UC Riverside

UCR Honors Capstones 2017-2018

Title

Science Suppressed: Aristarchus and the Effect of Authority

Permalink

https://escholarship.org/uc/item/50d839dv

Author

Cohen, Jordan

Publication Date

2018-04-01

eScholarship.org Powered by the California Digital Library
University of California

SCIENCE SUPPRESSED:

ARISTARCHUS AND THE EFFECT OF AUTHORITY

The text does not wrap; each field must be entered individually.

By

Jordan Nicole Cohen

A capstone project submitted for
Graduation with University Honors

May 7, 2018

University Honors
University of California, Riverside

APPROVED

_____

Dr. Denver Graninger
Department of History

_____

Dr. Richard Cardullo, Howard H Hays Chair and Faculty Director, University Honors
Interim Vice Provost, Undergraduate Education

Abstract

In the landmark work “The Structure of Scientific Revolutions” Thomas Kuhn proposed that scientific knowledge does not follow a linear progression, but instead is marked by revolutionary change that radically alters the underlying assumptions within a field. This appears to be an objective process that relies on the proof of a new theory or hypotheses that usurps the old. This process seems to negate some of the other processes that affect the adoption of scientific theories that lead to revolutions. A particular case is the first heliocentric theory first proposed by Aristarchus of Samos, a third-century BCE Greek scientist.

Aristarchus challenged the existing geocentric theory that was widely accepted by scholars within the ancient world. Yet, his theory failed to gain traction or acceptance in the scientific community. To fully understand why Aristarchus’s theory failed, it is necessary to observe the other surrounding factors, subjective factors often not associated with the scientific process, specifically authority. This paper utilizes the sociological theories of Max Weber to analyze Greek culture and the weight of authority figures within the Hellenistic period. As it is clear through the authority figures that surrounded Aristarchus, such as Aristotle, Cleanthes, and Claudius Ptolemy, that authorities subscribing to geocentrism were a large contributing factor to the negative reception of Aristarchus’s theory.

This paper ultimately seeks to revise how the scientific process is viewed by demonstrating that in premodern science, acceptance of theories was not controlled objectively and was at times driven by dogma. This can be viewed through the case study of Aristarchus as his theory failed to overcome the dogmatic following dedicated to a geocentric view. Extrapolating the use of subjective factors in viewing scientific change will provide more comprehensive views of the scientific process as it affects those engaged in the scientific community.

Acknowledgments

I would like to thank my faculty mentor, Dr. Denver Graninger, for encouraging me through this process and pushing me to become a better researcher and student, this project would not have been possible without his guidance. I would also like to acknowledge the Chancellor's Research Fellowship for funding to pursue this research.

Table of Contents

Abstract……....ii

Acknowledgments…….……...……..…....iii

Introduction.....1

Greek Science.....5

Authority in Ancient Greece.....14

Authority in Practice.....24

Aristarchus in the Scientific Debate.....32

Works Cited.....34

I. Introduction

Aristarchus of Samos lived in the 3rd century BCE and is now recognized as the first to propose a heliocentric theory, almost two thousand years before Copernicus.[1] Yet, Aristarchus is not written about in history books or even regarded as a largely important figure in the history of science. He is even often referred to as "the ancient Copernicus", despite having been the inspiration for Copernicus' own theory.[2] It would seem that Aristarchus is glossed over as a fun fact in the history of scientific development, a little known and sometimes invisible theorist who had the potential to change history.

Part of the lack of acknowledgment of Aristarchus is likely due to how little is known about his life and his theory. He came from Samos, which came under the Ptolemaic empire shortly before he would have begun studying. He would later move to Alexandria where he studied under Strato. It was common for Samians to move to Alexandria to study, as it was part of the Ptolemaic empire.[3] Although we have an estimate of when he lived and wrote and where he came from, a large part of his life is unknown, other than a few works and theories. The most complete theory that remains relates to the size and distance of the sun and moon from the earth.

The concern of this work, his heliocentric theory, comes in the form not of a full treatise, as the works of Aristotle and other contemporaries do, but rather in the passing mention of another author. Archimedes, the famed mathematician, was writing his own treatise unrelated to astronomy when he recalled

[1] Originally Copernicus had cited Aristarchus as an early inspiration for his own heliocentric theory, which would expand upon that of Aristarchus. Copernicus would later erase Aristarchus' name from his own work.
[2] Sir Thomas Little Heath, *Aristarchus of Samos* (London: Oxford University Press, 1959), 301.
[3] P.M. Fraser, *Ptolemaic Alexandria* (London: Oxford University Press, 1972), 397.

> But Aristarchus brought out a book consisting of some hypotheses, wherein it appears, as a consequence of the assumptions made, that the universe is many times greater than the "universe" just mentioned. His hypotheses are that fixed stars and the sun remain unmoved, that the earth revolves about the sun in the circumference of a circle, the sun lying in the middle of the orbit [4]

Archimedes immediately goes on to say that he believes this to be wrong, but instead uses it as a means of further exploring his own treatise on calculating large numbers. This begs the question, why is there not more mention of this theory, the same theory that would later change the history of science in Europe under Copernicus.

In an attempt to answer this question one might try to use the popular answer provided by scientist turned philosopher, Thomas Kuhn. Kuhn proposed that scientific revolutions have a natural process driven by objective scientific research. He theorizes that these paradigm shifts[5] occur in a similar process all throughout history, and it's natural change that occurs once traditional or normal science can no longer account for discovered anomalies. Kuhn's progressions begin with a pre-paradigm era in which there is no agreement on one definite theory and there are many theories that are incomplete. Later one of these theories will become more defined and accepted as the paradigm, and it is under these paradigms that "normal science" occurs. Normal science is when the larger scientific community has accepted this paradigm and scientific activity operates with the assumptions provided by the paradigm. For a while this paradigm will be maintained, until there are anomalies that challenge the fundamental assumptions of the paradigm, and when these assumptions occur, revolution follows.[6]

---

[4] Heath, 302.

[5] Paradigms are what define the standards for scientific activity within specific fields; these are the inherent truths that guide the questions that are asked when pursuing new scientific questions. One current paradigm is the law of gravity, something we now assume but was not always recognized. Shifts are defined by a fundamental change in these basic truths or assumptions that previously guided scientific activity.

[6] Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: The University of Chicago Press, 2012).

This revolution is what Kuhn calls a shift in the paradigm, as the "truths" or assumptions are changed and a new paradigm is accepted. Kuhn exemplifies this process in understanding the revolutions created by Copernicus and Einstein as they redefined their respective fields. Aristarchus had a revolutionary idea, he was challenging the normal science, and in his provisional theory, he was answering questions geocentrism could not. Yet, only a few sentences and asides of his theory prevailed and there was no revolutionary paradigm shift in the scientific world. In using Kuhn's model there still seem to be more questions surrounding Aristarchus. It then seems that Kuhn in his objective method of observing scientific revolutions fails to account for the subjective systems in place that can either impede or progress scientific change. What must be accounted for then are not the failures in Aristarchus' objectivity, although these will be addressed, but instead the subjective processes, the social structures and institutions that defined the scientific activity.

