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THE CHRISTOLOGICAL ORIGINS OF NEWTON'S FIRST LAW

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For now a hundred years the awarding of Nobel Prizes has been a major annual event. To the consternation of many the Prize in physics for 2000 did not go to theoretical physicists but to physicists whom the media quickly described as mere engineers. Herbert Kroemer, Zhores I. Alferov, and Jack S. Kilby received the Prize for making possible the Internet, which is surely a great engineering feat. It is transforming not only the world of communications, but the world itself. The number of Internet users stands today over a billion and is rapidly growing.

Whether engineers or not, the inventors of the Internet must have known a great deal about the theory which explains the motion of electrons in integrated circuits. It is another matter whether in making their invention, they had thought of the laws which govern all physical motions. In walking around in a building we hardly ever think of the foundations. Nor do we think of those who first laid such foundations that alone are capable of carrying ever larger constructions over them.

In the ever vaster edifice which is physics, Newton's three laws constitute the kind of foundations on which, and on which alone, one can safely build. The *Principia*, which is by far the most important single work in physics, is the unfolding of the contents of those three laws. Those three laws, especially the third law known as the law of force, supports all classical mechanics, all of general relativity, and is implicit in the Schrödinger equation, which is the basis of all quantum mechanics.

Newton merely hinted that he may not have been the first in every respect in laying those foundations. He never went beyond stating, and then only in private correspondence, that if he had seen further it was only

"by standing on the shoulders of giants."[1] Certainly striking is Newton's silence about those giants in the *Principia*. Much less would one find out from Newton that the statement about giants and standing on their shoulders had by then been at least five hundred years old. It was, so it seems, first used by Bernard of Chartres, who was quoted in the *Metalogicon* of John of Salisbury, the rector of the cathedral school of Chartres, and later bishop there.[2]

Newton stood on the shoulders of some giants even with respect to that stroke of genius, which is the third law, or the law of force. For the third law, or more generally Newton's idea of a central field of force, is inconceivable without Kepler's three laws, and without Galileo's demonstration of the time's squared law of free fall. Newton said nothing about the fact that his second law, that action equals reaction, came from Descartes. In old age Newton spent much time in erasing in his manuscripts references to Descartes. Newton's effort to turn Descartes into a non-entity should seem all the more ridiculous because several of the Queries in Newton's *Opticks* could have been taken verbatim from Descartes' *Principes de la philosophie*. It was that work, or rather its doctrine of vortices, which the *Principia* wanted to discredit and rightly so.

But this left intact Newton's debt to Descartes in regard to the first law, or the law of inertial motion. If pressed, Newton might have perhaps referred to Descartes. It is, however, almost certain that Descartes would not have admitted that the first law, or the law of inertial motion, was not entirely his brainchild. When it comes to pride, Descartes was even more overweening than were Galileo and Newton. The century of genius was full of hubris. It was also the century that first saw the appearance of the expression "medium aevum." The context was Etienne Rausin's history, or *Leodium*, of the cathedral and diocese of Liège, published in 1639.[3] Of course, Rausin merely developed a trend that started with the humanists who by then for more than a century had distinguished classical Latin style from the "media" and "infima" Latin style, or Latinitas.

[1] Letter to Robert Hooke. Feb. 5, 1676. in H. W. Turnbull (ed.), *Correspondence of Isaac Newton* (Cambridge University Press, 1959), vol. I, p. 416.

[2] See *The Metalogicon of John of Salisbury: A Twelfth-Century Defense of the Verbal and Logical Arts of the Trivium*, tr. with an Introduction and Notes by D. D. McGarry (Berkeley: University of California Press, 1955), p. 167 (Bk. III, ch. 4). John of Salisbury died in 1180.

[3] *Leodium ecclesiae cathedralis, sive de dominio, regalibus, mero, mixtoque imperio . . . libri duo* (Namurci: typis Ioannis van Nilst, 1639), 643pp. The expression occurs on p. 103.

