society, but colonial leaders very much wanted to get rid of it.[137] Perhaps the reason why it lasted so long though was because of the idea of predestination in Puritan society, since astrology gave people the ability to see into the future, it empowered them to prepare for what was yet to come. Overall, however, when it comes to the origins of Colonial American astrology, there is a connection to Ptolemy, because Ptolemaic tradition provided the inseparable fields of astrology and astronomy to the Western world and thus astrological ideas like genetic traits were culturally passed down to the Colonial Americans.

Moving on from astrology in Colonial America, we turn to the Colonial American belief in the Geocentric theory by Ptolemy. From its founding, Harvard University was teaching the Ptolemaic tradition. As a matter of fact, the first president of Harvard University, Henry Dunster, in 1640 was teaching the Ptolemaic tradition and Aristotelian natural philosophy from a book by Johannes Magirus. A German physics professor, his work was titled *Physiologia peripatetica*.[138] [139] Magirus' work, which was first published in 1597, was very popular at Cambridge University in the 17th century.[140] In his work, he talked about various astronomical subjects including: the planets, fixed stars, eclipses, and comets, based on the Ptolemaic tradition.[141] All these things were important to the astronomical studies of the Colonial Americans. Magirus also stressed the need to study nature and the universe to truly understand God.[142] This was the mentality that the Puritans especially embraced in the theological underpinnings of their astronomy. Harvard University would continue teaching from this book until 1671.[143] In addition, in the colonial almanacs as late as 1656 there were still Pro-Ptolemaic astronomy essays being written. For example, Thomas Shepards' essay in the almanac of 1656 titled "A Brief Explication of the most Observable Circles in the Heavens."[144]

In the early days at Harvard University, the first generation of students adopted the teachings of the Ptolemaic tradition without protest.[145] The reason for the Colonial Americans' unquestioned embrace of the Ptolemaic tradition, stems from the inability of

134. Perry Miller and Thomas H. Johnson. *The Puritans: A Source Book of Their Writings.* (New York: HarperCollins, 1963), 733.

135. Louis B. Wright. *The Cultural Life of the American Colonies*. (Mineola: Dover Publications, Inc., 2002), 220.

136. Nichols "Notes on the Almanacs of Massachusetts." *Almanacs of Massachusetts*, 20.

137. Butler, Jon. "Magic, Astrology, and the Early American Religious Heritage, 1600-1760," *The American Historical Review*, Vol. 84, No. 2 (1979), 339. http://www.jstor.org.proxy.uba.uva.nl:2048/stable/1855136.

138. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 415.

139. Rutkin, Darrel H. "Astrology," in *The Cambridge History of Science, Volume 3: Early Modern Science* edited by Katharine Park and Lorraine Daston. (Cambridge: Cambridge University Press, 2006), 555.

140. Katherine Neal. *From Discrete to Continuous: The Broadening of Number Concepts in Early Modern England*. (Berlin: Springer Science + Business Media, 2002), 12.

141. Alan Gabbey. "Newton, active powers, and the mechanical philosophy." in *The Cambridge Companion to Newton*. edited by Rob Iliffe and George E. Smith. (Cambridge: Cambridge University Press, 2016), 423.

142. Terhi Kiiskinen. "The natural philosophy of Sigfrid Aronus Forsius: between the created world and God." in *Medicine, Natural Philosophy and Religion in Post-Reformation Scandinavia*. Edited by Ole Grell and Andrew Cunningham. (London: Routledge, 2017), 157.

143. Wright, *The Cultural Life of the American Colonies*, 220.

144. Erwin V. Johanningmeier *Americans and Their Schools*. (Long Grove: Waveland Pr Inc, 1985), 14.

145 Morison, "The Harvard School of Astronomy in the 17th Century.", 3.

scholars to see the stellar parallax, meaning Colonial Americans in support of the Ptolemaic tradition were unable to see the differences in the stars, when viewing them from different positions. This is because they did not possess the technology to view the deviations of the stars. As scholar Rose Lockwood states in her article "The Scientific Revolution in Seventeenth Century New England," "The absence of any perceptible parallax in the stars was used early as an argument against the Copernican system, for if the Earth were in fact moving, then according to the critics, the stars should change in their relationship with one another. To evade this criticism, Copernicus had been forced to place the sphere of the fixed stars at such a great distance from the Earth that the shifting relationships would be imperceptible."[146] In turn, as scholar Louis B. Wright points out in his book *The Cultural Life of the American Colonies* "Many learned men of the seventeenth century, in the colonies as elsewhere, lived and died in Ptolemaic orthodoxy."[147] This anti-Copernican mindset would not dominate the colonies for too much longer though and it is due to the Puritans' outlook that the sciences contributed to their theology.

