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3. History of science in pedagogical, didactic contexts [Latent theme; Holton was educator, appt’d by Reagan to 1981 National Commission on Education (*National at Risk*).]

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"In summary, what emerges from explicit historical accounts, including Einstein's interviews with Shankland, is that the story we found…in **didactic or philosophical resources** is, at best, suspect and needs a serious critique"

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"You ask me, which of the philosophers' traits are idiosyncrasies? For example: their **lack of historical sense**, their hatred of becoming, their Egypticism. They think that they show their *respect* for a subject when they **dehistoricize** it – when they turn it into a mummy." *Twilight of Idols*, ch. 1

Nietzsche	:	philosophers
Kuhn/Hacking	:	philosophers of science (Carnap, Popper…)
Holton	:	"eminent scientists and some philosophical analysts"

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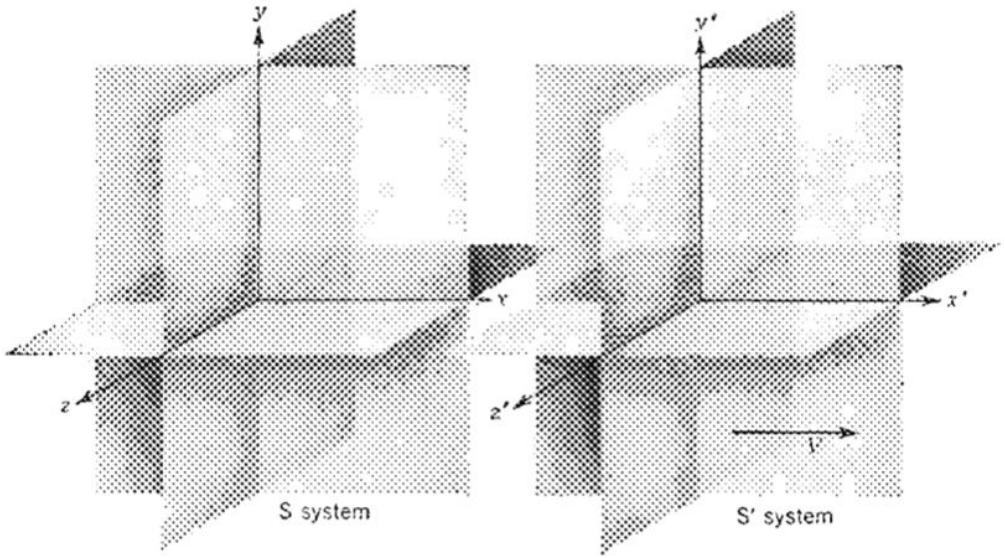

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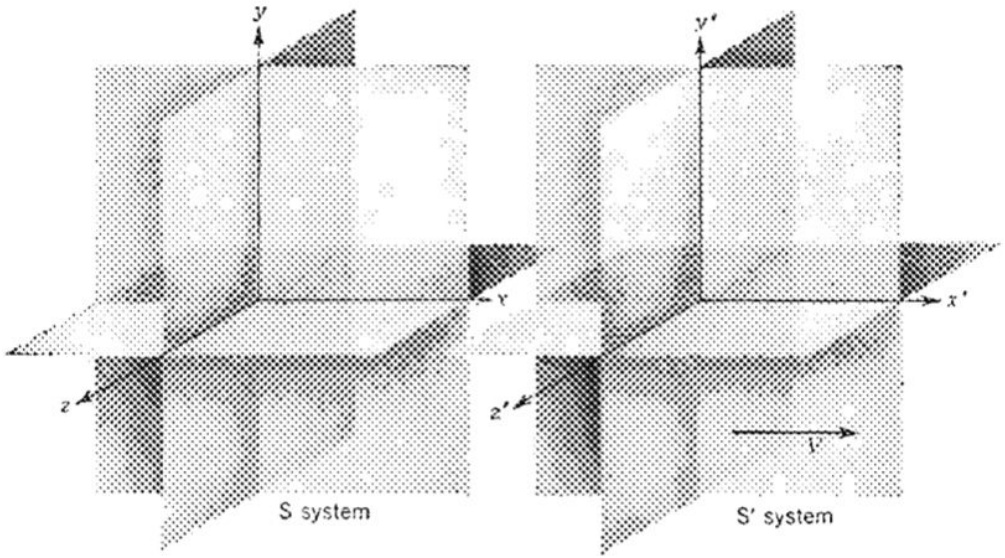
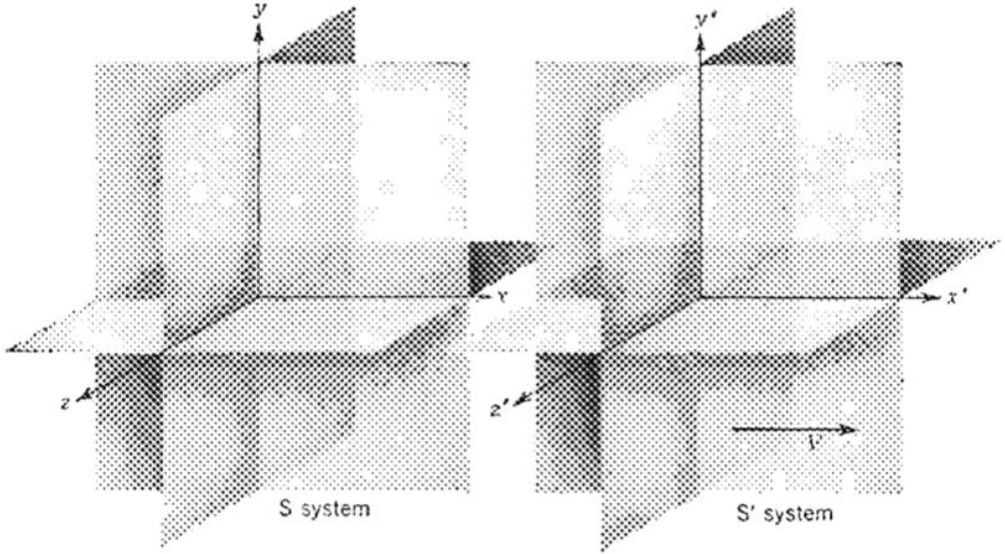


It has long been accepted that there is no meaning to absolute translational motion through space. This idea is supported by our everyday experience with the laws of mechanics as they apply inside a uniformly moving automobile, train, or airplane. In such a “moving” reference frame these dynamical laws appear the same as in a laboratory “at rest” on the earth.