Subjective factors, and more specifically authority, are a useful lens that can be used to view the changes in scientific development throughout history, including the case of Aristarchus. These subjective processes are not defined by the scientific activity itself and the methodology in determining these processes, but in the communities that scientists engaged in and the dogmas that shaped their opinions. While science may be objective in concept and even research, it is the interpretation of data and the denial of these anomalies and new perspectives that introduce subjectivity into the objective processes. Analyzing the larger scientific and social structures Aristarchus engaged in elucidates how scientific development actually occurs, outside of the objective name that it claims.

This is especially important to today as there is a rise in those who challenge scientific thought, and challenge paradigms with old dismissed ones. As people continue to push flat earth

theories and deny climate change, the rhetoric of science becomes dangerous in the hands of authorities, and it creates impact beyond the words and tweets of those who claim falsehoods. This paper seeks to show not that these paradigms should be challenged, but to exemplify the methods by which authority permeates scientific activity to deny it the objective process it deserves in order to create meaningful progress.

Although Aristarchus may be far removed from the scientific processes that exist today, there are still clear parallels between the authoritative processes that would lead to the rejection of his heliocentric theory. It should be noted that sources can be few and far between when consulting the ancient world, especially in the consideration of Aristarchus whose theory was not seen as worthy of recording. In order to develop a clear picture of his world I will consult authors from both contemporary eras as well as eras surrounding. By using a multitude of these sources we can build a better picture of how the everyday scientist engaged with each other and scientific methodology, defined themselves as scientists, and attempted to understand the natural world around them. I will also attempt to understand the drive to maintain this dogmatic view of geocentrism by explaining the reasons for geocentrism as well as reactions to Aristarchus's theory. Combined with modern theories regarding authority and scientific revolutions, the process by which Aristarchus's theory failed to become normal science becomes more evident, and speaks to a larger process of scientific subjectivity, in which science is distorted and warped to fit into desired narratives.

II. Greek Science

Greek science in antiquity is hard to pinpoint because there was no distinct field of science. Science in Greek antiquity operated on a spectrum and even included practices that are recognizable today, such as the use of observational data. In order to better understand this period and how Greek science operated it is necessary to also break down the various institutions and systems that were used to pursue scientific questions. These institutions are most evident in what were the academic centers of the Hellenistic world, namely Alexandria and Athens. Although there were differences between the two cities, there were still long standing institutions that would contribute to the development of scientific thought.

An important note in understanding Greek science, as mentioned before, is that there was no distinct field of "science". In fact, using the term science is anachronistic and is used only to describe the questions we recognize today as having scientific qualities similar to modern practices. In antiquity there are early developments in biology, astronomy, physics, mathematics, and other sciences still practiced today, however, there are also equal treatment by the ancients of astrology and cosmology. G.E.R. Lloyd, a prominent ancient historian, describes this problem, "'Science is a modern category, not an ancient one: there is no one term that is exactly equivalent to our 'science' in Greek."[7] Rather than imposing modern standards on an ancient time, science when applied to antiquity is used to refer to a certain method of thought, recognizable in its attempts to use method or observation to create hypotheses and theories in an attempt to understand the natural world. Since their science was not a distinct subject, their methods in understanding the world were broad. Although science was studied through a spectrum of qualitative and quantitative work, this work will focus on those who had a stricter, more

[7] G.E.R. Lloyd, "Preface" in *Early Greek Science: Thales to Aristotle* (London: Chatto and Windus, 1970).

quantitative approach guiding their research. In essence, this will focus on science that was intended to be objective, even if it failed in its attempt to become separate from dogma.

This work does not intend to impose a certain view of science from today as a means of measuring Greek scientific practices; it instead aims to understand the practices that were in place in antiquity and how authority affected the existing practices. Although Greek science itself is undefined and abstract, it is an aspect of this history that must be embraced in order to understand the process of exploring natural phenomena in Greek antiquity. This is also true of the scientific communities, which need to be further expanded on to explain where scientific inquiry took place and how authority operated on institutional levels.

The Hellenistic period of Greek science is unique because it is situated just as the philosophical schools in Athens and the Alexandrian Mouseion rose to prominence.[8] The establishment of these institutions would cement Alexandria and Athens as the learning centers of the ancient world. These two cities, operating as a larger representation of knowledge, would house various smaller institutions, which would hold their own authority in scientific knowledge. Despite having differing traditions, both would engage in similar practices, especially concerning the way scientific knowledge was shared.

Since our knowledge about the operation of philosophical schools is limited, we must infer from various practices across the Hellenistic world about institutional operations as a whole. Although the Mouseion and the schools in Athens provide a seemingly structured institution, these were not the only places where science was studied, however they will be the focus so as to clarify idea sharing in the ancient world. Classicist Jason König describes the

[8] The Mouseion is more commonly known as the Museum, which was situated in Alexandria, Egypt and is largely regarded as one of the first universities.

difficulty in studying the scientific community as a composite whole; "the key factor once again is the lack of any sustained institutionalisation of ancient expertise: the dominant pose in ancient knowledge-ordering writing is of the intellectual as free agent, working within an imagined virtual community of experts."[9] Although König described the community as imagined, strung together by individuals that knew each other, I will show that there was more emphasis on an individual's engagement in institutions which makes the scientific community more structured than imagined. The rise of the institutions in Athens and Alexandria will help us define these imagined communities, but also fail to incorporate all those who participated in scientific questions.

The first philosophical schools, and the first structured learning institutions were developed in Athens, first was Plato's Academy, which was followed by Aristotle's Lyceum. These schools would inspire other structured institutions to arise in Athens, including the Stoic and Epicurean schools. However, in an attempt to bolster the significance of Alexandria as the new capital of Egypt, the Ptolemaic rulers would establish a competing learning center, the Mouseion.

The Mouseion was modeled largely after Aristotle's Lyceum, making it a Peripatetic school[10], this will prove to be or greater importance as it would only elevate the status of Aristotle. The Lyceum's model was based on tradition in Greece, meaning that there was a devotion to the muses that was central to the schools.[11] Historian P.M. Fraser argues that Aristotle was even inspired by the cult brotherhoods of the muses, which emphasized a

[9] Jason König, "Introduction: Self-Assertion and Its Alternatives in Ancient Scientific and Technical Writing" in *Authority and Expertise in Ancient Scientific Culture*, ed. Jason König and Greg Woolf (Cambridge: Cambridge University Press, 2017), 6.
[10] Peripatetic refers to a tradition following Aristotle's, both referring to the structure of his school as well as his philosophies.
[11] Fraser, 317.

communal life in dedication to specific activities.[12] Within these schools, their dedication would then be directed towards different discoveries; it is evident through Aristotle's studies that the Lyceum would be more scientifically involved and would deviate from the religious model the school was based on.

