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The Reapproachment Between Theology and Science

It was at Göttingen, Germany, that the modern conversations between theology and natural science began. The *Göttinger Physiker-Theologen Gespräche* were the brainchild of two University of Göttingen professors, Professor of Mathematics, Günter Howe (1908-1968) and Professor of Physics, C.F. Von Weizsäcker (1912-). Christians both, they were concerned that the kind of intensity that the church had shown during the war in the struggle with Nazi-ism should, in the post-war era, be turned to integrating the insights of theology and natural science to rebuild the post-war world. This was particularly true, according to Howe, who called the first conversation for the summer of 1949, because, "the second era of the industrial age" in which we had been living since 1945 had untold, and as yet unfathomed implications for the way we would eventually think about and understand the reality of the world.

The first era of the industrial age, according to Howe, had begun with James Watt's (1735-1819) invention of the industrial steam engine in 1776. The second era eventuated from the splitting of the atom by Fritz Strassmann (1902-) and Otto Hahn (1879-1968) at the University of Berlin in 1938. That experiment laid the groundwork for the atomic age which exploded upon all of us with the nuclear devices dropped on Hiroshima and Nagasaki in 1945. The atomic bomb was not only a new weapon, for with it, as Einstein has reminded us, everything has changed except our thinking.

According to Howe, whether we knew it or not, we had been propelled into a new era of history and this made it imperative that science and theology understand one another. Science, which had brought this era of history into being, would be used, Howe insisted, either to enhance our lives and preserve us or to debilitate and destroy us. As any theology that does not understand the world scientifically, would become irrelevant to life, so any science that ignores the implications of the faith is likely to run rampant.[1]

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[1] Cf. Harold P. Nebelsick, *Theology and Science in Mutual Modification* (New York:

The Göttingen conversations took place yearly from 1949 to 1961. Through their impetus meetings on theology and science were held at the World Council of Churches level at Geneva in 1961; at Nyborg, Denmark in 1962; and at the Massachusetts Institute of Technology, July 1979. At the MIT conference, "Faith, Science and the Future," 350 delegates from the world over discussed the relationships between faith, science, and technology for a ten day period. The problems discussed included those of understanding as well as those with a more practical bent. These were related to energy, the environment, bio-ethics, gene engineering, the control of science, etc. The conversations were directed toward disseminating information about the different subjects involved as well as toward helping the delegates understand one another with regard to some of the very complex issues with which the whole world is faced in the age of science and technology. The exchange of views eventuated in reports that were designated for dissemination to the delegates and to the different churches of the World Council of Churches.[2]

Thus, beginning with the Göttingen conversations, we have been moving toward the realization of the necessity of a dialogue between faith and natural science on a world-wide level. Although in the past we have often thought that faith and science were adversaries, we know it has not always been so, nor need it continue to be so. Rather, a new interaction between faith and science may well be coming about with the result that we may hope to see a *faith-transformed science* and a *scientifically-informed faith*. This development will be helpful, however, only if we avoid a false synthesis of science and theology, on the one hand, and a false antithesis, on the other.

Examples of the false synthesis occurred both in the "medieval synthesis" of Thomas Aquinas (1225-1274) and in the *scientism* which followed Isaac Newton's (1642-1727) publication of the *Principia*. The false dichotomy between theology and natural science has resulted in modern times especially from the legacies of the philosophies of Reńe Descartes (1596-1650) and Immanuel Kant (1724-1804). Thomas integrated Aristotelian physics and metaphysics into theology with such tenacity that the former often determined the latter. For Newton not only could God be read off the world's order but space itself was *God's sensorium*. Descartes differentiated the "I that thinks" from "that which is thought about" with the result that both God and the human mind were completely abstracted from the reality of the world. Kant apriorized

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Oxford University Press, 1981), "Crisis and Dialogue," pp. 151-177.

[2] World Council of Churches Report, "The Church in Europe and the Crisis of Modern Man" (Geneva, 1962). The two-volume conference report has appeared under the title, *Faith and Science in an Unjust World, II* eds. Robert L. Shinn and Paul Albrecht (Geneva, 1980).

Newtonian *space* and *time* along with *causality* into categories of the understanding or into categories of the mind in such a way that mind was not only completely differentiated from the world, in the process of recognizing the world, the mind ordered and controlled it. The result was Kant's "Copernican revolution." It was a reversal of the dualistic thinking of Newton. Whereas, for Newton the mind reflected the world, for Kant, the world was a reflection of mind. Hence, if Newton may be classified as an *absolute realist*, Kant may be classified as an *absolute idealist*.

