Stanley L. Jaki

Science: Western or What?

IT IS A PLEASURE to be in Moscow and to have the opportunity to speak to a distinguished gathering of scholars and to do so under the auspices of the Academy of Science of the U.S.S.R. Even though the talk of a visitor from the U.S. is not on scientific technicalities, its factuality owes much to science. The jet plane and the radio waves that guided it here are products of science, and so is the amplifying system that makes one's voice audible to a large conference.

In Modern Times

There was a time not long ago, when purely scientific topics offered the only terrain where scholars from West and East could meet with the prospect of achieving a meeting of minds. On more than one occasion scientists held high their example to politicians that agreement between East and West is possible. Of course, not everything in life is science. Indeed science deals only with a rather narrow aspect of reality, the quantitative features of things. Scientists should have remembered that their products, insofar as they found military application, greatly heightened the tension between East and West.

Scientists should have also remembered that things have moved very far from the time of the Napoleonic wars, when Humphry Davy, the leading British chemist of the day, could travel freely all across France and claim that scientists are never at war. This was not entirely true even in the days of Napoleon. His novel strategy, a concentrated artillery fire on the center of the enemy troops, could not have worked without first-rate gunners, many of whom came from the École Polytechnique, the foremost science-school at that time anywhere in the world.

Only some military historians realized, long after Napoleon, that through science Napoleon might have invaded England a few months before Trafalgar. He should have ordered his engineers to make steamboats, such as the ones that were operating on the Firth of Forth in Scotland. On any windless day, when the British navy would be immobilized, French troops could have been landed on the English coast.

Had the Germans realized the effectiveness of their first use of poison gas—a scientific invention—the outcome of World War I might have been different. We all know about the role that radar, a scientific novelty around 1940, played in the outcome of World War II. If World War III did not take place, it was largely through realization on both sides that destructive tools created by science can easily turn military victory into an utterly self-defeating affair.

It may indeed be said that one reason those two great wars took place relates to the great advantage that science offered to

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the West over the last three or four centuries. Prior to the two wars, history saw the Western European nations conquer America, the Mid-East, and Africa. The effective conquest of the Americas demanded good science, the only thing that made sailing across the Atlantic relatively safe. In addition to magnets and sextants, one needed reliable pendulum clocks to keep accurate time, the only way to determine one's longitude on high seas or on land for that matter. The West learned about the Chinese during the seventeenth century, because the Court in Beijing was much impressed by the scientific know-how of the Jesuits. That the West established a global colonial empire by the late nineteenth century was largely due to its enormous technological superiority. It was then that Rudyard Kipling wrote his Ballad of East and West, which begins with the legendary lines:

> *Oh, East is East, and West is West,*
> *and never the twain shall meet,*
> *Till Earth and Sky stand presently*
> *at God's great Judgment Seat.*

Indeed, around 1895, exposure to science meant in those colonial lands an exposure to a way of thinking very different from the mentality characteristic of great ancient cultures, such as India and China, let alone of the mentality of primitive peoples. In China those opposing the Western colonizing powers almost to a man decried the mentality demanded by science as a mentality of lifeless mechanism. Gandhi for almost half a century fulminated against science while preaching the blessings of primitive village life, of an agriculture free of mechanization.

Yet, that same Western science has for some time offered a relatively smooth meeting ground between East and West. Science, it is enough to think of the Pugwash conferences and many similar gatherings, proved effective in lessening ideological conflicts. Sakharov would have hardly been so effective in his struggle to loosen up rigid political control had he not been a prominent scientist. Again, it is scientific prominence which gave weight to the insistence of the Chinese astrophysicist, Fang Lizhi, that the Party should democratize its procedures.

A principal point in the arguments of Professor Lizhi relates to science. To raise the standard of living, depends, so he argues, on the effective and broad use of science. Yet that use presupposes the free flow of information, which is obviously a chief facet of democracy. Moreover, Professor Lizhi takes science as an embodiment of democracy because the terms and laws of science are universally valid. Or to quote him: "In physics we cannot say that there is Chinese physics and Western physics."

This is true to a very great extent. The laws of gravitation and of electromagnetic induction did not become British because Newton and Faraday were British citizens. There is nothing Russian to Mendeleev's table of elements, nothing French to Carnot's cycle, nothing German to Clausius' law of entropy, nothing Dutch to the Lorentz transforms, nothing Italian to Galileo's telescope and Fermi's neutrinos.