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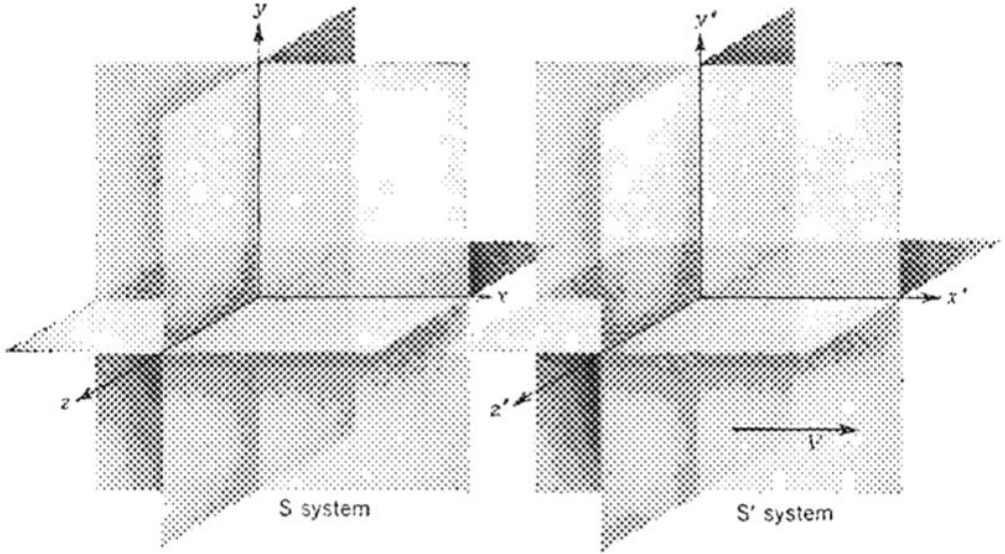
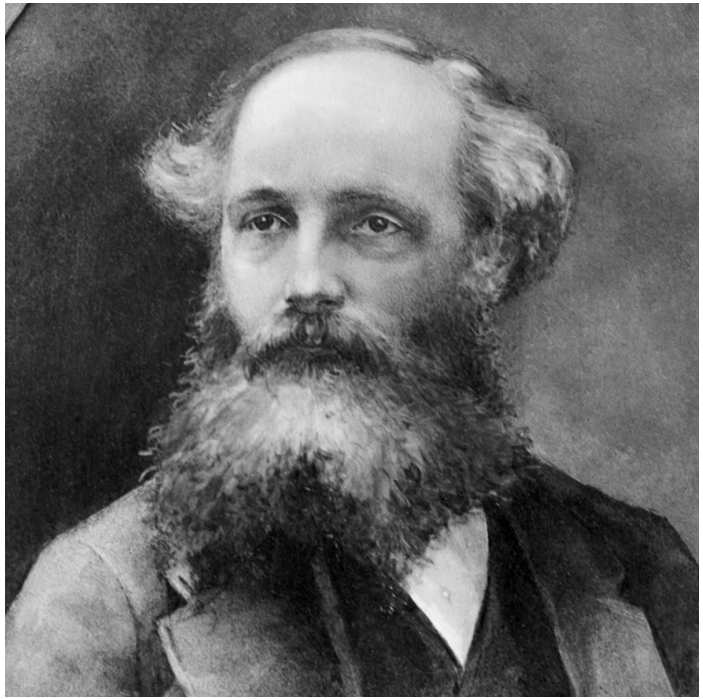
This property of the laws of mechanics leads naturally to the supposition that the universe is constitute such that it is impossible *by any kind of experiment whatever* to detect absolute motion through space. **This hypothesis is the principle of relativity.**



The principle of relativity was an accepted theory of physics for over two centuries. But when Maxwell, in 1865, formulated his dynamical theory of the EM field, it appeared that absolut motion through space might be detected by *optical* means! For our of Maxwell's equations there emerged the new and surprising result the *electromagnetic waves out to exist in empty space.*



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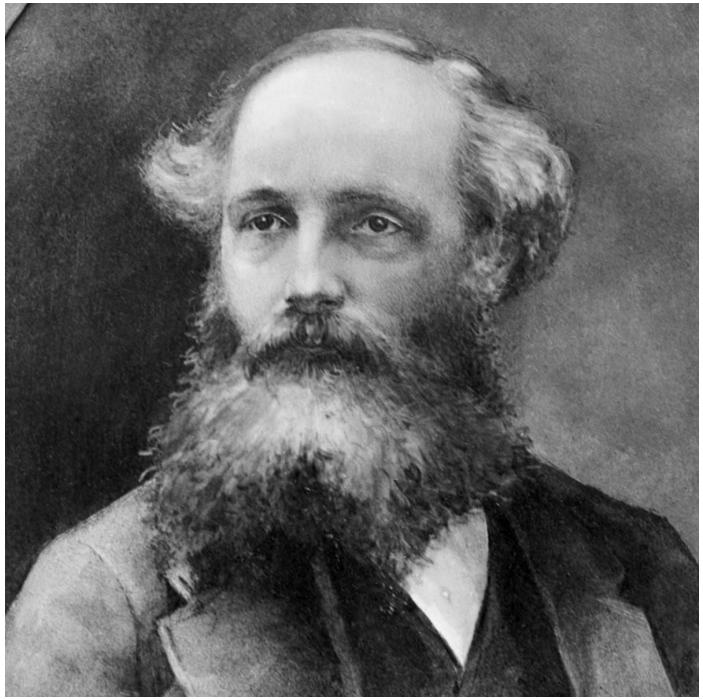

