BOUNDARY ISSUES IN SCIENCE: AN HISTORICAL APPROACH[*]

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Some years ago I had the opportunity to attend an extended seminar on the relationship between science and religion, funded by the Templeton Foundation. While most of the talks were quite interesting and informative, I felt somewhat out of place and initially did not realize the source of this sense of displacement. Then toward the end the week, during a discussion period, a Jewish theologian rose to make a statement. Like me, he had also found the talks very interesting but pointed out that most were given from the perspective of American Protestantism and, as a consequence, some of the issues discussed were irrelevant to him whereas other issues that were important for him were not discussed at all.

I immediately identified with his position and realized that as a Swedenborgian Christian my situation as an outsider was analogous to that of the theologian. For example, because Swedenborg's Writings strongly emphasize the spiritual internal sense of literal Scripture, it seemed that the issue of whether the seven days of creation were real days or general stages in physical creation was a non-issue. Yet for most of the conferees, Biblical literalism is a resurgent and important part of twentieth century Protestant fundamentalism.

The question then arises, "Are Swedenborgian Christianity and conventional Christianity like two ships that pass undetected in the night?" In the discussion of science and religion the answer is primarily a negative one. There are many issues in common, although possible resolutions of a

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given issue may differ. Age old concerns such as how God created the world, how God interacts with the His creation, and so forth are of mutual concern. Furthermore Swedenborgian Christians are keenly interested in new developments, such as the Intelligent Design movement, that seem to point more rigorously to a created universe.

Another part of the picture is that Swedenborgian Christians have tended to isolate themselves from traditional theological/philosophic studies and have created their own formats for discussion. Thus, they are often unaware of or reinvent existing arguments and points of view which may have bearing on their own discussions.

In this paper, I ultimately suggest some limitations of science in regard to the science/religion context. This is done within an historical survey of the general contours of the science/religion relationship. The historical emphasis is important as history shows science as developmental, in regard to both methodology and purview. I focus particularly on physical science and then on evolution. Once the historical context is established, I summarize the limitations of science and finally suggest where the recent phenomenon of Intelligent Design might fit into the discussion. Other Swedenborgian scientists might reach different conclusions.

I. INTRODUCTION

The relationship between science and religion has a history that extends back to the beginning of modern science,[1] perhaps to the time of Galileo's unfortunate interaction with the Inquisition. From that epoch to the present, the relationship between the two has been somewhat benign with sporadic flair-ups of hostilities as punctuation to more or less ongoing dialogue or separate monologues. Almost universally, early scientists held religious beliefs that often affected their more global interpretations of the natural world. Contrariwise, by the twentieth century, scientists tended to leave the possible metaphysical implications of science to the

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[1] We are making a distinction between science as modern science and that earlier version of the study of nature that goes back to the ancient Greeks, such as is exemplified by Aristotle's *Physics.*

philosophers. For the most part, the science/religion discussion was left in the hands of philosophers of science and theologians.[2]

In recent years, introduction of the notion of Intelligent Design has been catalytic in producing another round of hostilities between self-appointed spokespersons who purport to represent science or religion, but may represent only personal views. The problem is exacerbated by fundamentalists on both sides. On the science side, for example, naturalists seem to co-opt center stage and argue that all reality should be treated only scientifically, because all reality is material and therefore subject to scientific scrutiny. Any considerations that ideas other than scientific ones are valid sources of knowledge are immediately discounted as either foolish or mendacious. There are many problems with this philosophical position, but contrariwise, on the religious side, Christian fundamentalist/literalists have taken rigid positions that ignore the vast body of solid scientific evidence which manifestly contradicts some of the "scientific" statements in Scripture. This sort of isolationism, interrupted by occasional verbal salvos, is not helpful to those who see merit in both religion and science as sources of vital human experience and wisdom. The search for truth should be done in the spirit of willingness to consider innovative ways of thinking about both scientific and religious ideas.