It is largely because of the Enlightenment legacy represented especially by Kant that, by and large, both scientists and theologians still think of their two fields, if not as adversaries, certainly as alien. Although Professor Albert North Whitehead (1861-1947) and Herbert Butterfield (1900-) have both pointed out that natural science is the most important movement to affect humankind since the rise of Christianity, for the most part since the seventeenth-century rise of science and the demise of Newtonian "scientism" in the eighteenth century, science and technology have gone one way and theology has gone another. The cry of the Church Father Tertullian (c. 160-c. 239), "What has Jerusalem to do with Athens?" although originally a reference to theology and philosophy, is applicable to theology and science as well. As Tertullian's question implied a rhetorical, "Nothing," the "Nothing" would be the answer a good many theologians and scientists would give the question in our time were we to ask what theology has to do with natural science.

The result, to borrow a phrase from the British historian C. P. Snow (1905-1980), is that we live in "two cultures." On the one hand, we are aware of the hard, handable, practical realities which we can define, designate, shape, understand, develop and create through the means of natural science and technology. On the other hand, there are the soft realities of literature, poetry and the faith. The complete cleavage between that which we know by way of natural science and that which we know in the way of the humanities or in the categories of theology means that half the time we are hard-headed secularists, and the other half we are soft-hearted admirers of the traditions of faith and productions of the arts. Many of us are both at the same time. The Heidelberg philosopher, Georg Picht (1913-), has said that:

> The dialogue between religion and secular thinking is like a conversation between a person who is unable to speak and a person who cannot see. The one who cannot speak cannot talk about what he sees; the one who cannot see can only talk about what he doesn't see.[3]

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[3] Georg Picht, "Umweltschutz and Politik, *Zeitschrift für Rechtspolitik*, 4 JG., Heft 7 (1971), 137.

We are beginning to learn, however, as Lynn White, Jr. (1907-) has said that the rise of science itself is based on foundations of thought shared by the Christian faith:

> From the fourth century until the middle of the seventeenth, and even though with decreasing vigor, until the middle of the nineteenth, the astonishing Jewish heresy called Christianity was the chief force shaping the new superstructure which the European and American mind built on the Greek base.[4]

It is of utmost importance to realize, however, that although the "Greek base" was transferred to the West largely by means of the works of the Greek philosopher, Aristotle (384-322 B.C.), Aristotelianism itself had to be broken before natural science as we know it could develop. As early as the sixth century the Alexandrian Christian philosopher, Johannes Philoponos (c.490-566), took exception to Aristotle's doctrine of the eternal nature of the heavens on the basis of the Judaeo-Christian doctrine that the world was created by God out of nothing. According to the Christian understanding of creation advocated by Philoponos, the whole of creation, that of the heavens as well as the earth, is finite. It had a beginning and will have an end. Consequently, the heavens could not consist of the ever and eternal circling stars as Aristotle had thought. With eyes *schooled by the faith* Philoponos was able to see the heavenly movements as something less than symmetrical and regular. He showed that, because the stars precessed and the planets moved in different directions from that of the stars, perfect symmetry and perfectly circular motion around a common center, as Aristotelian thought had prescribed, was quite out of the question.

In the thirteenth century the Franciscans, Robert Grosseteste (c. 1170-1253) and Roger Bacon (c. 1214-1294) of Oxford also questioned Aristotle's doctrine of authority. Grosseteste showed that because there was a difference between eternal truth and truth as known in history, there could not be final causes in nature from the beginning as Aristotle had taught. Bacon questioned Aristotle's way of trying to know all truth by deducing it from principle rather than by attempting to know things by means of observation, experimentation and measurement. Further, Bacon insisted that Christians who knew God through the revelation of Scripture as the creator were in a favored position for knowing the creation for which the Creator was responsible.

Following Grosseteste and Roger Bacon, the philosophers John Duns Scotus (c. 1265-1308) and William of Ockham (c. 1285-c. 1349), again as over against Aristotle, taught that we have insight into the ways of nature not necessarily by listening to the authorities of the past and by

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[4] Lynn White, Jr., *Machina Ex Deo: Essays in the Dynamism of Western Culture* (Cambridge, Mass.: MIT Press, 1968), p. 33.

deducing answers from principles handed down but by use of intuition. In examining the things of nature in relationship to one another and then intuiting the relations that appear to exist among them, we gain knowledge into the existence of the things themselves. In addition, Ockham reintroduced the "law of parsimony" into the fourteenth century discussion. Known as "Ockham's razor," the "law of parsimony", which may be phrased as "the simpler the explanation, the more likely it is to be correct," is as old as the sixth century B.C. Pythagoreans, but when it was revived by Ockham it became re-accepted as a touchstone of truth. With that, Aristotelianism, with its deductive system and complicated cosmology on which the medieval theology of Thomas Aquinas (1225-1274) and medieval science depended, was shaken at its foundations. Shaken also was the belief in the authority of the church over the Bible, on the one hand, and the authority of the church over the state, on the other.

