THE DIALOGUE BETWEEN THEOLOGY AND SCIENCE[1]

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A. Theological Statement

I. Theology and Science

In the beginning God created the heavens and the earth." Theology has to do with God the creator; science deals with the heavens and the earth that God has created. On the face of it, it would seem that those who speak about God and creation, the *theologians*, and those who speak about structures and makeup of the heavens and the earth, the *scientists*, especially scientists who believe in God, ought to have much in common. They ought to be speaking to each other. The people of the Christian faith in general and the theologians in particular who speak about God do not *only* speak about God even when they "do theology." Since they are a part of creation, they also speak about God's relationship to that creation, and they speak about God in terms of creation. They speak about the heavens which "reflect the glory of God." They also speak about themselves, those who were created in God's own image. As human beings who are of the Judeo-Christian tradition, they speak about themselves as that part of creation whom, according to the biblical account of creation, God put in charge of the earth and the creatures he had created.

... So God created man in his own image, in the image of God he created him, male and female he created them. (Gen. 1:27)

... According to Genesis, God then commands humankind to take charge of creation.

God blessed them and said to them, Be fruitful and multiply and fill the earth and subdue it, and have dominion over the fish of the sea and over the birds of the air and over every living thing that moves upon the earth. (Gen. 1:28)

... Thus, from the very beginning, theology, which speaks of God and creation, and science, which knows the creation and must know it if humankind is to "have dominion over it," would seem necessary if not indispensable to one another. Such being the case, we might expect that the theological side of us, which understands God's command, and the scientific side of us, which knows something about birds and fishes and living things and the kind of earth that keeps them alive and keeps us alive by keeping them alive, would have the greatest interest in one another.

... Theology is the discipline that guides our thinking about God, ourselves and the world, life here and hereafter in relationship to God. It reflects upon the language and concepts of faith. Natural science is our ordered thought about creation or, more particularly, "nature." It deals with the physical world, that of the heavens and the earth, including plants, living creatures, and ourselves in relationship to our earthly and cosmic environment. Science is our attempt to know

[1] * Due to the length of this statement, "The Christian Influence on the Development of Science," "The marriage of Newtonian Science and Theology," "The Enlightenment Influence on Theology," and the bibliography are not included in this volume.

and order nature. As applied science ("technology"), it includes our interaction with nature, its preservation, utilization, or as also happens, its exploitation.

... As far as creation is concerned, theology tells us, or should tell us, or at least help us to learn what the purpose of humankind and creation is. It answers questions concerning the ultimate purpose of human life, which, according to the Westminster Catechism, is "to glorify God and to enjoy him forever." Science, by which we attempt to understand nature in terms of itself, how it is ordered, and how it is or ought to be arranged, is a prime means by which we may faithfully glorify God here and now. It is a most important instrumentality through which we learn about and care for nature, even as in faithfulness we look forward to enjoying God forever. Using poetic license we may say that if theology is to proclaim, as did Amos, that justice should roll down as the waters and righteousness as an everflowing stream, science, including applied science-technology, learns about, charts out and furnishes channels for the flow. Thus, theology orients life to God and God's purposes. Science provides the thought and practical dimensions by which this orientation becomes concrete with regard to our physical world.

... Theology and natural science though oriented to different "objects"—theology to God, science to nature—have common concerns. If they are to be effective and directed rightly, they ought not only recognize one another's importance, they ought consciously to be in dialogue with one another and even depend upon one another. For the most part, however, such is not the case.

... Thus, a good many of us have grown up to think of faith and theology, art and literature, as isolated from science and technology. It is with reference to this "schizophrenia" which affects us as individuals as well as people that the British historian C. P. Snow designated the division between the "arts" and the "sciences" as "The Two Cultures."[2] Our loyalties are divided between the "humanities"—such as literature, the arts, philosophy, and theology, on the one hand, and the "sciences"—physics, engineering, biology, medicine, and business, etc., on the other. The two sides of ourselves and our civilization acknowledge one another but have little real conversation. Although the problem is being ameliorated to a certain extent by recent interdisciplinary conversations and studies, by and large the representatives of the "two cultures" pass as ships in the night, blinking their presence to one another perhaps, but failing to read one another's signals or tune their radios to one another's wavelengths. The Heidelberg philosopher, Georg Picht, deplores this gulf within us by comparing the "dialogue" between faith and secular science to a "conversation" between a person who can see but cannot talk and a person who can talk but cannot see.

... The one who cannot talk cannot say what he sees. The one who is sightless can only talk about what he doesn't see.[3]

... Thus even though history indicates that modern science developed in the West in the milieu created in relationship to Christianity and that no movement since the rise of Christianity has so changed the face of civilization as has the rise of modern natural science,[4] science and theology seldom see themselves as complementary. Science has learned to distrust or to belittle theology, even while theology has tended to neglect science, leave it to itself, doubt its ultimate value, or be suspicious or fearful of it. Such a situation, however, has not always obtained nor need it continue.

II. Biblical Perceptions and Scientific Development

... Scripture itself, if seen from a perspective which is concerned with uncovering the relationships of the Judeo-Christian tradition to natural science, would seem to support a relationship of *mutuality* between theology and science rather than a relationship of *discord*. In

Genesis 1–2:4a, God is proclaimed as the sovereign creator and lord who creates the universe through his word. Creation results from God's *bara*. In reserving the Hebrew word *bara* exclusively for God's creative activity, the writers of the Old Testament proclaim God as both sovereign over and independent of his creation. The sovereign creativity expressed by *bara* is carried over into the New Testament as well, where in the Hellenistic context the Apostle Paul spoke of God calling "into existence the things that do not exist" (Rom. 4:17).[5] In the sixteenth century the same concept is emphasized by the Protestant Reformers who insist on the doctrine of *creation ex nihilo*, "creation out of nothing." This stood in sharp contrast to the then dominant Aristotelian-influenced doctrine of the medieval church in which God was conceived as *permeating* creation by way of "first and final causes." In Aristotle's scheme, star spirits and heavenly divinities capriciously exercised their influence over both nature and humankind. Conversely, the God who is sovereign over and responsible for creation, God, whose *bara* brings into existence the things that do not exist, effectively freed nature from capriciousness and allowed it the kind of stability and dependability which was necessary for the development of modern science.

... In the Genesis account of creation, God's gracious rule is emphasized in the ordering and classification of creation. There are plants bearing seed and trees bearing fruit (v. 12). There are the domesticated animals: "cattle" (v. 24). There are reptiles, insects, small quadrupeds: "the creeping things" (v. 24). And there are the nondomesticated animals: "beasts of the earth" (v. 24). Each is created and put in its place.

... In the creation of humankind a new factor is brought into play. Rather than simply following the procedure of bringing humankind from the ground as with the plants and animals, God takes special counsel before creating humankind, "Let us make man." Further, he decides to make human beings "in our image," "after our likeness." A most important implication of this "image" is spelled out in the designation of humankind's vocation. "Let them have dominion" (v. 26). Thus Adam and Eve express their "likeness" to God in representing God's dominance over creation, in expressing his loving rule and care for creation. As God is the lord over the totality of creation including humankind, so human beings are to act as God's *viceroys*. Verse 28 makes it explicit. They are to have dominion over the creatures of creation.

. . . fill the earth and subdue it, and have dominion over the fish of the sea and over the birds of the air and every living thing that moves upon the earth.

... Under God and in responsibility to God, humankind is given the awesome task of subduing the earth and ruling its nonhuman creatures. Here, then, at the very beginning of the biblical account, human beings are given responsibility to take charge of the world. It is out of this understanding of responsibility for nature that modern science and technology have developed.

... It is to be noted, however, that the terms "dominion" and "subdue" in the Genesis account are not to be taken as giving humankind the right of "exploitation." Dominion is to be understood in the sense of "service." It is to be expressed as stewardship, as care of and as commitment, to the well-being of nature. It refers to keeping the animals in order, separating the wild ones from the domesticated ones, and keeping these from trampling the plants. Subdue refers to the cultivation of plants. Adam and Eve are to be God's cowherds and shepherds. They are to be God's gardeners. They are to keep creation in order and use the plants for food.

... This sense of relationship with the whole of creation, even of an intimate solidarity between humankind and nature, is made explicit in Genesis 2. There humankind is made of the very stuff

of which nature is "made." Then "the Lord God formed man out of the dust of the ground" (v. 7). Again, humankind is given the task of caring for creation. God sets Adam in the midst of the garden "to till it and keep it" (v. 15).