IV: The Shift Towards the Copernican Tradition

The Copernican tradition came to replace the Ptolemaic tradition. This would occur due to three major factors: The Puritans' religious openness to new scientific ideas, the use of Greek intellectual thought by the Puritans, and the scientific aid given by England. To start, I will focus on the scientific thought behind this shift towards Copernicus and the debates that were being held. For example, the role of important ideas regarding logic and mathematics was central. Before adopting the Copernican tradition, Colonial Americans in academia had already set the stage for this transition. Despite embracing the Ptolemaic tradition, the Colonial Americans stilled gazed at the heavens above to learn more about them.[148] As a result, as the scientific revolution occurred, the Colonial Americans did not isolate themselves.[149] In fact, the Puritans would do the exact opposite. In fact, several Puritans became members of England's top scientific group, the Royal Society, and in 1683 Puritans even created their own scientific organization called the "Philosophical Society."[150]

This movement all began in the New England almanac of 1659 by Zechariah Brigden who made the following statement, which would change Colonial America forever: "In the lowest room of the world is placed the sun, which challengeth to it itself a central motion…which is evidenced by the admirable invention of the telescope…After Venus is placed y Earth, which befides her diurnal revolution in 24 houres, hath an anual periodical through y ecliptique performed in 365 dates...that this is the true & genuine system of the world."[151] Therefore, he asserted that the sun is at the center of the universe and that the Earth revolves around it. Because of this daring essay the freedom of thought would be tested early in Colonial America. Naturally, such an essay would most certainly catch the attention of the Puritan church leaders. As mentioned earlier, however, the church was open to the ideas of Brigden, in turn leaving room for Colonial

146. Rose Lockwood. "The Scientific Revolution in Seventeenth-Century New England." *The New England Quarterly*, Vol. 53, No. 1 (1980), 89. http://www.jstor.org/stable/365290.

147. Wright, *The Cultural Life of the American Colonies*, 220.

148. Milton Sernett. *Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter" by Nathaniel Hawthorne*. (Saint Louis: Concordia Seminary, 1967), 18.

149. Sernett. *Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter" by Nathaniel Hawthorne*, 18.

150. Sernett. *Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter" by Nathaniel Hawthorne*, 18.

151 Zechariah Brigden. *An Almanack of Coelestial Motion for this Present Year of the Christian Era 1659*. (Cambridge: S. Green, 1659), 14. https://catalog.hathitrust.org/ Record/010586548?type%5B%5D=all&lookfor%5B%5D=Zechariah%20Brigden&ft=.

American science to grow.

Next, Brigden's almanac was then followed by other Pro-Copernican almanacs like *An almanack for the year of our Lord 1661* by Samuel Cheever, Cheever also came out in support of the Copernican tradition arguing "The ancient opinion of the Earth's motion...is quite rejected...Copernicus now appeares, and allowing the Earth her diurnall and anuall motion, cleares up by infallible geometricall demonstrations that all motions are performed about the Sun the undoubted center of y Planetary Orbs....Whereupon in this age, Galileus, Bullialdus, Keplerus, Gassendus, and fundry other mathematicians, have learnedly cortuted the Ptolemaick & Tychonick systeme, and demonstrated the Copernican Hypothesis to be most confentneous to truth and ocular observations."[152] This was a huge development for Colonial America, because a trend started to occur, where year after year the Copernican tradition was being favored in the local almanac in New England.

In 1671, the shift towards Copernicus would continue, as the work of Johannes Magirus would be removed from the Harvard University curriculum, due to a supposed student protest against a requirement to study the Ptolemaic tradition. In response, Harvard University replaced Magirus' work with Adrian Heerboor's *Parallelismus Aristoteliscae et Cartesianae Philosophiae Naturalis* written in 1643, which was in favor of the Copernican tradition.[153] This would also lead to dramatic changes to the New England almanacs, which would no longer give any type of support to the Ptolemaic tradition. Evidence of this comes from Colonial American scholar John Foster and his almanac called *An Almanack of Coelestial Motion for this Present Year of the Christian Era*, where he states "The Ptolemaick Hypothesis having for many centuryes of years been the basis of astronomical calculations, is now in this latter age of the world by astronomers wholly rejected. Who have found out a way by far more plausible for the salving of the wonderful variety of motions and appearances among the planets, they being now generally of opinion (how strange forever it may seem) that the Earth moves and that the sun stands still."[154] This is fascinating, because only about 16 years after Brigden's essay, the Ptolemaic tradition died among the scholarly community in New England.