The *empirical habit of mind* whereby things were known not by authority as such but by examination of the relevant evidence bore fruit in the Protestant Reformation of the sixteenth century and in the development of natural science in the seventeenth. The Reformation itself greatly influenced the cause of science first by helping to create a milieu in which *relatively free inquiry* could take place and second by restressing the biblical understanding of the doctrines of *creation, the covenant, history and salvation.*

The emphasis on the biblical doctrine of *creatio ex nihila* (creation out of nothing) meant that God was the Lord of all creation. Creation was not divine nor was the divine as such a part of creation. Therefore Aristotle's heavenly divinities that were thought to control both the ways of the stars and the ways of humankind as well as his divine first and final causes, which were thought to penetrate all of creation, were seen to be unjustified in the light of biblical revelation. God was the Father-Creator, creation was creation, dependent upon God alone, who had banished all powers and principles. Creation was basically good. It could, therefore, be handled, measured, and examined in human terms and it was subject to human categories of understanding.

In addition, God's creation of humankind in his image could be interpreted to mean that Adam and Eve were commanded to be in charge of creation. They were to be "fruitful and multiply and fill the earth and subdue it" (Gen. 1:28). This does not mean that we are to exploit creation as Lynn White, Jr. in his article, "The Historical Roots of Our Ecologic Crisis" has accused the Christian faith of being responsible for having encouraged.[5] Rather, it means that humankind has been called into a

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[5] *Science* (10 March 1967) Vol. 155, No. 3767, 1203-1207.

covenant relationship with God. God commanded Adam and Eve to care for creation as he cares for it. They were to be shepherds of creation, to be guardians of it as a shepherd king was understood as being the guardian of his people. Creation is, thus, a gift put in the care of humankind and humankind is to guard it and to protect it. They are responsible for keeping and/or re-establishing the harmonious order in which God had created his world.

In that the Reformation understanding of the doctrine of the covenant emphasized that humankind was responsible under God as God's partner in the reconciling process of the world, it emphasized also the place of *work* as a proper activity for God's children. Work, which was necessary for Adam and Eve to keep the garden is also necessary for science. It is necessary for the making of instruments as well as for the putting of science into practice. For the Reformation, work was understood to be not a matter of drudgery, as it was in ancient Greece where mind-work was the occupation of gentlemen and hand-work was the work of slaves. Rather, for the Reformers as for the Bible, mind-work and hand-work were understood to go together. As the mind directs the hand, so too the hand sometimes leads the mind. Thus, *homo sapiens* (wise humanbeings), those who know nature, became *homo faber* (fabricating humanbeings), those who manufacture and use instruments both to cultivate and to examine nature.

Of momentous importance was the Reformation's re-evaluation of history and salvation. For the Greeks and even for certain aspects of Augustinian neo-Platonic and Thomistic-Aristotelian theology, the world was a matter of corruption, a place to escape from and history was a matter of downhill devolution. History was a movement from perfection to imperfection. The Reformation, by contrast, stressed the biblical doctrine that the world was good and that time was the time of God's salvation. The new heaven and the new earth were interpreted as eschatological events to be sure but there was also an eschatological impingement upon the present. Through the works of salvation the whole of nature, including humankind, was understood as being drawn into future fulfillment. It was the *future view of the present* that allowed one to see history as dynamic cooperation with God. Present activity contributed to bringing the promised future into being. The Calvinist Francis Bacon (1561-1626) could talk about serving God through *scientia* because through applied science, *i.e.*, technology, humankind was enabled to use nature for human welfare. In science, then, brain-work and hand-work, thinking, theory, manipulation and experimentation go together. Mind and body inform and form one another. Faith promises an eschatology, a goal-orientedness toward the future in which cooperation with God is productive of a better world. Science and technology provide the means to bring that world about.

The development of science, then, was greatly enhanced by (1) the understanding that the world was emancipated from the intervention of the divine spirits and from divine causes within nature, (2) the conviction that oppressive doctrines of authority had no validity and could be set aside, (3) the rebirth of confidence that arose with the assurance that people were God's partners in the service of humankind and responsible for the improvement of their lot, and (4) the rekindling of faith in an open future, a future for which people were both responsible under God and in behalf of which people were actively involved in the work of bringing about. It was thus as convinced Christians that at the beginning of the seventeenth century such men as Francis Bacon (1561-1626), Galileo (1564-1642), and Johannes Kepler (1571-1630) were freed to begin to see the world in a new way, in a way that was compatible to nature. The seventeenth-century revolution in science was the result.