Yet the model of cult brotherhood would continue to inform the structure of the school. Historians know that each school had a scholarch, the one who was regarded as the head of the school of the philosophy, who would represent the school of thought. The Mouseion would also follow this model, although they would be called the Chief Librarian.[13] Under the heads there is little known about the structure, although we can infer that the rest were in positions of lower status compared to these leaders. Although in a larger institution like the Mouseion the positions may have become more stratified, we do not have a clear picture of what this stratification would have looked like. Largely, the philosophical schools in Athens and the Mouseion were created under similar processes, as it is believed Demetrius of Phaleron, a Peripatetic philosopher and expelled tyrant from Athens, advised on the organization of the Mouseion.[14]

The Mouseion would also deviate from its predecessor, relying on a different model of engagement. While individuals in the Lyceum and the Academy were reliant upon the community that they engaged with and would develop their thinking from those communities, in Alexandria, the studies were much more independent and reliant on the patronage of kings. This type of independence meant that it would have been harder to gain authority because the Mouseion was more of a collection of individuals that were not directly engaged in a school that taught similar teachings and that they would have to gain authority on an individual basis, not

[12] Ibid.
[13] Ibid.
[14] Ibid, 315.

through their institution. While Fraser infers that there would have been some method for delivering formal lectures in the Mouseion, most exchanges would have been shared through informal lectures and discussions.[15]

Surely there are to be many differences between the Mouseion and the schools in Athens, other than individuality and patronage system, a stark contrast is the questions that were being studied. In Fraser's work detailing aspects of Ptolemaic Alexandria, he explains the types of subjects that were being studied in the Mouseion. An important contrast is that physics and physical sciences were not something that were fully explored in Alexandria, that the assertions made through the Lyceum "with its highly organized approach to the collection of scientific data, seems to have regarded as sufficient or at least to have remained without a rival."[16] Demonstrating that in some matter, scientific fields were already established and authoritative in Athens, and Alexandria had little contributions to make. While this is not evident to our concerns regarding astronomy, it is important to note that the main tradition was established in Athens.

It is not to say that authority was impossible to gain under the Mouseion, in fact many people did, however, it was a different process, as they had to receive patronage and were not in a direct community of like-minded thinkers like the philosophical schools of Athens were. Since there were not schools headed by one leader defining the paradigm in how things were studied, it seems that most people in Alexandria instead sought out mentors who would guide their learning. These institutions show that authority was operating on multiple levels in antiquity, both through the individual and through larger institutions, which will help understand where Aristarchus stood within this community.

[15] Ibid, 318.
[16] Ibid, 338.

As the communities themselves were not defined, neither are the processes about how various scientists would have engaged with each other. However, from both the institutions that they composed and the texts left behind we can discern some ways information might have been reviewed and shared among the community. It is evident that there were indeed discussions and debates by various scientists across different regions, and that none of the theories developed in a vacuum, this is apparent in a later exchange between Archimedes and Eratosthenes.

All scientific developments were made on the basis of or while engaging with past works, whether they were building upon them or refuting them. This practice demonstrates the necessity of being a part of an institution, because it was only through these institutions that one would be able to access past works.[17] Since books were rare and expensive, it was only through the extensive libraries of institutions that important works were circulated and collected, and if one wanted to engage with past works to have a foundation for their own work, they would need access to these libraries. This use of building off past works is evident in the treatises written by scientists. A prominent example is in the extensive works of Galen, an ancient Greek physician. Although Galen was from a later date, the second century CE, it is reasonable to assume there were not many changes in the way scientists engaged. The communities might have become more distinct, but the processes of sharing information or the way authority was defined would have largely remained the same. For example, the schools and their hierarchies would have been distinct, but there were also many who engaged in schools of thought while not being directly related or physically attached to the schools. Yet, theories and works would have been shared among this larger imagined community much like it was in the Hellenistic period.

[17] Ibid.

Galen's writings often draw upon the work of others, such as Hippocrates, Plato, and Aristotle.[18] It was important for scientists to be able to cement their works in a tradition of older discoveries, much like we do today. Galen's usage of the various other authors is important because it shows that there was an awareness of who was a part of the scientific community. Galen did not rely on poets and astrologists but instead referred to those who held similar methodologies as him, methodologies that were more strict in evidence and reasoning in their form. Lloyd even explains how Galen would criticize Chrysippus for citing poets in his works.[19] The works of Galen show not only were there growing standards of "science" in antiquity but that there was also knowledge about who other scientists were.

However, in the same period as Aristarchus, Eratosthenes and Archimedes show that there was also a tradition of engaging with other scientists outside of written works. Archimedes and Eratosthenes were both renowned scientists in their fields, mathematics and astronomy respectively. Fraser catalogs how the two engaged with each other and collaborated on their works in Alexandria. This is especially important to note considering it was believed that Aristarchus resided and worked in Alexandria. Fraser explains how Archimedes relied on Eratosthenes to review his work, not only does this show collaboration among the scientists but also that there was some method of review even without strict institutions and modern rules of peer review.[20] There is also mention of Archimedes asking Eratosthenes to circulate his works to peers as another form of review, which Eratosthenes would have easily been able to do as Chief Librarian.[21] The reliance on the circulation of his works shows again that there was a tradition of review and engaging with other scientists. In addition, Archimedes belief that Eratosthenes

[18] G.E.R. Lloyd, "Scholarship, authority, and argument in Galen's *Quod animi mores*" in *Principles and Practices in Ancient Greek and Chinese Science*, ed. G.E.R. Lloyd *(*Great Britain: Ashgate Publishing Company, 2006), 14.
[19] Ibid, 16.
[20] Fraser, 404.
[21] Ibid, 402.

would know who to circulate the work too is evidence that the imagined communities were much more concrete and established in the ancient world than they appear to us today. Although the institutions themselves might seem vague, and it's hard to define who was considered a scientist with a modern lens, the ancients themselves were vary aware of who engaged in the same questions.

Aristarchus is also evidence of this tradition, as Cleanthes directly responded to him in one of his written works. In Diogenes Laertius' biography of Cleanthes, he includes a list of his works, one of which is titled "A Response to Aristarchus."[22] This demonstrates that in some matter, others had access to the work presented by Aristarchus, and it was to some degree a theory that Aristarchus had developed, rather than just a proposition. It also shows that to some degree Aristarchus was a part of the scientific community and was recognized and being read, to what extent will be explored later. However, we do know that Cleanthes was the scholarch of the Stoic school in Athens, and that there were connections between the two intellectual capitals, and therefore knowledge about who was a member of scientific studies across the two cities.