Another example, of this movement towards Copernicus comes from Charles Morton, who states "What is said may suffice to Shew that the old doctrine of the heavens was imperfect, and that this latter seams more probable, and better suted to other things in nature, we shall have occasion to speak of hereafter this recommends itself to our acceptance as the most artificial for that it is the most Simple, and intelligible, and free from the other Intricacies as may be seen in the diagram. Absurd and intricate the old is yet, Tichoes imperfect, the Other is compleat."[155] In his 1687 Harvard textbook Morton wrote *Compendium Physicae*, declaring the Copernican tradition to be the only complete astronomical model, whereas the Ptolemaic tradition and others are not.

This was incredibly important to the scientific revolution in Colonial America, because the almanacs were the most widely spread literature in the colony. Now, one should also point out that this shift was more in the academic community, rather than the general public, because most of the public was not educated enough to understand essays in the almanacs. However, because Harvard University would sponsor the new astronomy as truth and something that is in line with the Bible as well, the Copernican tradition developed great authority among the church and its members in the colony.[156] It also helped that scientists all around Europe and Colonial America were making discoveries, which helped cement the new astronomical theory in Western science. As scholar J. Rixey Ruffin

152. Samuel Cheever. *An almanack for the year of our Lord 1661*. (Cambridge: S.G. and M.I., 1661), 15. https://catalog.hathitrust.org/Record/010586540.

153. Wright, *The Cultural Life of the American Colonies*, 220.

154. John Foster. *An Almanack of Coelestial Motion for this Present Year of the Christian Era*. (Cambridge: S. Green, 1675), 14.

155. Morton, *Compendium Physicae*, 24.

156. Morison, "The Harvard School of Astronomy in the 17th Century.", 16.

points out, "As discoveries proceeding from the New Science multiplied, acceptance of heliocentrism was increasingly inevitable. Astronomers had grappled with a host of questions about celestial bodies, distances, and forces since Copernicus had first advanced his theory. By 1700, many of those questions had been answered."[157] This was made possible by the use of tools like the telescope, which helped scholars better amass evidence for heliocentric ideas.[158] Thus, among the scholarly community in the West, the Copernican tradition had prevailed.

Despite this strong push towards Copernicus, the general public still was not completely convinced of the Copernican tradition. For example, in 1713 some were still advocating for the Ptolemaic tradition, including Colonial American Daniel Leeds.[159] In 1714, when Puritan Minister Cotton Mather had stated in a sermon that the Copernican tradition was correct, a church member named Samuel Sewall commented "I think it inconvenient to assert such problems", ergo insinuating that such statements were inappropriate.[160] Also in 1722, a Colonial American by the name of Nathaniel Bowen argued that the Earth was the center of the universe.[161] Because of these developments, in 1723, some Copernican scholars expressed their remorse that the Copernican tradition had not yet become fully recognized by the public.[162] These attacks on the Copernican tradition would not go unanswered by the Pro-Copernican scholars and many would respond to the Pro-Ptolemaic remarks through essays.

For example, scholars like Thomas Fleet in 1720 or the anonymous writer, B.A. Philo-Astro, responded to criticism of the Copernican system. B.A. Philo-Astro especially played an important role in rebuking these anti-Copernican attacks and was quite a thoughtful writer with deep insight into the perspectives of Colonial America. One particular instance revealing this was his response to Nathaniel Bowen, in which B.A. Philo-Astro pleaded with the public not to condemn ideas that do not conform to their preconceived notions.[163] As Philo-Astro himself claimed in regard to the almanac he wrote in 1723, his almanac was meant for the "unlearned" in hopes that they could "know the general Opinion of the Learned World."[164] Also attempting to protect the Copernican tradition, you had Colonial Americans like Nathaniel Ames, who claimed the new Copernican astronomy was proven by mathematics stating, "Mathematical principles are far above the capacity of the generality of men."[165] Ames also took on the scriptural resistance towards the Copernican tradition, because many had interpreted the Bible to be based on the Ptolemaic tradition. For example, the passages from the Bible like Ecclesiastes 1:4-5, which has lines which say "the Earth abideth forever", "the sun also ariseth, and the sun goeth down, and hasteth to his place where he arose" or in Psalm 93, which says "the Earth also is established, that it can- not be moved."[166] These lines were used in an attempt to take away the legitimacy of the Copernican tradition. In response, Ames would argue against these passages deeming them to be metaphorical. Earlier we saw Brigden also take on this problem arguing that the Bible was subject to interpretation.

Another cause of the public backlash towards Copernican astronomy was the rapid pace at which

157. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735." *The New England Quarterly*, Vol. 70, No. 2 (1997), 311. http://www.jstor.org/stable/366705.

158. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 81-82.

159. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 308-309.

160. Morison, "The Harvard School of Astronomy in the 17th Century.", 7.

161. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 308-309.

162. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 309.

163. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 310.