In the sixteenth century Nicholas Copernicus (1473-1543) had resdiscovered the sun-centered universe first postulated by Aristarchus of Samos (c. 320-c. 250 B.C.) in the third century B.C. Copernicus wasn't really believed, however, even by the community of scientists until Galileo and Kepler made their contributions to astronomy. With his telescope Galileo saw mountains on the moon, the sun as a natural, rotating celestial body, and the four moons of Jupiter orbiting the planet in a way that reminded him of the planets orbiting around the sun. Kepler's contribution was his three laws of planetary motion.

Working on the observations of Tycho Brahe (1546-1601), the Danish astronomer, who had traced the planetary motions night after night for twenty years, Kepler noted an eight minute of an arc deviation in the orbit of Mars from the circular that, try as he would, he could not reduce to circularity as required by the Copernican system. Finally he quite literally stumbled upon the ellipse (which, incidently, Aristotle has specifically disallowed) and found it was the only orbital shape that matched the mathematical implications of Tycho's observations. Kepler deduced that rather than the sun being at the perfect center of the ellipse, it was situated slightly closer to one end than the other. Further calculations convinced Kepler that, rather than the planets moving in equal arcs in equal time, a vector, or a line extending from the sun to each of the planets swept equal areas as described by the planet's orbit in equal times. Lastly, Kepler related the velocity of each planet as it moved around the sun to its distance from the sun. The cube of the distance was related to the square of the time.

Thus, Kepler "brought the heavens to earth" with his three laws of planetary motion; that is, heavenly and earthly bodies were observed to conform to the same mathematical laws. Newton sealed the matter by combining Galilean dynamics with Keplerian cosmology by way of the law of universal gravitation. He showed that the same force that causes the planets to move around the sun in elliptical orbit varies in accordance with Kepler's inverse square of the distance between the bodies. This force (of gravitation) also keeps the moon moving around the earth, and causes objects *like the famous apple*, to fall to the earth. Further, Newton showed that the attraction between two bodies, which is inversely proportional to the square of the distance between them (action at a distance) gives the rate at which a planet must fall toward the sun or the rate that the moon must fall toward the earth in order for the bodies to remain in orbit.

Being Christians, Galileo, Kepler and Newton all apologized for the discoveries on the basis of faith. Galileo reminded the ecclesiastical authorities that Copernicus was a priest and a canon. Although Galileo generally maintained "that the intention of the Holy Ghost is to teach us how one goes to heaven, not how the heaven goes," he also pointed out that "a hundred pages of Holy Scripture . . . teach us that the glory and greatness of almighty God are marvelously discerned in all His works and divinely read *in the open book of heaven*."[6]

For Kepler, who had studied theology before turning to mathematics and astronomy, the heavens showed forth divinity. God was the "great geometrician." *Geometry* by which the planetary movements were measured was of God himself. Besides being the system by which the heavenly planets could be understood, geometry was implanted in human nature so that the mind could apprehend nature by reflecting on it in terms of mathematics.[7]

Newton was so certain that his science was of God that he used his scientific discoveries to read God off from the orderly patterns of creation. So enthusiastic were Newtons followers that the Newtonian system became the basis for the religion of *Newtonianism*. People such as John Ray (1627-1705), John Toland (1670-1722), and especially Richard Bentley (1662-1742) used Newtonian science to "prove" the "existence" of the creator. Bentley's classic sermon, "A Confutation with Atheism from the Origin and Frame of the World," challenged any atheist, who was so blind as not to be able to ascribe the heavens beautifully and wonderfully ordered to a divine maker,[8] Newton himself wrote more pages of theology than of science. So interested was he in theological questions that in the second edition of the *Principia*, he admitted that the proofs of God which he was certain resulted from his cosmology were as important to him as was his law of gravitation. In his "General Scholium," a section he added to the second edition, he pointed out that God

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[6] Galileo Galilei, "Letter to the Grand Duchess Christina," *Discoveries and Opinions of Galileo* (New York: Doubleday, 1957), pp. 175-216.

[7] Johannes Kepler, *Harmonices Mundi* (Lincii Austriae, M.DC.XIX), Lib. IV, 119.]

[8] Richard Bentley, *Eight Sermons* (Oxford: Clarendon Press, 1800).

was necessary first as the divine artificer who put the planets in their places. Secondly however, God continued to be necessary to sustain that order. And thirdly He was necessary to intervene in the system from time to time to give it a "tune up."