... From the onset of life on earth, according to biblical understanding, humankind is charged with the care of creation. In being commanded to dominate, subdue, cultivate, and care for nature, they are free and even ordered to learn about it and to handle it rather than simply to admire it or to be dominated by it. In becoming world-knowing and world-shaping, people become natural scientists. In applying science to nature, they develop "technology."

... We know all too well, as Professor Lynn White has reminded us, that the "dominion" eventually gets out of hand and results in exploitation. We do not agree with Professor White, however, when he lays the blame for the kind of exploitation which damages and threatens to destroy our natural habitat upon "orthodox Christian arrogance toward nature" which, according to White, follows the "imperative of the Genesis command."[6] Rather, if, as we have pointed out, the intent of the Genesis command is to express God's care for nature through humankind, then exploitation for which humankind is unfortunately responsible is due to sin and selfishness. It represents a misunderstanding of God's command. To exploit nature is to rebel against God rather than to follow his demand for the dominating, loving care of nature.

... The Genesis creation accounts, of course, are "pre-fall." They represent the idyllic circumstances as they were considered to have existed before human sin, before Adam and Eve were driven from the garden. As the creation account unfolds in Genesis 3, sin enters the world. Though the consequences of sin are later ameliorated by God's graciousness, in the Genesis account sin disturbs not only the harmonious relationship between God and humankind, it destroys the harmony between human beings and, very important as far as science is concerned, sin causes the relationship between humankind and nature to be disturbed and distorted as well. Humankind falls out of the harmonious relationship with God and nature in which they were created. The result is estrangement, pain and suffering. All of creation—the creatures, humankind, and even the land-is affected. The serpent which is cursed to go on its belly and eat dust is designated as humankind's enemy. The woman is cursed with having to endure pain during childbirth and to be subservient to her husband. Even the ground is cursed to bring forth thorns and thistles. And Adam, who must weed them out, is cursed with such toil that he shall sweat even while he eats until he "returns to the ground" from which he was taken (Gen. 3:14 ff.). Disharmony and disobedience reign. Cain's murder of his brother Abel again affects the fruitfulness of the soil. "When you till the ground, it shall no longer yield to you its strength" (Gen. 4:12). The earth, in fact, becomes corrupt and filled with violence. Humankind becomes "so rebellious" (Gen. 6:7) that God determines to blot out his creation with the flood and start anew.

... Even after the flood, however, humankind remains in charge of nature. Again the creatures are delivered into human hands (Gen. 9:2) and, again, exploitation is forbidden. Now, however, the animals are given Noah for food in addition to the plants. Even as they are placed in danger of exploitation, so they are placed under protection. God will demand a reckoning of "every beast as well as of every man" (Gen. 9:5). The covenant which God makes with Noah and his descendants is also made with "every living creature—the birds, the cattle and all the beasts (Gen. 9:10 ff.) Noah, like Adam, becomes a gardener, a tiller of the soil. Significantly, the Hebrew word for till is *abad* which is to *serve* the earth.

... Even sinful humankind, then, in a sin-struck world is to live in symbiosis with nature. The structure of nature including humanity is bent toward mutual benefit. Thus, as Isaiah put it, "He did not create it (the world) a chaos, he formed it to be inhabited." Further, Isaiah tells us, God did not speak "in secret," but he "declares what is right" (Is. 45:18 f.). Thus according to the biblical understanding, there is a rational relationship between nature and human nature. It is a relationship which opens reality to the kind of understanding wherein we are enabled to see the whole of nature as a matrix of interimpinging and mutually beneficial interconnections.

... The Old Testament proclamation of the creating power of God over creation and the understanding of the integral relationship between humanity and nature continues in the New Testament. The prologue to the Gospel of John, which has Genesis 1 as its background, puts creation in a Christological context. Again, it is stressed that it is through God's sovereign Word that all things are made (Jn. 1:3). In moving into thought forms understandable in the Hellenistic world, "the Word" is equated with light and with life (cf. 2 Cor. 4:6, 5:17). The same Word which is responsible for creation, the Word which was the light of humanity and through which the world was made (Jn. 1:3, 4, 10), is also the power of salvation. "The power to become the children of God" (Jn. 1:12), the power of the new creation, is thus shown to be the power of the original creation as well. This power reveals itself in creation explicitly as "the Word (which) became flesh and dwelt among us full of grace and truth." (Jn. 1:14)

... In this way, the New Testament scriptures relate the salvation of humankind with creation itself, and creation itself is seen to be caught up in the history of salvation. For the Apostle Paul, Christ is the new "Adam," the new man who represents life analogous to Adam who, because of his sin, represented death. Christ is the firstfruit of the new order (1 Cor. 15:23 ff.) which is being brought to birth in the power of the Spirit (Jn. 3:5). As the resurrected Lord, he is identified as the *Pantocrator*, the Greek term meaning "The Almighty," "the ruler of the universe" (2 Cor. 6:18 ff., cf. Rev. 1:8, 4:8, 11:17, 15:3, et al.). Jesus Christ, who is proclaimed as the first born of all creation (1 Cor. 1:15) and promises that all will become new (Rev. 21:5), is thus the basis of the Christian hope and the ground of its future. Since "all things have been put under his feet" (Ep. 1:22, Heb. 2:8) the totality of reality finds its focus and its end in him. The mystery of God and the goal of creation are revealed in him, Christ "is the image of the invisible God, the firstborn of all creation." He is both responsible for creation and the one in whom its coherence is obtained. "All things were created in heaven and on earth, visible and invisible, whether thrones or dominions or principalities or authorities—all things were created through him and for him," and "in him all things hold together." (Col. 1:15-17).

... Our own involvement in relationship to nature becomes evident in Romans 8, where the Apostle Paul sets the whole of creation in relationship to humankind as together the totality of reality looks forward to salvation which is to come.

We know that the whole creation has been groaning in travail together until now; and not only the creation, but we ourselves, who have the first fruits of the Spirit, groan inwardly as we wait for adoptions as sons, the redemption of our bodies. (Rom. 8:22–23)

... When humankind is redeemed, creation, which has been subjected to futility, (Rom. 8:20), will itself "be set free from its bondage to decay and obtain the glorious liberty of the children of God" (Rom. 8:21). It is most important to understand that the suffering to which the Apostle Paul refers to in Romans 8 is not a suffering of despair. Rather, we suffer and creation suffers with us because we have the "first fruit of the Spirit." In contrast to the estrangement, disharmony, and frustration of this world, we have a taste of what the world should be like; and we are frustrated

because the taste of harmony serves to increase an appetite which remains unsatisfied. Our suffering in this sense is a sign of our hope, a hope that looks forward to the completion of the salvific process, the redemption of our bodies. In this destiny the whole of creation is caught up. ... It is in the light of this hope, in being caught up in the vision of a new reality for which we as human beings have responsibility, that science, by which we learn of nature, and technology, by which we care for it and control it, can be seen both within the concern of Christian faith and a proper expression of that faith as related to the world. As theoretical chemist Walter R. Thorsen has recently written, "I think that the scientific revolution, and the new kind of thinking it encourages, should properly be understood as a new expression of Christian thought, not as an irrelevant and divergent secularism."[8]

B. THE BACKGROUND FOR THE DIALOGUE BETWEEN THEOLOGY AND SCIENCE

I. Science—Blessing or Bane?

Thus, from a biblical and Christian point of view, we may well be able to understand science, the discipline by which we understand nature and technology, the method used in applying science to nature and by which nature is altered as both necessary and beneficial. If used correctly, science and technology are means for carrying out the God-given mandate to exercise caring domination over nature.

So ubiquitous have science and scientific thinking become that as we Christians cannot possibly think of our lives without thinking of the faith, so we who live in the scientific-technological age would have difficulty thinking of ourselves and our world without thinking of science and its effects upon us. When we think of the technical aspects of housing, food, heating, health, education, commerce, transportation, the utilization of natural resources, and the preservation and enhancement of life, or whether we think of pollution, the energy crisis, over-population and hunger, or war with its destruction and the consequent danger to people and the planet, we think in terms of science.

Time was, in fact, and that time is well within living memory, that we thought that science either had or would soon have the answers to our problems. We were certain that if something went wrong or would go wrong, science would find a solution and applied science—technology—would fix it. Yet in our time we are seeing what appears to us to be incontestable evidence that science–technology can no longer deliver on its promise. When it does deliver, it demands a delivery cost that we may not be able to afford.