It took another fifty years before the expression appeared in the title page of a book, and of a textbook at that. The title reads "Historia medii aevi a temporibus Constantini Magni ad Constantinopolim a Turcis captam deducta," Or "The history of the Middle Ages narrated from Constantine the Great to the capture by the Turks of Constantinople" (1688).[4] The author was a German, Christopher Cellarius, or Keller. The German "Mittelalter" did not appear until 1725, and did so in a book which, though written in German, still carried the expression "medium aevum" on its title page.[5] The Académie Française approved of the term Moyen Age only in 1835, a term which did not become popular until used by Balzac and Victor Hugo. Such is at least the information one can gain from *Le Grand Robert*.[6] According to *The Oxford English Dictionary* the word "medieval" first appeared in 1827.[7] As late as the early 20th century, a Belgian author of books on the Middle Ages still thought that lexicographers would soon recommend that the terms "Moyen Age" and "médiéval" be discarded.[8] If ever there was a wrong prognostication, this was it.

While those terms were and still are often used in a pejorative sense, the centuries immediately preceding the Renaissance were not invariably held to be dark ages. In his famous *Esquisse d'un tableau historique des progrès de l'esprit humain* (1795) Condorcet praised the scholastics for having worked out indispensable principles for rational discourse.[9] Auguste Comte

[4] Published in Jena, the book was one in a series of textbooks on history by Cellarius (1638-1707).

[5] *Historie der römischen Huren-Regiments der Theodorae und Maroziae*...was the beginning of the long title of the work, written by the Lutheran controversialist Valentin Ernst Löscher (1674-1749) and published in Leipzig in 1705, a title which certainly foreshadowed the pejorative meaning eventually attached to the words "medieval" and "Middle Ages."

[6] Second edition (Paris: 1986), Tome VI, p. 628. There is no reference there to Auguste Comte, which indicates that he proposed and expounded his doctrine of the law of three phases without using the expressions "Moyen âge" or "médiévale."

[7] See 2nd ed. (1989), vol. IX. p. 542. Much earlier was the first appearance of "Middle Ages." See *ibid.*, p. 743. In *Merriam Webster*, which mainly considers the American usage, 1827 is given for the first appearance of "medieval" and 1840 for "Middle Ages."

[8] Godefroid J. F. Kurth (1847-1916), *Qu'est-ce que c'est le moyen age?* (Paris: Bloud, 1905). See the article "Middle Ages" by Victor Day in *Catholic Encyclopedia*, vol. XI (New York: The Gilmary Society, 1911), p. 501.

[9] See the Seventh Stage in *Sketch for a Historical Picture of the Progress of the Human Mind*, tr. J. Barraclaugh, with an introduction by S. Hampshire (New York: The Noonday Press, 1955), p. 95.

too thought that the age of positive or scientific reason had to be preceded by a metaphysical age, which, in his view, was a great improvement on the age of mythology. Comte and the positivists even praised the medieval centuries for their accomplishments in social organization and architecture. The 19th century was the age of neogothic style, yet no one, however sympathetic to the Middle Ages, would have thought that some scientific achievements too might be found there. Pierre Duhem did not expect at all to find the origins of Newton's first law in medieval centuries as he tried to present the full history of the principles of rational mechanics in his book *L'Evolution de la mécanique*, first published in 1903.[10]

When, two years later, Duhem stumbled on the contrary evidence, he should not have been so surprised. After all, since the celebration in 1873 of the 400th anniversary of Copernicus' birth, many read Copernicus' way of coping with the physical problems created by the earth's twofold motions, especially by its rotation. Although Copernicus indicated at least qualitatively the rotational speed of a point at middle latitudes, he showed no anxiety over the dynamical problem thus created.