The position I take is that the scientist can be religious, and that the theologian can understand and respect the work of scientists. Religious scientists in an earlier day spoke of there being two books of revelation: Scripture and Nature. Emanuel Swedenborg wrote of the two foundations of truth: Revelation and Nature.[3] Prominent scientists from Newton's time through the British nineteenth-century movement of natural theology automatically assumed that scientific study of nature was to the further glory of God.[4] While the twentieth century brought a more naturalistic attitude, there are still many scientists and theologians who see science

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[2] There are a few writers who have experience in both science and theology. Included in this select group are John Polkinghorne (physicist and theologian), Stanley Jaki with doctorates in both physics and theology, and Arthur Peacocke with degrees in both chemistry/biology and theology.

[3] Emanuel Swedenborg, *Spiritual Experiences*, § 5709.

[4] For a summary of this thought, see chapter 2 of John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford University Press, 1986).

and religion as coming from a single wellspring. In the minds of these thinkers, science and religion are, in some profound sense, both connected and complementary. As a Swedenborgian Christian and practicing physicist, the author shares this view.

Section II of this paper provides a brief history of science in order to survey the various ways that science has been viewed since its tentative beginnings in the sixteenth century. In this way we develop some sense of the limitations of science which, at first sight today, seems like a set-in-concrete means of gathering truth.

Science is a human endeavor, and while the practice of the "scientific method" has developed over several centuries and with various discipline-dependent emphases, it seems important to understand the possibilities for variation and change in the method. What might have been acceptable science three centuries ago might not be acceptable now. And similarly, the contours of science in the future might be different from current practice. Furthermore, formal studies in the philosophy of science often speak of scientific *methods* because one methodology may not be universally applicable to all branches of science.

Section III of the paper looks very briefly at how scientists and others have viewed science and its possible theological connections. Special emphasis is placed upon the idea of design in both its earlier version as natural theology and its current manifestation as intelligent design (ID).

Finally, section IV examines the subject of issues in science and religion through the filter of Swedenborg's theology in the hope that such analysis will suggest appropriate boundaries and possibilities for science .

II. BRIEF HISTORY OF SCIENCE

Introductory science education gives the impression that science is the doing of the scientific method. (However, based upon that experience, we might be forgiven for thinking that science is even more narrowly defined as the memorization of formulae and the doing of difficult, but standard, science problems in order to pass a difficult, but fairly standard examination.) Students of science might be given the following description of the scientific method. Step one measures or observes some data either in the laboratory or in the field. Step two analyses the data to determine trends and possible generalizations. Step two may involve the creation of a new model or the use of an existing model which abstracts the main features of the data. This model may or may not have a mathematical component. Step three uses the model to predict the results of measuring some new data. Step four compares the prediction with the results of the new measurements and possible feedback to step two for modification of the model. It is assumed that all scientists who apply this process to similar data would come to similar (although possibly not identical) conclusions. However, the scientific method may not be as straightforward as our naïve description implies, and we again stress that methodologies may vary with different sciences.

Science—A New Thing in the 16th Century

As with any mature area of human endeavor, science and the scientific method have evolved over time. An understanding of the methodology and epistemology of science requires some familiarity with its historical development. Let us pick a few events or people that serve as landmarks in this development. We begin with Francis Bacon (1561-1626) and Galileo Galilei (1554-1642).

The Baconian philosophy of science gave experimentation priority. Data was to be collected and classified without preconception. Such collections of data would readily lend themselves to inductive generalization and improved human understanding of our universe. But Bacon's methodology ignored at least two important features. First, the data does not self-organize. Second, the experimenter *does* bring preconceptions to his work. One common and useful preconception is that the universe is uniform and non-chaotic. The observer must also assume that the universe is relatively unchanging, that what happens now can also happen in the future. Why observe the planets now, unless one can say something about their behavior next year? Such are the sort of assumptions necessary to believing that science is a fruitful activity. Putting these two ideas together, that data needs organization and that certain assumptions are required, goes beyond the Baconian philosophy. This extension of the scientific method then leads to conclusions, theories, and predictions.