164. Thomas A. Horrocks. *Popular Print and Popular Medicine: Almanacs and Health Advice in Early America*. (Amherst: University of Massachusetts Press, 2008), 5.

165. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 309.

166. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 311.

new scientific developments were occurring and the fact that new questions, which were once considered unthinkable, suddenly became a part of the academic discourse and this ultimately spooked the public. For example, ideas such as an infinite universe and countless inhabitable worlds beyond Earth, all arose from the logical implications of Copernican analysis.[167] This is because people could no longer complacently think of Earth as being special, but rather had to grapple with the idea that Earth was potentially part of something larger and was itself no longer unique.

Therefore, the Copernican tradition did not fully become accepted by the non-academic public until after 1720. According to Ruffin, most ideas about the Copernican tradition previous to this were rejected by the non-Harvard community.[168] This was because heliocentric theory did not start to become adopted by Colonial scholars until after Brigden's essay in 1659 and after 1675 the Colonial almanacs faced competition from other almanacs and had to compete for the public's attention. In fact, by the end of the 17th century Harvard University sponsored almanacs would stop being published, due to this increase in competition with other almanac makers.[169]

Moving on, these Puritans intellectuals were the first of the Colonial Americans to apply Greek scientific traditions of reason and mathematics to the world around them, setting the foundations for what would become American astronomy. This is reiterated by Milton Sernett in this quote: "Far from disdaining intellectual pursuits, the Puritans were the earliest of Americans to apply reason to the world about them. American science owes much to the men who gathered around the 'optic tube' at Harvard in those early days. Yet in spite of their many associations with the scientific revolution in England and on the Continent and in spite of their own discoveries in the laboratory of Nature, the greatest Puritan thinkers never dared to question the fundamental theological maxim that God revealed his providence in the portents about them."[170] It was also the fact that like Copernicus, Colonial Americans through the use of reason and mathematics realized the discrepancies in the Ptolemaic tradition. Much like Copernicus, for example, they realized that the mathematics of Ptolemy did not fit the physical system of Aristotle. As a result, due to their piety these Colonial Americans felt the need to re-explain the true nature of the universe.[171] Thus, without the scientific inquiry of the Colonial Americans. American science would not become the powerhouse it is today.

Next, we will examine Puritan religion and its cohesion with the pursuit of science. To start, the scholar Jon H. Roberts in his chapter "Science and Christianity in America: A Limited Partnership" in the book *American Christianities: A History of Dominance and Diversity*, offers a very thought-provoking quote, which says "The conviction that the creation attested to its creator prompted some Puritans to play an active role in appropriating and disseminating knowledge gleaned from natural philosophy."[172] This is where the Puritan shift towards the ideas of Copernicus begins, with this Puritan openness to the Greek practice of natural philosophy. This can be seen in the memoirs of the first president of Harvard, Henry Dunster, who was also an educator there. In his memoirs from 1654, Dunster describes the requirements of the education at Harvard University to obtain a degree, stating "Every scholar that on proof is found able to read the original of the Old and New Testament into the Latin tongue, and to resolve them logically, and is instructed

167. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 313.

168. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 313.

169. J. Rixey Ruffin. "'Urania's Dusky Vails': Heliocentrism in Colonial Almanacs, 1700 1735.", 307.

170. Sernett. *Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter"* by Nathaniel Hawthorne, 74.

171. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 79.

172. Jon H. Roberts. "Science and Christianity in America: A Limited Partnership." in *American Christianities: A History of Dominance and Diversity* edited by Catherine A. Brekus and W. Clark Gilpin. (Chapel Hill: University of North Carolina, 2011), 328.

in the principles of natural and moral philosophy, withal being of honest life and conversation, and at any Public Act hath the approbation of the Overseers and President of the College, may be invested with his first degree: but none shall expect it until he hath been four whole years in the College, in which he hath lived blameless, and hath faithfully performed all public exercises."[173] Also at Harvard, students had to be well trained in the field of mathematics, mastering the subjects of arithmetic, geometry, and astronomy.[174]