There was, of course, some problem. In view of that speed, bodies, such as clouds in the air, should have fallen behind. To cope with this problem Copernicus first presented an answer in terms of the traditional or Aristotelian explanation of motion, that is, in terms of the nature of bodies that prompts them to occupy their natural place: "What would we say about the clouds and the other things floating in the air, or falling or rising up, except that not only the Earth and the watery element with which it is conjoined are moved in this way but also no small part of the air and whatever other things have a similar kinship with the Earth? Whether because the neighboring air, which is mixed with earthly and watery matter, obeys the same nature as the Earth [?]."[11]

Here Copernicus should have pointed out that only by contradicting the Aristotelian explanation of motion could one attribute to the air the same propensity as possessed by the water and the earth, that is, the so called heavy elements. Possibly Copernicus thought that this would be clear to most of his readers and that they did not care much for the fact that according to Aristotle it was in the nature of the air to move away

[10] Paris: Joanin, 1903. See also my *Uneasy Genius: The Life and Work of Pierre Duhem* (Dordrecht: Nijhof, 1984), pp. 179-80.

[11] *On the Revolutions of the Heavenly Spheres* (Great Books of the Western World, 16; Chicago: Encyclopaedia Britannica, 1952), p. 519 (Bk. I, ch. 8).

from the earth's surface. The point to watch is, however, Copernicus' conviction that he could expect his readers to be already accustomed to a very different idea of motion. Here are his words about this new idea: "or because the movement of the air is an acquired one, in which it participates without resistance on account of the contiguity and perpetual rotation of the Earth [?]."[12]

If there is no kinship or same nature, in which properties or qualities of bodies come naturally, they must acquire, and this is the word used by Copernicus, those qualities in some extraneous way. He also refers to the absence of resistance. Now to anyone aware of the difference between the Aristotelian theory of motion and Newton's laws of motion, very striking should seem Copernicus' idea about an acquired motion on earth that goes on because there is no resistance. But to anyone aware of historical research carried out by Duhem a century ago, there is no need to explain why Copernicus puts forward that idea of acquired motion without feeling the need to give an explanation.

That research brought out the fact, totally unheard of in the first decades of the 20th century, that the typical explanation of the novelty offered by Copernicus did not lie in the fact that he was a genius. Surely, it is always easy to assume that someone is a genius and then dispense with serious investigations. At that time it was all the easier to handle the problem with a reference to Copernicus' genius because even in respect to the heliocentric ordering of planets Copernicus did not mention Aristarchus of Samos as his remote predecessor. Few made much of the circumstance that Copernicus crossed out the name of Aristarchus in the manuscript of *De Revolutionibus* which Rheticus saw through press. And nobody, except Duhem, paid attention to that acquired motion.

Duhem indeed found that Copernicus himself stood on the shoulders of giants. They were Johannes Buridanus, professor at the Sorbonne and his disciple, Nicole Oresme, who subsequently became bishop of Lisieux. As a student in Cracow around 1490, Copernicus learned natural philosophy or physics from Buridan's commentaries on Aristotle's *De coelo* or *On the Heavens*. By then those commentaries had been about a century and a half old, available in many copies in medieval universities all over Europe. Even today there are about a dozen copies of those commentaries in Cracow. A reason for this is the fact that professors in those universities had very often been former students at the Sorbonne where the number of students was

[12] *Ibid.*

about sixty thousand or so in Buridan's time. Paris at that time was the unrivalled capital of learning.

In those commentaries the first law appears in the form of the impetus theory, or the idea that in order to produce motion it is enough to give an impetus or push to a body and have it thereby move by itself. Buridan illustrates the idea with a reference both to terrestrial motions and to the motion of the celestial bodies. In the texts that follow the gist of the impetus theory is given in italics, so that it may stand out in its context which remains, of course, very important if one is to appreciate its novelty and the source of that novelty. The text, which I will quote in English, first appeared in print in the original Latin and in French translation in 1913, in the third volume of Duhem's epoch-making work *Etudes sur Léonard de Vinci, ceux qu'il a lus et ceux qui l'ont lu*. Duhem's full-scale discussion of the topic, in the sixth and seventh volumes of his *Système du monde* should have appeared in 1917 and 1918, but they did not see print until forty years later. They finally were printed because Louis De Broglie, the discoverer of the wave nature of matter and Perpetual Secretary of the Académie des Sciences in Paris, refused to tolerate any longer an anti-Duhem conspiracy in Paris and threatened the publisher Hermann, which was part of that conspiracy, with a law suit.[13]

But back to Buridan's passages as they stand in English translation in Marshall Clagett's *The Science of Mechanics in the Middle Ages*.[14]