Galileo is our first example of an observer who developed theories from observations. His observations of the moons of Jupiter must have supported his pre-existing propensity toward heliocentrism, and given him further incentive to make heliocentric conclusions about the motions of planets. Thus, his view of planetary motion is testimony to his theoretical development from observation and experimentation. It is interesting to note that Galileo would set up his telescope in public places and urge bystanders to look at the moons through the telescope. Educated scholastics, however, would often refuse to look, since the observations might force them to reject their a priori geocentric notions of celestial mechanics. Not only did they have a vested interest in the traditional explanations but they also feared that Galileo's telescope might be bit of optical chicanery. Galileo's study of the pendulum also reflects his process of observation and theorizing. He collected data by timing the oscillations of a swinging lamp in the cathedral at Pisa using his pulse as a clock. In part, this data led him to his deduction that the period of a pendulum was independent of the amplitude of the oscillation. (This theoretical conclusion may also be partially due to philosophic presumption that we will discuss later.) While Galileo's conclusion was later shown to be erroneous, or at least only approximately true for small amplitudes of oscillation, there was nevertheless an inductive leap to the general conclusion. Thus, deduction/induction and logic are used to develop the theory. The combination of these two approaches, experimental and analytic, leads to the beginnings of science in the modern era and shows science to be, at least ideally, impartial and logical.

There is a third important element in this early application of the budding scientific method—the public nature of science. Galileo set up his telescope in public places and urged others to make the observations or do the "experiment," in order to verify his own observations. The gathering of data by many and the subsequent testing of ideas and theories within a community of scientists is required in order to promote objectivity. Today, scientists meet and discuss at conferences, they collaborate especially in large projects, they attempt to reproduce results obtained by others, and they publish their findings in journals where each article is reviewed by peers who are experts in the field. The community of scholars is large and membership requires years of training and experience.

A fourth element is also present, at least implicitly, in Galileo's study of the pendulum: the fact that his modest theory of pendulum motion included only natural or material considerations. There was no appeal to supernatural forces. Consistently science has maintained this confinement to the natural world, most simply on the basis that if science uses testable reproducible material data, then explanations must lie in the realm of the natural world. Non-natural explanations are not testable and therefore are non-scientific. But we note that the exclusion of supernatural explanations from science does not logically exclude such explanations from human thought. Such non-natural causes may well be the ultimate reality, but science cannot methodologically adjudicate a debate in that arena.

The confinement of scientific theories to naturalistic explanations is a tremendous strength of science and, at the same time, a dangerous trap that can limit human thought. On the positive side we have noted that naturalistic explanations are testable in the sense that laboratory results are physical and public. Results are objective and open to all, and all observers will agree closely. For example, if a voltmeter registers ten volts in an experiment, observers will agree that such is the case within a certain experimental error. As human beings we generally agree about effects that are tangible and physically manifest. On the other hand, confining our thoughts to physical effects brings a tremendous loss of sensitivity to the rest of reality. Individual and differing emotional responses to music and poetry, varieties in religious experience, varieties of ethical responses, depression, joy, and many other non-physical aspects of human behavior are amenable to scientific analysis and explanation in only the crudest of ways. Psychology is indeed a science, but it is also much more. The most scientific of the sciences is physics, but physics, even as a basis for chemistry and biology, is not close to subtending the totality of human experience. But let us return to the historical development.

The modern period beginning in the seventeenth century saw the development of the basics of the traditional view of what we now call the scientific method, the hypothetical-inductive model. The scientist observes data, she develops a theory that encompasses the data, and using the new theory, predicts outcomes of new experiments. She then performs the new experiment, and if the experiments vindicate her theory, she submits her findings, data, and theory, to the larger scientific community for objective judgment. There are problems with this picture, but for the moment we continue with another historical figure, Isaac Newton (1642-1727).