If we concentrate on the possible dangers to our world, dangers which are present because we have forgotten our God-given vocation of stewardship in relation to the world and have used science and technology for exploiting the planet rather than in caring for it, then the words of Jeremiah come to mind.

... Thus says the Lord:
... "Cursed is the man who trusts in man
... and makes flesh his arm,
... whose heart turns away from the Lord.
... He is like a shrub in the desert,
... and shall not see any good come.
... He shall dwell in the parched places of the wilderness,
... in an uninhabited salt land." (Jer. 17:5–6)

... A more contemporary statement is made by the German biologist Friedrich Oehlkers who paints a poignant picture of the possible long-term, even irreversible, ill effects of falsely conceived and falsely applied science and technology.

For the animal and plant world man is the very incarnation of evil itself. He is equipped with superior sinister powers. He goes around in all his ways according to his own caprice. He plants vegetation where and how he will and he destroys it again according to his pleasure. He modifies plant life according to his own shortsighted advantage because he possesses only a superficial knowledge of the laws of change and the vegetation follows him willing and still. The destruction, however, which man causes to the planet that has been entrusted to him is so terrible and at the same time so irreversible that in the long run in destroying the planet he must also destroy himself.[9]

... The seriousness of the matter is such that we shut our eyes to the negative aspects of science and technology only to our peril. Science makes possible machines to save human energy, and the result is the energy crisis. The demand for the production of energy and machines causes the environmental crisis. The extraction of materials from the earth and their remanufacture that supports the standard of living we think necessary are having devastating consequences—the pollution of the ground, water, and air to the point that life itself may be endangered. Science makes possible labor-saving devices, and the effect is unemployment. It encourages mechanized agricultural, and the outcome is surplus agricultural workers who leave the land and their communities and inundate our already overcrowded cities, overtaxed housing, water, sewage, police, and energy resources. Science's promise of welfare for the masses via mass production produces massive social dislocation. Science promises riches for everyone, and only the few become wealthy—and that often at the expense of the poor whose numbers, on a worldwide scale, increase rather than decrease. Science makes possible enormously costly weapons of "defense" for protection against "our enemies." The world spends more than 1.4 billion dollars a day on armaments—*a million dollars a minute*—while the poor are neglected and literally starve to death for want of food. The more costly and sophisticated the weapons become, the more insecure we are; because, being universal, science is no respecter of nations. Whatever one nation can build, the "other side" can build as well; and the more one side builds, the more the "other side" must build because "they" fear "us" at least as much as "we" fear "them."

... In sum, as Francis Bacon (1561–1626) pointed out in the seventeenth century, "science is power." It is a power available to anyone anywhere who has the capacity to master its formulas and translate these into technological gadgets and machines. These, in turn, can be used for good or for ill. Each machine exacts its own price for being and for functioning, and that price is a continually inflating one.

... Science is not neutral. It, like all human and natural phenomena, is subject to sin and thus to distortion. Since science provides the means for enormously magnifying the power of humankind over nature by utilizing the powers of nature, it is potentially extremely beneficial and/or extremely deleterious. It can be used positively or negatively, productively or destructively. From a Christian point of view, it is used responsibly when it is used in promoting the welfare of the whole of humankind, the planet, and the universe. It is a welcome power when it it utilized for the benefit and for the survival of life in its most universal connotations.

II. Science's Distrust of Theology

... Though, as we have noted, efforts are being made to bring science and theology together, some scientists are skeptical of any such conversations and that for good reason. The early

history of the development of science in the West during which science was forced to struggle to free itself from the domination and persecution of the Church is reason enough for many scientists to doubt the "good intentions"of theology in this regard.

... During the emergence of modern science in the West, the authorities of the medieval church were so certain of the trust of the faith (which for them encompassed both theology and natural science or "natural philosophy," as it was then called) that they considered deviation from orthodoxy as heresy and treated those who did not conform with utmost severity.

... Persecutions began early. In the thirteenth century, the Franciscan monk Roger Bacon (c. 1214–1294) was victimized for his "scientific ideas." Bacon, one of the earliest pioneers of modern science, rejected the church's claim that "scientific truth" could legitimately be given by authority and proclaimed his trust in observation and experimentation instead. In the early fourteenth century Francesco degli Stabili (1267–1327), popularly known as Cecco D'Ascoli, professor of astrology in Bologna, had the temerity to direct his encyclopedic vernacular poem, "L'Acerba," against Dante's astrological theories and thus exposed his "heretical" views. He was condemned and burned at the stake in 1327. Nicholas Copernicus (1473–1543), in the same year he died, was able to have his revolutionary *The Revolution of the Heavenly Spheres* (which set out his helio-centric theory) published with relative impunity, perhaps because the Lutheran theologian Andreas Osiander (1498–1552) who took on the task of seeing the work through the press, added his so-called "Traitorous Preface." The preface which Osiander added emphasized that the Copernican system was only a convenient *hypothesis* for simplifying the calculation of planetary motion. Half a century later, however, when Giordano Bruno (1548–1600) proclaimed the theory as fact and united his Copernican ideas with pantheistic ones by which he hoped to reform the church, he was imprisoned for eight years, tried, condemned and finally in 1600, he was burned at the stake. The flames were fair warning to anyone whose theological and cosmic speculations were considered dangerous to the then revived Aristotelian teaching of the medieval church.

... The fire of the stake, however, was no match for the mind fueled by the scientific spirit. In 1609 Galileo Galiei's (1564–1642) telescope enabled him to see mountains on the moon, spots on the sun, and the satellites of Jupiter which, as they coursed around their mother planet like so many planets around the sun, seemed a proper analogy to the Copernican system. Whether because of the publicity accorded to Galileo's findings or not, in 1616 the same year Galileo's findings began to be public knowledge, the Holy Office officially condemned as heretical the proposition that "the sun was immovable in the center of the world and the earth revolved around it" and placed Copernicus' *Revolution of the Heavenly Spheres* on the *Index of Forbidden Books* accordingly. In the same year Galileo was summoned to Rome and was warned to regard the Copernican system as theory and not to propagate it as fact. Though Galileo was silent for a time, both his telescope and his reason prevented him from holding his tongue and, more specifically, his pen indefinitely.

... In 1632 Galileo published his *Dialogue Concerning the Two World Systems*. The book, written in Italian for all to read and with biting satire that few could miss, not only advocated the sun-centered universe but appeared to brand as silly anyone who was so simple as to continue to believe the earth stood still at the center of the world. The emerging "scientific world" was delighted; but the ecclesiastical authorities, whose world was threatened, were insulted and incensed by Galileo's audacity.

... Seven months after the *Dialogue* was off the press, Galileo was summoned to Rome a second time. There, in June 1633, under threat of torture, which the authorities probably did not intend to carry out, Galileo at age 73, being "vehemently suspected of heresy," was forced to kneel and to swear that he always believed and would hereafter always believe "all that which is taught and preached by the Holy Catholic and Apostolic Church." Coerced by the church authorities he pleaded to:

. . . wholly forsake the false opinion that the sun is the center of the world and moves not, that the earth is not the center of the world and moves.[10]

... Galileo knew that he had perjured himself. Whether or not, as tradition has it, he rose from his knees, stamped his foot upon the earth which he had just sworn stood still, and murmured, "*Eppur si muouve*!" ("It still moves!"), the Inquisition had triumphed. The truth of "revealed" authority had quashed that gained by scientific observation. Galileo's writings, which set out his scientific theories, were placed on the *Index*, off limits to the faithful. Henceforth the faithful were expected to entrust the understanding of both God and nature to the science of theology. Reason based upon experimentation and observation might lead to speculation about nature; truth, however, whether in the realm of theological science or natural science was considered to be given by revelation. It was a matter which was both ascertained and decided upon by the authorities of the church.