> [The impetus then also explains why] *one who wishes to jump a long distance drops back a way in order to run faster, so that by running he might acquire an impetus which would carry him a longer distance in the jump*. Whence the person so running and jumping does not feel the air moving him, but [rather] feels the air in front strongly resisting him.
>
> And you have an experiment [to support this position]: *If you cause a large and very heavy smith's mill [i.e., a wheel] to rotate and you then cease to move it, it will still move a while longer by this impetus it has acquired.* Nay, you cannot immediately bring it to rest, but on account of the resistance from the gravity of the mill, the impetus would be continually diminished until the mill would cease to move. And if the mill would last forever without some diminution or alter-

[13] See my *Reluctant Heroine: The Life and Work of Hélène Duhem* (Edinburgh: Scottish Academic Press, 1992), p. 236.

[14] Madison: The University of Wisconsin Press, 1961, pp. 524 and 536.

> ation of it, and there were no resistance corrupting the impetus, the mill would be moved perpetually by that impetus.

Buridan amplifies his first example with a reference to what may appear a very strange notion, but was not strange to Aristotle or to those who were raised on Aristotle. The notion, of which more later, is the notion of *antiperistasis*, or the idea that the body moves forward because the air which it separates as it moves forward flows past it, and then closes in behind it and acts thereby as a propellant.

In the second example, which is about the moving of a smith's wheel, or in modern terms a flywheel, Buridan amplified on motion by impetus with a clear reference to the role of resistance and also to the idea of perpetual motion. In other words, he states nothing less than that in the absence of resistance the motion would go on undiminished. But unlike the motion of a long jumper, which is more or less linear, the wheel's motion is circular. It would have been too much to expect from Buridan to distinguish the two motions, that appear, almost three hundred years later, undistinguished also in Galileo's idea of inertial motion.

But Buridan's idea of inertial motion contains something far more important and decisive than the distinction between linear and circular motions or rather inertia. Most important is the idea that the mover and the moved thing need not remain in continual contact in order to make the motion of the moved thing a continued reality. Here too the novelty becomes clear if one considers it against its Aristotelian background. Again the words that carry the idea of motion by impetus, or inertial motion, are given in italics.

> Also, since the Bible does not state that appropriate intelligences move the celestial bodies, it could be said that it does not appear necessary to posit intelligences of this kind, because it would be answered that God, *when He created the world, moved each of the celestial orbs as He pleased, and in moving them He impressed in them impetuses which moved them without His having to move them any more except by the method of general influence whereby he concurs as a co-agent in all things which take place;* "for thus on the seventh day He rested from all work which He had executed by committing to others the actions and the passions in turn." *And these impetuses which He impressed in the celestial bodies were not decreased nor corrupted afterwards, because* there was no inclination of the celestial bodies for other movements. *Nor was there resistance which would be corruptive or repressive of that impetus*. But this I do

> not say assertively, but [rather tentatively] so that I might seek from the theological masters what they may teach me in these matters as to how these things take place...
>
> And thus one could imagine that it is unnecessary to posit intelligences as the movers of celestial bodies since the Holy Scriptures do not inform us that intelligences must be posited. For it could be said that *when God created the celestial spheres, He began to move each of them as He wished, and they are still moved by the impetus which He gave to them because, there being no resistance, the impetus is neither corrupted nor diminished.*

The intelligences Buridan refers to come from Hellenistic writings in which Aristotelian and Neoplatonic ideas are fused together, especially as is the case in Plotinus and Pseudo-Dionysius. In the latter they appear as angels in charge of celestial bodies. Buridan rightly notes that those intelligences cannot be found in the Bible and that therefore the Christian is not obligated to take them seriously.

