Lightning in a Wine Cask: Vernacular Meteorology and Terminology in the *Goodly Gallerye* of William Fulke

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Abstract: Lightning and thunderbolts have been sources of wonder since classical antiquity. Interpretations of these aerial and destructive phenomena had roots in the Homeric tradition and further evolved in the meteorological writings of Aristotle and others. In Aristotelian and early encyclopedic writings, lightning and thunderbolts were explained as different manifestations of the dry exhalation or wind. Writers categorized thunderbolts based on their subtlety, speed, and effects. In the sixteenth century, William Fulke viewed thunderbolts similarly to his antique predecessors but interpreted wondrous aspects and categorizations in light of the scientific and religious convictions of Elizabethan England. His English meteorological text, *Goodly Gallerye*, demonstrates an attempt to standardize terminology in the vernacular while also maintaining continuity in descriptions and interpretations of lightning and thunderbolts. This continuity can also be seen in subsequent writers on lightning and thunderbolts who used chymical theories of meteorology.

Keywords: Lightning, thunderbolts, vernacular meteorology, terminology, chymistry, William Fulke.

1. Introduction

Aristotle's treatment of lightning and thunderbolts in his *Meteorology* became part of a long tradition in antiquity to explain the causes of these phenomena in relation to each other and as products of the dry exhalation. As relatively common but remarkable experiences, lightning and thunderbolts appeared in poetry and a variety of other creative works and often provoked wonder.[1] Accounts of strange, violent, or wondrous effects often accompanied descriptions of lightning and thunderbolts even in works that otherwise emphasized causal explanations. Some of the most prominent examples of this persist in Pliny the Elder's *Natural History* and Seneca's *Natural Questions*. These writings explained that lightning could, among other effects, melt coins in a purse without charring the bag, or that the penetrative power of lightning could poison and coagulate wine in a jar without shattering the container.[2] A list of strange effects accompanying descriptions of the causes of lightning and thunderbolts became mostly standard and remained consistent in meteorological works even as Aristotelian explanations on the causes of windy meteors evolved through commentaries and other writings.

The Latin encyclopedic tradition and scholastic commentaries of the Middle Ages demonstrate continuity with the period of antiquity in modes of discussing lightning and thunderbolts. Like Aristotle, many considered lightning and thunderbolts to be distinct from each other.[3] In his *Natural Questions*, Seneca differentiated between lightning and thunderbolts by designating the former as a harmless flash in the sky and the latter as tending to be more destructive due to its striking something.[4] The material, speed, and subtlety of a thunderbolt determined what effects it would have when striking an object. Based on this, writers identified distinct kinds of thunderbolts that were identifiable according to the effects they had when striking an object. Isidore of Seville put forth a tripartite view of thunderbolts in his encyclopedic work *Etymologies* and distinguished between them according to the exceedingly fine and penetrative power of lightning.[5] Adelard of Bath similarly characterized thunderbolts in a tripartite scheme according to their effects.[6] In his commentary on Aristotle's *Meteorology*, Albertus Magnus addressed others' views and offered his own, ultimately describing thunderbolts and accompanying effects similarly to his Greek and Latin predecessors.[7] Many writers maintained a tripartite organization of thunderbolts, but few were in complete agreement about what these thunderbolts did or what their exact cause was. Differences in theory and method surely contributed to these differences, but an intermixing of Greek and Latin terms through translations and commentaries is perhaps another contributing cause.[8]

Andrew Dickson White in his nineteenth-century series considered ancient writers on meteorology to be inadequate for developing serious theories but thought they showed "at least the germs of a science."[9] In his view, the rise of Christianity hampered scientific growth in this area because writers heeded scripture in their works. White explored theories of thunder and lightning as steeped in religious contexts with undertones of superstitious ideas and offered the idea that effects of lightning striking coin purses, wine vessels, sword sheaths, and a variety of other objects were used in the Middle Ages as part of Christian moral lessons.[10] In a more recent work that addresses the standard strange effects of lightning strikes, S. K. Heninger examined meteorological theories in relation to great works of English literature. His main touchpoint for meteorological theories is the Puritan divine William Fulke (1538-1589), who, in addition to numerous theological writings, authored a few works on topics relating to natural philosophy. Heninger draws attention to Fulke's adherence to ancient classifications of lightning and the terms Fulke uses to describe them.[11] The tradition of lightning effects accompanying explanations of lightning

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causes maintained interest beyond superstitious tales and works of literature. Fulke's use of these terms involved careful attention to Greek and Latin works in choosing how to present this information in the English vernacular. As a whole, his work on meteorology sought to subvert superstitious theories while promoting his religious ideals.

A wider accessibility of texts through printing contributed to a growth of vernacular texts in the Reformation era. In sixteenth-century London, Fulke published the *Goodly Gallerye* (1563), one of the earliest writings on meteorology in English. Fulke's explanations of meteors in general and types of lightning in particular maintained many of the methods and characteristics born in classical antiquity, but they were also coupled with responses to ongoing debates and controversies in England. To combat the popish superstition of his Catholic predecessors, Fulke's works on natural philosophy emphasized natural causation and focused on giving a clear explanation of philosophical concepts to the common folk. In the *Goodly Gallerye*, Fulke wedded Greek and Latin traditions of meteorology for a scientifically lay audience in English. In so doing, he committed to somewhat new terminology and made decisions about how words and concepts should be understood in the English vernacular.

2. Lightning and Thunderbolts in Ancient and Medieval Traditions

As part of an inquiry into the natural world, Aristotle's *Meteorology* seeks to explain the causes of sublunary natural phenomena. Books I-III of the *Meteorology* cover the causes of phenomena such as comets, clouds, rainbows, haloes, wind, and earthquakes, while Book IV, previously thought to be spurious, covers the generation of metals and topics related to matter theory.[12] Aristotle saw meteors as having material and efficient causes. The primary material cause of meteors is the dual exhalation: one hot and dry, the other cold and moist. The motion of the heavens and heat from the sun drawing up the exhalations constituted the main modes of efficient causation. Aristotle did not offer formal or final causes of meteors. This general coverage and scope of topics formed a tradition that flourished in medieval universities and persisted up through the early modern period.