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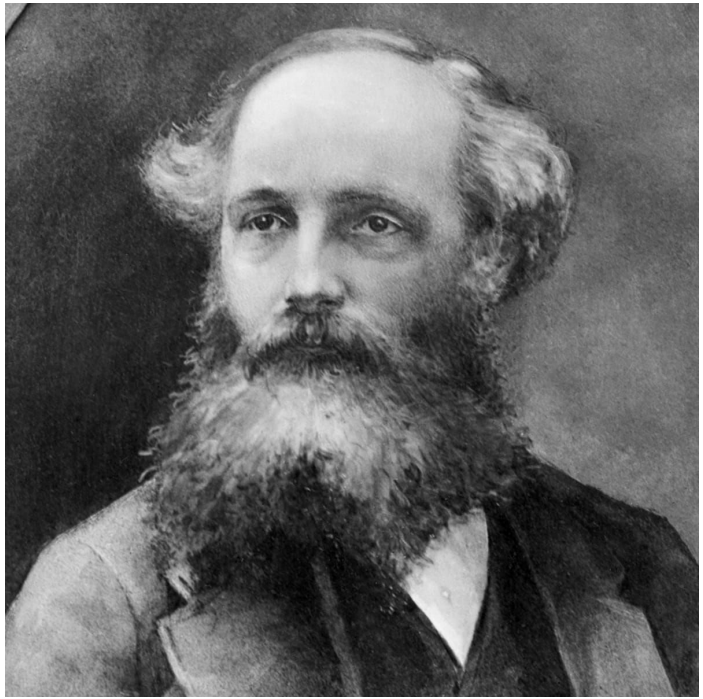
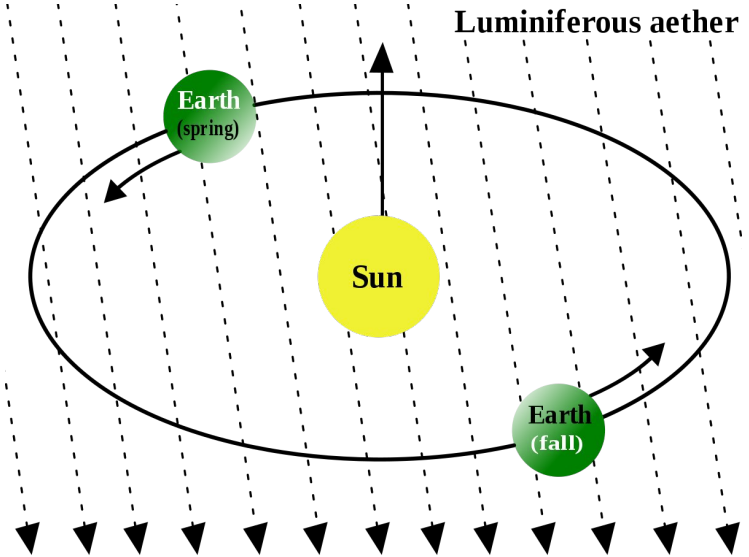


All wave motion with which we are familiar possess a *medium* for its propogation. This medium must ordinary possess both *inertia* and *elasticity* if the speed of propagation is to be other than zero or infinity. The speed of light is far greater than that of any other known wave motion, so that the inertia-like property of space must be very tiny and its “elastic” shear rigidity correspondingly very great.



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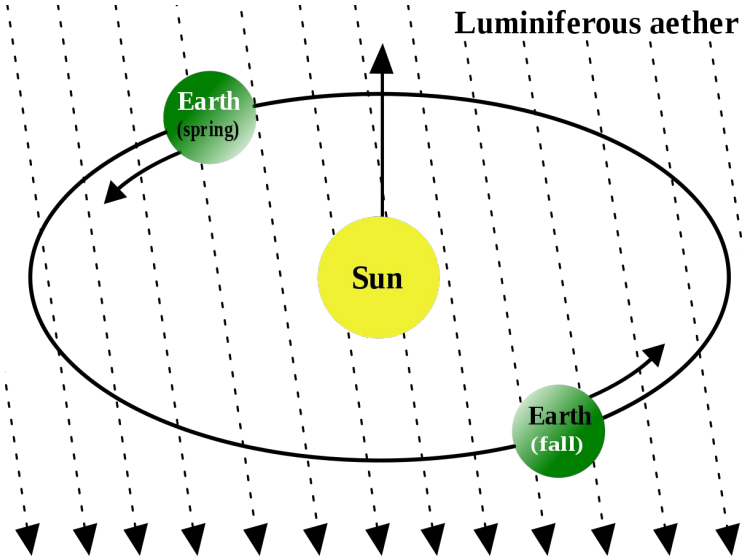
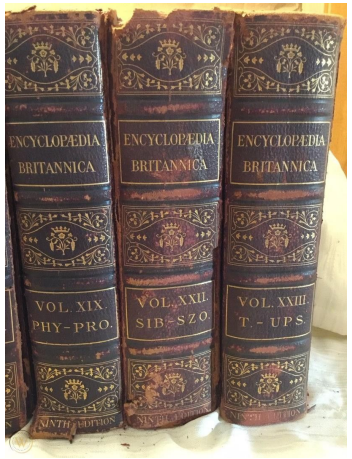
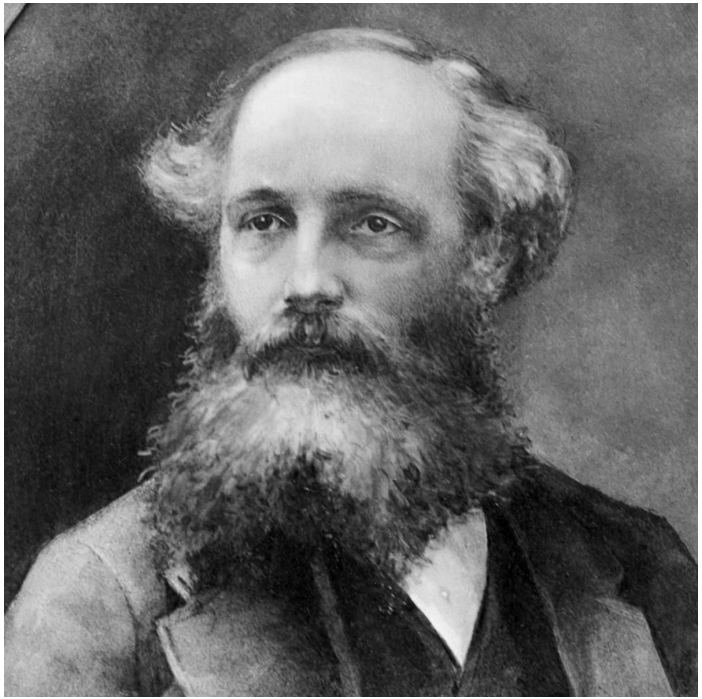


Whatever difficulties we may have in forming a consistent idea of the constitution of the aether, there can be no doubt that the interplanetary and interstellar spaces are not empty, but are occupied by a material substance or body, which is certainly the largest, and probably the most uniform body of which we have any knowledge. (“Ether” Britannica 9th) **1889**