Buridan's reference to inclinations of bodies echoes, of course, the Aristotelian notion that bodies are propelled according to the volition proper to their nature. This notion is of Socratic origin, set forth in the *Phaedo*. There Socrates tried to overcome the mechanistic physics or rather ideology of the Ionians which left no room for purpose and free will. That mechanistic philosophy was dirty bathwater containing the baby, or the nascent quantitative physics. It would have been too much to expect from Socrates to distinguish between the two. The entire Socratic-Platonic-Aristotelian tradition was, with respect to science, a fatally wrong move, whereby the baby was thrown out with the dirty bathwater.[15]

The reaction to the problem of purpose in the 17th, the 18th, and 19th centuries was the reverse. There purpose was thrown out in the interest of purely quantitative or mechanistic considerations. But back to Buridan, or rather to the theological matrix of his impetus theory or idea of inertial motion. While in reference to terrestrial motions it was possible to refer to another terrestrial agent that triggers the motion, in the case of celestial bodies, or the universe, this was not the case. There a Christian, like Buridan, could refer only to the Creator. This is what Buridan did, and, most naturally, with an almost explicit reference to the words of Genesis 1, "In the

[15] See my article, "Socrates, or the Baby and the Bathwater" (1990), reprinted in my *Patterns or Principles and Other Essays* (Bryn Mawr, PA: Intercollegiate Studies Institute, 1995), pp. 50-62.

Beginning when God made the heaven and the earth..." Far more importantly, Buridan also states that once God creates, whether bodies or their motions, He keeps those entities in existence simply by a "general influence."

In saying this Buridan simply restated the theological distinction between two divine actions: one is creation out of nothing, the other is the conservation in existence of what has already been created. It is in this distinction, so clear in Thomas Aquinas, who wrote two generations before Buridan, that lies the idea of the autonomous character of the laws of nature or the laws of science. In the Christian theological idea of creation, and there alone, nature can be both fully created and fully autonomous at the same time. For only a God that can create out of nothing, can give an autonomous existence to something created, without having his power diminished. Hence the independence of science, which does not become an *a priori* imposition of this or that human idea on nature.

This is to be kept in mind in reading Buridan's reference to "theological masters." The reference is a roundabout expression of Buridan's conviction that the theological masters would find nothing wrong with the idea of impetus or inertial motion. This is exactly what happened, in a tacit recognition of the fact the theology is not about the *how* of the motion but only about its ultimate origin or *why*. Buridan's impetus theory found no opposition, theological or other. Clearly Buridan's expressed something that was in full harmony with a number of implicit and explicit assumptions, or to use an expression coined in Newton's time, with the "climate of thought."

In Buridan's simultaneous application of the same law to celestial and terrestrial motions one can see anticipated Newton's view that the same law governs the motion of the moon and the fall of a stone on the earth. Buridan also anticipates Popper's dictum that all science is cosmology. The true laws of physics, or rather the laws of true physics, must have a validity throughout the cosmos or the universe.

Of course, the motion of the earth is not a rectilinear inertial motion. But Buridan's idea, as applied both to the celestial bodies and to various motions on earth, implies what is the very essence of inertial motion. The idea was never stated before because it was revolutionary. The idea consists in the view that it is possible to give with a single, instantaneous act a quantity of motion, or impetus (or momentum to use the modern word) to a body and that the quantity would be maintained undiminished if the body moved in a frictionless medium.

Now why is this notion so revolutionary? Not so much because nobody had said it before, but because it represents a radical break with all earlier

standard thinking about motion, especially about the motion of the celestial bodies or of the heavenly sphere. To see this one should recall briefly Aristotle's ideas of motion. According to Aristotle the origin of all motion is in the motion of the heavenly sphere of the fixed stars. This motion is somehow transmitted to the planets down to the moon. The earth itself is motionless.

The transmission is not by means of some mechanism but by some desire. The farther a planet is from the celestial sphere, the less perfect is its desire for the source of motion and therefore the more irregular is its motion. The sphere of the fixed stars alone has a perfectly regular motion, or a motion with constant velocity, because it alone is in direct contact with the Prime Mover, which is not really different from the sphere itself.

Aristotle, let this not be forgotten, is a thorough pantheist. The universe for him is a living entity and divine in its upper parts. In line with this, Aristotle posits that the mechanism causing the motion of the sphere of the fixed stars is not a mechanism but a desire of that sphere for the Prime Mover.

