early theories on the cause of thunder and lightning

Since the time of the ancient Greek civilization, few atmospheric phenomena have aroused the interest of men of science so much as thunder and lightning. The fact that they are closely associated with electricity was not realized until the eighteenth century. Prior to that century, the many proposed theories on the cause of thunder and lightning were far afield from the true nature of this phenomenon. The eminent eighteenth century mathematician, Leonard Euler, expressed the general opinion of eighteenth and nineteenth century scientists toward these early theories when he stated: “In truth, every thing advanced on the subject, previous to the knowledge of electricity, was a mass of absurdity, and little calculated to convey instruction respecting any of the phenomena of thunder.” Absurd or not, these theories were proposed by noted scientists of their time, and constituted a significant part of early meteorological speculation.

The first theory of thunder and lightning for which the author is known, was the one proposed by the Greek philosopher Anaximander (ca. 611 B.C.—ca. 547 B.C.). According to Anaximander, the movement of air caused thunder. That is, the peals of thunder were the sounds of the blows of air on a cloud. To the question of why it thunders in a clear sky, he answered that even in the absence of clouds the atmosphere is often shaken and rent by the bursting forth of air. Lightning was due to the fire in the air being ignited by the great agitation of the air. A student of Anaximander and friend of Pythagoras, Anaximenes (ca. 585 B.C.—ca. 528 B.C.) shared Anaximander’s theory of thunder and lightning.

A different theory was presented by the noted Athenian teacher and natural philosopher Anaxagoras (ca. 500 B.C.—ca. 427 B.C.). Anaxagoras held that the upper region of the atmosphere is composed of a flaming-hot substance, which he called “aether.” It was not the blows of air which caused the thunder and lightning, but the upper aether descending into the lower atmosphere. When this aether fell, some of it got caught in the clouds and burned in the atmosphere with a fiery glow which was the lightning. As the clouds contained moisture, this fire was instantly extinguished, causing a loud, sputtering noise which was the thunder. Thus, Anaxagoras believed that thunder necessarily followed lightning.

A theory similar to that of Anaxagoras was advocated by the Greek philosopher and poet Empedocles (ca. 455 B.C.). Aristotle attributed to Empedocles the theory, which has been universally accepted up to comparatively recent times, that the universe consisted of four basic elements, earth, fire, air, and water. Like Anaxagoras, Empedocles claimed that lightning was fire flashing through the clouds, and thunder was the noise of this fire hissing when quenched. However, the theory of Empedocles differed from that of Anaxagoras. Hence, Empedocles claimed that the fire in the clouds was some of the sun’s rays which had been trapped in the clouds.

In antiquity the atmosphere was believed to be composed of mixtures of three basic elements: air, fire and water. Thus, all atmospheric phenomena had to be the result of some interaction among these three elements. As thunder and lightning were atmospheric phenomena, their cause had to be due to some interaction of air, water and fire. The speculations concerning thunder and lightning by the scientists, or rather the natural philosophers, of antiquity were thus based upon this belief.

The next theory to arise was that put forth by one of the intellectual giants of ancient Greece, Aristotle (384 B.C.—322 B.C.). His treatise, Meteorologica, was the first comprehensive work on meteorology, and was the undisputed meteorological authority for nearly two thousand years. At the end of the second book of his Meteorologica, Aristotle considered the cause of thunder and lightning. The atmosphere, according to Aristotle, was made up of two exhalations, a dry, hot exhalation, and a moist, cool exhalation. The dry exhalation produced the thunder.

Aristotle explained the production of thunder and lightning as follows: “Thunder is due to the forcible ejection of the dry exhalation trapped in the clouds in the process of condensation. The ejected exhalation usually catches fire and thus produces lightning.” Aristotle criticized the theories of Anaxagoras and Empedocles and maintained that lightning occurred after thunder.

Later discussions on the cause of thunder and lightning by the Greek natural philosophers followed closely the theory of Aristotle. The theory proposed by the noted cosmographer and geometer Posidonius (ca. 135 B.C.—ca. 44 B.C.), was that thunder was the report of the dry air bursting from its entrapment in clouds. This was essentially Aristotle’s theory.

With the ending of the Golden Age of Greek science,
around 100 A.D., scientific activity and speculation radically declined throughout most of the world. The Dark Ages were fast approaching with their drought in scientific advancement. Thus, it was not surprising that in this period up to 1000 A.D., very little speculation came forth from scientific men on the cause of thunder and lightning.

One of the few noted men of science living during the Dark Ages was the Venerable Bede (ca. 673-735). This Englishman and Church scholar was one of the founders of English meteorology. In his work De Natura Rerum, Bede discussed many meteorological phenomena, including thunder and lightning. According to Bede, thunder was generated by the clashings of clouds, driven by the winds conceived among them. Lightning was due to the friction of these colliding clouds. Bede also held some superstitious beliefs concerning thunder, such as his claim that thunder with a west wind signified "a very bad pestilence."