Interestingly enough, there is also a mention of some means of publication, of making works official in the correspondence between Archimedes and Eratosthenes. Fraser explains that Archimedes delayed publishing something because he first wanted Eratosthenes to review it.[23] This method of publication is important not only because of its implications about peer review but also because it signifies that if works were being read contemporaneously, it was most likely that these were prepared works the author wanted to be read. Although we may not possess it, this means that Aristarchus's works were most likely reviewed in full and contained more than

[22] Diogenes Laertius, *Lives of Eminent Philosophers 7.5 Cleanthes* (Cambridge, Massachusetts: Loeb Classical Library, 1925).
[23] Fraser, 404.

the basic representation we have from Archimedes' *Sand-Reckoner*. However, this is more important for understanding the importance of being a part of the institutions in antiquity. Since publishing was an official process, and books were so hard to access, it again demonstrates the necessity that someone was a part of the institutions that had collections of books. If someone were on the outside, and did not have access to as many books, or was unaware of current work and relying only on old work, they would not have the same opportunities as those who were in established institutions. This was a new feature in the Hellenistic era, as before there were not set institutions like the philosophical schools and the Mouseion that were dedicated to research and academic pursuits.

Institutions that arose during the Hellenistic period would have significantly contributed to shaping the scientific communities of that era. It is through these institutions that scientists were able to identify each other and engage and respond to various ideas. Idea sharing, in addition to the access of traditional texts, would be a necessity for those who wished to explore scientific ideas. Although there is evidence that some scientific ideas were explored in ways that seem astonishing through a modern lens, it seems there was also an understanding among the more evidence based scientists, that more qualitative works were to be given less authority or credibility. Greek science existed on a spectrum, but was not as vast as previously believed. Institutions within the Hellenistic period would help to define the previously imagined scientific community, creating a greater community to engage with in scientific debates. By observing the ways these scientists shared ideas, and what it meant to be a part of a certain institution, we can perceive how authority permeated both individual and larger institutional levels.

III. Authority in Ancient Greece

Authority held significant power in ancient Greece, as those who held it would be able to use rhetoric to make their ideas gain prominence. The practice of using authority was not limited to the Hellenistic era, as there was a tradition of people gaining authority both generally and in specific fields for being connected to wisdom. The claim of wisdom would often give people authority, depicted by how others looked to them for answers regarding various aspects of their lives.[24] However, there were various types of authority within ancient Greece that operated on different levels, seen through the Seven Sages, religious authorities, and leaders of philosophical schools. By understanding the tradition of wisdom and its connection to authority in the context of ancient Greek culture we can better understand the various factors Aristarchus had to overcome as he developed his theory.

Max Weber, a well-known sociologist, based his definition of authority on three "pure types"; describing various ways authority had been gained and held throughout history, the ancient world not being an exception.[25] Weber's three pure types are based on how authority becomes legitimized, rather than based on a system of fear or reward. These types are traditional, legal, and charismatic leadership, which attempt to explain why people feel obligated to adhere to their authority. Legal authority is based on a collective group's beliefs in a system of rules and therefore the belief in the people who are given authority under those rules or laws. Traditional authority is based on a belief in traditions and the authority that are afforded to people within those traditions, this can also be social traditions such as patriarchal authority. Lastly, charismatic authority is more tied to the individual and the authority that person commands

[24] Trevor Curnow, *Wisdom in the Ancient World* (London: Duckworth, 2010), 130.
[25] Joshua Derman, *Max Weber in Politics and Social Thought: From Charisma to Canonization* (New York: Cambridge University Press, 2012), 180.

through their actions and the respect people connect to them.[26] Weber argued that these three types were often combined to create various types of authority. His definition will help provide background as to how one could gain authority within the institutions that studied science in the ancient world. Due to the loosely structured scientific communities, we can then view authority within specific individuals and schools of thought, defining the scientific community by those who are engaged within it and held authority within it.

Although Weber provided the three pure types (legal, traditional, and charismatic), he also believed that it was more common for authority to be composed of different aspects of the three, that it was not "pure" in process.[27] In the ancient world we can observe these various types of rulership forming and how they affected the scientific world. This also shows how authority spreads between individual levels and larger processes, which can both be observed in the scientific communities of ancient Greece.

It is necessary to show that authority was recognized and used in science and different debates because there is the false belief that the Greeks relied completely on rhetoric and who had the best argument. Yet, the recognition of authority in the ancient world contradicts the belief that audiences had to be persuaded by the best argument. However, this is a common belief in ancient studies, historian T.E. Rihll argues, "They [ancient Greeks] did not…judge the validity of a scientific claim on content alone, and they were not in the habit or accepting things on authority, for which the Greeks had a healthy disrespect."[28] However, this is not a belief that was fabricated by historians, this was a belief held by the Greeks themselves, ancient authors often write of their need for proof. Rihll cites Plato's *Gorgias* as evidence of what Greek

[26] Ibid, 180.
[27] Ibid, 181.
[28] T. E. Rihll. *Greek Science* (New York: Oxford University Press, 1999), 13.

scientists expected out of their arguments, taking it at their word and not their practice in recording the function of scientific debate.[29] Despite a disrespect of authority, it seems that ancient Greek practice counters this in actuality, as authority was relied upon heavily for various information. The use of authority is evident throughout Greek history, both in the Hellenic era and before.

The Seven Sages are an important depiction in the role of authority and especially how authority was connected to wisdom within the ancient world. The Seven Sages are lists of people who were considered to hold a special wisdom or knowledge recorded in Greek history. They are seemingly unrelated individuals, from different times and disciplines[30], who were connected through their renowned wisdom.[31] Some figures include Solon, a famed legislator and poet, and Bias, who was known as a persuasive speaker.[32] Although there are changing lists about who composed the Seven Sages, they remain a landmark in the history of authority in ancient Greece. The histories recounted about the Seven Sages and the ideas they held show that people held these individuals in high regard because they had some connection to wisdom that could not be obtained by ordinary people. While the names of the Seven Sages often differ, the way these individuals are revered in literature and history of ancient Greece show that these people become manifestations of wisdom and symbolically represent knowledge.[33] The importance is not in the person himself necessarily, but the knowledge that they represent. Initially they would gain authority charismatically, based on the wisdom they were able to share and the ideas the represented. As they gain this charismatic leadership within their respective fields they then are

[29] Ibid, 13.
[30] The total list of the Seven Sages amounts to around 21 differing names, all ranging from the fifth to seventh centuries BCE (Curnow, 7).
[31] Curnow, 6.
[32] Ibid, 7.
[33] Ibid, 11.

able to gain a greater following and perpetuate their own ideas. Richard P. Martin explores this charismatic authority with sages as performers, citing the large audiences and attraction they would gain through the use of their knowledge publically.[34] These ideas then gain more traction or they come to represent a model of knowledge within their field, and come to represent traditional authority as they themselves became representative of wisdom.