In modern terms, there is a continual contact between the source of motion and the things moved. Now if such is the case one is in the presence of an uninterrupted application of force. Therefore, in terms of Newtonian physics the result can only be an accelerated motion. But, of course, the sphere of the fixed stars is not accelerated. It moves at constant velocity. Clearly, Aristotelian physics and Newtonian physics are poles apart.

This difference between the two can also be seen in a much less discussed remark of Aristotle about a theory of motion, called *antiperistasis*, already mentioned above. According to that theory a stone which is thrown moves through the air because it separates the air in front of it, so that the air is forced to flow past the stone. The air therefore finds a vacuum in the wake of the stone and, since nature abhors vacuum, the air quickly closes in behind the stone and acts like a moving force. One can only wish this were true. There would be much less need for gasoline to drive our automobiles, but I am afraid space travel would be impossible.

The really revealing thing in this remark of Aristotle is that he does not reject it out of hand. Why not? Because, being a very systematic thinker, he might have seen *antiperistasis* as the natural part of a much broader theory of motion. There everything was moved in terms of a continual contact between the mover and moved. This was certainly the case with Aristotle's explanation of celestial motion. The explanation well illustrated the dictum that all science is cosmology. And if one does not forget Aristotle's pantheism one may just as well say that all cosmology is theology.

This is true not only of Aristotle, Ptolemy and Plotinus, but also of Copernicus, Newton, Laplace, Einstein and especially of all those who have been the chief spokesmen of the various forms of modern scientific cosmology, the Big Bang, the steady state, and the theory of multiple universes. They would have generated far more light if they had come clean with their theologies or countertheologies.

But back to Newton, about whom Alexander Pope wrote: "Nature and Nature's laws lay hid in night: God said: 'Let Newton be!' and all was light." The real light Newton generated was his recognition that in the motion of the moon or any of the planets two kinds of motions were fused together. One was an accelerated motion, the gravitation of the body toward the center, the other was a tangential motion. In the absence of gravitation, the moon would fly away from the earth, and the planets from the sun, and they would do so along a rectilinear path.

About the origin of the force of attraction among gravitating bodies Newton had no clear ideas. He seemed to think that the gravitational and the inertial mass were the same but also that the force of gravitation was inherent in matter. It was not in the *Principia* that he rejected as absurd the idea of action at a distance. He seemed to lean toward the idea of a mechanical transmission of gravitation.

But Newton was rather clear on the origin of the inertial motion of bodies. In the Scholium, which appeared in the second edition of Newton's *Principia*, Newton ascribes the inertial motion of planets to an act of God who carefully adjusted the measure of that inertial motion to the central force. His statement is very similar to Buridan's statement.

Therefore if we look for the origin of that kind of exact science which is the quantitative study of the motion, the question of the origin of the idea of inertial motion should seem central. Its original appearance in Buridan's writings, or in 14th-century Sorbonne, cannot be disputed. But the registering of a fact is not its explanation. To us moderns nothing may seem more obvious, more natural, more self-explanatory than the idea of inertial motion. Actually its formulation represents the greatest, the most decisive breakthrough in natural philosophy.

That breakthrough took place less than seven hundred years ago. In the span of man's three-million-year-old history it happened a mere moment ago. And the novelty remains intact even in reference to the first construction of the pyramids, an extraordinary engineering feat, five thousand years ago or with the invention of phonetic writing, an even greater intellectual achievement, about that time. The question therefore rightly arises why

Buridan's breakthrough came so late? Why is science such a latecomer in human history? The answer lies with the plainly theological context of the first appearance of that first law of motion.

There is nothing speculative about the fact that Buridan's dictum is in a clear theological context. It is the context of the doctrine, for Buridan a dogma, of creation out of nothing and in time. For him, in all evidence a genuine Christian believer, that doctrine was a dogma, defined in the fourth Lateran Council in 1215. Of course, the Council merely defined a long standing belief. Already around 200 A.D., Tertullian insisted that the Christian doctrine of creation is a doctrine about creation out of nothing, or else the Creator would be in need of some pre-existing matter. Such a pre-existing matter was invariably postulated in all the gnostic distortions of early Christian beliefs, such as a book by the gnostic Hermogenes, whose illogicalities Tertullian exposed.[16]

Equally ancient was the conviction of genuine Christians that the past history of the universe is strictly finite. This is what is meant by creation in time. They may or may not have understood the biblical phrase, "In the beginning" or *bereshit*, which, after all, is an anomaly in Hebrew grammar,[17] but they took that phrase to mean that there was an absolute beginning for all. It also inspired the notion that history, human and cosmic, is not a circular treadmill but a linear move toward a goal, a move best symbolized by an arrow.