In the Aristotelian tradition, thunder, lightning, whirlwinds, firewinds, and thunderbolts were all thought to have the same material cause of the dry exhalation (ξηρᾶς ἀναθυμίασις), differing only in manifestation and degree.[13] Aristotle explains the cause of lightning and thunder in *Mete*. 2.9 and covers the remaining three phenomena in *Mete*. 3.1.[14] Aristotle explains that thunder and lightning are products of ejection that are produced, as opposed to latently existing in clouds. The exhalation, being hot, is forced out of a cloud as it condenses and cools, much like a fruit pit would shoot out from beneath one's fingers when pressed.[15] The percussion of the exhalation against other clouds is heard as thunder (βροντή). When the ejected wind (πνεῦμα) catches on fire, it is called lightning (ἀστραπή). Thunder and lightning are characterized according to their subtlety and rarity. When the wind is more compact and denser, it causes a hurricane (ἐκνεφίας). When the winds in a cloud run into each other they are caused to move in a circular fashion as an "unripe hurricane" or whirlwind (τυφῶν), which is a sort of hurricane that is trapped in a cloud. When whirlwinds are drawn out of the cloud and become finer in texture and thus catch fire, they are called firewinds (πρηστήρ). If the firewind is of great quantity and squeezed from the cloud, it is called a thunderbolt (κεραυνός).

Frederick Bakker has shown that this structure of explaining like phenomena together in a group was a trend in many antique writings treating topics considered to be meteorological.[16] In most writings, lightning and thunderbolts are considered as separate phenomena. Aristotle differentiated between lightning and thunderbolts according to their causes. Aristotle put forth only one cause for these phenomena, but many others like Epicurean philosophers offered multiple possible causes for one phenomenon.[17] Like Aristotle, writers did not often separate lightning into distinct categories and types, however thunderbolts as a separate and distinct phenomenon was typically categorized into groupings. As it concerned thunderbolts, many writers paid heed to the causes, characteristics, and effects.

The effects of thunderbolts according to Aristotle depend on their speed, subtlety, and resistance of the material of the objects they strike. Aristotle identifies two types of thunderbolts based on their effects. A fine-textured and non-scorching bolt is called gleaming (ἀργῆς). A less fine-textured and scorching bolt is called smoky (ψολόεις). Both of these names are used in Homeric references to Zeus' lightning.[18] Aristotle explains the properties of these types of bolts in terms of subtlety and speed, which can be determined from examining how they interact with objects when struck. For instance, the gleaming bolt, in addition to its fine texture, moves rapidly and thus does not harm objects. The smoky bolt moves more slowly than the gleaming bolt, but it still moves quickly enough to not burn objects, instead only blackening them. Objects that fight back or offer resistance (ἀντιτυπήσαντα) suffer, but objects that do not offer resistance do not suffer. For instance, a bronze spearhead melts when struck by a thunderbolt, but its wooden handle is unharmed. The reason for this is that the wind is able to percolate through the wood on account of its texture (διὰ μανότητα).[19] Similarly, thunderbolts can pass through garments without burning them, but instead leaving them threadbare.

Pliny's *Natural History* maintained different goals and methods from Aristotle, but the manner of explaining lightning and thunderbolts is very similar. In the second book Pliny discusses the causes of thunder (*tonitrua*), lightning (*fulmina*), heat-lightning (*fulgetra*), hurricanes (*ecnephias*), whirlwinds (*typhon*), and firewinds (*prester*).[20] A thunderbolt (*fulmen*) is a firewind that always had fire in it and did not catch fire after bursting from the cloud.[21] Pliny says that several types of thunderbolts are reported. Dry thunderbolts cause an explosion rather than a fire. Smoky (*fumida*) thunderbolts do not burn, but rather blacken.[22] A third type is called bright (*clarus*), which has a remarkable nature (*mirificae maximе naturae*). This third type can drain wine casks without damaging their lids or leaving a trace. It can melt gold and copper and silver in bags without singeing the bags or melting the wax seal. Pliny's explanation of causes differs

from Aristotle, and Pliny discusses three types of thunderbolts instead of Aristotle's two, however both of them refer to a bright kind and a smoky kind. Aristotle and Pliny are also similar in that they discuss stormy phenomena in relation to each other, but one key difference is Pliny's penchant for the strange and odd wonders, whereby he names effects that thunderbolts have when striking plants and creatures.[23]

In like fashion, in the *Natural Questions* Seneca discusses the cause of lightning flashes (*fulgurationes*), lightning bolts (*fulmina*), and thunder (*tonitrua*).[24] He differentiates lightning flashes from lightning bolts in a number of ways, one distinction being that a lightning flash is a threat (displays fire) whereas a lightning bolt is an attack (emits fire).[25] Seneca explains that there are differing types of interpretation of thunderbolts rather than three distinct types.[26] Like Pliny, Seneca puts forth a tripartite differentiation of thunderbolts, but differs in their descriptions and names. One type of thunderbolt bores because it is subtle, thin, and pure and thus can travel in and out of substances through narrow openings. A second type scatters and breaks materials rather than traveling through them. The third type clings to materials and thus burns them, leaving black traces. Seneca gives a familiar list of effects wrought by thunderbolts. This includes a description of what happens to swords in sheaths, coins, and wine casks when struck, which appears in a few different sections of Seneca's text.[27] A rough equation between the types of thunderbolts offered by Pliny and Seneca could be bright with boring, dry with scattering, and smoky with clinging.

Aristotle, Pliny, and Seneca had differing purposes for including such examples and explanations in their writings. Aristotle discusses thunderbolts and stormy phenomena as different manifestations of the same material in order to demonstrate that wind is indeed the material cause of them.[28] Seneca makes a similar appeal. When differentiating between lightning flashes and thunderbolts, Seneca emphasizes their relationship because they have the same nature.[29] In his discussion of winds, Pliny makes an appeal to the genre of natural history and accounts from travelers, lamenting that many are not sharing this newly acquired knowledge.[30] Pliny's inclination toward the wonderous and strange occurrences of thunderbolts is perhaps influenced by his desire to collect a wide variety of stories and accounts. Seneca and others, like Epicurean philosophers, addressed violent phenomena in relation to fear, offering natural causation as a way to abate fear of death. Many early writers who included these phenomena focused primarily on establishing a clear material causation; final causes or ultimate purposes are not emphasized.

The Aristotelian and early Latin tradition maintained continuity up through the Middle Ages in explanations of thunderbolts most notably in the distinction of types and explanations of their effects, which were determined by subtlety, speed, and material of the object struck. Translations and commentaries between Greek, Latin, Syriac, and Arabic texts influenced how ideas and concepts relating to lightning and thunderbolts were interpreted by later writers. Encyclopedic works like Isidore's *Etymologies* or Bartholomaeus Anglicus' *De rerum natura* offered continuity of the Latin tradition by maintaining a tripartite organization of thunderbolts. The Syriac meteorology, attributed to Theophrastus, puts forth multiple possible causes of thunder, lightning, and thunderbolts rather than grouping thunderbolts into three types, where continuity is maintained in this text through the description of effects that thunderbolts have due to the subtlety, speed, and material.[31] The translation of Aristotle's *Meteorology* by Gerard of Cremona, the text from which some scholastic writers drew, contained a lacuna at the part of the text where thunderbolt effects are discussed.[32] The medieval corpus of meteorological texts was not fully congruous on how types of thunderbolts should be classed or what the precise cause was, but the method of discussing thunderbolts, primarily by subtlety, speed, and effects, was a great continuity between them.