... To be both accurate and fair, it must also be noted that although eventually science for the most part developed under the auspices of Protestantism, (thus historian Herbert Butterfield could say that Protestantism became the "ally" of scientific civilization[11]) we know, too, that science and the scientists have sometimes been less than welcome to Protestant authorities. As early as 1539, four years before Copernicus' *Revolutions of the Heavenly Spheres* (1543) was published, Martin Luther, who was in Wittenberg where the Copernican theory was known, accused Copernicus of being "a fool" for insisting that "the earth moves and goes round, not the heavens or the firmament, sun and moon." Copernicus would, according to Luther, "turn the whole of astronomy upside down." Scripture, however, in Luther's opinion, knew better for "Joshua ordered the sun to stand still and not the earth" (Josh. 10:12).[12] We know, too, that Johannes Kepler (1571–1630) who studied theology but turned to science and "proved" the Copernican system with his three laws of planetary motion, was in trouble with his Protestant community over both his science and his theology. It is one of the ironies of history that Kepler's combination of Copernican Cosmology and Calvinistic theology made him more welcome among the Jesuits than among his Lutheran brethren.[13]

... Better known, and affecting us still, is the storm that arose among Christians over Charles Darwin's (1809–1882) publication of *The Origin of Species* in the year 1859. Darwin's detractors, who objected to the theory of evolution because it seemed to them to contradict the Genesis accounts of creation, had, in many instances, been convinced of the accuracy of Archbishop Usher's (1581–1656) chronology. By calculating the dates of events of history on the basis of the records of Scripture, Usher designed creation at 4004 B.C. So convincing was Usher's chronology that his dates were printed in the margins of some of the reference editions of the King James version of the Bible. Thus, there was *written evidence* that evolution, which according to *fossil evidence* required millions of years, was simply preposterous.

... Even prior to the publication of *The Origin of Species*, respected British naturalist and conservative Christian Philip Gosse (1810–1881) put forth his anti-evolutionary position in his famous *Omphalos* (1857). Being a naturalist Gosse knew about fossils which appeared much

older than the same 6000 years which according to Usher the earth was supposed to have existed. Being a Christian, however, Gosse argued in all seriousness that God had placed fossils in the rocks of the earth's crust to deceive us. God had created them when he created the earth in order to tempt us into believing in evolution and thus to test our faith.[14]

... The difficulty of reconciling the scriptural accounts of creation with the evidence of natural science is nicely illustrated by the fact that it was not until thirteen years ago, in 1969, that the General Assembly of our own church (The Presbyterian Church in the United States) officially concluded: "that the true relation between the evolutionary theory and the Bible is that of noncontradiction and that the position stated by the General Assemblies of 1886, 1888, 1889 and 1924—which had interpreted Scripture as being opposed to the theory of evolution—was in error and no longer represents the mind of our Church."[15]

... It is worthy of note to realize that the Assembly of 1969 was fully cognizant that its position differed not only from that of the Assemblies of 1886, 1888, 1889, and 1924, but that its decision most likely differed from the understanding of those who wrote the Westminster Standards as well. Hence the report reads:

It may be that the Westminster Divines understood the "six days" as well as such phrases as "of the dust of the ground" and "the rib of man" in a literal sense: but, as they were merely using the words of Scripture with no intention to argue the theory of evolution (of which they had never heard), we are free to interpret their words in a different sense, just as we now do the words of Scripture. Nowhere is the process by which God made, created or formed man set out in scientific terms. A description of this process in its physical aspects is a matter of natural science. The Bible is not a book of science. As John Calvin said, commenting on Genesis: "To my mind, this is a certain principle, that nothing is here treated of but the visible form of the world. He who would learn astronomy and other recondite arts, let him go elsewhere." (Genesis Commentary—on Chap. 1, verse 6)[16]

... It is to the credit of the 1969 Assembly that it was able to anticipate the concern of this paper it stated:

Our responsibility as Christians is to deal seriously with the theories and findings of all scientific endeavors, evolution included, and *to enter into open dialogue* with responsible persons involved in scientific tasks about the achievements, failures and limits of their activities and of ours. The truth or falsity of the theory of evolution is not the question at issue and certainly not a question which lies within the competence of the Permanent Theological Committee. The real and only issue is whether there exists clear incompatibility between evolution and the Biblical doctrine of Creation. Unless it is clearly necessary to uphold a basic Biblical doctrine, the Church is not called upon and should carefully refrain from either affirming or denying the theory of evolution.[17]

... After stating its conclusion "that the true relation between the evolutionary theory and the Bible is that of noncontradiction" which we mentioned above, the Assembly ended its argument by reaffirming the teaching of Genesis:

... We reaffirm our belief in the uniqueness of man as a creature whom God has made in His own image.[18]

... In view of the seriousness and the rancor of the one hundred year history debate between what many Christians considered to be the proper biblical understanding of creation, on the one hand, and the Darwinian theory of evolution, on the other, it should not come as a surprise to note that

even today the controversy has not really been laid to rest. Some Presbyterians still have trouble making distinction between the message of Scripture and scientific theory, the distinction called for by Calvin in the passage cited above. The emergence of the "creationistic" viewpoint among serious Christians in the last few years and the concerted efforts to influence state legislatures into mandating that public schools teach "creationism" as well as "evolutionism" are ample evidence of the fact that all questions in regard to faith and science have not been resolved.[19]

III. Theology's Distrust of Science

... The above survey, brief though it is, is evidence enough to indicate that science's distrust of theology is understandable. At the same time, theology may very well have grounds to distrust science. The reasons for theology's suspicion of science are subtle; they concern the structure of scientific thought as well as some of the conclusions which result.

... First of all, theology objects of science's representation of itself and its method as being all-encompassing and self-sufficient. In this mood, which thankfully is no longer universal among scientists, science considers that the only reality which exists, which is worth knowing about or can be known is that which science itself is able to know and to verify. Secondly, as mentioned above, there is growing concern about both the deleterious efforts of the application of science by way of technology to the world in which we live along with the fact that those in charge of the scientific and technological enterprise have not always been as candid as might be desired about the dangers of these effects.

... At another level, theology has become skeptical of science because of the allure of science itself. Science very easily becomes "sacred science" or "scientism." As "sacred science" it is all-inclusive, all-fulfilling and all-pervasive. Fulfilling the prediction of the French philosopher Auguste Comte (1798–1857), made over a century and a half ago, science has become the "new spiritual power" destined "to exercise an even greater influence over temporal affairs than did the church at the height of her influence in the Middle Ages."[20] In the words of the German physicist-philosopher C. F. von Weizsacker, science has developed into a "universal religion."[21] We believe in it, we trust in it, and, because of its benefits, we live according to its dictates.

... Since we also realize however, that scientific knowledge is constantly changing, what is considered right today may very well prove wrong tomorrow, we are becoming skeptical of this "new religion." We are beginning to realize that though science and technology remain indispensable for our continued existence, existence itself may be endangered by an over-evaluation and over-dependence on natural science as such.

... At the same time, we recognize that those who reject science and its achievements and issue the romantic cry of "back to nature" forget that the lives we live, and for the most part think we should continue to live, depend on science and technology. Thus, though, as we pointed out in Section B, I., there are arising among us today serious questions regarding many of the directions science is taking as well as to the price it demands for reaching its goals, there is no realistic possibility of rejecting it. Rather, it would seem that those of us who attempt to understand reality in light of the biblical perspective as elucidated in Section A, II above, may well want to adopt an attitude of cautious trust in science. Since science is here to stay if we are, it would seem that it would be most propitious for us to join in the effort of asking how science and technology are to be understood in light of the Christian faith, and how they are to be utilized for the benefit of humanity and the world. An examination of the roots of the development of science in the West may help us to understand that science and theology have more in common than is generally acknowledged.

C. THE PRESENT PERSPECTIVE

I. The Development and Promise of Post-Newtonian Science

Even though most of us still see our universe in Newtonian terms and construct our cosmologies and theologies accordingly, physics itself has long since left Newtonian thinking behind. The Newtonian-Laplacian world is the common-sense world. It is the world which Copernicus, Kepler, Galileo, Newton, and their successors taught us to accept and enabled us to understand and "see." All objects which are stopped stay stopped until something moves them; all moving objects continue to move out into space in "rectilinear directions" (straight lines) until something stops them. The planets, which were it not for the sun would fly off into space, are pulled into their orbits around the sun by the sun's gravity. So, too, the moon, were the earth's gravity suddenly to cease, would fly off in a rectilinear direction into space. Like the stone in David's sling, as long as David held both ends of the sling securely in his hand, the stone spun round and round in a circular orbit. When David let go of one end of the sling and released the stone when facing Goliath, the stone flew off in a rectilinear straight direction for Goliath's forehead and that was the end of Goliath. Who knows what the moon, if let loose by the earth, might collide with and put an end to?

Grounds for the questioning of the Newtonian worldview, in which all possible forces were supposed to have been calculated or at least were thought to be calculable, began to appear in the first half of the nineteenth century with Hans Christian Oersted's (1777–1851) experiments with electricity and Michael Faraday's (1791–1867) discovery of the electromagnetic field.[80] The behavior of the electromagnetic charges could not be reduced to the forces of inertia and gravity. They repelled as well as attracted. Bodies acted in relationship to their *charge* and the *square of the distance between them*, as well as in relationship to their *mass* and their *distance from one another*. The distance between them was found not to be empty but to consist of electromagnetic forces. Space became identified as a *force field*.