The twelfth century was the century of the translators; those men who translated into Latin the ancient Greek works which had earlier been translated into Arabic. One of the best known translators was the English scholar Adelard of Bath (ca. 1120). Adelard was the first to translate the Koran into Latin. He also wrote commentaries on various subjects in the natural sciences. In one of his works, Quaestiones Naturales, Adelard considered the question of thunder and lightning. This work was in the form of questions by a nephew, followed by answers by his uncle (Adelard). The dialogue leading to Adelard's theory of thunder and lightning proceeded as follows:

NEPHEW: Is, then, your science bold enough to give the cause and origin of thunder, or is it unable to solve this most difficult problem, for in face of thunder the philosopher is no braver than the rest?

ADELARD: Nothing is difficult, unless one loses heart. Hope on, and you will find the right road: so far as I can, I will explain this phenomenon.

With these inspiring words, Adelard then explained that thunder in the winter was due to the breaking of ice colliding in clouds; in the summer, it was caused by the melting of the colliding ice. As for lightning, Adelard observed that in all violent collisions of bodies, the lightest thing in them was the first to be separated from them. The fire-like aether in the air was the lightest substance in the air, and the violent collisions of ice in clouds forced this aether out of the air, causing the lightning.

Aristotle's influence in the field of meteorology continued into the sixteenth century. Since his meteorological work had become generally known in the Western civilization the previous century, speculation on meteorological phenomena closely followed the Aristotelian view. An example of Aristotle's influence was given in a work by the sixteenth century mathematician Leonard Digges (died ca. 1571). In his A Prognostication of Right Good Effect, which contained empirical rules for forecasting the weather, Digges presented the following explanation of thunder and lightning:

Thunder is the quenching of fire, in a cloud. Or thunder is an exhalation hot and dry, myxte with mousture, carried up to the middle regio, there thyched and wrapped into a cloude; of this hote matter, coupled with moystnes, closed in the cloude, groweth a stryfe, the heat beatyng, and breakyng out the sydes of the cloude, with a thundringe noyse: the fyre then dispersed, is the lightynge.

In the seventeenth century, one of the greatest men in the history of science, René Descartes (1596-1650), offered his theory in the cause of thunder and lightning. This theory appeared in an appendix to this famous work Discours de la methode . . . , entitled "Les Meteores." Descartes claimed that thunder was due to one cloud suddenly falling on another cloud beneath it; the resonance of the air producing the loud noise of thunder. Lightning was caused by the presence of inflammable exhalations between the two clouds.

The insight of Descartes concerning this meteorological phenomenon was no greater than those of his predecessors. Like his predecessors, Descartes had to base his speculation on preconceived and erroneous theories on the atmosphere. It should be noted that the major instruments, such as the thermometer and the barometer, used in studying the atmosphere were not invented until the seventeenth century. The lack of accurate information concerning the atmosphere seemed to have affected the seventeenth-century scientist's speculations on the cause of thunder and lightning more than it did those of antiquity, if one may judge this effect by how far-fetched the speculation was. Nothing could better illustrate this than the last theory which will be considered in this paper; the one put forth by John Wallis (1616-1703).

A contemporary of Newton, Wallis was a highly gifted and respected mathematician and physicist and one of the founders of the Royal Society of London (1660). In an article on thunder and lightning, appearing in the Philosophical Transactions of the Royal Society of London, Wallis noted that the principle ingredients of gunpowder were nitre and sulphur. These ingredients were also present in vapor form in the atmosphere. Thunder was the explosion of a "convenient mixture of nitrous and sulphurous vapours," which somehow were ignited. Lightning, of course, was the flash of the explosion. Just as the flash of fire would follow a string of gunpowder, so would the lightning flash from place to place, following the jagged path of the explosive vapor.

The fact that these early theories on the cause of thunder and lightning appear absurd in the light of current knowledge concerning the atmosphere was not the fault of the authors of these theories. In the early history of meteorology, the method of obtaining explanations of natural phenomenon was the reverse of the general method employed today. Instead of em-
ploying the inductive type of reasoning of drawing conclusions based upon experimental evidence, early speculation was based on a deductive form of reasoning where the explanations of natural phenomenon had to conform to accepted natural beliefs; in particular the belief that the atmosphere was composed of the basic elements of air, fire, and water. The use of the deductive approach was due to the fact that these early scientists did not have the instruments needed to study the atmosphere. Without these instruments, the only approach open to them was the deductive one.

Erroneous as they were, these early theories on the cause of thunder and lightning were of some benefit to the development of meteorology. The fact that even noted scientists could not provide a satisfactory explanation of thunder and lightning helped to motivate the study of these phenomena by eighteenth-century scientists. Thus, indirectly these theories contributed to the advancement of the science of meteorology.

References