3. Meteorology in the English Vernacular

William Fulke (1538-1589) was well-acquainted with the heritage of texts from the classical and medieval periods. His works demonstrate a command of Latin literature in poetry and natural philosophy. Fulke had humanist leanings that cherished beautifully written prose.[33] Many of the texts Fulke cites in *Goodly Gallerye* (1563) were available as printed works in Latin by this time in the sixteenth century, though Fulke's mastery of other languages and his emphasis on correctly interpreting texts is evident from his other works.[34] In his *Antiprognosticon* (1560), Fulke recounts his reading of Hippocrates' *Airs, Waters, Places* in Latin as well as Greek, in which he found the margin notes of the Latin version misleading and inadequate, thus necessitating a closer look at the text.[35] Fulke's penchant for beautiful prose and clearly rendered translations perhaps influenced his later work on an English translation of the New Testament (1589) as a response to the Douay-Rheims Vulgate translation.[36]

Fulke participated in the movement of making texts available in the English vernacular. His contributions included not just translations, but also the rendering of interpretations and explanations into plain and common language. The Latin version of his *Antiprognosticon* was reprinted in English in the same year with a significant amendment to the original text.[37] This second English edition contained a second part directed at "common folk," in which Fulke describes his writing in this second part of the text as plain and "omyttyng all colours of rhetorke, and all impediments of paynted speache."[38] As opposed to the original Latin version of the text, the English amendment emphasizes the role of God in nature, a theme that is also evident in the *Goodly Gallerye*. From this it may be drawn that Fulke's writings for those not well-versed in philosophy emphasized clarity in explanations, terminology, and the role of God in the natural world.

The *Goodly Gallerye* was not the only work in English that discussed meteorological topics.[39] A printed edition of John Trevisa's English translation of Bartholomaeus Anglicus' *De rerum natura* appeared in 1495.[40] Almanacs with inclusions of meteorological topics were also available, such as Leonard Digges's *A Prognostication of Right Good Effect* (1555).[41] Nevertheless, Fulke's *Goodly Gallerye* seems to have filled an empty niche in English literature on the topic. This text underwent sever-

al reprints since its initial publication in 1563, with versions appearing in 1571, 1602, 1634, 1639, 1640, 1654, 1655, and 1670. Despite undergoing title changes in 1602 and 1640, few substantial changes were made to the text.[42] The 1654 and subsequent editions include a prefatory note to the reader that vouches for its utility:

> And I may (without breach of modesty) affirm, that there is not in our language any book of so small a bulke, contains so much of the Doctrine of the Meteors. We daily behold and view divers meteors, but very few are skill'd in their causes; but those that are not, may be informed.[43]

The writer of this prefatory note explains the appendix of observations that a "person of quality" made to this book which "on perusal hath been found so advantagious."[44] Others made use of Fulke's text. The almanac writer Thomas Hill, against whom Fulke argued in his *Antiprognosticon*, drew upon the *Goodly Gallerye* in his meteorological text *A Contemplation of Mysteries* (1574).[45] Those with an interest in natural philosophy undoubtedly found Fulke's work on meteors useful, but it seems that one of Fulke's main goals in the *Goodly Gallerye* is to dispel superstition by explaining causes of natural and strange phenomena, thus clarifying his Puritan interpretation of natural phenomena.[46] In this way, Fulke's target audience for this text was perhaps those pushed and pulled by vernacular writings promoting superstitious renderings of the natural world, whether through astrology or otherwise.

From the outset, Fulke structures the *Goodly Gallerye* for a scientifically lay audience of those who have "not tasted the principles of philosophy."[47] Fulke's treatment of meteors generally follows an Aristotelian ordering of explanations. He sorts his work into five books. The first book introduces the general topic, terminology, and an explanation of basic frameworks in natural philosophy, corresponding roughly to *Meteorology* 1.1-1.3. Fulke lays the groundwork for understanding meteorology in this first section of the book. Fulke describes the relation of the four elements to one another. Earth and water combine together to make a ball, air wraps around that ball, and fire wraps around the air "as the peeles of an onion are within one another; after the same sort from the highest heaven to the earth that is lowest, one part that is greater compasseth round about another that is lesser."[48] Meteors, then, are generated either in the earth (wells, springs, earthquakes, metals, minerals) or in the air (rain, hail, snow, dew, blazing stars, thunder, lightning). Unlike Aristotle's text and the scholastic commentaries on it, in this first book Fulke does not attempt to situate meteorology in relation to other branches of natural philosophy.[49] However, he borrows some interpretations of Aristotle from commentators, such as the idea of three different regions of air, something that Aristotle does not explicitly mention, but still fits within his theory.

The remainder of the books are divided according to types of meteors, where the second book covers fiery meteors (*Mete*. 1.4-1.7), the third book covers windy meteors (*Mete*. 1.8; 2.4-3.6), the fourth book covers watery meteors (*Mete*. 1.9-2.3), and the fifth book covers earthly meteors (*Mete*. 3.6; 4.1-4.12). A number of other subjects that Aristotle does not mention are covered in Fulke's work. For instance, the discussion of other phenomena such as fire drakes in works like commentaries may have influenced Fulke to include them in his own work. Likewise, Fulke may have discussed Catholic ideas like purgatory being located in the middle region of air in order to dispel popish superstition on such topics by explaining them thoroughly. While this text is neither a commentary nor is it scholastic in nature, Fulke was acquainted with and influenced by medieval scholastic texts on Aristotle's *Meteorology*.

Fulke lays out basic theory and terminology in the first book. Fiery, airy, and watery meteors are imperfect mixtures, while earthly meteors are perfect mixtures. They are caused by vapors and exhalations. Vapors, like breath or steam, are warm and moist and create meteors when the sun draws them up through the middle region of air and they are mixed with cold. Exhalations, like smoke, are hot and dry and thus ascend up through the highest region of air due to their thinness and lightness. Some exhalations are drawn from clammy, fatty, or oily places that cause exhalations and vapors to become viscous and stick together, causing a variety of phenomena when kindled, like dragons, goats, candles, spears, and the *ignis fatuus* seen in graveyards. Fulke alerts the reader that the terms vapor and exhalation "must be well noted because they must be much used." The sphere of air is divided into three regions. The highest region is hot due to its proximity to the sphere of fire, the lowest region is warm because of the reflection of sun beams, and the middle region is cold and trapped between the two warmer regions on either side. This cold and dark region is prone to generate clouds and storms, which has led "doting divines" to believe that this middle region is where purgatory resides. Thunderbolts are airy meteors produced in the middle region of air, defined by their thinness and subtlety despite their cause being a kindled clammy exhalation.