Mathematics for the new physics was supplied by James Clerk-Maxwell (1831–1879), who formed equations which noted Faraday's field but which deviated from the necessities of Newtonian "natural law." The new way of understanding the universe was advanced by Hermann von Helmholz (1821–1894), who equated light with electromagnetic radiation. Further, for Newton, space was supposed to have been filled with an "ether." The "ether" was presumed to be that mysterious medium which surrounded all bodies located in it, through which all moving bodies passed. It was supposed to vibrate in waves when radiation such as light was induced through Christian Huygens as to whether light consisted of waves or of particles.*

Further experiments showed that, while in some cases light behaved like a particle, in others it behaved like a wave. Louis de Broglie (1892–) seemed to add to the confusion by suggesting that, if light sometimes appeared to be "wave-like" and at other times "particle-like," then perhaps electrons and other "particles" could sometimes behave like waves. At the microcosmic level, then, nature appears to be self-con be dependent upon velocity.* A rod changed its length or a clock ticked at a different rate, in relation to its velocity as regarded from a particular point of reference. Jules Poincaré (1854–1912) summed up the gist of both the Michelson and Morley experiments and of Lorentz's calculations (transformations) by announcing that "ether" did not exist and that absolute motion was not detectable. The only way we know anything moves is to compare it with something else that is either "stationary" or moving at a different rate.

Next came Albert Einstein (1879–1955), whose two theories of relativity, the "Special Theory" (1905) and the "General Theory" (1915), changed both the face of physics and our

concepts of the universe. The special theory which brought to completion the more partial understanding of his predecessors followed Jules Poincaré's advice of ignoring the "ether" entirely and adopted the two assumptions by which he was able to derive Hendrick Lorentz's transformation laws. These permit two observers in uniform relative motion to predict the results of one another's measurements of distance, time, and mass.

According to Einstein himself, the special theory, on which the general theory rests, applies to all physical phenomena with the exception of gravitation; the general theory connects the law of gravitation and its relations to the other forces of nature.[81] Without going into much detail, it may help to explain that the special theory was built on only two principles: (1) the velocity of light in empty space is always the same "independent of the state of motion of the observer of the light or of the source of the light," and (2) the laws of nature as determined by any one observer are valid for any other observer moving in uniform translatory motion relative to the first observer. It was the necessity of reconciling the two principles that made it mandatory to modify the laws relating to space and time. . . .* It became clear, for instance, that the time a thing took place depended upon relating the event to a time-measuring device, a clock, or to an observer who could say, "I see it now," and who could relate his "time of seeing a thing" to someone else's "time of seeing the thing." The time that something occurred depended, then, on both the position of the event and the observer as well as relation of the movement of the event to the observer or vice-versa. As Einstein himself explained, a lightning flash would occur at one time to an observer standing beside a railroad track and at another time—earlier or later depending upon where the flash took place—to an observer on a moving train.

It also became clear that the shape of measuring devices and the rate at which clocks tick increases. Though this may seem incredible to us, it simply means that velocity affects time and space. If, for instance, one clock and one rod were placed in the center of a gigantic phonograph record—the rod being laid down perpendicular to the record's radius and a twin rod placed parallel to the first along with a twin clock were placed at the edge of the record—then if the record were spun so that the velocity of its outer edge were to approach the speed of light, when observed from the center of the record, the outside clock would be seen to lose time and the outside rod would be seen to shrink in length.

*** There appears to be missing material in this sentence.**

"The special theory of relativity," as Einstein stated, "which was simply a systematic development of the electro-dynamics of Clerk Maxwell and Lorentz, pointed beyond itself."[83] It pointed to the general theory which
combined the principles of gravity and inertia. Again, according to Einstein, "the geometrical behavior of bodies and the motion of clocks depend on gravitational fields which, in their turn, are produced by matter."[84] In light of the
general theory, Einstein said, "We talk of the curvature of space."[85] "Hence, concepts of 'straight line,' 'plane,' etc. . . lose their precise significance in physics."[86] Consequently, Euclidean geometry, with its straight lines and triangles of precisely 180 degrees, by which one had heretofore defined the properties of space, had to be abandoned.

Though the general theory has not been proven in all particulars, three experiments which support it are: (1) "The revolution of the elipses of the planetary orbits round the sun," (2) "The curving of light rays by the action of gravitational fields," and (3) "A displacement of spectral lines toward the red end of the spectrum in the case of light transmitted from stars of

considerable magnitude."[87] The revolution of the elipses of the planetary orbits round the sun (that is, the egg-shaped orbits of the planets slowly turn so that their parahelion—the flattened curve of the orbit where the planet is nearest the sun—slowly makes its way round the sun in the direction of the planet's motion) was proved in the case of Mercury. The curving of light rays by the action of gravitational fields has been proven in cases of solar eclipses. Light from stars which, when measured rectilinearly, were behind the body of the sun could be seen because the sun's gravity curved the light from the stars around it enabling the light to reach the earth and the stars to be seen.

While the velocity of light in space is a constant (300,000 km/sec), the wave-length (i.e., color) of light seen by an observer depends on two other factors. The first is whether the observer and the light source (i.e., a star or galaxy) are approaching one another or are moving away from one another. The second is the relative velocity between the observer and the light source. If the source and observer are approaching one another, the light appears shifted toward shorter wave lengths ("blue" shifted). If the source and the observer are moving away from one another, the shift is to longer wave lengths ("red" shifted). Since the greater the velocity the more drastic the shift, astronomers can use the Doppler effect to measure the velocities of the movement of galaxies relative to earth.

In that light reaching us from distant galaxies is indeed "red shifted," astronomers conclude that the groups of galaxies are all flying away from one another. Since light from the more distant galaxies is shifted further toward "red" than light from the nearer ones it is concluded that the more distance the galaxies, the faster they are expanding away from us. Our nearest neighbor is the Andromeda galaxy, roughly 1.5 million light-years from us (a "light-year" is the distance light travels in space in one year—about six trillion miles) and it is constantly moving away from us.

Thus, we live in an astounding universe. First, since the galaxies appear to be racing apart from one another, the universe is expanding. Second, since something had to initiate this expansion, scientists hypothesize that the universe must have begun with a gigantic explosion and the inertia from this explosion continues to drive the galaxies apart from one another at an ever-increasing rate. If this hypothesis is accepted, this explosion (labeled the "Big Bang") involved all the matter in the universe and must have occurred about 15–20 billion years ago. Though the "Big Bang" theory of the origin of the universe was not accepted by scientists generally any more easily than was Einstein's theory of general relativity, the fact that in the 1950's radio-astronomers at Bell Laboratories discovered a "background" radiation of *just the kind which had been predicted* would have to exist if a "Big Bang" had occurred has made acceptance of the theory widespread.

Today there is even speculation that Big Bangs repeat periodically, that is, that the matter in the universe will not fly apart forever but that eventually the pull of gravity will overbalance the force of inertia and the universe will reverse its direction and begin to pull together. When it forms into a single, unbelievably compact mass, the gravitational pressures force all matter into such a dense quantity that another Big Bang will occur. If such is the case, we have an "oscillating universe" which continually recycles with a new Big Bang every 60 billion years or so. Other alternatives are that the universe will continue to expand forever or that it is a "steady state" and only appears to expand because we do not know how else to explain the "Doppler Effect."

Since the oscillating universe theory which seems most exciting to many scientists today depends on there being sufficient mass in the universe so that the mutual gravitational attraction can overcome the inertia of the galactic clusters which are presently flying apart from one another, there is an intense search for both inter-galactic matter and matter within the galaxies which is of extremely high mass. This accounts for the immense current interest in "black holes" which are "black" because they have such high gravitational force that not even light can escape them. They could provide for a great amount of mass not presently observed. Other investigations are directed toward "quasars"—objects which are thought to be extremely massive and which emit an incredible amount of radiant energy (it is not known how) and which lie at distances up to billions of light-years away from us.

While both the relativity theories and astronomical discoveries confound our general view of the universe, the most fundamental revision of Newtonian science, and hence of the way we understand reality, a revision that is most difficult for many scientists to accept, has come from investigations into the microscopic world of atoms and elementary particles. In 1900, Max Planck (1858–1947) found that he could successfully explain the nature of the radiation emitted by a hot object ("black body radiation") by assuming that the light energy was emitted in "Bundles" (discrete packets). This idea, as experimentation showed, was quite incompatible with Newtonian physics. These packets, or "quanta," as Einstein was to name them, were the basis for Planck's discovery of the universal constant "h" by which the units of all energy whatsoever including that of light can be measured.