While the Seven Sages consist of people from various fields, from poetry to pottery, it is important to note the tradition of the acclamation of knowledge within individuals. It is also significant that these sages stem from a much earlier era than the Hellenistic period of Aristarchus. The history of the Seven Sages show that before Aristarchus there was a tradition of adhering to personality and charismas, which would explain why certain people like Aristotle and Ptolemy would have a larger audience that accepted and listened to their ideas. Once Aristotle and Ptolemy had already gained a following, and a connection to wisdom in other fields, they became representative sages. Despite the fact that there was a strong belief in people only accepting the best argument, sages would be more accepted in the anticipation that they would have the better argument and they would already possess an audience to hear it. The tradition of the Seven Sages only contradicts the belief that there was a focus on argumentation and shows that people were aware of the charismatic authorities, a tradition that would carry over into the Hellenistic period.

There is further evidence that this tradition was carried into the ancient world, through the use of "sagehood" or "sages" in the Hellenistic era; especially in the consideration of

[34] Richard P. Martin, "The Seven Sages as Performers of Wisdom" in *Cultural Poetics in Archaic Greece*, ed. Carol Dougherty and Leslie Kurke (Oxford: Oxford University Press, 1998), 116.

stoicism, which would prove to be a large force against the theory of Aristarchus.[35] The attribution of the name sage to individuals within later Greek periods shows the continued tradition of the Seven Sages. There were two different definitions within stoicism, both the "'knowledge of human and divine matters' and 'fitting expertise'", showing the authority stoics, and others in antiquity, would have obtained the title "sage" under.[36] Yet, this type of sagehood largely differed from the original Seven Sages, later sages were those who carried the traditional authority of wisdom and adopted the name sage to depict this. It is significant in showing that expertise would have afforded someone the noteworthy title of sage, which shows that even those who were concerned with argumentation, like philosophers, understood the importance that stemmed from authority, in which it was the goal of many philosophers to achieve this sagehood. The status of sagehood was desired on the belief that it meant they were living the best life, but it also shows that they recognized that this title held authority in knowing what the best life was, and therefore would have held authority in many aspects of life.

Thales is a particularly important example, often named as a sage, who is largely regarded as both the first scientist and the first philosopher. While other names change regarding the Seven Sages, Thales is one of the most consistently mentioned names among the differing lists.[37] Although Thales was far from modern science, and even far from Hellenistic science in his methodology, he was one of the first recorded to attempt to conceive of the nature of the universe, putting him as the first natural scientist. Thales attempted to explain that the entire universe was composed of different forms of water, and that these different forms of water

[35] Stoicism refers to a popular school of thought in antiquity, developed by the Stoic school of philosophy in the Hellenistic period.

[36] Rene Brouwer. *The Stoic Sage: The Early Stoics on Wisdom, Sagehood, and Socrates* (New York: Cambridge University Press, 2013), 177.

[37] Curnow, 9.

composed all things. It's a stretch from the mathematical and scientific observations made by later Greek scientists, but what's important is what Thales represented as the genesis of natural science.

As one of the original Seven Sages, Thales held great respect in Greece, but also in later communities like the scientific community that Aristarchus was situated within. It was the trajectory of his type of thought, that reason and observation can be used to explain the universe that would guide later developments in science. Combining his status as a sage and a scientist shows us that the use of scientific thought and methods began with an authority. Thales held a special connection to wisdom, even when his theories were later replaced by new ones. In the same way Thales gained his status as a sage for his scientific view of the world, later authorities would as well, showing that from the beginning scientific thought had the potential to gain authority and be recognized as wisdom. Weber's charismatic leadership can explain authority that was given to these scientists, because it was people relying on an individual and their creative ideas, which Weber believed could transform people's subjective values about the world.[38] Thales shows that from the beginning science was driven by an authority, and that charisma through attractive ideas would be the driving force in attaining authority.

Yet, authority in the scientific world was not limited to charismatic leadership, there was also reliance on traditional leadership through religious organizations and authorities. Through religious engagements there are distinct traditions from two different realms. Authority was given to oracles and diviners as well as those who were outside of specifically religious contexts. Oracles and diviners were known to play significant roles in ancient Greek culture as they were

[38] Brouwer, 181.

looked to for answers from mundane predictions to predictions about the outcomes of a war.[39] However, there were also people who claimed to know about god, Zeus, Reason (or other conceptions of a supreme power), without being directly connected to a temple, oracle, or religious symbol that held authority on religious matters.

The existence of oracles and diviners, and especially those that were given high regards shows another form of recognizable authority within the ancient world. These diviners would also have gained charismatic leadership as specific oracles or diviners would gain a better record in the accuracy of their prophecies or advice.[40] Charismatic authorities towards specific diviners are depicted through the reverence of the Oracle of Delphi, and its significance as a trusted oracle in ancient Greece. As names of oracles and famous diviners were established it showed recognition in authorities among the Greek people, that there was a reliance on name and reputation for receiving information.

However, more important are those who were both scientists and religious authorities. Due to the fact that Greek science and academics operated within an amalgamation of subjects and practices rather than distinct subjects, it would not be uncommon for the natural scientists that attempted to understand the universe to also incorporate religious beliefs into their models of the universe. When various philosophical schools or philosophers would gain followers through charismatic authority, they would also perpetuate their views of god, affording them an authority on religion. Although it may seem insignificant that scientists would hold specific views of god, it is important to notice. In the ancient world, science, religion and philosophy were all seen as parts of the same process, which aimed to understand the world and would include god's place in

[39] Curnow, 74.
[40] Ibid, 75.

it.[41] The use of various approaches in thought would elevate even further the position of philosophers as they became experts in multiple subjects with dogmas that were able to explain the universe in one neat package, both with logic and faith, science and religion.

As we have seen through the creation of dogmas within philosophical schools, there was a certain authority afforded to those who claimed knowledge of god. Yet, as a head of a philosophical school, individuals were also able to obtain authority because of their position. Aristotle, as well as the other heads of philosophical schools (like Cleanthes), demonstrates that through this position they were able to obtain traditional authority. While philosophical schools were being newly developed and introduced into the Hellenistic era, they quickly became advisors to the people much in the same way religious authorities had been. Schools would be founded surrounding a charismatic leader or leaders, which would develop followers and a tradition would be established that would place these various schools into traditional leadership. Traditional leadership would be established into the hierarchy of the school, and whoever gained the top position would be afforded the most authority.