Fulke discusses causation in Aristotelian terms. The material cause of meteors is mostly from earth (exhalation) and water (vapor), but Fulke points out that the mixture of air and fire are also essential for the generation of meteors.[50] Fulke names two efficient causes. The first efficient (principal) cause is God, who works wonders and causes marvelous effects.[51] The second efficient (particular) cause comes in two parts. There is a far off efficient cause (remote) and a next (proximate) cause. The proximate cause is the qualities of heat and cold, which cause different effects in the vapors and exhalations. Fulke briefly discusses astrological causation by allowing for the stars and planets as an efficient cause, but the *Antiprognosticon* makes it clear that planetary influences do not make meteors significant, nor can astrology adequately predict the weather.[52] Fulke fitted within the bounds of traditional Elizabethan science by describing natural events in accordance with natural causes rather than supernatural ones.[53] His integration of theology with his views on natural philosophy seek not to emphasize God as a cause, but rather to dispel the popish superstition of the Middle Ages. One of the ways Fulke achieves this is through his use of second efficient causes and middle ends.

Fulke has little to say about the formal and final causes, which are not explicitly addressed by Aristotle. The formal cause is "so secret that it is known to no man," with Fulke's explanation being that "God's wisdom com-

prehends the essential form of all substances." If meteors do have an essential form, Fulke does not comment on it. The final cause is "so evident that it is plain to all men," which is the glory of God. Much like his discussion of efficient causes, Fulke introduces a second kind of final cause, which he calls "middle ends." These middle ends are the benefits that God's creatures reap, such as the fruitfulness of the earth, purgation of the air, threatening of God's vengeance, punishing of the world, and moving the world to repentance. All of these middle ends serve the chief final purpose, which is the glory of God. Fulke's addition of formal and final causes to the causes of meteors also lends credence to the fact that he was exposed to other Aristotelian texts.

4. Lightning and Thunderbolt Terminology in the *Goodly Gallerye*

Fulke leads the *Goodly Gallerye* with the claim that no writer that he has seen has explained the causes of phenomena that fall under the purview of meteorology. Fulke's acquaintance with and citation of Aristotle and other ancient authorities suggests this is a statement about the inadequacy of past writers to explain causation in an accurate way. The accurate way to account for causes according to Fulke includes God as an efficient and final cause. By this Fulke does not mean to suggest that causes of meteors cannot be understood in a natural way, but rather that his predecessors introduced superstition and doubt into their approach to meteorology, and a new approach is needed. One of the ways Fulke sets forth to remedy this is through his particular attention to terminology and clear explanations.

In the aforementioned claim that no writer has explained causes of meteorological phenomena, Fulke writes that the common definition of such phenomena that writers use "in no wise will serve us." Aristotle used the term "meteoron" to describe these phenomena, but he was "deriving it from doubtfulness." In response to hypothetical opponents who may argue that finding a term for these phenomena is a frivolous task, Fulke counters with an argument that some learned people might not recognize that the style of this book is "attempered to the capacity of the readers" and thus will interpret his plain style as ignorance. This explanation up front thus serves to "pluck the opinion out of their minds." The opening statements of the *Goodly Gallerye* frame Fulke as an authority on the subject of meteors and establishes the importance of precise language and terminology in discussing these things.

Much of Fulke's theory is free of technical jargon, but he emphasizes particular terminology in many cases. He often defines words when they are introduced and signals to the reader when they are particularly important to remember.[54] In his treatment of particular phenomena with many manifestations, Fulke sometimes chooses to invent names for categories of meteorological phenomena. He sorts earthquakes into four groupings but does not assign names to those groups, but he sorts and names groups of springs.[55] Fulke addresses terminology related to lightning using this latter method.

Lightnings are airy impressions and are thus covered in the third book of *Goodly Gallerye*. Fulke categorizes and names four types of lightning so that "under these four all the rest may be comprehended," acknowledging that other writers have also treated distinct types of lightnings.[56] He derives the four names from Latin: *fulgetrum*, *coruscatio*, *fulgur*, and *fulmen*.[57] Like Aristotle and other predecessors, Fulke distinguishes between lightning and thunderbolts. The lightning flashes typically cause fear rather than harm, but when thunderbolts occur, they usually cause harm.[58] The first three names (*fulgetrum*, *coruscatio*, *fulgur*) refer to lightning flashes, while the final category (*fulmen*) refers to thunderbolts. The category of *fulmen* is further divided into three separate types, which Fulke says is borrowed from Aristotle, Pliny, and Seneca.

Fulke explains *fulgretrum* in association with heat, as it is seen in as a flash in the sky that occurs in the warm periods of the year, such as the summer. Often translated as "heat-lightning" in sources like Pliny and Seneca, *fulgetrum* according to Fulke is generated when many thin, light, and hot exhalations are drawn up from the earth into the lowest or middle regions of air. The exhalations rise because of their nature rather than heat from the sun (since this usually occurs during the evening). When the hot exhalations meet with the coolness of the air, the resistance of contraries kindles the exhalations due to motion and beating back. This explanation of the resistance of contraries, for which Fulke does not use the term antiperistasis, is explained in more detail in other points of the text.[59] Most of the time, this lightning flashes in the air and is not harmful. The exception to this is when the exhalations are earthy and gross and so strike the earth, usually causing only small amounts of damage.[60] Fulke closes this section with an "old wives tale" about the frequency of this type of lightning, which may have functioned as a touchstone for some of his readers.

Fulke calls coruscation a visual phenomenon rather than a material one.[61] It is the appearance of fire (glittering) and the appearance of lightning (glimmering) rather than fire or lightning itself. Coruscation according to Fulke is achieved in two ways. One way is through the appearance of a reflection of enflamed clouds that are otherwise not visible due to their location. The second way is through a "double order" of thick clouds, in which lightning or inflammation pierces downward through the clouds like light through a glass. This description seems to match the way Cleidemus, as portrayed in Aristotle, describes lightning as a brightness or flashing (λαμπρός), or as an optical phenomenon rather than a material one.[62] This description also appears to match how Fulke describes burning spears in the second book of fiery meteors.