Because light, which is a form of radiation, had been regarded as wave-like since Christian Huygens' (1629–1695) experiments in the seventeenth century, Planck's discovery was revolutionary indeed. It was so revolutionary, in fact, that, though in 1918 he was awarded the Nobel Prize for discovering black-body radiation, he at first did not accept the reality of his own assumption. Rather, he regarded it as a "trick" necessary to explain nature.

The first to advance upon Planck's theory was Einstein who in 1905—the same year he propounded the theory of special relativity—hypothesized that light consists of "quantized" amounts of energy. By showing that the energy of the electrons emitted from a metallic surface illuminated by incident light was proportional to the frequency of the light involved, Einstein's theory explained that light behaves in a particle-like fashion. Even more important, Einstein was able to show that the proportionality between the kinetic energy of the ejected electron and the frequency of light involved was Planck's constant "h." The formula was responsible for Einstein's receiving the Nobel Prize in 1921 and for reopening the old controversy between Newton and Christian Huygens as to whether light consisted of waves or of particles.

Further experiments showed that, while in some cases light behaved like a particle, in others it behaved like a wave. Louis de Brogilie (1892–) seemed to add to the confusion by suggesting that, if light sometimes appeared to be "wave-like" and at other times "particle-like," then perhaps electrons and other "particles" could sometimes behave like waves. At the microcosmic level, then, nature appears to be self-contradictory. Nevertheless, this wave-particle "duality" was not only confirmed by experimental investigation but it has practical application. The construction and function of electrons.

Perhaps the most intuitive feature of quantum mechanics was Max Born's (1882–1970) "concept of probability" which he formulated in 1925. According to the probability theory the predictability of each particular was set aside in favor of a *predictable pattern* of an aggregate of events. In Newtonian science it was believed that, if conditions were specified, one could predict

the time evolution of a system with confidence because the behavior of each event was *determined*. With Newtonian physics, for example, solar and lunar eclipses could be successfully predicted to almost the second. Such is not the case when dealing with atoms and sub-atomic particles, however. According to present understanding prediction at the atomic and sub-atomic levels is impossible. Hence, as understood from a microcosmic point of view, nature, as we usually view it, itself appears to show a lack of determinism.

This lack of determinism is nicely illustrated by a sample of a radioactive substance. A sample contains many (billions of billions) atoms which, as far as can be determined, are identical in every aspect. In a certain period of time (the half-life) $^1/2$ of these atoms decay, emit radiation, and thereby change their nature. There is no way, however, that one can predict *which* of the atoms will decay. A single atom has a *probability* of $^1/2$ that it will decay during one half-life, and every atom has exactly the same probability. Which of the individual atoms decay is non-predictable and, as far as we know, is a matter of chance.

In 1927 Werner Heisenberg (1901–1976) attempted to bring some kind of order to the ensuing "chaos," by advancing his "Principle of Indeterminacy." From it the dual wave-particle nature of matter could be derived. According to Heisenberg's principle, it is not possible to determine simultaneously both the position of a body and also its momentum (mass x velocity). To the extent that position is determined, the momentum will be unknown and vice versa. Since the uncertainty principle places a definite numerical lower limit on the product of the uncertainties of the two, that lower limit being the ever-present constant "h," it assures us that an electron for instance will never behave *simultaneously* like a wave and a particle. When its position is measured, it behaves like a particle; when its momentum is measured, it behaves like a wave. Whether electro-magnetic energy exhibits particle-like or wave-like behavior depends on what is being observed and even more importantly, as far as our understanding of reality is concerned, whether energy acts like a wave or a particle, *depends upon the choice the observer makes as to which aspect of energy is to be observed*. The energy under observation cooperates and is observed to behave accordingly. Thus it seemed that our world would consist of wave-like energy if we wanted it to be so and particle-like energy if we chose otherwise. Mind and matter thus appeared no longer to be completely separate.

In 1927 also Niels Bohr (1885–1962), who was Heisenberg's teacher, confirmed and utilized Heisenberg's Principle of Indeterminancy by putting forth his Principle of Complementarity. According to Bohr, the particle "aspects"of energy and the wave "aspects"of energy, contradictory though they were, had to be understood as *complementary* to one another. Only in this way could we again have a concept of reality which would continue to make sense to us. Logic had changed. Rather than contradictory concepts as viewed in Newtonian physics excluding one another, contradictory concepts, which valid means of investigation showed to be equally necessary, had to be held together in our minds as complementary parts of our understanding of reality.

Most physicists who had grown up on a diet of predictability found the concept of probability, uncertainty, and complementarity difficult if not impossible to accept. It was thought that the inability to predict which atoms would decay in a radioactive substance was simply the result of our incomplete knowledge of the atom and that uncertainty was only a matter of ignorance. Surely, if we knew everything about an atom, we could predict when decay would occur; and the time would come when we would be able to predict the location and momentum of a particle simultaneously and with certainty. Einstein himself expressed his faith in a logical

ordered and eventually predictable universe saying, "God doesn't play dice." To date, however, we must conclude that nature has forced us to acknowledge that singular events at the microcosmic level cannot be understood as being determined. Rather, according to our best understanding, there is a *chance* involved that appears to be of the nature of reality itself. Thus, contrary to Einstein, Stephen Hawking, a black-hole specialist, is recently reported to have quipped, "God doesn't only play dice, but also sometimes he throws them where they can't be seen."[88] What Hawking means is not only that certain basic aspects of our universe seem to be matters of chance; he means also that we simply have not been given the evidence as to what makes the totality of the universe tick. Over against Einstein, experimental evidence has so far supported quantum mechanics and it is presently considered "correct"—that is, it is the best understanding of nature that we have available to us.

Since it would seem that most theologians work in ignorance of the implications of the way modern science discloses the physical universe (an ignorance that in one way or another is bound to lead to misunderstanding), a few points of modern science that should be of mutual interest to scientists and theologians may be worth mention.

1. *Our scientific knowledge of physical reality is totally dependent on our observations and measurements*. While Isaac Newton began his *Principia* with sweeping statements as to the nature of time and space which he "knew" to be undebatable and held by everyone in common, Einstein has forced us to recognize how our knowledge of time, space, and other physical concepts is *acquired*. In science, therefore, one should avoid hidden assumptions concerning the nature of reality and hold only to those which the data of experiment allow.

2. *The observed behavior of nature is influenced by the observer*. In order to gain knowledge about a system, one must interact with it. Though this was recognized to a certain degree before 1900, it was thought that, if the scientist exercised sufficient caution, the effect of the interaction could be made as small as one wished. Heisenberg's indeterminancy principle, however, now puts a definite numerical lower limit on the effect of the interaction on the system when a desired observation is made. The result is that the observer must be considered a part of the system rather than an outside onlooker who simply subjects reality as an object to himself.

3. *Strict causality, as expressed by Immanuel Kant, his predecessors, and successors until the twentieth century, is routinely violated in nature*. In our earlier example, two atoms of (say) radium may be completely identical (in the sense that every possible measurement or observation yields the same results), yet one of them may decay long before the other. Since causality in nature can no longer be considered intuitively obvious, as it was for Kant, for instance, the question is raised as to what other "intuitively obvious" concepts may be false.

4. *The Principle of Uncertainty indicates that not only is there no perfect predictability of particulars in nature, there is also no way that we can grasp the complexities of nature at a single instant*. The explanation of reality entails the elucidation of the history of the explanation including that of the method followed in reaching it. This means that all knowledge, that of nature, and also that which seeks to understand God is never whole; it is at best partially adequate. Its rendering of truth is as good, but only as good as the method by which that rendering was made. Only by telling and retelling the history or tradition of the understanding of that truth including the epistemology behind it does the "truth" become and/or remain viable.

5. *The Principle of Complementarity does not mean that there are two valid sides to every question or that the logic of contradiction is* passe. Rather, the Principle of Complementarity indicates that when there are two sides which, in the face of every possible objection and test

continue to persist, both sides must be recognized as being equally valid in spite of their being inconsistent with one another, in the classical sense.

6. *All sciences, including the science of theology, demand a precise and consistent method, a method which is both appropriate to its object and which may produce different answers in different times*. In the case of theology God is the object. He is a peculiar object, however, in that he is first of all the subject, the one who addresses us before we can know or understand him. Theology is the response to that address. It tests the validity of its conclusions on the basis of the record, the tradition of God's past address. Because it knows that the record is influenced by the circumstances of those who heard and who wrote what they heard in their own time, theology is open to changing its conclusions in the light of hearing and possibly new understanding in the present.