The supranationality of science should be even more evident when it comes to that backbone of exact science which is mathematics. The decimal system, which until recently formed the basis of practically all scientific calculations, saw birth in ancient India, a non-Western culture. There, long before Euclid and Diophantes, the art of counting became generalized to the level of second-degree equations.

In Ancient Cultures

Formulas that are equivalent to solutions of second-degree equations appear in ancient Babylon and probably also in China. Yet there is no evidence in either place of a system that could be called algebra as such. Even more startling should seem the absence of arithmetic generalization in ancient Egypt or among the ancient Maya. Society in both places was heavily organized, very bureaucratic, one may say, markedly socialistic. The storage and distribution of goods demand in such places a vastly organized bookkeeping. Yet the ancient Egyptians did not develop an effective counting system. With one exception, 2/3, all their fractions were unit fractions, such as 1/4, 1/5, 1/6, and so forth. Yet it was ancient Egypt that achieved, as early as 2000 B.C., that enormous feat of generalization and abstraction which is phonetic writing. Their hieroglyphic writing is the basis of all modern alphabets.

The case of the Maya is no less instructive. As they kept improving their lunar calendar and another calendar based on the phases of Venus, the Maya were forced to work with very large numbers. Yet their number notation remained so clumsy that they had to do mentally even relatively simple additions and subtractions, to say nothing of multiplication and division. No number notation seems to have developed among the ancient Inca, although their tightly organized society could have derived great benefits from it. Throughout the Inca realm, which had a speedy and efficient postal system, information about numbers was carried on quipus or strings with beads. Clearly, social needs are simply not enough to prompt necessary insights about matters that should seem most universally obvious to the human mind.

A similar conclusion imposes itself when one looks at geometry, which next to algebra forms another indispensable tool for doing science. Here too the ancient Egyptians pose a tantalizing problem. If practical measurement is the origin and mainspring of geometry, then ancient Egypt should have become its birthplace. Each parcel of arable land in the Nile valley had to be remeasured each year once the annual inundations of the Nile had receded. The construction of pyramids involved measurements and calculations that today would seem to be impossible to carry out without geometry. Yet, while the ancient Egyptians had a formula for computing the volume of a truncated pyramid, they did not seem to have its rigorous derivation. Without doubt, they could not teach geometry, properly so called, to Greek visitors such as Thales and Herodotus.

Geometry is a Greek invention, in fact one of the great glories of ancient Greece. One cannot help admiring Euclid's Fourteen Books on geometry of which the first two contain all that is being taught to the average educated modern man insofar as he learns the elements of trigonometry as well. A typical engineer or a physicist is familiar with the contents of Books III to VI. The contents of Books VII to XII are being taught only in graduate courses. Books XIII and XIV contain propositions whose proofs were not given by Euclid. Some of those propositions have yet to be proven, although first-rate geometers have applied themselves to the task. Our admiration for the achievements of the Greeks of old in geometry, should not blind us to their comparatively primitive number notation. The same Greeks, who made notable advances in number theory, used letters of their alphabet for numbers and in a way that made calculations even more cumbersome than is the case with Roman numerals.

The chief paradox posed by ancient Greece relates to their failure to invent science. Here a few preliminary remarks are in order, because it has become a cultural cliché that science was born in Greece. Undoubtedly, geometry is science and so is Ptolemaic astronomy. The latter provides, through a complex system of geometrical figures—the superimposition of circles in particular—a means whereby the position of planets can be predicted with as much accuracy as in the heliocentric system of Copernicus. Undoubtedly, it was a great scientific feat when Eratosthenes calculated the size of the earth, or when Hipparchus derived, also with the help of empirical data and geometry, the procession of the equinoxes.

But the Greeks failed to make any advance in the sense in which science, physical science, has been taken for the past 300 years or so. Science in that sense is the science of the dynamics that copes with the motion of bodies. In talking about the motion of celestial bodies, the ancient Greek astronomers did not advance from geometry to dynamics, for they imagined celestial spheres, each carrying a planet, as if they resembled a system of cogwheels.