Derived from the Latin *coruscatio*, "coruscation" was a relatively new word in English at the time of Fulke's writing, with early appearances found in English printed works from the 1490s.[63] Though some of these early uses of coruscation are found in conjunction with descriptions of lightning, it seldom appears in Pliny and Seneca, nor is it Greek in origin. However, its frequent use in later meteorological writings could perhaps be related to humanist interpretations of Greek sources. In his commentary on Aristotle's *Meteorology*, Agostino Nifo says that coruscation is what the Greeks call *astrepe*.[64] Gerard of Cremona

and William of Moerbeke used *coruscatio* in their Latin translations of Aristotle's *Meteorology*, and Albertus Magnus likewise employs it in his thirteenth-century commentary on the text with more careful differentiation of the terms.[65] Thomas Hill's *Contemplation of Mysteries* (1572) compares the terms *fulgetrum* and *fulgur*, but does not employ coruscation to explain lightning. Despite its absence in Hill's popular English meteorological text, Fulke likely influenced how the term coruscation was used in English. His definition of coruscation appears in a 1661 edition of a dictionary, well after the publication of *Goodly Gallerye*.[66]

Fulgur is the word most commonly used by Pliny and Seneca to refer to lightning flashes. According to Fulke, *fulgur* is caused when a violent exhalation breaks out of a cloud, which makes a noise (thunder) as it percusses the sides of the cloud. With that violence in exiting the cloud, the exhalation is set on fire and creates a big flash. Fulke discusses *fulgur* in relation to its timing with thunder, a subject also discussed in Aristotle, Pliny, and Seneca.[67] The fourth and final type of lightning Fulke describes is called *fulmen*. *Fulmen* is the most dangerous, violent, and hurtful kind of lightning. It occurs when a hot exhalation, enclosed in a cloud, breaks out and is set on fire and stricken down toward the earth with a great force. The thunder that accompanies this lightning is sudden, short, and great, like the sound of a gun. Fulke acknowledges that Aristotle, Seneca, and Pliny refer to this type of lightning in three categories and proceeds to describe them.

According to Fulke, the first type is called dry. This type of thunderbolt is most similar to Aristotle's gleaming, Pliny's bright, and Seneca's boring. Dry thunderbolts are distinguished by a lack of burning and a remarkably swift dividing. It is subtle, pure, and can thus pass through the pores of something as long as the pores are big enough. Those things that give place to it (have big enough pores) are not hurt by it, but the things that resist (have too small of pores) are divided and pierced by it. The subtlety of the lightning and the materiality of the objects determines the effects it has: it melts money in purses without harming the purses, it melts a sword without harming the scabbard, and it penetrates wine casks and coagulates the wine for three days.[68] In addition to the typical examples, Fulke adds a few notable others from Pliny, such as the killing of an unborn child with no harm to the mother.[69] He offers the same explanation for these stranger occurrences on the subtlety and material of the thunderbolt and the objects.[70]

Fulke's descriptions of the remaining two kinds are much shorter and less detailed. The second kind is called moist and is most similar to Aristotle's smoky, Pliny's smoky, and Seneca's clinging kind. Because it is very thin, the moist thunderbolt does not burn things to ashes, but rather blasts or scorches trees, corn, and grass and makes them black and smoky, as a moist log would scorch and blacken in a fire. Fulke does not name the third kind, but its description correlates with Pliny's dry kind and Seneca's scattering kind in that it is the most destructive. Fulke describes it as similar to fire and composed of gross and earthly substances, leaving marks where it has been or otherwise consuming and destroying objects.

After his brief discussion on the three types of thunderbolts, Fulke lists more wonderful and marvelous effects of lightning.[71] He names the reason and causes for them, some of which relate to the thinness and subtlety of thunderbolts, but other causes are related to the nature of humans and animals. Many explanations rely on an explanation of pores. Some of these descriptions have physical explanations, such as the case of few pore holes on certain types of trees. But lightning also has more mysterious properties that are felt with pores. Fulke tells of some who "behold" lightning that become blind, have face swelling, or become leprous because of the fiery exhalation being "received" into face and eye pores, suggesting that lightning does not always need to strike for its effects to be felt. Drawing from Seneca, Fulke also explains the poisonous qualities of lightning, which can be evidenced with the striking of wine or poisonous creatures. The cause of this is twofold and depends on materiality and subtlety. First, the matter of lightning becomes infected with brimstone and other poisonous metallic substances, and second, the thinness of the lightning allows it to penetrate into the body.

Fulke discusses thunderbolts in another way outside of the tripartite framework of the common ancient authorities, which is through the description of a thunderstone.[72] Continuing with similarities to gunfire, Fulke notes that a stone often shoots out with the ejected thunder, which is called a thunderbolt (*fulmen*). The stone is generated when the exhalation that generates the thunder is unctuous and contains metallic substances, like brimstone. Heat hardens the exhalation like a brick, which strikes toward the earth, causing varieties of destruction.[73] However, thunderbolts like this kind are not classed into one of the three groupings. Instead, Fulke describes the thunderbolt as a material object with an explanation of its thickness and sharpness in the third book on airy meteors, but also includes a more thorough entry on thunderbolts in the fifth book on perfect earthly mixtures.[74] Fulke's ideas on matter theory manifests most clearly in this last book, which corresponds most directly with Aristotle's fourth book of the *Meteorology*.

Fulke subverts ancient authorities by tacitly engaging with them and explaining the causes for accounts of strange occurrences. Most of his refutations are uncited rebuttals of wondrous explanations found in authorities like Pliny and Seneca, though he occasionally uses a more polemical tone when addressing particular problematic authorities, such as Albertus Magnus and the Epicureans. Fulke establishes himself as an authority to his lay audience in the opening portions of the *Goodly Gallerye*. But in practice, most of Fulke's innovations to meteorology come from older textual sources rather than things he has seen himself. Aside from a few examples, none of which are in the lightning section in the third book of airy meteors, Fulke does not rely on firsthand accounts of observation.[75] His method of debate relies on textual explanations and was influenced by the culture in England at the time.

The impressive number of reprints alludes the popularity of the *Goodly Gallerye*. This text differed from many vernacular meteorological treatises commonly printed that often encompassed almanacs or more of a focus on strange and superstitious occurrences. Fulke's goal of the accessibility of a scientific text to a common audi-

ence was achieved in part due to the types of explanation he used for a general population. Like ancient authorities before him, Fulke made a number of analogies that would have common touchstones so that "the common sort may understand it." Among the analogies, Fulke compares the sound of lightning and thunderbolts to artillery, which is an idea that is also present in Cardano's *De subtilitate*, a text from which Fulke drew.

Similarly to Fulke, in the *De subtilitate*, Cardano describes thunderbolts as the "fire of fires" and emphasizes their subtlety and describes their effects.[76] Fulke used Cardano as an authority, especially in the fifth book on earthy meteors. Like Cardano, Fulke's text is not in the style of a scholastic commentary, but rather a different sort of work on meteorology.[77] The two share many similarities, despite using different underlying frameworks and seeking different goals. Part of what differentiates Fulke from other contemporaneous writers is his continual emphasis on God and natural causation as a way to explain phenomena that were otherwise seen as superstitious. This goal was influenced by the common people for which he wrote, and his method of achieving it was in part due to his humanist leanings in the clarity of language. Perhaps most differently from Cardano, Fulke maintained an overall Aristotelian explanation of meteorology, though at times he hints toward the new chymical philosophy.