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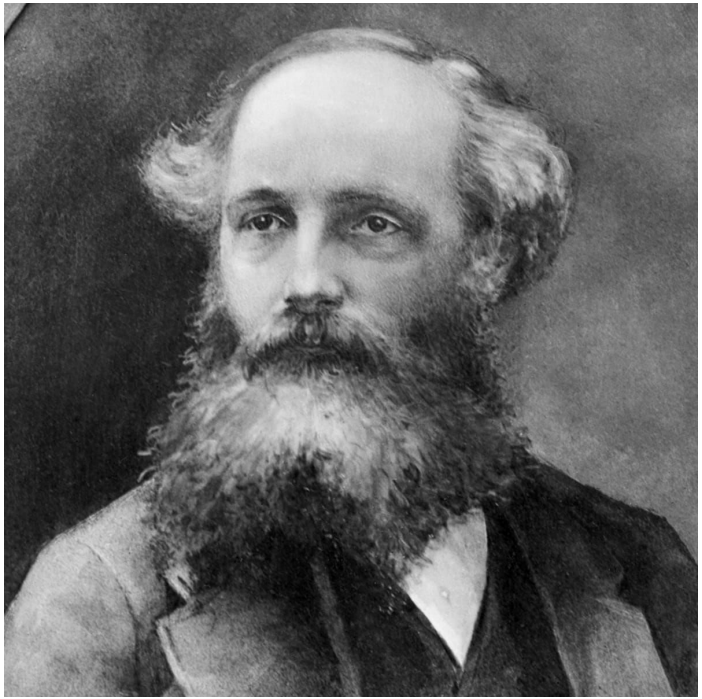
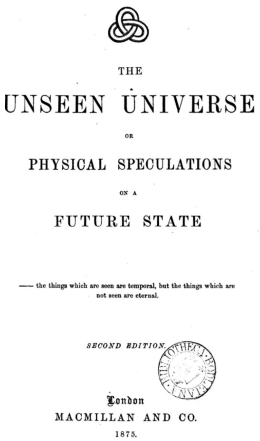



THE

UNSEEN UNIVERSE

OR

PHYSICAL SPECULATIONS

ON A

FUTURE STATE

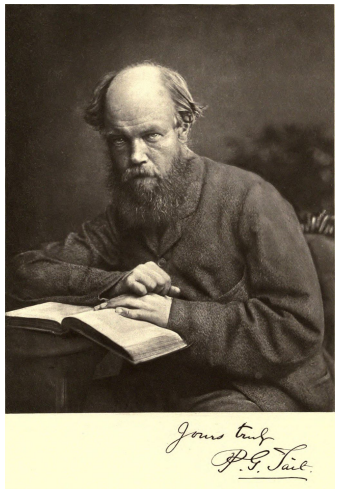
— the things which are seen are temporal, but the things which are not seen are eternal.

SECOND EDITION

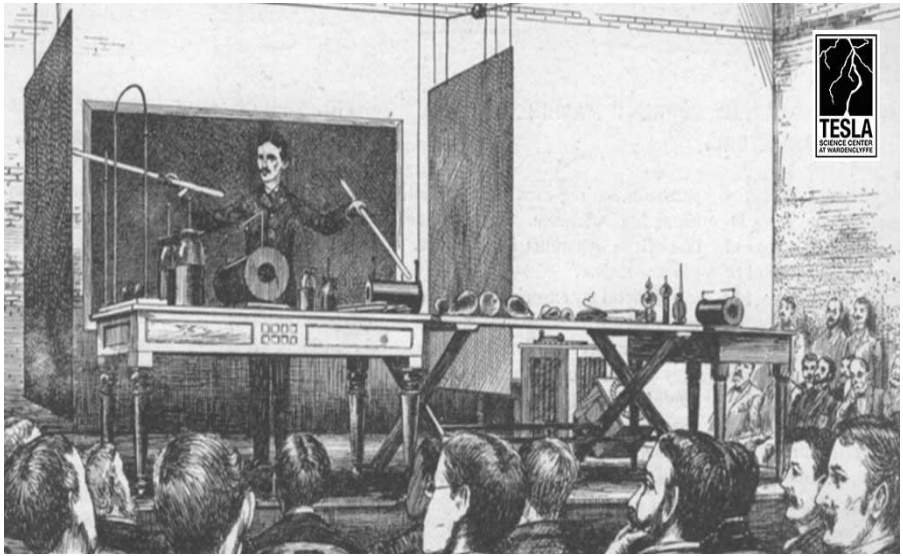
London

MACMILLAN AND CO.

1875.



“The recognition of the existence of ether, and of the functions it performs, is one of the most important results of modern scientific research.” **(1891)** ”Experiments with Alternate Currents of Very High Frequency and their Application to Methods of Artificial Illumination”



428. The ether. We have already indicated that if the wave theory is to be accepted, we must conceive, with Huygens, that all space is filled with a medium, called the *ether*, in which the waves can travel. This medium cannot be like any of the ordinary forms of matter; for if any of these forms existed in interplanetary space, the planets and the other heavenly bodies would certainly be retarded in their motions. As a matter of fact, in all the hundreds of years during which astronomers have been making accurate observations of the motions of heavenly bodies no such retardation has ever been observed. The medium which transmits light waves must therefore have a density which is infinitely small even in comparison with that of our lightest gases.

Further, in order to account for the transmission of light through transparent bodies, it is necessary to assume that the ether penetrates not only all interstellar spaces but all intermolecular spaces as well.