The Copernican revolution—the change from a geocentric universe to a heliocentric planetary system—was driven by several factors, one being the fact that the data of Tycho Brahe (1546-1601) and its subsequent analysis by Johannes Kepler (1571-1630) led to a simpler theory of planetary motion. The perceived virtue of simplicity has been important in the history of science and is referred to as Ockham's razor. This test, attributed to the fourteenth century English Fransciscan friar William of Ockham (c.1295-1349), states that the explanation of any phenomenon should contain as few assumptions as possible. The whole question of simplicity versus completeness is complex but, at any rate, Kepler postulated three laws which much more easily predicted planetary positions than did the complex epicycles of the old geocentric/Ptolemaic system. These laws are 1) planetary orbits are ellipses with the sun at one focus, 2) orbits sweep out equal areas in equal times, and 3) the square of the orbital period of any planet is proportional to the cube of the semi-axis of the elliptical orbit. Thus Kepler replaced the endless array of epicycles necessary to predict planetary positions with a few simple generalizations for the entire solar system.

But Newton brought a whole new level of generality to the study of motion. Kepler's laws applied to planetary motion only. Furthermore, Kepler's laws did not give any hint as to the cause of the planetary motion. Nor did they connect planetary motion to any other kind of motion such as that of pendulums or cannon balls. Newton's contribution, through his 1687 *Principia* and other writings, provided general laws of motion that would apply to planets, cannonballs, pendulums, and anything else that moved. His elucidation of concepts of mass, acceleration, momentum, gravity, and so forth, and his connection of these entities through the mathematics of geometry and calculus led to a much larger generalization than that provided by Kepler's laws. Newton's laws of motion and his law of gravity could be combined to generate Kepler's laws as just special cases of his mathematics. Similarly the trajectories of cannonballs and pendulums could also be predicted by Newton's laws. Even today Newton's laws quite satisfactorily describe and predict the motion of intercontinental missiles and telecommunications satellites. Newton's laws are therefore an important example of scientists' attempts to learn a few laws that encompass very large segments of natural phenomena. Newton's laws of motion and gravity are also prime examples of a deepening of the human understanding of how nature works. While Kepler *said* that the planets moved in a certain way because of gravity, Newton could *demonstrate mathematically* that planetary motion is a *result* of his laws of motion and his law of gravity, as are many other phenonmena. Newton's laws of motion and gravity, Maxwell's 1865 theory of electromagnetism, and Einstein's 1915 theory of general relativity are outstandingly successful examples of this sort of effort to generalize and deepen human understanding of nature.

Newton's work single-handedly set a model for physical science. It brought into prominence the role of mathematics and it ensured that studies of motion would be carried forward in the Newtonian context–-in the framework of his laws of motion and his theory of gravity. Never again could physical science move back to a non-quantitative study of mechanical systems.[5] But we also note that Newton himself did not try to describe the "being" of gravity. His famous statement " I make no hypothesis (about gravity.)" provides an example of the scientist being careful not to become the philosopher.

Second Thoughts About the Scientific Method

The scientific method continued to produce remarkable new knowledge, and even today its practice reflects much of the process that developed in the seventeenth and early eighteenth centuries.

However, further examination of the scientific method shows that the method is not as straightforward as originally supposed. One area where much discussion has occurred is in regard to the assumptions used in theory building. The example of Galileo's erroneous theory of the uniform period of the pendulum motion can illustrate the point. Galileo's timing device for measuring the period was his pulse. It might be reasonably

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[5] In his cosmogony Swedenborg described his minuscule elementary particles as various geometric forms but never applied mathematics to his schema in the same rigorous way that characterized Newton's work. On the other hand, Newton was dealing with known macroscopic objects whereas Swedenborg's schema was at least as philosophical as it was scientific.

argued that such a timing device was not accurate enough to distinguish between pendulum periods of differing amplitudes, but it has also been argued that Galileo's conclusion was at least as much a result of predisposition as it was of the data.[6] Galileo believed that the universe had been so ordered that motion would be simple. He saw no reason for large amplitude and small amplitude periods to differ. Furthermore, Galileo felt that the pendulum would do many thousands of oscillations without any motivational force whereas the evidence was that the amplitude gradually diminished. Whether Galileo was speaking to the case of a frictionless pendulum is not clear, but he certainly had no data to support this sort of almost perpetual motion.