While the schools themselves and the dogmas they represented would become a source of authority, this would help bolster individuals into positions of authority. Specifically, those who would become heads of the philosophical schools would command a deeper connection to wisdom and therefore authority because of the high position that they held. Historian Trevor Curnow argues that these leaders of philosophical schools would even take on a representative quality, in which they depicted the best way to live within their accepted dogmas.[42] It was these

[41] Here I use the term "god" which many correspond with the modern monotheistic view of God in Islam, Judaism, and Christianity. However, there were many interpretations of the meaning "god" as a singular, driving force of the universe, other terms for this god include "Zeus", "Pnuema", "Reason".
[42] Ibid, 9.

leaders that would continue the tradition of sagehood, even if they did not apply the term to themselves, although some did, others would recognize them as sages, and therefore authorities.

It is evident through the various uses of philosophers as advisors that people held them in high esteem because of the belief that they held inaccessible wisdom. While the philosopher would first have to gain his authority as a charismatic leader through his philosophies, the use of philosophers as advisors would also expand their authority because it would further their audience. It can then be seen that the philosophers who held greater positions as advisors were the ones that held more authority in the eyes of their contemporaries. Even greater authority was given to those who were connected to royalty, either as tutors or advisors, because they were able to tie their own charismatic authority to the more established legal authority of rulers. This was something Weber believed was essential for charismatic leaders to maintain authority; they had to develop their charisma into a larger system in order for their authority to last.[43] It can then be seen that the philosophers and scientists who were able to attach their authorities to more established versions, would be the persisting authorities in the Greek world.

In addition to Weber's versions of authority, there is also the historical record of authority. In reviewing the works written by those who were involved in the scientific communities we can see the identification of authority through citation. This will be used to determine who held authority, because those who were being written about and contested are those were seen as presenting the most important theories and ideas. While this is not a type of authority itself, this will help resolve who was seen as an authority through the ancient sources, as will be implemented in later portions of the paper.

[43] Derman, 182.

Although the Greeks may have believed that they were reliant on rhetoric, their esteem of various individuals and institutions show that they revered authorities. Weber's definitions of authority help illustrate the multitude of ways authority was exercised in the ancient world, the same types of authority that apply to modern and ancient eras. Together, these concepts will provide a clearer background and understanding in determining whom the authorities were surrounding Aristarchus and why Aristarchus himself lacked authority.

IV. Authority in Practice

In order to properly contextualize Aristarchus, one must also observe the authoritative figures that surrounded him in antiquity. These figures occupied various forms of authority and it was their positions of authority that would ultimately lead to the persistence of geocentric theory. To summarize the main processes that affected Aristarchus I will focus on three main figures, Aristotle, Cleanthes and Ptolemy Claudius. Aristotle would set the precedent for geocentrism before Aristarchus, Cleanthes as a contemporary of Aristarchus would reject his heliocentric theory and Ptolemy Claudius would build upon and expand the Aristotelian geocentric model to create a model that would last until the successful revolutions of Copernicus and Galileo.

Aristotle is a famous figure in history and was equally famous in antiquity, regarded as the epitome of a scholar and polymath, discovering basic biology, and writing extensive works on both ethics and astronomy. Yet, again Aristotle was not creating his geocentric model in a vacuum and was instead building off the work of Eudoxus, who was in turn following a Platonic model. Plato had proposed, in no great detail, that the heavens should be perfect and should be described therefore in terms of spheres, the most perfect geometric shape.[44] This would lead to the early Eudoxus' description of the heavens in terms of concentric spheres with the earth at the center. When Aristotle then read these works, he found that Eudoxus' model could be easily reconciled into his other views of nature and model of the universe, leading him to build upon Eudoxus' model.[45] Even here it is seen that without Aristotle's name there is already authority in this view because of the tradition it holds, stemming back to Plato and his own charismatic authority, there is a direct connection to very early philosophers and famous characters in Greek

[44] Lisa M. Dolling, *The Tests of Time: Readings in the Development of Physical Theory* (Princeton, Princeton University Press, 2003), 4.
[45] Ibid, 5.

history. In addition, there was no other perceived model, no question that the earth would not be central to the universe.

Yet, Aristotle as a figure adds authority to what can be seen as a "traditional" theory simply by being Aristotle. First and foremost, Aristotle would adopt charismatic authority, as his teachings and lectures would be largely regarded as truth because his work was so extensive and often well supported. This would later lead to his creation of the Lyceum, again following in Plato's footsteps by creating a school similar in form, which has been discussed previously. However, holding a position as the head of this school would also give him traditional authority. By being the one who defined the activities of the school and set a specific tradition of teaching, it would create a legacy of Aristotle's teachings.

As both the head and founder of a school, Aristotle's ideas would continue to pervade Greek thought, and especially Greek scientific thought, throughout history. This would be further proven as people in other institutions, such as that of the Mouseion would attempt to adhere to Aristotelian (or Peripatetic) thought.[46] Yet, Aristotle would be unique in that he would be able to also make use of legal authority. Aristotle is also largely known to have been the tutor of Alexander the Great, famous for his conquest of the Persian Empire, Egypt, and most of the known world. Aristotle was commissioned to tutor Alexander the Great by Phillip II, Alexander's father and the king of Macedonia. As Alexander would later conquer the many surrounding areas, it would lead into the Hellenistic era, in which Aristarchus would attempt to spread his heliocentric theory.

However, Aristarchus we know would now be met with Aristotle's geocentrism, which at the time seemed intuitive, that the earth was both still, as there was no obvious motion of the

[46] P.M. Fraser, *Ptolemaic Alexandria* (London: Oxford University Press, 1972), 317.

planet and that the moving celestial bodies then seemed to rotate about this fixed earth.[47] Aristotle, addressing previous astronomers' and philosophers' attempts to explain the celestial movements writes, "the natural motion of the earth as a whole, like that of its parts, is towards the centre of the Universe: that is the reason why it is now lying at the centre."[48] This view of the universe would continue to be perpetuated, despite modern views that Aristotle was a bad physicist.[49]

There is even further evidence as to how much people believed in Aristotle and considered him an authority through the amount of works by him that survive today. Considering that copying books was often expensive and time consuming, it shows great reliance on the works of Aristotle, that nearly all of his works are still widely accessible today. This is only because the Arabic astronomers and philosophers also respected his works and transcribed them, carrying them into the future of medieval philosophy.[50] Aristotle's use not only of a traditional model of the universe, but also his many claims to the three types of authorities as defined by Weber would contribute to the way he would set a strong precedent for later studies. By all accounts, Aristotle had created the paradigm that astrophysicists, astronomers, and cosmologists would attempt to reconcile in their view of the universe.