5. Conclusion

Lightning and thunderbolts continued to be held as remarkable for their effects on striking (or for avoiding striking) certain materials long after Fulke. In the modern era, newspapers, journals, and magazines have replaced the early-modern meteorological treatises and almanacs for discussing isolated and specific instances of odd lightning strikes. As recent as 1927, the American Meteorological Society published a piece discussing the Forest Service's employment of the "searchlight of science" on popular forestry lore to discover which types of trees are likely to be struck by lightning in a thunderstorm.[78] Differences in types of foliage struck by lightning have long been noticed in natural histories, but the modes of explanation for such phenomena have adapted to new meteorological theories for what is considered "scientific" for the time. Even with new frameworks, some of the problems to solve are quite familiar. A nineteenth-century magazine accounted for, among other strange experiences, an instance in 1836 of a man being struck by lightning while wearing a purse with gold coins inside.[79] The explanation for why the coins melted and left a strange impression is neither elusive nor wondrous, as the writer assures us that differing electricity intensities can account for the melting of these coins, and the rough texture of garments can account for impressions made through them. Adequate explanations of lightning phenomena demand explanatory frameworks depending on time, place, and audience. The situation for Fulke was no different in this respect.

Discussions of thunder and lightning after Fulke lent themselves particularly well to developing chymical theories of meteorology and emphases on manifestations of matter.[80] Lightning and thunderbolts continued to be explained as part of three groupings and differentiated by subtlety, speed, and effects, but there was some variation in how these descriptions were implemented in writings.[81] There is significant continuity in the way that lightning and thunderbolts have been described, even for authors subverting Aristotelian meteorological theories in the centuries after Fulke. For instance, René Descartes maintained a tripartite organization of thunderbolts, though with a different underlying framework from Fulke, which also included an explanation of thunderbolts as physical stones.[82] Ideas in matter theory and chemical philosophy proffered by people like Jean Fernel and Georgius Agricola manifest in small ways in Fulke's writings and were likely the result of influence by others like Cardano. In the seventeenth century, John Mayow explained the causes for the common lightning effects, like the melting of a sword in a sheath, using chymical theories of nitro-aerial particles.[83] He uses *fulmen* and *fulmine* interchangeably as words for thunderbolt and lightning, respectively.

The continuous ways that lightning and thunderbolts have been discussed in ancient and early-modern meteorological treatises contain more than superficial similarities or a passive retelling of details. Authors maintained different goals relating to individual worldviews and frameworks of nature that shaped the ways that authors chose to interpret causes of strange phenomena and effects. Part of the way Fulke presented his views depended on his goals of informing a scientifically lay audience on the principles of philosophy and dispelling superstition. His mode of achieving such goals used careful renderings of Greek and Latin terms and concepts into the English vernacular, keeping with his humanist proclivities for beautifully written prose. Fulke participated in the long tradition of viewing lightning and thunderbolts according to their materiality, speed, and subtlety with a precision that lent itself well to discussions of meteorological phenomena in a chymical framework.

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Notes

[1] S. K. Heninger, *A Handbook of Renaissance Meteorology: With Particular Reference to Elizabethan and Jacobean Literature* (Durham, N.C.: Duke University Press, 1960), 72; Lorraine Daston and Katharine Park, *Wonders and the Order of Nature: 1150-1750* (New York: Zone Books, 1998).

[2] Pliny, *Natural History*, 2.52; Seneca, *Natural Questions*, 2.52.

[3] For more on the distinct groupings of phenomena in Aristotle, see: Malcolm Wilson, *Structure and Method in Aristotle's Meteorologica: A More Disorderly Nature* (Cambridge: Cambridge University Press, 2013), 77.

[4] Seneca, *Natural Questions*, 2.16.1.

[5] Isidore of Seville, *Etymologies*, 13.9.

[6] Adelard of Bath, *Questions on Natural Science*, 65-67.

[7] Albertus Magnus, *Meteora*, 3.3.

[8] Craig Martin, "Scientific Terminology and the Effects of Humanism: Renaissance Translations of Meteorologica IV and the Commentary Tradition," in *Science Translated: Latin and Vernacular Translations of Scientific Treatises in Medieval Europe* (Leuven: Leuven University Press, 2008), 147–72.