The structure of a machine reflects geometry as an account of a static situation. Dynamics comes into the picture when one analyzes the motive force that drives the machine. How far the Greeks remained from formulating the laws of dynamics can easily be gathered from Ptolemy himself. Not, of course, from his *Almagest*, which contains a purely geometrical formalism on the celestial motions of the motion of planets. From Ptolemy's *Tetrabiblos*, still the bible of astrologers, one learns that he took the planets for living beings that influence and determine every event, including all human action, on earth. In another book of his, the *Hypotyposes*, Ptolemy described the planets as a group of dancers and as a group of well drilled soldiers to explain that the planets are never seen to collide with one another.

Ptolemy was not an exception in classical antiquity, looking at the universe as a quasi-living entity, a sort of an all-embracing organism. In fact, only the Atomists, very much a minority in ancient Greece, had a cosmology free of animistic traits. By holding that ultimately everything was fire, the Stoics did not deny a principal point of the Platonic and Aristotelian tradition in which the universe was the ultimate and foremost living being. Aristotle's continual recourse in his cosmology to biological images has much more to it than his being by profession a biologist.

But even among the Greeks only relatively few abstained from using crude biological analogies in reference to the physical world. Recourse to such analogies was the rule in other ancient cultures. In India the universe was spoken of as the huge body of Brahman, whose perspiration as it came through the pores formed bubbles, each of them a universe appearing without rhyme and reason. In the Confucian literature one finds accounts of the universe in terms of the parts, big and small, of the human body. In the Babylonian genesis the universe is built from the chopped up parts of the dead body of the great mother, Tiamat. In ancient Egypt the sky is often represented as the body of the female deity, Nut, who is down on all fours while the reclining body of Gebb, the male deity, represents the earth.

It was impossible to think of the universe in such, at times, crudely organismic terms and to have about the universe thoughts that would lead to the birth of a correct science of dynamics. Thinking of the universe as an organism meant at least two things: First, that the motions of the universe and the motions within it were the motions of an animal. Second, if the universe was the ultimate living being, it had to be taken for an entity whose motions were without a beginning and an end. The bearing of all this on the possibility of finding the correct laws of dynamics will be shown later. Also, as long as the universe was looked upon as an organism, one was tempted to understand the universe through introspection. After all, few things are so obvious to man as the fact that he is an organism with laws that seem to be obvious on a little reflection. Last, but not least, the universe seen as a huge animal suggests the idea of its going through endless cycles of birth, growth, aging, death and rebirth. It is no accident that all ancient cultures were dominated by one version or another of the doctrine of the Great Year.

But if everything repeated itself an infinite number of times, what was the point of making a major effort to improve one's lot? This question could but generate a pessimistic or lethargic outlook. It could be dissimulated only by brave rhetoric, such as Aristotle's dictum that all the comforts conceivable were on hand in his time. And he was one of the few lucky ones. Most free people, to say nothing of the slaves, had meat only once or twice a month.

So much for some likely reasons why the science of dynamics was not born in any of the great ancient cultures. They became just so many places for the repeated stillbirths of science. Such stillbirths came about in two ways. Either no effective action followed a promising start, or the start was already a step in the wrong direction. The former case has no better illustration than ancient China, the place where the magnet, blockprinting, and gunpowder were invented. Francis Bacon was, of course, quite wrong in thinking that two, if not three, of those inventions were made in the West. On the basis of that very erroneous Baconian empiricism, science should have been born in ancient China. Had this been the case, China would have developed the laws of dynamics, and with it the science of ballistics. They would have then easily colonized North America sometime in the twelfth and thirteenth centuries. A scientific China could have also discovered and conquered Australia, as well as Japan, Korea, and India. Yet there was no Chinese Marco Polo, no Chinese Vasco da Gama, no Chinese Columbus, although at that time the Chinese navy was on a par with the best ships available in the West.

The other case of taking the first step in the wrong direction, that is, toward a scientific dead-end, is illustrated by Aristotle's theory of motion. Why is it that he recalled with no criticism such a patently absurd theory as the one called *antiperistasis*, to explain the flight of projectiles? According to that theory a stone thrown forward is kept in motion through the air, which closes in behind the stone and thereby pushes it ahead. Even in Aristotle's time it had to be obvious that one could not lift himself by his bootstraps. Also, if one were thinking of the universe as one single organism, and this is what Aristotle did, it was inevitable to think that the continuity of motion had to be through some continuous contact between the mover and the moved. The parts of an organism can never be truly separate from one another. As a result, in Aristotelian physics, as Edmund T. Whittaker stated, every page was wrong. In that physics, one went with every step farther down a blind alley.