Thus, the Puritans, as they began to develop more as a society, began to explore the field of astronomy more and more in honor of their faith. This is somewhat surprising given our twenty-first century perspective, which tends to assume that intensely religious societies tend to ignore or reject scientific inquiry. But for the Puritans, much like the ancient Greeks, their religious beliefs only increased their thirst for astronomical knowledge. This can be seen in a quote by scholar Milton Sernett in his article "Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter" by Nathaniel Hawthorne", where Sernett argues "The 'warfare between science and theology' found no battleground in New England, where the clergy were leaders in liberalism and enlightenment, purveyors of new learning to the people."[175] This was not a problem when the Puritans were in England as well.[176] This was especially surprising, given the fact that Puritan science had to be able to navigate the biblical minefield that is the belief in a literal interpretation of the Bible, to which they subscribed wholeheartedly. For example, Colonial American scholar John Foster, who as mentioned earlier was a supporter of the Copernican tradition, attempted to fight off objections based on biblical scripture. This was a challenging task, because as he himself stated, the Bible had "infallible authority."[177] This is one of the most amazing things about the Puritans because you have these people who possess a persona that is incredibly rigid and pious and yet, these strict religious leaders are not taking a stand against science, but are rather for it. For them science is not an enemy, but instead a tool of God. This is also the view Claudius Ptolemy had about the relationship between science and theology. For instance, in the *Almagest*, when speaking of mathematics, which, thanks to him became the foundation of science in the West, he says, "For this is the best science to help theology…With regard to virtuous conduct in practical actions and character, this science, above all things, could make men see clearly; from the constancy, order, symmetry and calm which are associated with the divine, it makes its followers lovers of this divine beauty, accustoming them and reforming their natures, as it were, to a similar spiritual state."[178]

Interestingly enough, Colonial Americans had a very similar view of the field of mathematics as well, as described by Colonial American scholar Thomas Brattle. A professor of mathematics and astronomy at Harvard University, he characterized mathematics as, "The most true doctrine and discipline."[179] Because of this, modern day scholars like Lockwood argue "The scientific revolution was grounded in a mystical notion that God is a great geometer, and that mathematics is a revelation of God's intricately rational plan."[180] Therefore, Ptolemy and the Colonial Americans seem to have had quite a bit in common, when it came to

173. Henry Dunster. *President Dunster's Quadriennium Memoir*. (Cambridge: Harvard University Archives, 1654), 291. https://www.colonialsociety.org/node/411#ch04.

174. Elliot, *Science at Harvard University: Historical Perspectives*, 29.

175. Sernett. *Portent and Providence- An Investigation of the Puritan Habit of Deciphering the Will of God in the Natural and the Preternatural with Special Reference to "The Scarlet Letter"* by Nathaniel Hawthorne, 19.

176. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 196.

177. Foster, *An Almanack of Coelestial Motion for this Present Year of the Christian Era*, 14.

178. Ptolemy, *Ptolemy's Almagest*, 36-37.

179. Rick Kennedy. "Thomas Brattle and the Scientific Provincialism of New England, 1680-1713." The New England Quarterly, Vol. 63, No. 4 (1990), 597-599. http://www.jstor.org/stable/365919.

180. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 80.

their view of mathematics. It should also be noted that scholars in Europe like Galileo had also come up with this philosophy, but the origins of this concept started with Ptolemy.

Another important development of Puritan theology, which helped them transition towards the Copernican tradition, was their belief that their minds were part of God's creation. Therefore, their mind was competent enough to build an understanding of God's creation. This theological perspective would prevent an outlook that might deem science a useless field, due to the potentially detrimental anti-scientific belief that God's universe is unknowable. In turn, this made new ideas easier to accept, when discovered.[181] At the same time though, the advancement of science also began to shake up Puritan theology in unprecedented ways, because it opened up all previous knowledge of the universe to questioning and skepticism. This questioning even made Puritans uncomfortable, for example, as Rose Lockwood states, "These theories had devastating implications for the theology of the Creation. As the relationship between the new science and Puritan theology became apparent to New England astronomers, the confusion in their theories seemed to increase. Thus, when they came to consider the possibility of an indefinitely extended, or even infinite, universe, their close association of God with the created universe introduced the unnerving possibility of the eternity of the world."[182] Consequently, just as many societies have had to reconcile conflicting ideas, the Puritans too had to figure out how to preserve their theology, in light of seemingly contradictory scientific evidence. This will be touched upon more later in the chapter.

One of the best pieces of evidence portraying this revolution of theological thought came from the progressive Puritan scholar Zechariah Brigden, who makes a shocking claim for a Puritan in the following quote "The Scriptures being fitted as well to the capacity of the rudest mechanick, as of the blest Philosopher, do not intend so much propriety and exactness, as playness and perspicuity; and in Philosophicall truths therin contayned, the proper literal sense is alwayes subservient to the casting vote of reason."[183] This is unchartered territory for a Puritan, because here Brigden has challenged the religious status quo arguing that reason should determine the literal meaning of scripture, which represents a striking contrast to the statement made by Foster that I mentioned earlier. Lockwood claims, "New England compilers attempted to reconcile biblical cosmology with their interest in the new astronomy by arguing that the language of the Bible was more "suggestive" than literal."[184] Brigden though, does not stop there. He takes his critique of the Bible one step further, claiming, "The most seemingly contradicting Scripture is Psalm: 104. He hath founded the Earth; upon its Basis, that it should not be removed forever. But 1. Place is sometimes taken for the same with order, and in this sense the Earth doth not change its place, or is not removed. Or 2. The Basis of a figure, is that whereon it rests, answerable to which in the Earth is its center, on which the Earth is so founded, that it cannot suffer a total dissipation."[185] In turn, Brigden is arguing that the Bible is also subject to interpretation. This is a very clever strategy, because it turns what could be very controversial passages of the Bible into a matter of misunderstanding, rather than an attack on the Bible itself. This is important to note, because Puritans, who were protestants of course, were fully entitled to analyze and read the Bible which was deemed accessible to all. This is in contrast to Catholic views of the era, according to which only the church leaders had the intellectual authority to interpret scripture. In contrast, the Puritan communities were completely open to scriptural debate as a fundamental right of all who could read.

181. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 80.

182. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 89.

183. Brigden, *An Almanack of Coelestial Motion for this Present Year of the Christian Era 1659*, 15.

184. Lockwood. "The Scientific Revolution in Seventeenth-Century New England.", 79.

185. Brigden, *An Almanack of Coelestial Motion for this Present Year of the Christian Era 1659*, 15.

Brigden's role, though, in Colonial America does not stop there. He was also the first one to set the stage for the astronomical movement towards the Copernican tradition. Because in the New England Almanac of 1659, Brigden becomes the first Colonial American to support the Copernican tradition. One of Brigden's major sources for this almanac was the work *Astronomia Instaurata* by English astronomer Vincent Wing. Wing's book was possibly the first book to bring the discoveries of Copernicus, Galileo, and Kepler to English readers.[186] As a result of Wing's work, Brigden in his essay in the almanac of 1659 challenged Colonial American assumptions about astronomy and scripture, arguing in favor of the Copernican tradition and a common sense understanding of the Bible, where reason serves as the guide to understanding, as mentioned in the quotes above. Thus, one wonders how the Colonial Americans reacted to such a shocking essay? As a matter of fact, Brigden's essay was welcomed. Evidence of this comes from a letter exchange between the Colonial American scholar John Winthrop the Younger and Puritan clergyman John Davenport, who I mentioned earlier as a very conservative fellow. In the letter, John Winthrop the Younger was asking Davenport what he thought of Brigden's essay. Davenport then had this to say "The Almanack, which I had not seene before...The Author of it is wholly unknowne to me, save by his name in the title page…For he saith, Twice shall this planet, whereon we live and its concomitant the moone, widdow each other of theyre sunederived lustre. Now, the place, whereon we live, is the Earth The place, I say, not the planet. But he is not willing solus sapere. Therefore for his 4 proposicions he produceth, in his last page, sundry authors, who, he saith, have answered the objections from scripture against this opinion. I have not read theyre answers. But, if that be the breife or summe of them, which he notes, it will not be found, upon an exact search, to be satisfying. However it be; let him injoy his opinion; and I shall rest in what I have learned, til more cogent arguments be produced then I have hitherto met with."[187] This was quite a tolerant reaction given Davenport's extremely religious background and his history of disagreeing with things he saw as impious. If the Puritan church would have had a different reaction to Brigden, who appears to not have been an authoritative figure in the community, who knows what could have happened. Brigden could have even been excommunicated.[188]

Luckily for Brigden he wasn't and that is one of the incredible things about Colonial America. If people like Brigden were not given their voice, who knows how differently science would have developed in the colonies? As scholar Samuel Eliot Morison describes, "The reply of that worthy (March 18, 1659) is a delightful example of a tolerantly conservative attitude toward new theories…instead of opposing the acceptance of the Copernican theory, (Puritans) were the chief patrons and promoters of the new astronomy, and of other scientific discoveries, in New England."[189] Or as scholar Yeomans states, "Religious intolerance of Copernican astronomy dispersed by Colonial almanacs was practically nonexistent. Indeed, it was the Puritan clergy that most actively promoted science in the colonies during the seventeenth centuries."[190] As one can tell, the Puritans did very much have a Greek like view of the relations between God and scientific observation and how they connected. This should not be totally surprising though, when you consider the fact that the Puritans would study the Greek classics.[191] As a consequence of religious tolerance towards science, American astronomy would rapidly become top notch and among the best in the world, under Colonial America's successors.

186. Bessie Zaban Jones and Lyle Gifford Boyd. *The Harvard Observatory College: The First Four Directorships, 1839-1919*. (Cambridge: Harvard University Press, 1971), 3.

187. Morison, "The Harvard School of Astronomy in the 17th Century.", 13.

188. Morison, "The Harvard School of Astronomy in the 17th Century.", 13.

189. Morison, "The Harvard School of Astronomy in the 17th Century.", 12-13.

190. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 423.