Cleanthes is an important figure in analyzing a reaction of a contemporary to Aristarchus's work. Cleanthes lived and studied during the same period as Aristarchus, but in Athens, under the Stoic school. Not only was Cleanthes a part of the Stoic school but he was also to become the second scholarch of the school after the founder, Zeno. Cleanthes' position would

[47] Dolling, 6.
[48] Aristotle, *On the Heavens* (Cambridge, Massachusetts: Loeb Classical Library, 1939).
[49] Lindsay Judson, "Aristotle's Astrophysics" in *Oxford Studies in Ancient Philosophy* 49 (2015), 151.
[50] John Freely, *Aladdin's Lamp: How Greek Science Came to Europe Through the Islamic World* (New York: Alfred A. Knopf, 2009), 68.

afford him authority that would persist for many years, as both the head of a rising institution and a charismatic authority. Since Cleanthes was such an early contributor to Stoic philosophy, followers of the Stoic school would largely reference him as an authority on Stoic teachings, and therefore represent a larger traditional authority. Yet, Cleanthes was also interesting in that he gained authority as a charismatic leader, admirable for his work ethic, which is relayed by Diogenes Laertius as he described the patience he took in writing and how he worked hard despite not having a natural aptitude for physics. He was also known as the "water-carrier" because of his insistence to earn his own means through the manual labor of carrying water from a well.[51]

However, Cleanthes was also a major composer of the Stoic physics, which is driven by "pneuma", defined as an all-moving force that drove the movement of the universe, which Stoics believed to be predetermined by a god.[52] It is then obvious that the center of the earth was of great importance to the Stoics, as it was the entire basis not only for their religious beliefs but also for their conception of a deterministic world, in which everything was fated. Cleanthes highlights this in his famous *Hymn to Zeus:*

> This entire cosmos which revolves around the earth obeys you,
> wherever you might lead it, and it is willingly ruled by you;
> such is [the might of] your thunderbolt, a two-edged helper
> in your invincible hands, fiery and everliving;
> for by its blows all deeds in nature are <accomplished>.
> By it you strengthen the common rational principle which penetrates

[51] Diogenes Laertius, *Lives of Eminent Philosophers 7.5 Cleanthes* (Cambridge, Massachusetts: Loeb Classical Library, 1925).
[52] Pneuma, Reason, God, and Aither are all names for this active force that drives the universe. These forces are identical to Stoic conception of a material god driving the actions of the universe, to create a deterministic worldview in which everything is fated.

> all things, being mixed with lights both great and small.[53]

It is clear that not only does Cleanthes believe in the power of Zeus/Pneuma to completely drive the universe but also that he firmly believes that the earth must be the center of this universe. This gives Cleanthes even more reason to defend his view, and demonstrates why geocentrism would persist under the Stoic school of thought, because it was fundamental to their view of the world and god, which would define all beliefs they held. It was not because of an objective argument that Cleanthes believed in a geocentric world, but because the geocentric model was such a fundamental conception of his world, it was something he had to defend. This would carry on beyond him as Stoicism continued to gain traction and following within the ancient world.

However, Cleanthes was not only a staunch supporter for geocentrism and his predetermined world, he was also an active mind that was pursuing answers to define the universe within philosophy, where much scientific activity was conceived in Greek antiquity. Due to this, he was an active part of the imagined scientific community and was known to have read Aristarchus's book, or at least part of his argument. In Diogenes Laertius' biography of Cleanthes, there is even a work listed as "A Response to Aristarchus."[54] Even more evident of Cleanthes' reaction is Plutarch's account that Cleanthes wished to charge Aristarchus with impiety, because of his heliocentric theory

> Thereupon Lucious laughed and said: "Oh, sir, just don't bring suit against us for impiety as Cleanthes thought that the Greeks ought to lay an action for impiety against Aristarchus the Samian on the ground that he was disturbing the hearth of the universe

[53] Stobaeus, "The Hymn to Zeus by Cleanthes" in *Hellenistic Philosophy,* trans. Brad Inwood and L.P. Gerson (Indianapolis: Hackett Publishing Company, 1997), 140.
[54] Diogenes Laertius.

> because he sought to save phenomena by assuming that the heaven is at rest while the earth is revolving along the ecliptic and at the same time is rotating about its own axis."[55]

Cleanthes did not only disagree with Aristarchus, but he firmly believed that he should be charged legally because of this belief, which only demonstrates that there certainly was a dogma that supported geocentrism.

If we also suppose that Cleanthes held as much authority in the scientific community as he seems to, it would seem this very charge would make it even harder for Aristarchus to gain recognition and promote his hypotheses. Aristarchus was now fighting against both the legacy of Aristotle and his physics, but also the physics and religious doctrine of Cleanthes in the contemporary era.

Much later than Aristarchus, born in 100 CE was Claudius Ptolemy, who would develop the most comprehensive account of geocentrism, further perpetuating this system of Aristarchus's heliocentric version. However, it is hard to consider the authority that Ptolemy held, because so little of his life is known. He was known to have resided in Alexandria, his birthplace is unknown, and was known to hold Roman citizenship.[56] From this information we can only then ascertain that Ptolemy would most likely have worked in the Mouseion, however, in what position and in conjunction with whom, is widely unknown. In considering the work of Ptolemy it is instead important to know that while he greatly improved the geocentric system he still relied on Aristotelian arguments and commitments.[57] The reliance on Aristotle's previous model proves only further the amount of authority that Aristotle's authorship help. Even more

[55] Plutarch. *Moralia. Concerning the Face Which Appears in the Orb of the Moon* (Cambridge, Massachusetts: Loeb Classical Library, 1975).

[56] Dolling, 29.
[57] Ibid.

than three hundred years after Aristotle, Ptolemy still largely relied on his work. The only claim to authority one can give to Ptolemy is charismatic, based purely on his works. His works used more advanced math that could account for changing motions among the planets and also gained much traction because his work was so elegant and seemed to account for all the observable problems geocentrism had previously posed.

Instead, to understand why Ptolemy's work so clearly overshadowed Aristarchus' one has to look to the science itself, briefly this includes that Ptolemy's model and the geocentric model was more intuitive, based on the observed motion of the earth, namely that it did not appear to move. While Aristarchus's heliocentric model can account for the retrograde motion of planets and variation in planetary brightness throughout the year, he still could not account for how small this required the earth's orbit to be, which also begat a view that the universe was much larger than previously thought, which is alluded to in Archimedes' *Sand-reckoner*.[58] However, this is not the focus of this paper.[59] Ptolemy instead demonstrates a figure that relied on the paradigm set forth by an unquestionable authority like Aristotle. Although his science seemed elegant at the time and he answered many questions, it is only because Aristotle had guided his questions through a centuries old theory.