The next point to be kept in mind is that Buridan's breakthrough comes in reference to Aristotelian physics or rather pantheism. Buridan knew full well that for Aristotle the universe was uncreated and eternal. Buridan was not, of course, the first medieval Christian to disagree on that point with Aristotle. But he was the first to probe into the physical manner in which that beginning might have taken place. The result was a breakthrough toward a new theory of motion, toward the eventual full or live birth of modern science.

But, one may ask, why one had to wait for Buridan or for the Christian Middle Ages for that breakthrough? Had not Aristotle's writings been widely known to Jews and Muslims for many centuries before the Christian medievals became acquainted with them from the mid 13th century on? On the Jewish side there were Maimonides and Crescas who studied Aristotle at great length. But there is nothing similar to Buridan's statement in their

[16] *Adversus Hermogenes*, available in translation in all major modern languages.
[17] *Bereshit* is neither an adverb nor a construct case.

works, including Maimonides' *The Guide for the Perplexed* and Crescas' *Critique of Aristotle.*

The same is true of the great Muslim Aristotelians, Avicenna and Averroes. They were, of course, more Aristotelian than Muslim. Neither of them believed in creation and Creator. This disbelief of theirs they carefully kept hidden for fear of their lives from the persecutions of Muslim orthodoxy. But neither does one find the idea of impetus in the writings of the truly believing branch of Muslim philosophers, such as al-Ashari and al-Ghazzali, both believers to the point of being mystics. The reason for this is that both rejected, for reasons of Muslim orthodoxy, the idea that there can be laws of nature.

The question therefore may be raised for purely historical reasons about whether there was something special in Buridan's belief in creation and Creator. That something was simply the fact that Buridan's belief was a Christian's belief. This statement may appear trivial as long as one does not recall Paul's statement that God created everything in the Son. Such was Paul's way of asserting Jesus' divinity in his Letters to the Ephesians (3:9) and to the Colossians (1:16).

Creation is a divine prerogative. If therefore the work of creation is assigned to Jesus, he, in Paul's eyes, has to be God. Twelve hundred years later Thomas Aquinas said nothing new when he stated in the *Summa theologiae* that though God's power is infinite, he cannot invest any creature, however eminent, with the power to create.

Let me add one more datum, but simply as a historical fact or rather a sort of cultural thought experiment. Imagine that you live in the time of Plutarch who died around 120 A.D. Assume further that Plutarch had a Christian friend, perhaps from the wider senatorial clan of the Anicii. Assume further that this friend of Plutarch's suggested to him that he read John's Gospel which by then had been widely available. A fragment of a copy of it can with certainty be dated to about 120 A.D. It contains parts of the phrase, "And Pilate asked Jesus: Are you a king?" The other side of the fragment contains recipes for cooking.

So let us assume that Plutarch, once a chief priest in Delphi, begins to read John's Gospel. He would have stopped reading it with the first chapter. For there he would have read the phrase about a mere Jew, Jesus of Nazareth, that he was the only begotten or *monogenes* son of the Father. Now Plutarch, thoroughly familiar with the entire classical tradition, knew full well that in that tradition the word *monogenes* was used in two senses. One was the trivial daily sense about the only son of a father. The other was

a cosmological sense. *Monogenes* meant also the cosmos or the universe in the writings of Plato, Cicero and others, including Plutarch himself.[18] In that sense the universe was the first emanation and the only universal emanation from the First Principle which in turn was not different from the universe. This doctrine found a fully cosmological elaboration in Plotinus' *Enneads* around 250 A.D.