Newton recognized that the heavens were orderly but, according to his mathematics, they were not quite orderly as they might have been. The "slight disorder," was, Newton calculated, so serious that, if left on their own, the perturbations, or irregularities of the intersection orbits of Jupiter and Saturn were such that eventually the planets would crash into one another. Newton was therefore convinced that it was up to God to come to the rescue on occasion to reorder the two planets and prevent a tremendous cosmic collision. Hence God, the creator, was seen as having been necessary at the beginning; God was necessary in history to sustain the cosmic system and he would continue to be necessary in the future to reorder it. This God, who had so wonderously made and controlled all things, was worthy of worship and praise. With that, God as understood in terms of science, seemed much more real than God as understood according to the witness of the faith and in the minds of those to whom science appealed, the former took precedence over the latter.

It wasn't long, however, less than a hundred years later as a matter of fact, that the so called "Newton of France," Pierre Laplace (1749-1827) proved that Jupiter and Saturn did not need God to re-arrange them from time to time but got on very well by themselves, thank you. According to Laplace's calculations, which proved to be convincing, the orbits of Jupiter and Saturn were self-correcting at a periodicity of 929 and ¼ years. The universe as far as it was known appeared to function like "clock-work" after all. God may have been necessary for making it and winding it up but once started, it seemed to perpetuate itself by its own inherent motions and forces. For all practical purposes God, having completed his work, could retire. Hence, it is said that when Napoleon (1729-1821) asked Laplace where God fit in his cosmological scheme, Laplace replied, "Sire, je nài pas eu besoin de cette hypothèse" ("Sir, I have no need of that hypothesis"). As far as science was concerned, David Friedrich Strauss (1808-1874) recognized the reality of the situation when he said, "Gott ist heimlos und arbeitslos geworden" ("God has become homeless and unemployed.")[9]

Dietrich Bonhoeffer (1906-1945) from his cell in Berlin-Tegel has brought the statement into current theological discussion. On June 8, 1944, about a year before he was executed by an executive order of Adolf Hitler (1889-1945) Bonhoeffer wrote, "*Der Mensch hat gelernt, in allen wichtigen Fragen mit sich selbst fertig zu werden ohne*

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[9] David Friedrich Strauss, cited by Günter Howe, *Gespräch zwischen Theologie und Physik, Glaube und Forschung*, Band II (Gladbeck: Friezeiten, 1950), p. 157.

Zuhilfenahme der 'Arbeitshypothese: God'." (Humankind has learned in all important questions that God, as a working hypothesis [a god of the gaps, who is the explanation for that which we cannot as yet explain], has become superfluous.") On July 16, 1944, he wrote, "*Der Gott, der uns in der Welt leben lässt, ohne den Arbeitshypothese Gott ist der Gott, vor dem wir dauernd stehen.*" ("The God who allows us to live without the working hypothesis of God is the God before whom we continually stand.")[10]

It is hardly a coincidence that when Bonhoeffer wrote these words, he had C. F. von Weizsäcker's *Weltbild der Physik (The Worldview of Physics)* with him in his cell. In that book Weizsäcker, after discussing Laplace's cosmology that closed the universe to outside intervention on the basis of physics, repeats the story of the conversation between Laplace and Napoleon. Thus, as Bentley carried Newtonian physics, which was considered to need God, into theology to prove God, Bonhoeffer used the implications of the closed Laplacian system to show that, in reality, we no longer depend upon God to break into the world to rescue us out of our predicaments be they religious, noetic, moral, political, or scientific.

The Newtonian-Laplacian closed-world system was not the last cosmology that was to have implications for the way we understand reality however. Already in the early nineteenth century, Michael Faraday's (1794-1867) discovery of the "electro-magnetic field" and James Clerk-Maxwell's (1831-1879) equations which gave mathematical notation to electro-magnetic phenomena, induced cracks in the Newtonian-Laplacian closed system world-view where all was determined by known laws. A further step that helped to break up the absolute determinancy of the Newtonian-Laplacian system was made by Albert Michelson (1852-1931) and Edward Morely (1838-1923) whose experiments of 1881 and 1887 failed to verify Newton's *aether* with which space was supposedly filled and by which the *ethereal world* of space was supposed constituted. The Dutch physicist Hendrik Lorentz (1853-1928) analyzed Maxwell's equations and introduced transformations (mathematical equations) that dealt with the velocity of light. Because the Lorentz transformations were based on "local co-ordinates" and "local times," that is, dimensions and times that were specific only in relationship to a certain locality rather than being related to all times and all places, they cast doubt on the Newtonian understanding that space and time were absolute dimensions of the world. Rather both the shape of spacial objects and duration or "time" were calculated to depend on designated "local conditions." In 1899, Jules Poincaré (1854-1912) cast further