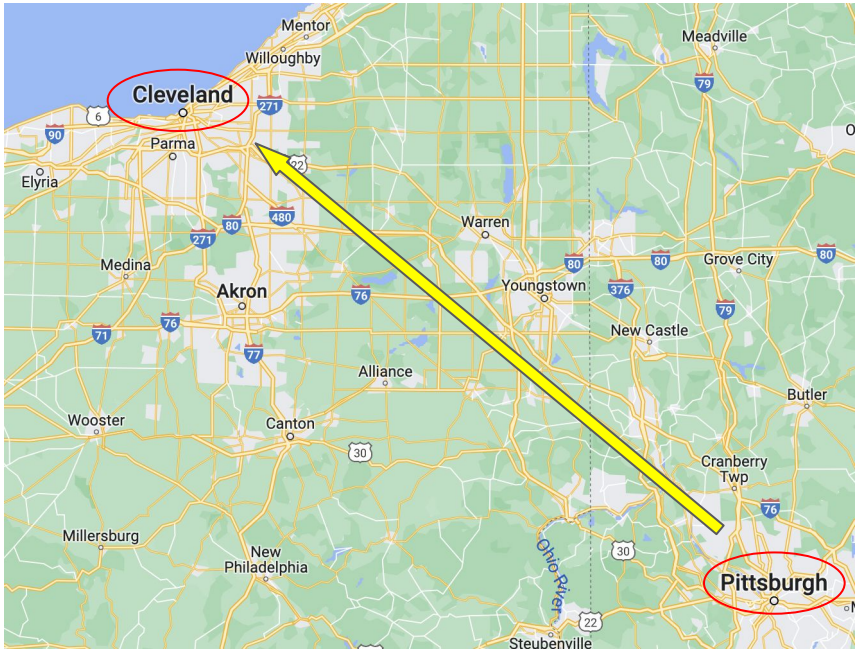
1920

"Practical Physics"

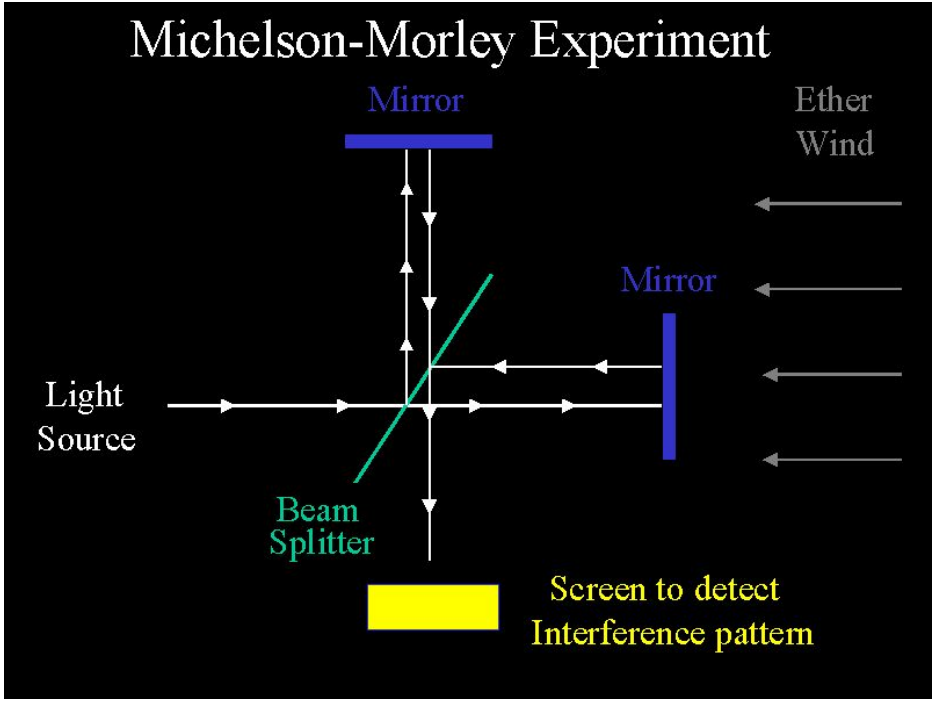
Millikan

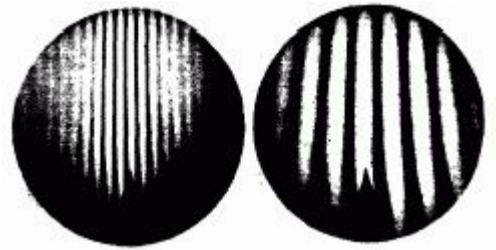
If space is not really empty, but filled with a rigid medium, there might be some meaning to absolute motion after all. And it even appears possible that our speed through this medium might be measured by comparing the speed of light in different direction – (A Duhemian experiment of *application*.)

Such an experiment was carried out by Michelson (1881) and by Michelson and Morley (1887).



In the latter famous experiment the times of traversal of a light ray through equal paths parallel and perpendicular to a supposed direction of motion through the ether were compared by measuring the phase difference of a “split” monochromatic light beam in traversing an interferometer. This experiment was sufficiently sensitive that a speed of about 10km/s should have been detectable; yet, in spite of the fact that the earth’s orbital speed around the sun alone amounts to 30 km/s, *no effect was observed.*





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The most serious proposal advanced was that bodies which move through the ether suffer a change of shape *just sufficient* to make the speed of light *appear* to be the same in various direction. The change that is needed is a contraction in the direction of motion of the body.

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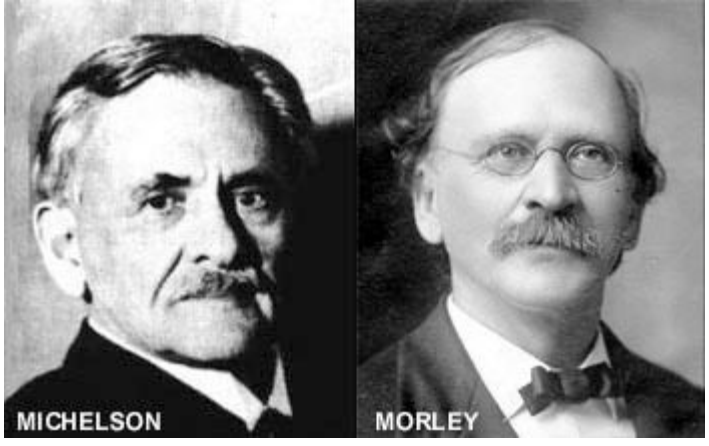
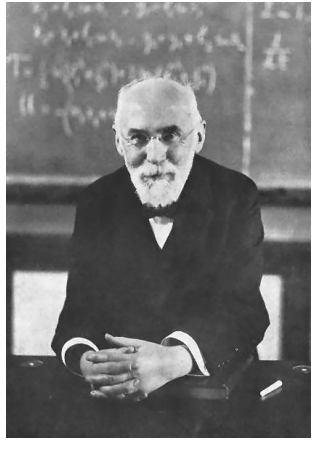
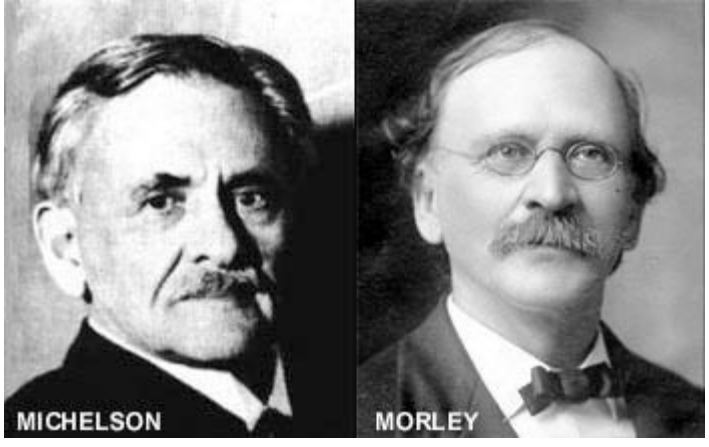
The most serious proposal advanced was that bodies which move through the ether suffer a change of shape *just sufficient* to make the speed of light *appear* to be the same in various direction. The change that is needed is a contraction in the direction of motion of the body. **This effect, called the Lorentz-FitzGerald contraction, was supposed to follow from Maxwell's equations. But no one was successful in proving that it actually did. Furthermore, later experiments have shown that a simple length contraction is not alone sufficient; a *time dilation effect is also necessary.***