The physics in which not only the first step was right, but also prompted further steps in the right direction, was classical or Newtonian physics. Its first step consists in Newton's three laws of motion. The first of them, the law of inertial motion, is an impossibility in Aristotle's physics. In Newton's physics it is the basis of all other laws.

Breakthrough in the West

Not only was Newton a Western European but so were all the scientists from whom he learned very important things. In reverse chronological order they were Huygens, Descartes, Galileo, Kepler, and Copernicus. None of them was eager to give credit to his immediate, let alone remote, predecessors. Today the whole story of the pre-Cartesian and in fact, pre-Copernican development of the idea of inertial motion is well known. The names connected with that story are all Western names. At the beginning of the story is John Buridan, a fourteenth-century professor at the Sorbonne, a Western place of learning if there ever was one. If one takes science as the study of things in motion, and if one recognizes the primary importance of the law of inertial motion, one can specify the date of the Western birth of science.

The time is 1330 or thereabout, when John Buridan took the chair of philosophy at the Sorbonne. As was the custom of other professors, he taught by offering a commentary on various works of Aristotle. One of the most important of those works is a cosmology, usually referred to as *De caelo* or *On the Heavens*. There Aristotle states most emphatically that the universe is eternal and that therefore there had been no beginning to the foremost of its motions which is the daily revolution of the celestial sphere.

Buridan was not, of course, the first Christian to read Aristotle and to reject his teaching about the eternity of the universe and of its motion. For Christians it had been for many centuries an explicit tenet of their faith that the history of the universe is strictly finite. For this is the meaning of the phrase that God created the universe out of nothing and in time. But Buridan did what no Christian philosopher or theologian had done before him. He reflected on the manner in which motion was given to the celestial bodies, once they were created.

Buridan's thinking was genuinely scientific because it was about the *manner* in which bodies moved. In substance he stated that in the beginning, when God made the heaven and the earth, He imparted to the celestial bodies a certain amount of impetus, by which Buridan meant the equivalent of what later came to be called momentum.

Then he added that those bodies keep their momentum undiminished because they move in a frictionless space. Such a motion is an inertial motion. Buridan taught at the Sorbonne for over twenty years and the same is true of Nicole Oresme, his most important student and successor in the chair. Oresme faithfully repeated Buridan's ideas in an even more famous series of lectures. Copies of Buridan's and Oresme's commentaries on *On the Heavens* can be found in such ancient university libraries as Oxford, Salamanca, Cambridge, Bologna, Pavia, Cologne, Toulouse, Sevilla, Vienna, and last but not least, in Cracow. It was in Cracow that Copernicus learned about inertial motion. He used it to explain why birds and clouds and the very atmosphere do not fall behind on a fast-rotating and even faster-orbiting earth.

The formulation by Buridan of the idea of inertial motion is the very spark that functioned with respect to science as does the sparkplug in an automobile. The sparkplug is but a small part of the entire machine, but an all-important part. It makes the motor start and thereby puts the entire car in motion. That very spark or Buridan's idea of inertial motion failed to turn up in any of the great ancient cultures. The reason for this should seem obvious, if one recalls the theological context in which that spark appeared in Buridan's mind. All of those ancient cultures were pagan. The essence of paganism, old and new, is that the universe is eternal, that its motions are without beginning and without end.

Belief in creation out of nothing and in time is the very opposite of paganism. Once that belief had become a widely-shared cultural consensus during the Christian Middle Ages, it became almost natural that there should arise the idea of inertial motion. Certainly, the idea appeared very natural to Buridan, to his contemporaries, and to the subsequent eight generations between Buridan and Descartes. In the entire vast manuscript tradition during that period there are but few instances of a rejection of Buridan's ideas whereas its endorsements are numerous. Insofar as that broad credal or theological consensus is the work of Christianity, science is not Western, but Christian.