The point is that Galileo's theory was heavily laden with assumptions that were only marginally warranted. Thus, while the data gathered by Galileo and others may have satisfied the criterion of objectivity, the theories were more suspect. The existence of some questionable theories led to various reactions. For example, the philosopher David Hume (1711-1776) reacted against assumption-laden theory with a renewed emphasis on empiricism, the importance of the data. He and others advocated concern for keeping generalizations and inductions strictly based upon data. Such a view was later extended and formalized as *logical positivism*, a phrase associated with a Vienna circle of scholars during the late 1920's and 1930's under the chairmanship of the German philosopher Moritz Schlick (1882-1936). At this time there was much discussion about the implications of the mathematical results of quantum physics as well as other branches of science. Quantum mechanics suffered (and still does) from certain problems of interpretation. While its predictions of measured quantities were accurate and wide ranging, the meaning of the measurements was sometimes in question. As a reaction partially to interpretive problems in quantum physics, logical positivists sought to limit conclusions from data to those which strictly followed from the data by logic. For example, if quantum mechanics predicted a certain result from logic, that is mathematics, then a scientist should read no more into the result than was stated by the equations. There was no reality worth discussing except data and numbers. Positivists felt that all knowledge should be reduced to

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[6] H. Erlichson, "Galileo's pendulum," *The Physics Teacher* 37 (1999): 478-479.

the empirical and its logical consequences. Such a position has sometimes been called "instrumentalism" because the only knowable reality is what is seen on measuring instruments. Positivism eventually lost favor in the philosophy of science, but it did provide for an emphasis on explanations as being based in the material observable and logical world. As a philosophic position, it does have problems and has been abandoned.[7] The historical legacy was that positivism and empiricism tended to promote stricter and rigidly naturalistic, reductionist explanations of scientific data.

The foundational structure of scientific theory faced another challenge in regard to the connection of theory and data. The French physicist and philosopher Pierre Duhem (1861-1916) showed that a theory was typically made up of several interconnected hypotheses, some major and some minor.[8] The question arises, "If a theory was tested and found to be incorrect, which of the hypotheses is the incorrect one?" Furthermore, of the several hypotheses, some are major and some are minor. If a major hypothesis is incorrect, then showing that the originally-proposed theory is incorrect should result in the rejection of a major hypothesis and therefore a major scientific framework. If, on the other hand, only a minor hypothesis is incorrect, then perhaps only minor modification is required. Duhem claimed that the physicist is in no position to determine which hypothesis has been invalidated. The Harvard philosopher Willard Van Orman Quine (1908-2000) went further, through a series of arguments, to suggest that data itself does not substantially affect world views, and that contradiction between data and theory usually leads only to minor modification of the overall set of assumptions and hypotheses. Thus the strict policing of theories through their empirical justification is not perhaps the stringent criterion for scientific correctness that it was once thought to be. One possible and perhaps extreme intellectual consequence, then, is that a given theory cannot be proved true by any experiment. More remarkably, data cannot coerce belief![9]

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[7] See, for example, Del Ratzsch, *Science and its Limits* (Downers Grove IL: Intervarsity, 2000), 30.

[8] See, for example, Alister E. McGrath, *Science and Religion: an introduction*, (Oxford: Blackwell Publishers, 1999), 67.

[9] Thus it is philosophically respectable to say of some observed phenomenon, "I don't believe my eyes!"

Continuing further in this vein is the work of Karl Popper (1902-1994). Popper's *Conjectures and Refutations* suggested that theories could not be proved true by empirical testing but that theories could only be *falsified* by empirical testing. The combination of the Duhem-Quine thesis, logical positivism, and now Popper's work might lead us to believe that almost any conclusion from data is suspect.

Following on from the Duhem-Quine thesis and Popper's falsifiability, Princeton historian of science Thomas Khun (1922-), while still a graduate student in physics, published a book entitled *The Structure of Scientific Revolutions* in which he suggested that the history of science was characterized by a series of scientific revolutions involving changes in *paradigms.* Khun defined paradigm as a scientific world view with a collection of assumptions and theories about the natural world. For example, the Newtonian world view of a clockwork deterministic universe would be a paradigm. When quantum mechanics and indeterminacy appeared, a scientific revolution occurred and the new paradigm of quantum physics gained ascendancy. Between revolutions science is in a non-crisis mode and practices what Khun terms "normal science." The view of science as a sequence of revolutions has been criticized as overlooking transitions of gradual change in world view, yet the fact remains that some changes have been rather abrupt and the model, while not universally applicable, does have a basis in historical fact.