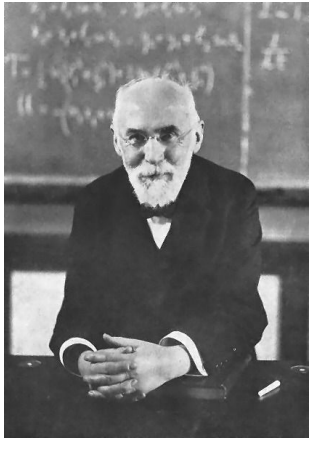
Einstein finally proposed a radically different approach to the problem proposed by the Michelson-Morely experiment.





Einstein finally proposed a radically different approach to the problem proposed by the Michelson-Morely experiment. **He explained its null result simply by returning to the *principle of relativity,* which directly asserts the impossibility of detecting absolute motion through space. He found, however, that this requires that our notions of space and time as independent, universal quantities must be fundamentally modified, and that time must in fact be treated on an equal basis with the three length dimensions of space.**





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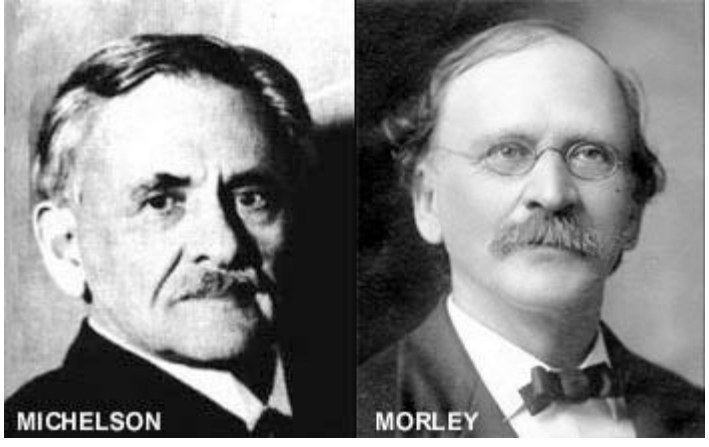
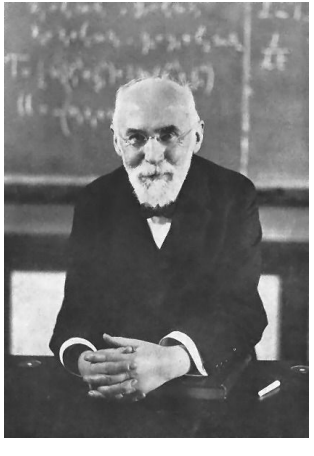
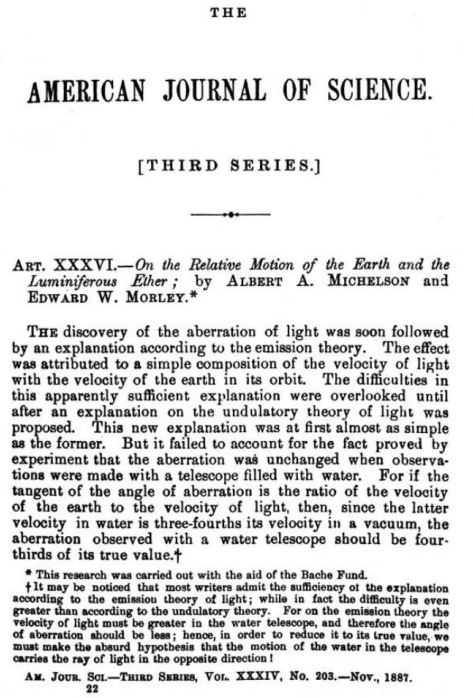




All that was the didactic, popular, folklorish account. It jumps from the MM experiments directly to Einstein (perhaps mediated by the Lorentz-Fitzgerald contraction).

Pedagogical goals inform how a presenter can tune the mathematical and theoretical complexity of the exposition. I've given a minimal account. I recommend the original MM paper, which is in fact accessible.



THE

AMERICAN JOURNAL OF SCIENCE.

[THIRD SERIES.]

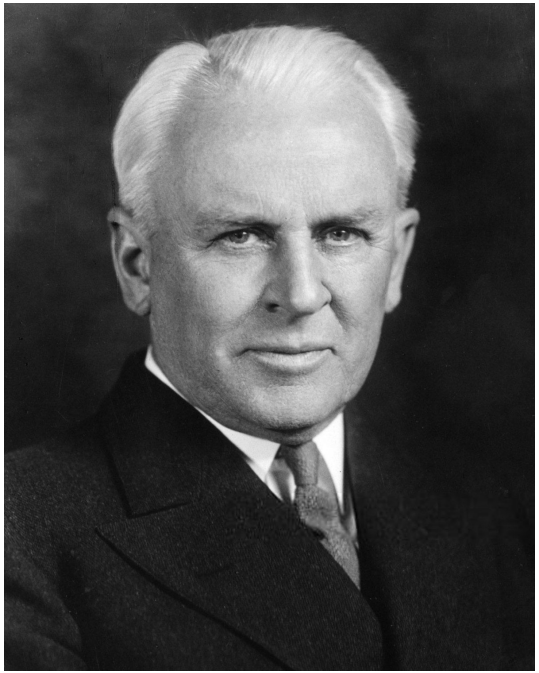
ART. XXXVI.—*On the Relative Motion of the Earth and the Luminiferous Ether;* by ALBERT A. MICHELSON and EDWARD W. MORLEY.*