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[10] Dietrich Bonhoeffer, *Widerstand und Ergebung* (München, Chr. Kaiser, 1952), pp. 215, 258, 241.

doubt upon Newton's understanding of the world by announcing that ether did not exist and that absolute motion was undetectable. The motion of any one object could be known only by comparing its "movement' to another object that was itself either "standing still" or was moving in a different direction from the first. In addition Poincaré predicted a new mechanics based on the presupposition that no velocity could exceed that of light.

Then in 1905 Albert Einstein (1879-1955), whose thoughts coincided to a large extent with those of Lorentz and Poincaré, introduced his Special Theory of Relativity. The theory, based on the invariance of the velocity of light, made space and time dependent on velocity and showed that all inertial systems (systems in which objects were in motion) had to be measured relative to the particular system with which the observer in question was involved, hence the "theory of relativity." With that the *place* of the observer of any phenomenon became an absolutely important ingredient in the assessment of the particular phenomenon in question.

Einstein illustrated the matter by showing that a single bolt of lightening would appear at different times to an observer who was riding on a train than to another observer who was standing beside the track. For the first, the place of observation, "the coordinate system" was the moving train; for the second, "the coordinate system" was the "stationary ground" beside the track. Given that the train was headed south and the lightning struck at a location south of both observers and at the "very instant" when the two observers were parallel to one another, the lightning would appear to the one moving south on the train toward the place the lightning struck before it would appear to the one who was standing beside the track. This is the case because by the time the light from the bolt of lightning reached the two observers, the distance between the lightning and the observer on the train who was moving toward the bolt would be slightly less than the distance between the lightning and the observer standing beside the track. Time, therefore, is not absolute but it is dependent upon position and velocity. It is not the same for everyone because the time things happen for us depends upon where we stand and the direction in which we are moving. Likewise space is lengthened or shortened in relation to velocity. Clocks tick more slowly and horizontal rods appear shorter at high velocities than at low velocities.

During the same year, 1905, Einstein showed by the photo-electric effect that light rays consisted of particles with mass-energy and that the energy of light depended upon its frequency. It was for this, by the way, rather than for his theories of relativity that he was to receive the Nobel Prize. The theory of the photo-electric effect is integral to the theory of relativity nonetheless, because, to return to the train and the lightning, not only will the lightening appear to the observer on the train moving toward the lightning before it appears to the observer standing beside the track, but in addition, the lightning will have more energy for the observer who is moving toward it than it will for the stationary observer. This is the case because the energy of the lightning is enhanced by that of the moving train. Einstein explained this relationship of matter and energy with the famous and infamous formula: $E=mc^2$ (energy equals mass times the square of the velocity of light), which, as we all know, is the formula for nuclear fission and fusion. The formula has implications for the energy of the sun and the stars and our ability to generate electricity by nuclear plants or to blow up the world with nuclear devices.

As Einstein had based his Special Theory of Relativity on the velocity of light, so he based his 1915 General Theory of Relativity upon its mass-energy. The theory connects gravity with inertia. So far the General Theory has passed three tests. The first had to do with the effect of gravity upon light, the second with the measured advance of the perihelion of the orbit of the planet, Mercury, and the third with the Doppler effect as related to light, the so-called "red shift."

The effect of gravity upon light and the Doppler effect have greatly changed our understanding of the universe. The observation that light is affected by gravity, *i.e.*, and that the gravitational force of matter bends light rays, indicates that since the universe is populated with matter, "straight" lines as defined by beams of light are really curved. Newtonian space, which was though to extend infinitely and rectilinearly in all directions is seen to be untrue. "Straight lines" as defined by Euclidean geometry and the formulas based upon them are abstractions applicable only to our confined *mesocosmic* world (our middle world between the *microcosm* and the *macrocosm*). As far as the macrocosm is concerned, Riemannian geometry where all lines are curved and all triangles have more than 180 degrees is applicable. These cosmic lines or "world lines" vary in concentration and are shaped in relation to mass. Perhaps mass or matter is nothing more than the concentration of that of which the world lines consist.