It also appears that Aristarchus may not have held much authority himself. Like Ptolemy, there is little know about his life, it is commonly asserted that he resided in Alexandria and often believed that he may have studied under Straton, who would later become the scholarch of the Lyceum in Athens.[60] It then seems that Aristarchus was perhaps on the lower rungs of the ladder

[58] Ibid, 6.
[59] For a fuller account of the exact sciences see *Aristarchus of Samos* by Sir Thomas Heath (Oxford: Oxford University Press, 1913) and "Claudius Ptolemy" in *The Tests of Time: Readings in the Development of Physical Theory* by Lisa M. Dolling (Princeton, Princeton University Press, 2003).
[60] Fraser, 397.

in the Mouseion, and was later left without a mentor when Straton adopted the position of scholarch in the Lyceum. I would even say that despite having connections to an important authority as Straton, it would have been without use to his heliocentrism as the Lyceum as Aristotle's school would have been firmly connected to a geocentric model. The fact that so little of Aristarchus's works are recorded, heliocentrism entirely referred to second hand, and only a portion of one other work, *On the Sizes and Distances of the Sun and Moon*, remain, it seemed even in antiquity his writings were not deemed worthy enough to record, or at least no where near the care that was taken in recordings work of others like Aristotle. This evidence then seems to say that Aristarchus held little authority in the Hellenistic world, and his theory would have been given even less consideration than others because of his low position.

Although there are three main figures that are covered here, there were many others that also supported the same geocentric system against Aristarchus's heliocentrism. Even if some were not directly countering Aristarchus, there was little consideration of his theory and more reliance on geocentrism as the set paradigm. These three figures show that authority permeated Greek thought, in which there was little chance that Aristarchus would ever be read and then if he was, ever taken seriously.

VI. Aristarchus in the Scientific Debate

There are many modern scholars who argue that Aristarchus' theory was rejected because there were no scientific anomalies. Based on scientific observations and data, the current geocentric universe was able to fully address a clear picture of the universe. This is not to say that there is not basis in this argument, and it is clear that Aristarchus was only solving a couple visible problems in the geocentric model, such as retrograde motion of planets. It is also true that Aristarchus' answer was not intuitive; there was no experience of planetary motion or easily visible evidence. Yet, it is not my argument that authority is the only factor that played a role in the rejection of Aristarchus' theory, but rather that it was a significant factor among others.

Even Thomas Kuhn asserted that Aristarchus' story was not relevant to his account of scientific revolutions because Greek astronomy had not yet reached a paradigm surrounding geocentrism; he believed their astronomy remained pre-paradigm.[61] Yet, it is evident through Cleanthes' reaction to Aristarchus' heliocentric theory that there was a paradigm driven by dogma. This dogma would define the paradigms of the debate, in which geocentrism was adopted before heliocentrism was even explored. This was largely because the dogma was so easily accepted on the basis of authoritative figures that supported it, such as Aristotle. It would be these authority figures, and the belief in their status as scientists that would play a large role in the rejection of Aristarchus. His story shows that science is not as objective as it may appear on the surface and subjective factors, like authority, are necessary to demonstrate a full historical picture of the scientific process.

It is evident that science can be used as rhetoric, whether it's in the denial of new science or existing science, it is the interpretation and use of scientific facts that introduce subjectivity

[61] Kuhn, 76.

into a supposed objective process. It is necessary to then explore these subjective processes when explaining the history of science, to clearly depict the processes that are affecting the historical record. This form of analysis can also reach into more modern science, and there can be more of an effort to use science not as rhetoric but to read it as fact based on objective evidence. Science continues to become more political as it is more easily applied to the policies and changes we implement. When legal authorities deny the objective science in order to pursue a different policy, they impede scientific progress in the same way Cleanthes did. Science cannot be denied or used to fit a narrative that appeals to any individual, but instead must be used as a framework for creating a narrative that supports the scientific data.

This paper also leads to further questions, which may better be explored in the future to more clearly depict how institutional structures and authority permeate scientific activity and belief. Questions include: how cult brotherhoods informed the academic institutions and what the existing structures of the cults were, how Aristarchus' status as a Samian new to the Ptolemaic empire affected his work in the Mouseion, further exploration of the Seven Sages and what they represent to Hellenistic scholars, how originality and tradition functioned together within ancient Greek science, a clearer depiction of the hierarchal structures of philosophical schools and the Mouseion, and how the audience of scientific work may have informed the work that was being pursued. A more in depth analysis of these questions might also elucidate the role of authority in the history of scientific developments.

Works Cited

Archimedes. *The Sand-Reckoner of Archimedes*. Cambridge: Cambridge University Press, 1897.

Aristotle. *On the Heavens*. Cambridge, Massachusetts: Loeb Classical Library, 1939.

Brouwer, Rene. *The Stoic Sage: The Early Stoics on Wisdom, Sagehood, and Socrates*. New York: Cambridge University Press, 2013.

Curnow, Trevor. *Wisdom in the Ancient World.* London: Duckworth, 2010.

Derman, Joshua. *Max Weber in Politics and Social Thought: From Charisma to Canonization.* Cambridge; New York: Cambridge University Press, 2012.

Diogenes Laertius. *Lives of Eminent Philosophers 7.5 Cleanthes*. Cambridge, Massachusetts: Loeb Classical Library, 1925.

Dolling, Lisa M. *The Tests of Time: Readings in the Development of Physical Theory*. New Jersey: Princeton University Press, 2003.

Martin, Richard P. "The Seven Sages as Performers of Wisdom." In *Cultural Poetics in Archaic Greece: Cult, Performance, Politics*, edited by Carol Dougherty and Leslie Kurke. New York: Oxford University Press, 1998.

Fraser, P.M. *Ptolemaic Alexandria*. London: Oxford University Press, 1972.

Freely, John. *Aladdin's Lamp*. New York: Alfred A. Knopf, 2009.

Heath, Sir Thomas Little. *Aristarchus of Samos*. Great Britain: Oxford University Press, 1959.

Judson, Lindsay. "Aristotle's Astrophysics" in *Oxford Studies in Ancient Philosophy* 49. Oxford: Oxford University Press, 2015.

König, Jason and Greg Woolf. *Authority and Expertise in Ancient Scientific Culture.* Cambridge: Cambridge University Press, 2017.

Kuhn, Thomas S. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press, 2012.

Lloyd, G.E.R. *Early Greek Science: Thales to Aristotle.* London: Chatto and Windus, 1970.

------. "Scholarship, authority, and argumentation in Galen's *Quod animi mores*." In *Principles and Practices in Ancient Greek and Chinese Science,* edited by G.E.R. Lloyd. Great Britain: Ashgate Publishing Company, 2006.

Plutarch. *Moralia. Concerning the Face Which Appears in the Orb of the Moon*. Cambridge, Massachusetts: Loeb Classical Library, 1975.

Rihll, T.E. *Greek Science.* Oxford: Oxford University Press, 1992.

Stobaeus. "The Hymn to Zeus by Cleanthes." In *Hellenistic Philosophy.* Translated by Brad Inwood and L.P. Gerson. Indianapolis: Hackett Publishing Company, 1997.