191. David A. Lupher *Greeks, Romans, and Pilgrims: Classical Receptions in Early New England*. (Leiden: Brill, 2017), 2.

However, not all scholars see the Puritans as Pro-science and having religious beliefs that are open to free scientific thought. Take for example, scholar Milan Zafirovski who serves on the editorial board of the *American Journal of Economics and Sociology*, who in his work *The Protestant Ethic and the Spirit of Authoritarianism: Puritanism, Democracy, and Society* writes a scathing critique of the Puritans arguing "A specific and salient dimension or outcome of Puritanism's antiscientific as well as antiartistic authoritarianism is its adoption and use of science, knowledge, technology, and even the arts for essentially authoritarian and inhuman purposes. These aims range from domestic political and moral-religious authoritarian control and oppression, including totalitarian theocracy."[192] Zafirovski elaborates on his argument claiming, "In brief, for early US Puritanism, science or knowledge 'without emotional faith had no value.' Hence, for New England's Puritans there was no such thing as 'science for the sake of science.'…In short like medieval Catholicism, Puritanism seeks and succeeds to restrict science and knowledge 'to make room for faith.'"[193] Essentially, Zafirovski sees Puritans using science for power and control, not for the sake of science, but rather in support of theocratic rule. Finally, his most forceful attack on the Puritans, Zafirovski claims "And if not knowing the exact context, one may equally think that the above describes the well-known fascist, including Nazi, suppression, and manipulation of science, which confirms that Puritanism is the religious-theocratic substitute or proxy for fascism in this as well as other respects."[194]

In response to Zafirovski, his argument seems to oversimplify Puritan society. It is true that the Puritans were extremely religious, and he is correct to argue that Puritans studied science for reasons of faith. It is further true that Puritan society was theocratic and in many ways intolerant of deviation from acceptable behavior. However, Zafirovski overstates his "presentist" claim that Puritans restricted science because of their faith. In fact, as I described above the Puritans were in numerous instances quite tolerant of views that could even be seen as contradictions of scripture. As we saw with Zechariah Brigden's ground breaking essay in the colonial almanac of 1659, which challenged the status quo. Instead, reacting in condemnation of his work, as the Catholic Church did to Galileo, Davenport said that he would wait to see more arguments and that Brigden is welcome to his opinion. These colonial almanacs and the debates that took place in them represented an important feature of Puritan society. Thus, the reality of Puritan society does not fully square with Zafirovski's contention. The Puritan faith adapted to science, rather than stifling it based on claims of faith. In fact, it is reasonable to argue that Puritans were important to the advancement of science. Their study of the heavens and interest in publication demonstrated persuasively that it was possible for men of faith to embrace scientific attitudes. In a world dominated by religious believers of whatever stripe, it was important for science to find support from groups like the Puritans. As a whole, Zafirovski's line of thinking seems ahistorical.

His determination to paint the Puritans as comprehensively authoritarian, not to mention his comparison of the Puritans to the Nazis, suffers from a misunderstanding of history. As stated already in earlier chapters, there were in Puritan society elected officials, public discussions about policy, and as revealed by scientific debates significant freedom of thought. When analyzing past societies, it is important to examine them on their own terms, not in a way that is completely divorced from their reality based on our modern perceptions of how society should be. If we don't do this, one can lose track of the meaning of events in the environment in which they occurred. When it came to science, the Puritans of Colonial America were paragons of tolerance, far more reasonable than most of their contemporaries.

Finally, I shall describe the critical influence England

192. Milan Zafirovski. *The Protestant Ethic and the Spirit of Authoritarianism: Puritanism, Democracy, and Society*. (Berlin: Springer, 2007), 161.

193. Zafirovski, *The Protestant Ethic and the Spirit of Authoritarianism: Puritanism, Democracy, and Society*, 152, 163.

194. Zafirovski. *The Protestant Ethic and the Spirit of Authoritarianism: Puritanism, Democracy, and Society*, 287.

had on Colonial America in their astronomical work. A good example of the help Colonial America received from England was in 1672, when Harvard University received its first astronomical reflector telescope by the famous telescope maker James Short of London. This type of telescope uses mirrors to reflect light to form a clearer image and arrived in Colonial America thanks to John Winthrop the Younger, who, while on a trip to London to get a charter to the create Connecticut, had rekindled his relationships with English astronomers by helping them form the English Royal Society.[195] [196] The simple presence of a modern telescope in Colonial America is persuasive evidence of the thirst for discovery among the Puritans. Winthrop was also someone who was published by the Royal Society and received considerable praise.[197] As a result of Winthrop's journey, he brought back a telescope and gifted it to Harvard University.[198] Even when back in Colonial America, Winthrop was in contact with Isaac Newton and Johannes Kepler. In addition, Winthrop received scientific books and manuscripts from English scholar Samuel Hartlib, which would be contributed to the Harvard University library.[199]