The "red shift" which astronomers observe with regard to all galaxies indicates that the galaxies are speeding away from us and from each other in all directions. Since the more distant the galaxies, the more pronounced the shift, it is concluded that the further the galaxies are away from us the faster they are moving. Hence in all probability the universe is expanding. If so, it is *finite, i.e.*, enclosed by curved lines but *unbounded* because the space enclosed by these lines is being enlarged as the galaxies race outward from one another. Whether or not the universe will ever reverse its direction and begin moving inward depends, according to present theory, on whether or not the universe contains a sufficient amount of matter to overcome the inertia of the galaxies that appear at present to be racing outward.

Equally perturbing for our usual Newtonian understanding of the world is the *quantum theory*. Four years before Einstein proclaimed the Theory of Special Relativity, Max Planck (1858-1947), in 1901, discovered that energy radiated from a hot body (black body radiation) was delivered in distinct units or *quanta* (as they were to be named by Einstein) rather than as a steady force. In his 1905 experiment in which he demonstrated the photo electric effect, Einstein in fact showed that light itself consisted of these *quanta*. The experiment showed that light, which at the time was considered to be made up of waves, consisted of exactly the same kind of the discrete units (quanta or photons) that Planck had demonstrated to exist in the case of black body radiation (Planck's "h"). With that the physical world began to be understood very differently than Newton and Laplace and even Descates and Kant had conceived it as being.

In 1924, Louis de Broglie (1892-) propounded the theory that electrons could be considered as either particles or as waves depending upon how the they were measured. If one set up an apparatus which measures light, for instance, for its particles, it registered itself as photons. If one set up an apparatus which measures light as waves, it registered it as undulatory motion. Hence it appeared that there was a basic contradiction in nature. Nature could be seen as waves or particles with equal validity. Particles were, in fact, observed to behave like waves. In 1926 Max Born (1882-1970) found that light which, according to quantum theory, acted like rapid fire machine-gun bullets was not only emitted in distinct units or quanta but the trajectories and targets of the individual quanta could neither be traced or predicted. Rather, when the particles were fired toward a target, they were left a pattern which indicated that they were sprayed over a comparatively wide area. It wasn't possible to know which particle hit where or to trace the path by which it got there. If one fired a sufficient number of particles at a target however, it was possible to predict the pattern of hits that would result. Hence, although individual particles were indeterminable, if one had a large number, the results were predictable *statistically*. At the heart of nature, therefore, there would seem to be an indeterminancy which belies any attempt at exact pre-determination of all particulars. Quantum physics, has set the perfectly predictable universal ideal of classical Newtonian physics aside.

The non-determinancy pattern of modern physics was further strengthened in 1926 when Werner Heisenberg (1902-1976) put forth his Indeterminancy Relation theory. Heisenberg postulated and later verified that there was no way that one would measure a particle or a wave for both its momentum (mass velocity) and its location at the same time. Simultaneous measurement for location and for momentum was impossible. In other words, were one to measure a particle for its momentum, one could measure momentum alright, but one could not locate the particle. If one were to check the particle for its location, one could know where the particle was, but then one could not measure its momentum.

Next, in 1927, Niels Bohr (1885-1962) pronounced his Principle of Complementarity. Bohr took Heisenberg's Indeterminancy Relation another step and insisted that both the "momentum picture" and the "location picture" and the "location picture" were necessary if we were going to understand reality somewhat adequately. In other words, although the two pictures cannot be known at the same time, and knowing the one militates against the other, the two complement one another. They cannot be made at the same time. They can never be instantaneous. The one must be made before the other. The more precisely one knows the one, the less precisely one can know the other. Nevertheless, according to Bohr, we must keep both *in our minds* and allow them to *complement* one another if we are to know reality at all adequately.

The principle, radical as it is for physics, is according to C.F. von Weizsäcker and A. M. Klaus Müller, an instance of the whole *epistemological process* (the way we know anything at all). With regard to the experiment in question, the only way that one can verify that one is measuring the same "object" when one measures it first for its momentum and then for its location, is by explaining the experiment under which the observation took place. In so doing one seeks agreement that there is a high probability that one has been dealing with a single kind of "object" when at one instant the instrumentation registers location, and at another it registers the momentum.

Equally important, the fact that the momentum and location of a particle cannot be ascertained simultaneously demands the scientist's decision as to which "aspect of reality" or perhaps which "reality" will be measured first. The scientist sets up the apparatus according to preference and the energy shows itself according to the set up. Here, then, it would appear that there is an interdependence of mind with matter in such a way that we can no longer say that nature is absolutely determined nor can we say how it will function in all particulars independent of the decisions of those who observe it and who interact with it.