Much of what we have discussed occurred in the modern period, which ran its course by perhaps the mid-twentieth century. But putting a date on the end of the modern period seems naïve. Modernity embodies the notion of material and other progress that man has achieved since medieval times. It connotes "enlightened thinking," progress, the development of public legal systems, modern democracy, public education, and technological innovation. Some believe that the modern era is now followed by the *postmodern* era, which involves a reaction to and analysis of the darker side of the modern era. Postmodernism postulates that human activity is strongly conditioned by the current dominant culture. Science, as well, is seen as not immune to cultural bias, and therefore the doing of science and the choice of worthwhile scientific problems is culturally conditioned. For example, a well developed problem is the classical physics of trajectory motion: the motion of a cannonball in a constant gravitational field. One of the first examples of military research that used Newton's physics is seen in the 1742 book by the British mathematician and engineer Benjamin Robin (1707-1751) entitled "New Principles of Gunnery." Among other things in the book, Robin describes the so-called ballistic pendulum and its use to measure the muzzle velocity of cannonballs. In 1838, the French mathematician Siméon Denis Poisson wrote a long monograph on the effect of the earth's rotation on projectile motion with obvious military implications.[10] History tells us that these years were times of conflicting European expansionism and that military science would have been very much in fashion. Based on this and other cases, the postmodernist sees science as being practiced and dominated, even today, by males of western European descent, who bring to the work all the prejudices of that group.

As another example, female concerns are largely ignored, as is the practice of science according to a feminist model. Furthermore the "reality" that lies behind our data is really just a function of the scientist's social conditioning. Thus a white male scientist might see one reality; an African female scientist might see another reality. Gender bias may be a problem in the selection of problems for research. It may also obscure the reality behind the data. For example, the assumption by Darwin and others of survival of the fittest as a primary mechanism in nature may have partially resulted from a male-dominated culture of competition. Some feminist advocates have suggested that science reject objectivity itself as being a male ideology. However, as with much else we have described, there are problems with postmodernist views of science, but postmodernist critics are catalysts to progressive change in scientific methodology.

Up to this point, we have concentrated on physical science. As a vehicle for the discussion of science, physics seems to be the most pristine form of the practice of science. It is most susceptible to mathematical and therefore logical analysis of its well-controlled experiments. Physics seems most capable in making precise, testable predictions, often based upon complex mathematics. Physics contains several substantial theories: Newtonian mechanics, Maxwell's classical theory of electromagnetism,

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[10] S. D. Poisson, "Sur le movement des Projectiles dans l'air, en ayant egard a la rotation de la Terre," *Journal de L'Ecole Polytechnique*, 26 (1838): 1-176 and 27 (1839): 1-50.

Quantum physics, relativity, and thermodynamics, not to mention the marvelous developments in astrophysics and cosmology. However, for a prominent and somewhat contrasting example, we switch to biology and describe one of the most challenging revolutions that occurred during the mid nineteenth century.

Science Hits Home

During the eighteenth century the Swedish naturalist Carl von Linné (1707–1778), also known by the Latin name Carolus Linnaeus[11] and related by marriage to Swedenborg, produced an ever-growing and important work *Systema Naturae* in which he surveyed and classified much of the plant and animal world. The final version (1768) extended to twenty-three hundred pages. Linnaeus' view, that species were unique and fixed from the beginning—the moment of creation—was quite influential. (This position is still popular with fundamentalist creationists.) While this static position seemed almost universally held, this same era spawned the beginnings of another idea. Erasmus Darwin (1731–1802), Charles Darwin's grandfather, wrote philosophically of a world wherein animals evolved and changed. Jean-Baptiste Pierre Antoine de Monet, Chevalier de Lamark (1744–1829) more explicitly put forward notions of evolution and adaptation. Lamark is especially remembered for his erroneous but innovative idea that characteristics acquired by animals during a lifetime could be inherited. Charles Lyell's *Principles of Geology* (1830) also promoted a view that, due to the forces active within the earth, the earth had gradually changed over time. And earlier, Robert Thomas Malthus (1766–1834) had written *Essay on the Principle of Population* (1798) which put forward the notion that plants and animals were produced in much greater abundance than could possibly survive in our limited environment. Thus there was a competition for food and space within nature and, having observed declining living conditions in contemporary England, Malthus also projected these same environmental limitations to the human condition.