This conclusion, which may seem startling, however logical it may appear, needs further explanation. A reason for this relates to the circumstances of my very presence here in Moscow. I am part of a group of scholars who were invited here to give their views about various aspects of life and thinking in the West, and especially in the United States. Consequently, this essay may imply that what I have said now is a widely-shared opinion in the West. Nothing could be further from the truth. This, of course, does not mean that my conclusion, namely, that in a very specific and all-important sense science is not Western but Christian, may not be true. Truth is not measured by so-called scholarly consensus. The latter is all too often like fashions. They come and go while truth survives. Truth is like facts. Facts will prevail, and one must be careful not to be found in opposition to them.

Modern Peevishness

The facts of the pre-Cartesian history of inertial motion are well established. They were first listed in the monumental historical studies of Pierre Duhem who died in 1916. His *Origines de la statique*, his *Études sur Léonard de Vinci*, and the first five volumes of his *Système du monde* were widely reviewed by 1920 or so. In spite of this, Duhem's chief message, the medieval Christian origins of science, was little spoken of. The message must have been resisted even in the best academic circles where respect for scholarly research, no matter what its message may be, is claimed to be the foremost precept. For the first twenty years the typical resistance to Duhem's message consisted in silence, hardly a scholarly attitude.

A classic example of a seemingly more scholarly attitude, or quasi-silence, can be found in the famous lecture series, *Science and the Modern World*, which Alfred North Whitehead delivered at Harvard in 1926. There, in the first chapter entitled "The Origins of Modern Science," Whitehead listed two beliefs that had to be widely shared so that science might be born. One is belief in order—in an orderly world. The other is the conviction, to quote Whitehead, "that every detailed occurrence can be correlated with its antecedents in a perfectly definite manner, exemplifying general principles." Then Whitehead asked: "How has this conviction been so vividly implanted on the European mind?"

Whitehead's answer is that "when we compare this tone of thought of Europe with the attitude of other civilizations when left to themselves, there seems but one source for its origin. It must come from the medieval insistence on the rationality of God, conceived as with the personal energy of Jehovah and with the rationality of a Greek philosopher." Whitehead's answer is a classic in suggesting the correct reply, but hiding its true nature in the same breath. To see this it should be enough to take a close look at the basis of the answer, or a comparison between medieval European culture and various earlier cultures, and in particular a comparison of the notion of God prevailing in them.

According to Whitehead, "in Asia the conceptions of God were of a being who was either too arbitrary or too impersonal for such ideas to have much effect on instinctive habits of mind. Any definite occurrence might be due to the fiat of an irrational despot, or might issue from some impersonal, inscrutable origin of things. There was not the same confidence as in the intelligible rationality of a personal being." But the real difference between the various Asian conceptions of God and the medieval Christian conception of God lay not in one being impersonal and arbitrary, and the other personal and logical. Even from the purely conceptual point of view the comparisons drawn up by Whitehead should seem gravely defective, if not plainly illogical. The more impersonal a factor is, the less arbitrary it has to be. Clearly, the real difference must lie elsewhere. The concept of God in ancient great cultures did not essentially differ from the notion of the universe. All ancient cultures were pantheistic. By contrast, the Christian concept of God has for its essence the belief that He is truly a Creator, that is, a being absolutely transcendental to the world. He exists whether He creates a universe or not.

A most interesting feature of that first chapter in *Science and the Modern World* is that whereas Whitehead speaks there of God as Jehovah, he never speaks of God as a Creator. In fact he does not mention God as a Creator throughout the whole book, not even in its next to last chapter which is on "Science and Religion." In not making any reference to God as a Creator, Whitehead remained consistent with pantheism, which was his own religious belief. Toward the end of his life he made it clear that in 1916 or so, he abandoned the Christian faith that he had learned from his father, an Anglican clergyman.

While pantheism might have given personal comfort to Whitehead, it made him distinctly uncomfortable in face of some major facts of history. Such a fact was the belief of medieval Christians, or of genuine Christians in any age for that matter, in a personal transcendental Creator. Moreover, for those Christians the transcendental Creator was substantially identical with the Incarnate Logos, or Reason Incarnate. They also believed that He could only create a fully logical or rational universe. It may sound most surprising that the first unambiguous declarations about the unrestricted rationality of the universe are found not in Greek philosophical writings but in the writings of Saint Athanasius, the great defender of the divinity of the Logos against the Arians.