THE discovery of the aberration of light was soon followed by an explanation according to the emission theory. The effect was attributed to a simple composition of the velocity of light with the velocity of the earth in its orbit. The difficulties in this apparently sufficient explanation were overlooked until after an explanation on the undulatory theory of light was proposed. This new explanation was at first almost as simple as the former. But it failed to account for the fact proved by experiment that the aberration was unchanged when observations were made with a telescope filled with water. For if the tangent of the angle of aberration is the ratio of the velocity of the earth to the velocity of light, then, since the latter velocity in water is three-fourths its velocity in a vacuum, the aberration observed with a water telescope should be four-thirds of its true value.†

* This research was carried out with the aid of the Bache Fund.

† It may be noticed that most writers admit the sufficiency of the explanation according to the emission theory of light; while in fact the difficulty is even greater than according to the undulatory theory. For on the emission theory the velocity of light must be greater in the water telescope, and therefore the angle of aberration should be less; hence, in order to reduce it to its true value, we must make the absurd hypothesis that the motion of the water in the telescope carries the ray of light in the opposite direction!

The special theory of relativity may be looked upon as starting essentially in a generalization from Michelson's experiment. [T]his experient, after it had been performed… by Michelson and Morley, yielded with great definiteness the answer that there is . . . no observable velocity of the earth with respect to the aether.



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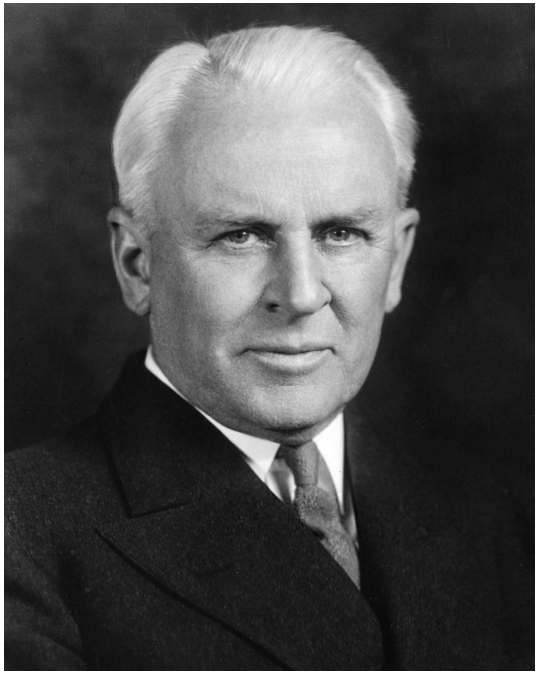

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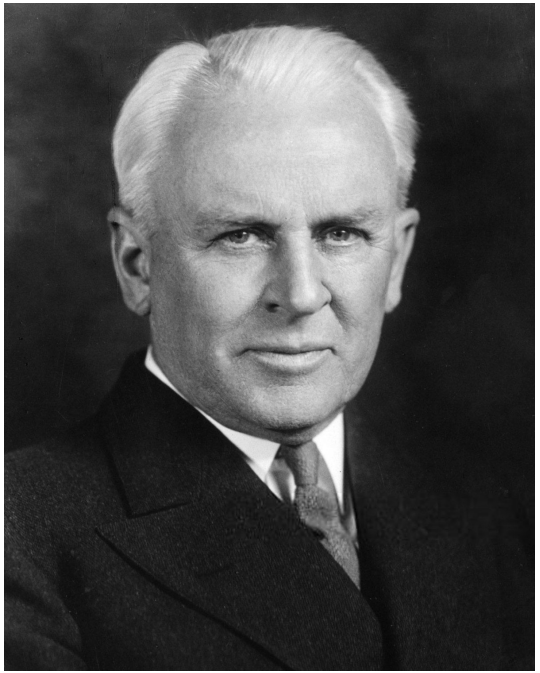

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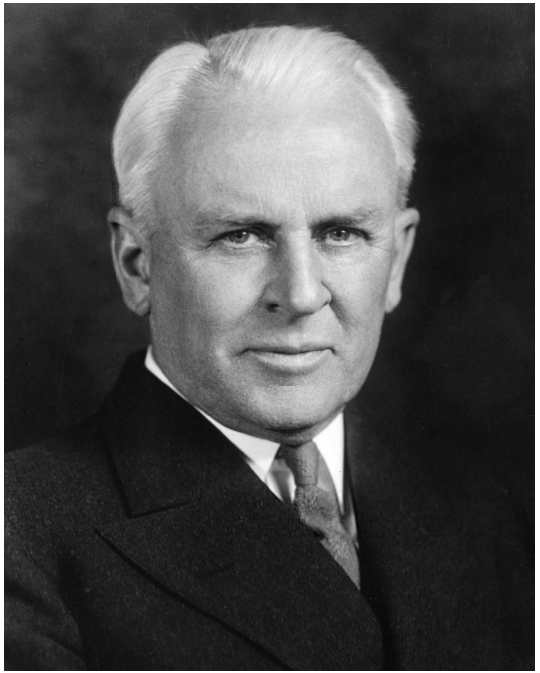

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What light do documents shed on the case, particularly those that appear to provide contradictory evidence?

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And if they were, why are there a few who say they were not?

How important were experiments *x1, x2, x3,...* to theory T?

What role did experiments *1, x2, x3,...* play in historical episode?

What is the quality of the evidence?

What light do document shed on episode E? Especially when counter to dominate narrative?

If episode E is not(P), then why do so many assert P?

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What can this case tell us about the relation between experiment and theory in modern physics?

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For years after Einstein's first publication (1905) no new experimental results came forth which could be used to "verify" his theory in the way most physicists were and still are used to look for verification…As Max Planck noted in 1907, Michelson's was then still regarded as the only experimental support.

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In retrospect it seems therefore inevitable that during the decade following Einstein's 1905 paper there occurred – **especially in the didactic literature** – a symbiotic joining of the puzzling Michelson experiment and the all-but-incredible relativity theory.