Plutarch therefore would be faced with a decision: if he accepts Christ as the *monogenes*, he has to stop considering the universe as the *monogenes*. The choice was not a question of mere semantics. The choice was and still is a choice between Christian monotheism and pantheism. The choice cannot be evaded by replacing pantheism with panentheism, unless one clearly states that panentheism still means creation out of nothing and in time and not a gradual emergence from the first cause or principle. But this is the kind of statement which is skirted by most champions of panentheism nowadays.

Still something is to be said of the pantheism that dominated not only ancient Greece and Hellenistic culture, but all the great ancient cultures, especially India and China. It should be easy to imagine how different history would have become if Buridan's breakthrough had occurred there and not in the Christian West. Today a maharajah might reside in a palace, where Buckingham Palace, or the Elysée Palace, or the White House stands nowadays. What could be true of a maharajah, might also be true of a mandarin.

So much in a nutshell about the most ignored and most crucial question of the history of science. The question has two sides to it. One is the invariable stillbirths of science in all ancient cultures.[19] All of them could boast of great intellects and of great technical achievements. But science, which is the science of motion, they failed to come up with. If it is true that all science is cosmology, then the ultimate reason for that failure is to be looked for in the pantheistic cosmologies that dominated all those cultures in the form of the idea of eternal returns. The swastika was its invariable symbol, which in turn implied a circle, which, because all points of it were equivalent, could not inspire the idea of an absolute start.

The other side of the question is not merely monotheism of which the idea of creation out of nothing is a strict corollary. If one considers the fact

[18] The major references are in Kittel's *Theologisches Wörterbuch zum Neuen Testament*, under *monogenes*.

[19] For details see chapters 1-6 in my *Science and Creation: From Eternal Cycles to an Oscillating Universe* (Edinburgh: Scottish Academic Press, 1974; 2nd enlarged edition, 1987).

that the actual forms of monotheism—Jewish, Christian and Muslim—are rooted in the same revelation given to Abraham at a given point in the past, it is possible to see a natural connection between the idea of creation out of nothing and the idea of creation in time. The latter, of course, simply means that the past history of the universe is strictly finite. Neither of those ideas can be proved or disproved by science. Science can no more specify the truly first moment of cosmic existence than it can prove the eternity of the universe. There is no measurement either of the nothing or of eternity.

But if one considers the fact that neither the Jewish nor the Muslim sages were able to come up with the true form of the science of motion, but only Christian scholars could do this, then one has to look beyond mere monotheism to Christian monotheism. As pointed out above, Christian monotheism is riveted in belief in Jesus in whom the Father created all. In other words, Christ would also loom large as the Savior of science, a point worth pondering in this year 2000.[20]

Regardless of the merit of this conclusion, the question remains about the origin of science, the most fundamental and least discussed question about science itself. One may be in error about giving a specific answer, and there have been some patently erroneous ones, which I discussed over twenty years ago in a series of lectures given at Oxford.[21] Those very wrong answers date mostly from the 18th and 19th centuries. Silence about the question has been almost total during the 20th century, which, in view of the vast evidence made available by Duhem, is inexcusable.

At any rate, truth comes out much sooner from saying something erroneous than from saying nothing or from resolutely refusing to acknowledge that there is a question, and a most serious one. It is simply not enough to say that those origins are medieval. And it flies in the face of the historical and scientific method when escape from the weight of that medieval provenance is sought in the facile remark that Buridan's insight would have come anyhow.[22] The *anyhow* is an easy escape from the clutches of the *how* and of the *why*. Of these two words, the *how* keeps science on the move, the other, the *why,* keeps the human intellect alive in the broadest sense, and makes thereby possible science as well.

[20] A point which I fully developed in my Wethersfied Institute lectures, *The Savior of Science* (1988; 2nd entirely reset edition, Grand Rapids, Michigan: Eerdmans, 2000).

[21] *The Origin of Science and the Science of its Origin* (Edinburgh: Scottish Academic Press, 1978). French translation: *L'origine de la science et la science de son origine* (Paris: Editions ESKA, 1996).

[22] Marshall Clagett, in a personal conversation.