[9] Andrew Dickson White, *A History of the Warfare of Science with Theology in Christendom*, vol. 1 (New York: D. Appleton and Company, 1896), 323.
[10] White, 1:338.
[11] Heninger, *Handbook of Renaissance Meteorology*, 75–76.
[12] For explanations of the basic concepts of Aristotle's meteorological theories, methods, and types of phenomena he covers, see: Craig Martin, *Renaissance Meteorology: Pomponazzi to Descartes* (Baltimore: John Hopkins University Press, 2011), 5–14; Craig Martin, "Meteorology in Renaissance Science," in *Encyclopedia of Renaissance Philosophy*, ed. Marco Sgarbi (New York: Springer, 2022), 2178–85; Liba Taub, *Ancient Meteorology* (London: Routledge, 2003), 77–115. For more on the debates surrounding the authenticity and authorship of *Mete. IV*, see: Craig Martin, "Pores, Parts, and Powers in Sixteenth-Century Commentaries on Meteorologica IV," in *Atoms, Corpuscles and Minima in the Renaissance*, ed. Christoph Lüthy and Elena Nicoli (Leiden: Brill, 2023).
[13] In *Mete*. 2.9.369a27 Aristotle calls the material of these phenomena dry exhalation (ξηρᾶς ἀναθυμίασις), whereas in *Mete*. 3.1.370b5 it is simply called wind (πνεῦμα). *Mete*. 3.1.371a3-6 states "all these phenomena are wind, and wind is dry and warm exhalation" (trans. H. D. P. Lee), and in *Mete*. 3.1.371a1-2 Aristotle says that "it is evident... that smoke (καπνός) is wind and that smoke burns" (trans. H. D. P. Lee). Whatever Aristotle's precise material cause, it seems to be a rare and subtle material with the capacity to catch fire.
[14] Wilson, *Structure and Method*, 227–33.
[15] Aristotle, *Meteorologica*, 3.1.369a25. Aristotle uses a similar explanation in *Mete*. 1.4 on the creation of shooting stars.
[16] Frederik Bakker, *Epicurean Meteorology: Sources, Method, Scope, and Organization* (Leiden: Brill, 2016), 76–78; 127–60.
[17] Bakker, 8–75.
[18] Wilson calls ψολόεις a traditional name (*Structure and Method*, 60), though it appears to be poetic and not related to Aristotle's typical word for smoke (καπνός) that he uses when describing the hot and dry exhalation (*Mete*. 1.4.341b21) or visual appearances with smoke.
[19] To the best of my understanding, this phrase is ambiguous as to whether the wind percolates through the wood on account of the texture of the wind or the texture of the wood. Because some interpretations see μανότητα as porousness, my best reading of this passage is that this is referring to the texture of the wood. Aristotle does not use the word πόρος in this passage.
[20] These words appear in a few different passages in the second book of the *Natural History*: thunder (*tonitrua*) 2.43; lightning (*fulmina*) 2.43; heat-lightning (*fulgetra*) 2.43; hurricanes, which H. Rackham translates as cloudburst (*ecnephias*) 2.49; whirlwinds, which Rackham translates as typhoon (*typhon*) 2.49; firewinds or fiery whirlwinds (*prester*) 2.49-2.50; whirlwinds as a subset of cloudbursts (*turbinem*) 2.50.
[21] Pliny, *Natural History*, 2.50.
[22] Rackham equates this with ψολόεις from *Mete*. 3.1.371a21.
[23] Pliny remarks that thunderbolts can drain casks without damaging their lids or leaving other traces (2.52); melt gold and copper in bags without singeing the bags or melting the wax seal (2.52); a pregnant woman will survive a lightning strike while her unborn child is killed (2.52); things struck by lightning fall in the opposite direction as the flash (2.55); all living creatures burned by lightning are killed (2.55); lightning does not penetrate more than five feet below the ground (2.56); lightning does not strike a laurel bush (2.56); lightning strikes neither the sea-calf nor the eagle (2.56). Pliny also discusses some people being struck by lightning, such as Marcia whose unborn child was killed while she survived, and Marcus Herennius, who was struck on a calm-weather day. Pliny goes on to say that some Tuscans think gods send thunderbolts (where Jupiter hurls three kinds), and some of these bolts are discussed in having planetary causes (2.53). Pliny cites historical records of thunderbolts being caused by prayers (2.54). He talks about thunderbolts in relation to prophecy (2.53, 2.54); discusses which one comes first, thunder or thunderbolts (2.55); elaborates more about augury; and enumerates more things that it can and cannot strike (2.56).
[24] Seneca, *Natural Questions* 2.12.
[25] Seneca, *Natural Questions* 2.12. He also differentiates the two in 2.16, 2.21, and 2.57.
[26] Seneca, *Natural Questions* 2.40.
[27] *Natural Questions* 2.31 lists the melting of swords in sheaths, coins in boxes, and wine in a cask (in addition to a number of other effects). *Natural Questions* 2.52 and 2.53 repeats some of these examples.
[28] Aristotle, *Meteorologica,* 3.1.371a30-31. Aristotle gives other evidence as well, such as ocular evidence with the burning of the temple of Ephesus, which H. D. P. Lee identifies as having occurred in 356 BC.
[29] Seneca, *Natural Questions*, 2.21: "I do not drag out this point at length just to play with words, but to prove that these phenomena are related and are of the same category and nature" (trans. Thomas H. Corcoran).
[30] Pliny, *Natural History*, 2.45.
[31] Bakker (*Epicurean Meteorology*, 70) doubts Theophrastus as the true author of this text and points to the debate over this authorship. On effects, see: Hans Daiber, "The Meteorology of Theophrastus in Syriac and Arabic Translation," in *Theophrastus: His Psychological, Doxographical, and Scientific Writings*, ed. William W. Fortenbaugh and Dimitri Gutas (London: Routledge, 1992), 265–66; see also Hidemi Takahashi, *Aristotelian Meteorology in Syriac* (Leiden: Brill, 2004) for Syriac meteorology, which maintains similar descriptions.
[32] Pieter L. Schoonheim, ed., *Aristotle's Meteorology in the Arabico-Latin Tradition: A Critical Edition of the Texts, with Introduction and Indices* (Leiden: Brill, 2000).
[33] Richard Bauckham, "Science and Religion in the Writings of Dr. William Fulke," *The British Journal for the History of Science* 8, no. 1 (1975): 17–31.
[34] Printing made available many works in different genres, such as works explaining wondrous or strange experiences of weather. See: Arianna Borrelli, "The Weatherglass and Its Observers in the Early Seventeenth Century," in *Philosophies of Technology: Francis Bacon and Its Contemporaries*, ed. Claus Zittel et al., vol. 1 (Leiden: Brill, 2008), 67–130; Heninger, *Handbook of Renaissance Meteorology*, 23–29; Vladimir Jankovic, *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Chicago: University of Chicago Press, 2001), 33–44. Borrelli ("Weatherglass," 11-12) argues that works such as Girolamo Cardano's *De Subtilitate* were influenced by travel. Borrelli ("Weatherglass," 11-13) discusses the availability and impact of vernacular works on meteors, including William Fulke.
[35] William Fulke, *Antiprognosticon*: "...but when I looked nerer to hym selfe, I found no man so frendly to me."
[36] Fulke also published a defense of the English translation of the scriptures against Gregory Martin.
[37] Fulke did not translate the work, but he did author the addendum. See Bauckham, "Science and Religion," for controversy over the authorship of the addendum.
[38] William Fulke, *Antiprognosticon*: "Herafter foloweth a short treatise, as well for the utter subversion of this fained art, as also for the better understandyng of the comon people."
[39] Heninger, *Handbook of Renaissance Meteorology*, 16–20.
[40] Other editions were printed in 1535 and 1582 (with additions by Stephen Batman). For debate about editions of Trevisa's translations, see: A. S. G. Edwards, "The Text of John Trevisa's Translation of Bartholomaeus Anglicus' De Proprietatibus Rerum," *Text* 15 (2003): 83–96.
[41] Multiple editions, appearing as early as 1555. This text discusses lightning in similar ways to previous traditions. A few historians argue that Fulke was probably acquainted with this text, though Fulke does not cite it. On the absence of Digges and Dee in Fulke's writings, see: Sanford Larkey, "Astrology and Politics in the First Years of Elizabeth's Reign," *Bulletin of the Institute of the History of Medicine* 3, no. 3 (1935): 171–86.
[42] For the printing history and catalogue of all changes to the title pages, see: William Fulke, *A Goodly Gallery: William Fulke's Book of Meteors (1563)*, ed. Theodore Hornberger (Philadelphia, 1979), 10–17. A note to the reader was added before the table of contents beginning in 1654, also with some additional materials pertaining to Fulke's fifth book on metals and stones added in subsequent printings.
[43] William Fulke, *Meteors* (London 1654), a2r-a2v.
[44] Fulke, *Meteors* (London 1654), a2r-a2v.
[45] For more of Hill's publishing history, see: Francis R. Johnson, "Thomas Hill: An Elizabethan Huxley," *Huntington Library Quarterly* 7, no. 4 (1944): 329–51.
[46] See also: Rienk Vermij, "A Science of Signs: Aristotelian Meteorology in Reformation Germany," *Early Science and Medicine* 15, no. 6 (2010): 648–74.
[47] Fulke, Meteors (London 1654), 10.
[48] Fulke, *Meteors* (London 1654), 11.
[49] In other words, Fulke does not place this book after a discussion of things in Aristotle's *Physics*, *On the Heavens*, and *On Generation and Corruption*; nor does he promise that subsequent works will discuss perfectly mixed substances with substantial forms, like minerals or animals.
[50] He cites a reason for this, first invoking Aristotle for the vapor and exhalation, then the subtlety of air and fire as a reason why they are not the primary material cause. Fulke invokes the Philosopher (Aristotle) for this, as he says that vapor is a watery thing that is not water, and exhalations are earthly in nature but are not earth. Meteors must be drawn from