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In retrospect it seems therefore inevitable that during the decade following Einstein's 1905 paper there occurred – especially in the didactic literature – a symbiotic joining of the puzzling Michelson experiment and the all-but-incredible relativity theory. **The undoubted result of Michelson's experiments could be thought to provide an experimental basis for the understanding of relativity theory, which otherwise seemed contrary to common sense itself; the relativity theory in turn could provide an explanation for Michelson's experimental result in a manner not as “artificial” or “ad hoc” as reliance on the supposed Lorentz-FitzGerald contraction was widely felt to be. It has proved to be a long-lasting marriage.**

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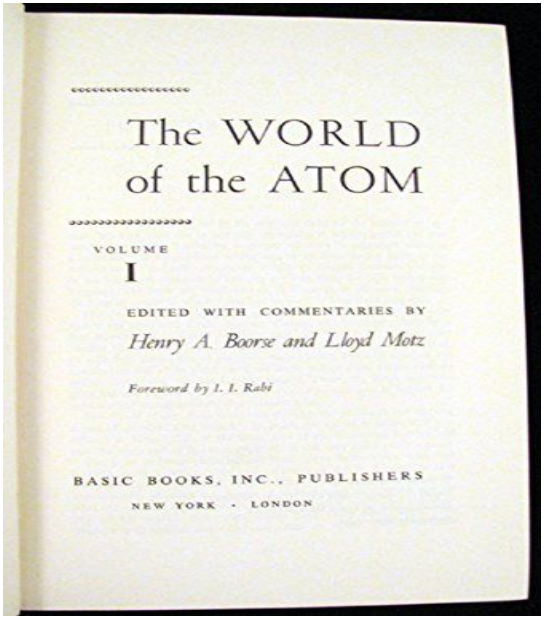

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Kuhn: “[Scientists themselves have drawn] an image of science mainly from the study of finished scientific achievements as these are recorded in the classics and, more recently, in the textbooks from which each new generation learns to practice its trade. **Inevitably, however, the aim of such books is persuasive and pedagogic; a concept of science drawn from them is no more likely to fit the enterprise that produced them than an image of a national culture drawn from a tourist brochure or a language text.”**

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But be not dismayed: “It is no more comforting to find only unambiguous evidence for one position on a complex issue, for that may indicate that only part of the evidence is in.

Parenthetical remark:

In historical research we may have much trouble understanding how scientist S arrived at claim C; sometimes not. At one extreme is **Ptolemy** who, for lack of citing his sources, has been called “the greatest fraud in history” (according to Owen Gingerich).

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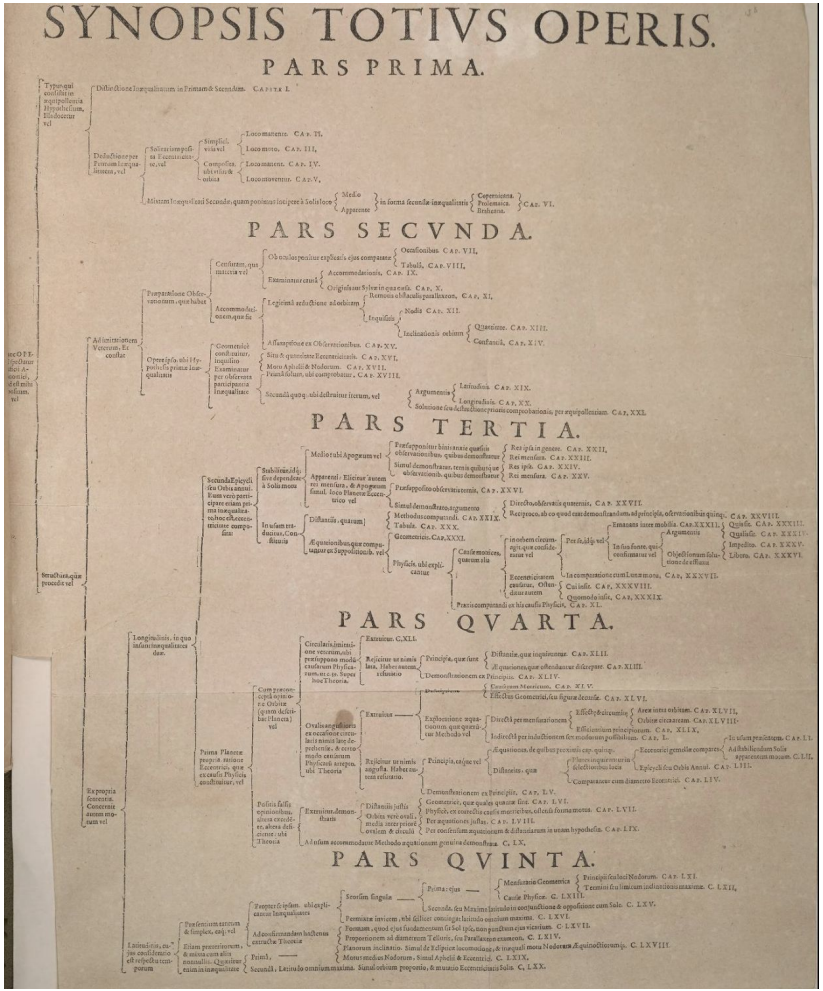

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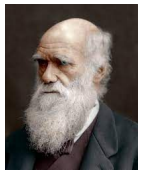
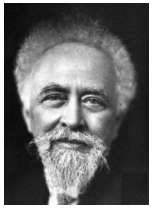

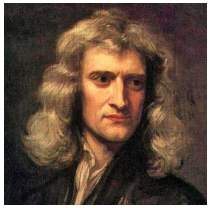

It is plainly dangerous to quote only [cherry-picked] sentences [of Einstein, Darwin, Perrin, Ptolemy, Newton…] and then reference [episodes *x1, x2, x3…*] and to call these an “historical account,” as [philosophers and historians] have done in order to imply [(controversial) claim P].

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Reading Holton's article you may have asked yourself: "I see the Hps but where's the hPs…in fact, where the **HPS**? Holton's paper, for all its virtues – stylistic elegance, pedagogical understanding, and (most of all) historical insight – is bereft of anything recognizable as a philosophical argument. That said, I will admit there is enough philosophical clay to mould the figure of an argument that says something interesting about logical positivism. Yet Holton's argumentative mission is directed mainly toward a historical goals: setting the record straight about the genetic relationship between the MM experiment and Einstein.