Weizäcker and Müller have argued again and again that in Heisenberg's interpretation of quantum mechanics we see at an extremely basic level, at the level of the composition of the atom itself, that we do not stand in a neutral relationship to nature nor does nature stand in neutral relationship to us. Rather, there is here not only the two-picture complementarity that Weizsäcker has named "circular complementarity" wherein it is necessary to allow the two "pictures" of reality to interact with one another, but there is also a mind-matter circular complementarity in which mind is a partner to matter and matter a partner to mind.[11] From these few examples of modern physics, it is possible to see that as far as our picture of the world is concerned, we have moved in a real sense beyond pictures so that rather than pictures, it is the mathematical symbols which express realities beyond the usual three-dimensional universe we experience. The realities referred to, however, are the realities of which nature is composed. Nature is neither completely determined, nor is it complete without us. We are a part of it. The way it shows itself to us depends to a certain extent on the way we approach it. Thus, we find that we and nature exist in interdependence upon one another. Physics itself, then, shows reality to be an inter-related whole with an *open-ended future*. As the conscious parts of nature who have "choice ability," we are put into the awesome position of being able to influence and, to a certain extent, to shape that future.

Further, if we understand the God of the Old Testament and New Testament as the one who intervenes in the world, not automatically, not as a *deus ex machina* (a god of the machine) but through inspiring humankind to intervene in the world for the good of all creation, then this non-determined, open-ended understanding of creation is exactly the kind of creation we should expect. If so, the same kind of science that in the last century was so powerful in constructing the concept of a materialistic pre-determined mechanical machine-like, spirit-denying universe, has rediscovered the interaction between the conscious and the unconscious parts of nature. The same physics which, according to the German theologian Karl Heim (1874-1958), was once one of the main forces that drew people out of the church, out of the Christian faith and led them to put their faith in natural science, progress, scientific materialism and Comtian positivism is now reversing itself as far as pure determinancy and the concept of a "closed world" is concerned. In the words of the physicist Pascual Jordan (1902-), "Physics which once said, 'Nein,' to the faith has now taken its 'Nein' back again."

This does not prove the faith, however. As von Weizsäcker has put it, there are two attitudes in relationship to science that are of no use at all to theology or the church. The first is an ignoring or a rejection of the findings of natural science as if theology alone knows the whole truth and can state it without reference to thought about the world. The second equally fateful stance is the complete acceptance and submission to the findings of natural science along with the attempt directly to incorporate these findings into the formulas of faith itself.

However, just as the closed system deterministic world-view of the eighteenth and nineteenth centuries not only became a view of the scientist but a world view which stretched far beyond science and into the

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[11] C. F. von Weizsäcker, *Zum Welbild der Physik* (Stuttgart: Hirzel, 1970), p. 292 and A. M. Klaus Müller, *Die Präparierte Zeit* (Stuttgart: Radius, c. 1972), pp. 293-307.

conceptions of faith, so the open non-determined, spirit-matter interacting world-view moves us beyond the subject-object dichotomy that science has known since Descartes and Kant. It may possibly inspire us to conceive of a new kind of world wherein we may see faith and natural science as complementary and interdependent aspects of reality.

Science is important to theology not only for what it knows but especially because it indicates to us how it is that we know anything at all and how we discover and articulate what we know. In both science and theology we know *in faith.* In science we have faith that the world is orderly and knowable, that is, that its structures are accessible to the structures of mind. Then on the basis of our learning and observations we project hypotheses and by means of experiment we attempt to verify them and work out our knowledge of the world accordingly. In theology we have a faith that God is knowable and has acted so as to reveal himself to us, *i.e.*, that he has made himself accessible to our minds. We examine the witness of that revelation in Scripture and in the light of the church's confessions and history, think through the implications of that understanding, examine our own appropriations of those traditions, and work out our knowledge of God accordingly.

In both science and theology we begin with what we have been taught but as we understand the context of that thinking and see the content of doctrine in relation to the milieu in which it arose, we may be open to re-articulating the faith for our time. All doctrines (teachings) of the Christian faith are admittedly understood in relationship to the particular milieu (co-ordinate system) of the Judaeo-Christian tradition. We verify them by repeating their history and by attempting to validate their generality. The more universal their range, the more convinced we become of their validity.

Faith precedes knowledge but knowledge, by which the "object" of faith is given conceptualization, arises by the continual putting into juxtaposition our faith understandings and those of the context or contexts in which these understandings arose and in which they continue to elicit allegiance. In theology as well as in natural science we both believe and attempt to understand. In natural science we believe there is a world and science is dedicated to understanding that world. In faith we believe in God and our theological efforts are devoted to attempting to understand the one in whom we believe. In both theology and natural science our quest for truth follows the motto of Anselm of Canterbury (1033-1109), "*fides quaerens intellectum,*" "faith in search of understanding."