# The Death of the Luminiferous Aether

## *The Evolution of Scientific Thought*

**Written by Miguel Botran** **Illustrated by Zimeng Xiang**

Scientific knowledge can feel monolithic and unchanging; we forget that many scientific ideas have been abandoned. It is important to look at the dogma of the past, to see how old scientific knowledge has been superseded by new ideas. Examining superseded scientific theories reminds us of the ever-changing nature of scientific knowledge.

The luminiferous aether, the hypothetical medium through which light propagates, is one such superseded scientific theory. We now understand that light acts as both a wave and a particle through wave-particle duality. However, in the 19th century people thought light acted only as a wave, and that waves needed a medium through which to propagate. It therefore seemed natural that light would have to propagate through a medium. At the time, it was understood that sound propagated through air and other materials, water waves propagated through water, and, theoretically, light propagated through the luminiferous aether.

Today, we know that the luminiferous aether doesn't exist, and that light travels instead through empty space — but how did we come to know this? The theory of the luminiferous aether came to an unexpected halt due to the 1887 Michelson–Morley experiment, conducted by scientists Albert A. Michelson and Edward Morley, who had hoped to prove the existence of the luminiferous aether. However, before we delve into the 1887 Michelson–Morley experiment, let us first explore the status of the luminiferous aether in the scientific community up to that point.

Throughout history, light has been considered both a particle and a wave at various points in time. At the time of the 1887 Michelson-Morley experiment though, it was generally understood that light acted only as a wave. In 1704, Isaac Newton put forth in his book *Opticks* the theory that light was made of particles. Newton's theory still required an aether, but was, at the time, the most accurate theory of light in terms of predictions and experimental observations. Newton's theory of light didn't explain diffraction, the interference effect of light waves that creates repeating patterns of bright and dark bands, so he proposed an "Aethereal Medium" being responsible for the phenomenon. Newton's understanding of light was eventually overturned in the early 19th century due to experiments like those done by Thomas Young, who demonstrated light's wavelike nature in a double-slit experiment. This theory of light as a wave differed from older theories as these were proposed to be transverse waves, not longitudinal waves. This understanding of light as a transverse wave once again revived the need for a medium through which light can travel. However, instead of acting like a fluid, the medium had to act more as a solid because transverse waves only travel through solids.

The idea of a solid that solely interacted with light initially raised questions in the scientific community, but George Gabriel Stokes developed a model which acted as a solid when interacting with high frequencies and acted as a fluid at lower speeds, explaining why the earth and other planets could travel through this medium. In the 1860s, James Clerk Maxwell published his works, which successfully combined the electric and magnetic forces and also proposed that visible light was an electromagnetic phenomenon. Maxwell's equations described all electromagnetic waves propagating at a fixed speed.

Physicists in the 19th century were concerned whether the luminiferous aether was dragged by or entrained by the motion of the Earth. Some believed there was no relative motion between the Earth and the luminiferous aether, while others proposed that an aether wind was created by the motion of the earth through the luminiferous aether. Maxwell's equations were understood by many to mean that the luminiferous aether was the absolute frame of reference for the universe, such that it appeared universally still.

The idea behind the 1887 Michelson–Morley experiment was simple: if the luminiferous aether was the medium through which light propagates, then we must be moving through it as Earth orbits around the Sun. This meant that measuring the speed of two different perpendicular light rays would yield different results, as one of the light rays would "speed up" more due to extra velocity added by the luminiferous aether's motion relative to the Earth's orbit and rotation. However, Michelson and Morley instead noted that the speed of light never changed between the perpendicular light rays. Numerous other recreations of this experiment pointed to the same result: the luminiferous aether doesn't exist. Eighteen years later, Einstein proposed his Special Theory of Relativity, in which the speed of light was constant, regardless of reference frame, and in which light did not require a medium through which to propagate. Einstein's Special Theory of Relativity struck the death blow to the luminiferous aether theory, as the latter's presence was no longer required for a working theory of light.

The story of the luminiferous aether's birth and death is a perfect encapsulation of scientific progress. Experiments like the 1887 Michelson-Morley experiment remind us of the unexpected results that the scientific method often leads us to. Science history is full of superseded scientific theories like the luminiferous aether: spontaneous generation, caloric theory, phlogiston theory, contact tension, and, of course, the ptolemaic system. As expressed in the introduction of *Twenty-Five Years of Asymptotic Freedom* by theoretical physicist David Gross, "Science progresses in a much more muddled fashion than is often pictured in history books.... Consequently, historians of science often ignore the many alternate paths that people wandered down, the many false clues they followed, the many misconceptions they had. These alternate points of view are less clearly developed than the final theories, harder to understand and easier to forget, especially as these are viewed years later, when it all really does make sense. Thus reading history one rarely gets the feeling of the true nature of scientific development, in which the element of farce is as great as the element of triumph."