water and earth as opposed to fire and air because the latter (fire and air) is too subtle and too thin. All exhalations are made by making a grosser body more thin. Elemental fire is so subtle and thin and cannot be made thinner. If air was made thinner, it would turn into fire. If the fire were made thicker, it would be air. If the air were made thicker, it would become water.

[51] Fulke cites Psalm 148:8 for this.

[52] Fulke, *Meteors* (London 1670), 7. The far off cause is the same as the cause of all other natural effects: "the sun with the other planets and stars, and the very heaven itself in which they are moved." Compare with Fulke, *Antiprognosticon* (London 1560): "Seying the cause of the wynde is not forsene by the starres, no more can the wether that is partly caused by it, nor yet the dearthe or plentie whiche chaunceth by occasion of the weather, bee by astrologie foreshewed" (D7r); "By this definition [Aristotle's explanation of the cause of wind], all power of signifying starres is cleane excluded" (D6v).

[53] Paul H. Kocher, *Science and Religion in Elizabethan England* (Los Angeles: Anderson and Ritchie, 1953), 153–65; Bauckham, "Science and Religion in the Writings of Dr. William Fulke."

[54] As in the case of vapor and exhalation.

[55] Fulke, *Meteors* (London 1670), 121-125.

[56] Fulke, *Meteors* (London 1670), 55.

[57] In the 1634 version of this text "fulmen" is listed instead as "flumen." This appears to be a misprint seen only in this edition and only in this portion of the text.

[58] Here Fulke uses a similar distinction to Seneca.

[59] It is unclear if Fulke is purposefully avoiding this Aristotelian term.

[60] The texture of the exhalations can also cause different colors depending on the time of day that they are seen.

[61] Fulke names *coruscatio* in the initial list of types of lightning, but uses the English "coruscation" in all other instances.

[62] Aristotle, *Meteorologica*, 2.9.370a19.

[63] The word coruscation appears with reference to lightning in William Caxton's 1490 printing of the *Eneydos*, as well as in the English translation by John Trevisa of Bartholomaeus Anglicus' *De Proprietatibus rerum* (1495), also in reference to lightning.

[64] Agostino Nifo, *In libris Aristotelis Meteorologicis commentaria* (Venice 1547) 92v: "Aristoteles premittit intentionem, et dicit pro post haec dicamus de corruscatione, que grece astrepes dicatur, et tonitruo, quod grece brontes appellatur" (book 3, section 2.173). Aristotle uses astrepe (ἀστραπή) for lightning and keraunos (κεραυνός) for thunderbolt.

[65] On differences of terminology in between Greek and Latin works, see: Martin, "Scientific Terminology."

[66] *Glossographia: Or a dictionary interpreting all such hard words* (London 1661), L6v-L7r "A flash of lightning, or a kind of seeming sparkling fire, which appears in Mines by night. 'Tis (saith an Author) a glistering of fire rather then fire indeed, and a glimmering of lightning, rather then lightning itself." Compare with an earlier, similar definition from *The New World of English Words: Or, a General Dictionary* (London 1658), K2r: "Lightning, a flashing or glimmering of light."

[67] Fulke notes that *fulgur* may also appear without thunder.

[68] These examples appear in many sources, but their manner of presentation is most similar to Seneca's.

[69] Other examples include the burning of a hand.

[70] Fulke, *Meteors* (London 1670), 61: "Because the matter is very subtle and thin and burning and will pass through whatever does not give it free passage."

[71] With respect to striking people, Fulke describes the causes and effects of lightning striking sleeping and awake persons, pregnant mothers, and recites the account from Pliny about the virgin who was struck by lightning on the day of Cicero's birth. On plants and creatures, he explains the sea calf, eagles, and trees.

[72] Thunderstones are not part of the three-fold view of thunderbolts, but they are not a new invention; for example, Pliny writes about them in *Natural History*.

[73] It can strike down steeples, high buildings of stone and of wood, pass through them, and set them on fire. It can cleave trees and set them on fire.

[74] Fulke writes that the thunderbolt is sharp pointed (small) at one end and thick at the other end. This is caused by the heavier (moist) parts going to the bottom.

[75] Fulke gives an account of lightning striking a steeple in the section on thunder, and Fulke records an observation of thunderstones in the fifth book on earthy meteors.

[76] Heninger (*Handbook of Renaissance Meteorology*, 81) identifies Pierre de La Primaudaye as calling lightning "much hotter then all other fire," which is an idea he perhaps obtained from Cardano.

[77] Hornberger (*Fulke's Book of Meteors*, 17) suggests Fulke and Cardano wrote in similar styles.

[78] "What Trees Draw Lightning," *Bulletin of the American Meteorological Society* 8 (1927): 85–86.

[79] *Athenaeum*, no. 1535 (March 28, 1857), 409.

[80] Paola Bertucci, "Enlightening Towers: Public Opinion, Local Authorities, and the Reformation of Meteorology in Eighteenth Century Italy," *Transaction of the American Philosophical Society* 99, no. 5 (2009): 25–44; Martin, *Renaissance Meteorology*, 80–105.

[81] As a small sampling from the next two centuries, Thomas Willsford *Nature's Secrets* (London 1658), unlike Fulke, recounts the common litany of lightning effects without separating them into three groups; Franz Xaver Mannhardt's *Elementa Ignis* (1734) divides the lightning into three types in a separate section of the text, very similarly to Fulke.

[82] René Descartes, *Les Météores* (1637), seventh discourse.

[83] John Mayow, *Tractatus Quinque Medico-Physici* (1674), book 13.