None of these points is as much as hinted at in Whitehead's *Science and the Modern World* or in any of his writings, a fact indicative either of lack of scholarship or perhaps of bad faith. Both lurk in between the lines of his often quoted declaration: "The faith in the possibility of science, generated antecedently to the development of modern scientific theory, is an unconscious derivative from medieval theology." Facts, fully established by scholarly research, show that the derivative in question was the result of a fully conscious reflection. As to Whitehead's bad faith, it gives itself away by the phrase that precedes that declaration: "I am not arguing that the European trust in the scrutability of nature was logically justified even by its own theology."

It seems that Whitehead was most eager to make sure that his readers should not give substantial credit to medieval Christian theology in connection with the rise of science, let alone to that faith's pivotal point which is the very divinity of Christ himself. Would it have been difficult for a man with Whitehead's mind and learning to see something most crucial in the belief that held Christ to be the only begotten Son of God? Was not that belief the principal safeguard for Christians that saved them from sliding into pantheism? Did not classical Greek and Roman antiquity provide enough evidence that in pantheism the universe is looked upon as the only begotten (*monogenes*) procreation from the divine principle?

So much for quasi-silence (by way of illustration) as a means of coping with the momentous significance of Duhem's historical researches. They constituted a revolution in Western man's understanding of the very origins of his greatest pride, science. That revolution, which remains largely to be implemented, has been from about 1940 on resisted by the claim that there is a revolutionary break between the science of Buridan, or of the science of impetus, and the science of Galileo. The claim was first made by Alexandre Koyré, whose religious history parallels that of Whitehead, with the difference that Koyré reached pantheism not from a Christian but from a Jewish background.

Revolutions or the Revolution?

Undoubtedly, it would pay to look into the impact that Koyré's pantheism had on his historical researches into the origin and chief characteristics of Galileo's science. Here, let me note only the price one has to pay if one accepts Koyré's contention that Duhem was wrong in claiming a continuity from Buridan through Oresme and Leonardo to Galileo and beyond. The price is that if Koyré is right, science must be taken with him as a succession of disconnected periods, a mere sequence of revolutions. Such a sequence is not a continuity and therefore cannot represent a progress.

In other words, if Koyré's critique of Duhem is accepted—and many modern philosophers and historians have accepted it—one cannot give a logical account of a *fact*, the fact of scientific progress which it would be absurd to deny. A telling point of that logical conundrum is that neither Koyré nor his disciples—such as Thomas Kuhn of MIT, Paul Feyerabend of Berkeley, Bernard Cohen of Harvard, to mention some principal ones—provide a clear definition of what they mean by revolution, while they profusely use that word. If they mean a complete break with the past, that is, with all former ideas, they invite incomprehensibility of the prerevolutionary phase as seen from the vantage point set by the revolutionary change. To ward off the specter of incomprehensibility, they usually resort to some scientific expression, such as incommensurability, mutation, and paradigms.

The last of these is best left to Latin grammarians. They never expected their students to undergo a mental mutation or a revolutionary reorientation as they proceeded from a paradigm noun of the first declension to a paradigm noun of the second declension. As to genetic mutation, it consists in an extremely minute rearrangement of the chromosomatic material and not in its complete replacement. This is why one species can be instrumental in the rise of another species.

As to incommensurability, it occurs in a right-angled triangle with unit sides. The hypotenuse is an irrational number. Yet, no rationality was displayed by that Pythagorean of old who on discovering that the measure of the hypotenuse of such a triangle is an irrational magnitude, drowned himself on the high sea. As to those moderns who cavort in the idea of incommensurability and do so in the name of their philosophies of science, they should rather take note of the Bulgarian proverb: Those who want to drown should not torture themselves in shallow waters. At any rate, they seem to ignore a principal lesson about revolutions, the point best conveyed in the French saying: *Plus ça change plus ça reste la même chose* [the more it changes, the more it remains the same].

This is certainly true of the American Revolution. It was a revolution only inasmuch as it wanted to gather the best from past political wisdom. It emphatically asserted continuity with the past. And this was precisely the professed aim of Marx and Lenin. Undoubtedly, the results have become very different. The differences in question could and did create enormous conflicts, but also have promoted a serious reconsideration. The latter has come about mainly because of science, Western science, that is, the very last point in this essay.