The lesson of science—a lesson illustrated by the above, a lesson that should be the subject of discussion among scientists, theologians, and philosophers—is that from all we know, the universe is both amazing and complex in nature. Einstein has noted that the most remarkable thing about nature is that we are capable of any understanding of it at all, even if not with complete knowledge. However, whereas two hundred years ago, scientists as well as philosophers and theologians thought the universe was a very orderly place—complex in its magnitude, but governed by deterministic laws, and evolving with the predictability of a clock, we are today very cautious in our statements about how the universe behaves. The universe continues to tick but we know with some certainty that it doesn't tick like a clock.

The more we learn about the universe, the more we learn that we have much more to learn. Our systems are adequate only to a certain degree. Our thinking is open-ended; the more we know, the more certain we become that there is mystery which is beyond our knowledge. As in theology, so now in science also we see, but we see in a glass darkly. Though within limits we can gauge the results of certain processes, we cannot predict from what we know all that is yet to be. The future is open-ended.

II. The Restrictions of Finitude

... Finitude itself presents both a problem and an opportunity to which some of the six points mentioned above point. It is indeed a significant cause of both. We know that Cardinal Nicholas of Cusa (c. 1401–1464) was quite wrong when he conceived of an infinite universe as a proper correlate of the infinite God. We know, too, as emphasized above, that Laplace was wrong in thinking that, if we knew the position of a single particle and the forces that were exerted upon it, we could extrapolate reality forward and backward from a never-begun beginning to a never-ending end. Physics itself, as indicated by the Heisenberg-Bohr theory, makes us realize that precision in measurement of one aspect of reality stands in inverse proportion to precision in another and that the path of an energy particle from source to target can neither be predicted nor precisely traced.

... Jacob Bronowski has pointed out that our equipment of brain and senses is simply not adequate to know nature easily or adequately.[89] This crisis of finitude goes more deeply than that, however. The crisis is not only one of difficulty or inadequacy but, as in quantum physics, there is a crisis of contradictory evidence. Not only does the universe give us inadequate answers, but also the answers it gives are at times incompatible with one another. We do not know what is true and right in all particulars. Thus, the universe is beyond our ken and our ken is split down the middle and does an about face on us. The more we know of and concentrate on any one aspect of reality, the more certain we are to be ignorant of and to miss and neglect other

equally important and equally vital parts of the world. Hence, our knowledge is inevitably limited and inadequate. If it is precise and covers the gist of any particular phenomenon, it may well be contradictory with regard to other equally important and equally well-founded phenomena.

... In addition, since again as quantum physics shows us, we "see" the universe in accordance with the way we set up our apparatus to "see" it, within limits the universe complies with our choices. The Cartesian subject-object split which projects the mind as completely separate from the world and the world as completely separate from the mind no longer holds. Rather, reality responds to our approach to it. To an important degree the universe behaves toward us according to the action we take toward it.[90]

... In short, quantum physics would seem to indicate that there is some degree of mind-matter interaction. How, then, do we proceed without being bound and gagged by seeing a thousand contradictions to every proposed solution? We proceed by understanding that the view which we have, whether in science or theology, is essentially a matter of "faith." Though there are contradictions in the way the universe appears to us, we have, as Einstein has said, a basic faith both in a fundamental rationality which is shared by both the *universe* and *our minds*. The structure of nature and of the mind accord with one another to a degree that the universe makes sense to us. If it appears to be nonsense then we search both nature and our minds until new factors, or reappreciated old ones, come into focus so that our explanation of reality can again "make sense." In this way we can see that the basic faith of the scientists is analogous to that which Augustine applied to theology, *fides ut intelligam* (faith leading to understanding).

... In science we *believe* the universe is such and such a way, and we gather evidence to support our belief. Sharing that *conviction* with others, along with the explanation of method we have used to "prove it," we invite and/or challenge the community of scientists *to believe* as we do and to check out that belief with their own experiments. Once the scientific community became *convinced* of the Copernican system, for instance, the Ptolemaic system was seen to be inadequate and was set aside. When Einsteinian relativity was recognized as being more adequate than Newtonianism, the Newtonian system was seen to be valid only as a limited case and then only in situations where ultra-precise measurements could be disregarded. In this way, science has uncovered and continues to uncover reality, to revise old theories and discover new ones. As Einstein put it in his obituary to Ernst Mach:

. . . concepts which have proven useful in ordering things often acquire such authority as to seem "inevitable," "necessary," and even "*a priori*." If we remember their human origins, however, the conditions on which their usefulness and justification depend and their relationship to experience, then their "exaggerated authority" is broken. They may then be removed if they do not legitimate themselves, corrected if their correspondence with given experience was too careless, replaced by others if a new system which we prefer for good reasons can be developed.[91]

... As in the Reformed tradition, the church as well as theology live under the banner *ecclesia reformata, semper reformanda*, the church reformed always in the process of being reformed, so science, too, is always being reformed. Understanding of truth, therefore, is always incomplete, somewhat inadequate, even contradictory at points, and always open to revision. While both in science and theology we can *conceive* of truth as ultimate, in our finitude we cannot know the truth either finally or absolutely. Therefore, in science as in theology, we live by faith and not by sight.

III. The Way Ahead

... Finitude itself, then, is one of the causes of our continuing crises and a basic constituent of any solution which seeks to respond to them. We do not know nearly enough and some of what we know contradicts other equally important aspects of knowledge. Thus, in addition to the crisis of will—not doing what we know we should—we have a crisis of perception—not knowing what we should do. To paraphrase the Apostle Paul, and use concepts of faith as analogous to those of science, it is not only that "we do not do the good we want" (Rom. 7:19), but also we do not know precisely and in all particulars what is good. Since, however, as we said early on, we are convinced that God who creates and saves the universe endows reality with stability, and history with meaning, we understand the challenges to our present knowledge as opportunities to dig more deeply into the mystery of reality. In doing so our minds may be opened to that which is as yet undisclosed to us. We have confidence in our method not only because "it works" but because we are convinced that God who separates light from darkness and reality from chaos intends that we, who are to dominate and care for the world, are built to understand it. That understanding is the way that we in a scientific mood may understand the sustaining mercy of God for which the Apostle Paul is eternally grateful. Hence, we, like he, may trust that God, who has begun a good work in us, will bring it to completion (Phil. 1:6). In the meantime, we may also be encouraged, as was the Apostle Paul, that grace is sufficient for us (2 Cor. 12:9) and that it will be possible to fight the good fight, finish the course, and keep the faith (2 Tim. 4:7).

... Thus we may move forward with confidence. To move forward with confidence, however, means to trust in *justified knowledge*, knowledge we have learned to depend upon, knowledge which has been "proven" according to the most stringent criteria available to us, knowledge which takes into consideration as wide a spectrum of human experience as possible. Knowledge thus given and substantiated must utilized. It must be used because only if it is used will it continue to be viable and be the basis for yet additional knowledge. Only if we use the knowledge that science and technology afford us will we be able to sustain the world as we know it and acquire the knowledge and technology necessary to sustain it in the future. The world thus sustained includes ourselves; utilization and pursuit of knowledge are thus basic to survival.

... We must then use our knowledge to intervene in the world. We must use technology. We must, however, intervene with caution for at least two reasons. First, we know that every time we do one thing we neglect doing another which may be of equal importance. Second, we know that every solution to a problem we solve will itself be the cause of another problem which will have to be solved. Hence, there are no ultimate solutions; there are only solutions applicable to a particular time and place. We proceed with caution, also because every solution is costly and to a certain degree unpredictable.

... Small solutions reflecting our actual state of humility rather than grandiose ones would thus seem most advisable. We ought to try developing appropriate technology that is as environmentally friendly as possible and *fits* the situations for which it is designed. The use of the term *fit* means that the design of any solution must be made in relationship to the whole *understanding grid* of time, place, and culture for which that solution is designed. Besides material and energy factors, human ecological and human concerns, that grid includes the value structures of a society, social, political, and economic considerations—in short, all the varied aspects that make up the particular life pattern which the "*solution*" is going to affect and thus alter. E. F. Schumacher's technology of "appropriate size" and "with a Human Face" points in this direction.[92]

... Solutions to problems demand energy. Really they demand the transfer of energy, whether mental energy, motive energy, or material energy. Energy is not created or destroyed; it is only gathered and distributed. The gathering and distribution themselves use energy. To use it is to cause its flow from centers of higher concentration to centers of lower concentration. However, as long as we live, we have no choice but to contribute to that process. Added to this is the realization in our time that the sources of energy we are now tapping are in finite supply. Thus, we must count the cost of all interventions into nature and take stock of the situation using the best knowledge available to decide if and how intervention should proceed.