These were not the only interactions between Colonial American astronomers and English astronomers though. As mentioned earlier, a few Colonial Americans contributed to the work of Isaac Newton. It was also the case that scholars like Thomas Brattle had worked with famous English scholars back in England, perhaps most notably Robert Boyle and John Flamsteed,[200] When he moved to America, he remained in touch with them and they both influenced Brattle and his astronomical research.[201] Scholar Rick Kennedy emphasizes this in the following quote: "In the process of recognizing Brattle's achievements, however, we should be careful not to de-emphasize the implications of New England's provinciality, a burden Brattle thought had limited his opportunities. That very provinciality, though, is also the key to Brattle's importance, since his statement of mathematical idealism provides the first explicit connection between England and New England of this fundamental tenet of the scientific revolution... An important link between the Old World and the New, Brattle directly imported the scientific ideas of Boyle and Flamsteed and taught them to interested students at Harvard, thus nurturing ideas that would bear fruit in subsequent generations."[202] Therefore, Brattle represents a prime example of the impact England had on Colonial America.

Harvard was founded based on the idea of following the English university traditions and attempted to replicate Cambridge and Oxford.[203] This also entailed adopting the English university curriculum.[204] It is hardly surprising that Colonial American scholars were wanting to replicate the English motherland by using them as a guide for scientific education.[205] Ergo, England had great influence over Colonial American astronomy and the research of English astronomers was commonly referenced.[206] In fact, England was so influential that the English Royal Society even sponsored Colonial American research. It wasn't until John Winthrop the Younger that Colonial American science started to exert academic independence by reforming Harvard University into a scientific

195. Morison, "The Harvard School of Astronomy in the 17th Century.", 17.

196. Jones and Boyd, *The Harvard Observatory College: The First Four Directorships, 1839-1919*, 10.

197. Brasch. "John Winthrop (1714-1779), America's First Astronomer, and the Science of His Period.", 156.

198. Morison, "The Harvard School of Astronomy in the 17th Century.", 17.

199. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 416.

200. Kennedy, "Thomas Brattle and the Scientific Provincialism of New England, 1680-1713.", 591.

201. Kennedy, "Thomas Brattle and the Scientific Provincialism of New England, 1680-1713.", 591.

202. Kennedy, "Thomas Brattle and the Scientific Provincialism of New England, 1680-1713.", 600.

203. Dunster, *President Dunster's Quadriennium Memoir*, 279.

204. Bremer, *The Puritan Experiment: New England Society from Bradford to Edwards*, 196.

205. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 414.

206. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 422.

institution.[207]

Yeomans describes this dependence on England in the following passage: "The Colonial scientist was forced to work independently; indeed, the virgin American terrain made communications between colonists so difficult that they often relied upon English correspondents for news of other colonists."[208] Yeomans really puts the experience of the Colonial astronomer in perspective. To think about how different the atmosphere was being in a brand-new society, in a very foreign and unknown land is one thing, but to attempt to do scientific research there as well is even harder. The fact that these colonists were able to make an impact and contribute to the works of people like Newton was highly significant.

V: Conclusion

All in all, the ideas of Athenian philosophers Aristotle and Plato thrived under Athenian democracy. As a result, like the passing down of genes from generation to generation, the Athenian ideas of the freedom of thought would go on to make up the educational foundations put in place in scholarly Alexandria. Eventually, the great astronomer Claudius Ptolemy would build on these Athenian philosophical foundations, specifically using Plato's objective empirical reasoning to determine that mathematical inquiry was the best tool for the pursuit of knowledge. In turn, this would lead him to create through mathematics the most advanced astronomical theory the world had ever seen, until the creation of the Copernican tradition. Because of this, the Ptolemaic tradition would greatly influence Colonial Americans over a thousand years later, leading the Colonial Americans to inherit astrology and the geocentric theory. However, due to the intellectual freedom of thought tracing all the way back to Athens, a relationship between faith and science similar to that of the Greeks became instilled in Colonial America, where becoming closer to God came through scientific study. Thus, also with some help from academics in their native England, these Colonial Americans would use ancient Greek wisdom to replace the Greek Ptolemaic astronomy. Compared to their counterparts in Europe, the Colonial Americans like their native England quickly adopted the Copernican tradition. Therefore, the Colonial Americans' Greek style tolerance towards scientific inquiry was crucial to their scientific advancement and the replacement of the Ptolemaic by Copernican tradition.

207. Brasch. "John Winthrop (1714-1779), America's First Astronomer, and the Science of His Period.", 156.

208. Yeomans "The Origin of North American Astronomy—Seventeenth Century.", 425.

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