There was a time when one could argue that science is a principal tool of enslavement and misery. Of course, Marx did not think that this should necessarily be the case. He in fact thought that once wholesale misery sparked revolutionary uprisings, and as a result the tools of production got in proper hands, poverty would be eliminated. He would be very much surprised, were he to see today that those tools of production achieved a substantial rise in living standards only insofar as they were handled by capitalists. The credit for this should not go to capitalists as such. Capitalists did not create the belief that man is free and that therefore man is creative. Capitalists played very little part in that creativity explosion that has characterized science for the past hundred years and increasingly so with every passing decade. The principal part is played by man's urge to know and to invent. Unlike classical capitalism that thrived on loans and interests, modern capitalism thrives on inventions that come in at an accelerated rate.

That exchanges between East and West are today extending far beyond meetings of scientists has much to do with science. Industrial applications of science are very much at work even when in all appearance such exchanges have nothing do with science. The meetings of the World Bank and of top financiers have much more to do with technology than it appears at first sight. Any issue of the *Wall Street Journal* or of the *Times Financial News* is proof of this.

Herein lie both an opportunity and a danger. The opportunity is that the more two, potentially hostile sides talk to one another, the better the chance that they discover many things they commonly share or aspire to, such as a good road toward a more securely established peace and prosperity. The danger lies in the fact that to preserve peace and broadly shared prosperity much more is needed than a greater availability of material goods and conveniences. An undue preoccupation with such goods, with the technical and scientific tools needed for their production, may promote a shallow pragmatism which has plain self-interest as its chief standard.

Unbridled, unprincipled self-interest, be it the self-interest of individuals, of nations, of social classes, of races, has always been the source of conflicts. To keep that self-interest under control, better and deeper motivations are necessary than the ones science can deliver. This received a momentous reminder in 1950 from Bertrand Russell, hardly a champion of ethical rules or a friend of Christianity. At a time when the Cold War was at its height and the space race got on a seemingly runaway course, he suggested nothing less than what the world really needed was Christian love: "If you feel this [Christian love], you have a motive for existence, a guide in action, a reason for courage, an imperative necessity for intellectual honesty."

All these commodities—motivation, guidelines, courage, and intellectual honesty—are indispensable in scientific work. To do physics today, one need not be Western, one need not even be a Christian. Science or physics has its highly-developed and well-proven techniques—theoretical and experimental. Such techniques remain universal even if their origin shows some specific connection with Christianity. But they require a philosophical and ethical underpinning if the purely quantitative results of physics or science are to be integrated into the broader human context.

With philosophy and ethics on hand, one

has within easy reach a religion which recognizes all just demands of reason, while rightly resisting its unjust demands. Those unjust demands are nowadays couched in specious references to science. Such is the claim, for instance, that science has proved experimentally the eternity of matter and, by inference, its being in no need whatsoever of a Creator.

I was a member, together with Professor Ambartsumian, of the panel on cosmology at the seventeenth World Congress of Philosophy in Düsseldorf in late August 1978. There I and a thousand-strong audience heard him make that claim about the eternity of matter. Of course, that was still the Brezhnev era. I am certain he would not today make that claim, which is absurd philosophically and nonsensical scientifically. Today even the church bells are free to ring without fear throughout all of Holy Russia. It is a land with as many brave and honest men as can be found in any other land.

One of those lands is the land of the Afghans, where the British tried to do a hundred years ago what you tried recently and failed. A hundred years ago a famed British poet, Rudyard Kipling, rode around the Khyber pass, an area which seemed to prove that there can be no meeting between East and West. There Kipling also learned a heart-warming story about two brave and honest men: Kamal, an Afghan chieftain, and a young British cavalryman, the son of a colonel of the Border Guards. Their story is about the recovery of the colonel's favorite horse. Through their encounter in which both Kamal and the young British soldier have the opportunity to kill one another, they learn about their bravery and sincerity. The result is far more than the restitution of mere material goods, such as a fine horse. To quote Kipling:

But there is neither East nor West,
Border, nor Breed, nor Birth,
When two strong men stand face to face,
though they come from the ends
of the earth.