... It is also because of our finitude, because we do not really know enough and that which we know is somewhat contradictory, that the dialogue between science and theology which, as mentioned above, the 1979 General Assembly recognized as important must go on. The conversation must go on, because theology ought to be able to provide some guidance for science and technology. Theology ought to be able to provide the basis for concern for the whole of reality which natural science does not necessarily have on its own. The conversation must continue, because it is only when we see science in a theological perspective and theology in a scientific perspective that either discipline can possibly approach an appropriate level of relevance and universality. In this way we may respond to the biblical mandate that every member of the human race accept responsibility to participate in caring dominion over creation.

... The crises which we mentioned in the introduction—energy, environmental, social and political—must, of course, be overcome. This will involve a whole roster of ethical decisions. Our technology is on trial. We cannot live without technology, but we already have evidence that even our present technology endangers the totality of life on earth. A new faith-science perspective may enable us to gain a new environmental-technology perspective which could well affect the way we both think about and interact with the world.

... Since we are finite and limited, the more grandiose the solutions we attempt the greater may be their possibility for good but also the greater and the more irreversible will be the flaws of the consequences which they will inevitably entail. Since we are finite, our knowledge finite and our technology finite, appropriate solutions even though put forth with boldness will be characterized by finitude. They will be solutions which are appropriate to a finite universe. As Professor Georg Picht has put it:

... The dream of the unlimited possibilities was a mad illusion.
... The technical world is a world of dreadful limited possibilities.
... The hungry millions will not be able to migrate to another star.
... The resources on the earth are not inexhaustible.

The faster the expansion of science and technology is driven forward, the faster it reaches its non-transgressible limits.[93]

... This does not mean that as Christians we give up hope in the midst of crisis. Rather, from the perspective of faith, the crisis itself can be seen as a sign of hope. It is only because we realize *the mess we are in* that we are put in a position of having to seek solutions for the mess. At a deeper level, it is only because we realize that other solutions may be possible besides the ones that do not seem to be working at the present, that we see *the mess we are in* in the first place. It is hope and a vision of a *better world* which raise our anxiety about the condition of the world today. It is because we know that the future can be better that we find the present less than satisfactory. It is, as the Apostle Paul put it, because we have the first fruits, that allows us to anticipate the harvest to come.

... What is needed is not only the employment of the rationality we now know. We need a new rationality, a *faith-informed rationality* applied to science and a *science-informed rationality* applied to faith. As our decisions in science may then be made in the light of faith, so our thinking in the faith may be carried out with the rigors employed in the scientific method. Faith and science thus complement one another. Faith gives us hope for survival, survival in the sense not only of life but of an acceptable level of life for everyone, and the motivation to achieve conditions for that kind of survival. Science provides the tools intellectual and material, to get on with what we have to do.

... We may balk at the enormity of the task. We may even be tempted to see the impossibility of accomplishing it. However, to follow the Apostle Paul in another context, though we may be afflicted, we are not crushed and though perplexed, we are not given to despair (2 Cor. 4:8). We remain convinced that he by whom all things were created continues to sustain creation by holding it, along with us, in relationship to himself.

... He is the image of the invisible God, the first-born of all creation;
... for in him all things were created, in heaven and on earth, visible and invisible,
... whether thrones or dominions or principalities or authorities—
... all things were created through him and for him. He is before all things,
... and in him all things hold together. (Col. 1:15–17)

Notes

A. C. P. Snow, *Two Cultures and the Scientific Revolution* (New York: Cambridge University Press, 1959).
3. Georg Picht, "Umwelschutz and Poltik," *Zeitschrift fur Rechtspolitik*, Jg., Heft 7 (1971), 137, cited by A. M. Klaus Müller, *Die paraparierte Zeit* (Stuttgart, Radius verlag 1970), p. 596.
4. Alfred North Whitehead, *Science and the Modern World* (Cambridge: University Press, 1926), p. 3. Herbert Butterfield, *The Origins of Modern Science 1300–1800* (London: Bell and Sons, 1949), p. 174.
5 .The biblical account of creation stands in sharp contrast to the Babylonian *Enuma Elish* where the gods are born out of pre-existent chaos.
6. Lynn White, "The Historical Roots of Our Ecological Crisis," *Science*, 155:3767 (10 March 1967): 203 ff.
7. Cf. Robert Nelson, *Science and Our Troubled Conscience* (Philadelphia: Fortress, 1980), 72 ff.
8. Walter R. Thorsen, "The Spiritual Dimensions of Science," *Horizons of Science*, ed. C. F. H. Henry (San Francisco: Harper & Row, 1978), p. 231.
9. Friedrich Oehlkers in a speech at the University of Freiburg, 1957.
10. J. J. Fahie, *Galileo, His Life and Work* (London: John Murray, 1903), pp. 319 ff.
11.Butterfield, *Origins of Modern Science*, p. 181.
12.Quoted from Luther's "Tischreden," Kap. L by Herbert Meschkowski, *Das Christentum imJahrhundert der Naturwissenschaften* (München: Ernst Reinhardt Verlag, 1961), p. 86. The English translation of Luther's statement in *Table Talk*, Luther's works, Vol. 54, ed. and trans. T. C. Taggert (Philadelphia: Fortress, 1967), p. 358, which dates the statement June 4, 1539, softensLuther's original language.
13.This may explain Butterfield's statement that Kepler was "persecuted by the Protestant Faculty at Tübingen" and "actually took refuge with the Jesuits in 1596." Butterfield, *Origins of Modern Science*, p. 57.
14.Gosse, who was a respected naturalist in his day and who was later elected to the British Academy, was a member of the conservative Plymouth Brethren. Cf. Meschkowski, *Das Christentum*, pp. 85 f.
15.*Minutes of the General Assembly of the Presbyterian Church in the United States*, 1969, p. 61.
16.Ibid., p. 60.
17.Ibid., pp. 60 f. Italics added.
18.Ibid., p. 61.
19.The article on "scientific creation," entitled "In the Beginning" by S. David Carriker in *PresbyterianSurvey*, Vol. 10, No. 11 (1980), 26 ff. is to the point. It should give those who desire to prohibit theteaching of Darwinian evolution in the classroom pause to realize that the most vivid example ofsuch prohibition took place in the Soviet Union. Under the influence of the Russian agronomist Trofim Denisovich Lysenko (1898–), head of the Institute of Genetics of the Soviet Academy ofSciences, the theory of natural selection, which was considered to be in contradiction to communistdogma, was put in disrepute. The result was that Soviet biology and agricultural advances, whichdepend on the application of the principles of "natural selection" were held back for thirty years.
20.August Comte, "Considerations sur le pouvoir spirituel" (1826) cited by Stanley Jaki, *TheRelevance of Physics* (Chicago: University of Chicago Press, 1970), p. 469.

21.Carl Friedrich von Weizsäcker, *Zum Weltbild der Physik* (Stuttgart: H. Hirzel Verlg, 1970), p. 260.
80.Albert Wells, *The Christian Message in a Scientific Age* (Richmond, Va.: John Knox Press, 1962), pp. 41 ff.
81.Albert Einstein, *Essays in Science* (New York: Philosophical Library, 1934), p. 55.
82.Ibid., p. 56.
83.Ibid., p. 57.
84.Ibid., p. 58.
85.Ibid.
86.Ibid.
87.Ibid., p. 59.
88."The Unfettered Mind," *Science 81*, Vol. 2, No. 9 (Nov. 1981): 73.
89.Jacob Bronowski, *Magic, Science and Civilization* (New York: Columbia University Press, 1978), p. 44.
90.Cf. Bernard d'Espagnat, "The Quantum Theory and Reality," *Scientific American* (Nov. 1979), pp. 158 ff.
91.Albert Einstein, "Obituary to Ernst Mach," *Physikalische Zeitschrift* 17 (1916), 101, somewhat simplified in translation.
92.E. F. Schumacher, *Small is Beautiful* (New York: Harper and Row, 1974), pp. 63 ff.
93.Georg Picht, *Prognose, Utopie, Planung* (Stuttgart, Ernst Klett Verlag, 1971), p. 40.