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[11] See, for example, "Carolus Linnaeus" by Anja Hübener, in *Emanuel Swedenborg, the continuing vision*, edited by Robin Larsen (New York: Swedenborg Foundation, 1988).

Charles Darwin (1809–1882) read Malthus' essay in 1838 and immediately perceived that the fittest variations of a species would survive over others.

These openings in the static picture were precursory to the 1851 publication of *Origin of the Species* by Charles Darwin. Darwin was concerned with several mysteries: the adaptation of species to particular environmental needs, why species die out, non-uniform distribution of species geographically, and vestigial structures which served no purpose. As an experimentalist, Darwin's most famous data-gathering occurred during a five-year voyage (1831–1836) on the *H.M.S. Beagle* to chart the coast of South America. Darwin spent about two-thirds of his time on shore examining plants, fossils, animals, birds, and aboriginal peoples. At home in England he constantly observed his environment, especially noting the ability of human breeders to produce animals that were more highly valued than the norm. Thus Darwin's controversial theories did rest upon a significant amount of observational and experimental evidence. Darwin's theories, most famously put forward in the *Origin of the Species* and *The Descent of Man* (1871), are briefly stated as follows.[12]

Because species can vastly increase their numbers, and because species actually exhibit stable numerical populations and resources are limited, therefore competition occurs for available resources thus providing the population-limiting mechanism. Furthermore, since no two individuals are the same within a species and much of this variability is genetically based and therefore inheritable, the competition for resources is not random, as survival depends on advantage characteristics being reproduced. Thus survival depends on more genetically-favored members gradually gaining ascendancy (survival of the fittest.) Eventually, over the generations, this natural selection process leads to new species (evolution.) Application of these ideas to the animal kingdom can lead to the notion that man is not a separate creation but the result of the evolutionary process as well. This last suggestion immediately focused the attention of both critics and proponents of Darwin's work.

Darwinian evolution eventually received additional support from the rediscovered work of Gregor Mendel (1823–1884). While Mendel wrote

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[12] This summary is adapted from Richard T. Wright, *Biology through the eyes of faith* (San Francisco: Harper, 2003), 121.

his ground breaking paper on the genetics of pea plants *Experiments with Plant Hybrids* in 1865, it was not really appreciated until the early twentieth century. Thus began the modern science of genetics and a sequence of research that led to what is now called the *neo-Darwinian synthesis* or the *modern evolutionary synthesis*. The study of the fruit fly, extensive statistical analysis and many other developments including the modern understanding of DNA, have placed evolution on strong footing within the biological community.

The theory and experimentation related to Evolution must then be seen as the watershed event for biology. While critics of evolution can perhaps point to gaps in the evidence, the overwhelming majority of biologists see evolution as *the* natural mechanism that operates in nature to produce the developments in the plant and animal kingdom that we observe over time.

The theory of evolution represents somewhat of a departure from the practice of science that we outlined for physics. In physics, we were able see clear connections between data and theory in a controlled experiment. Yes, Darwin's horse breeder friends could do experiments to produce a better horse, but the number of variables and the number of conditions that were not experimentally controllable in breeding were huge compared to the number of variables and the tight controls possible in a physics experiment. (Of course, practitioners of modern molecular biology might dispute this claim, but let us remain, momentarily, with what was possible in Darwin's time.) So the experiments that backed Darwin's theory might be considered less determinant than in other sciences. Second, we note that evolution is a theory that looks backward in the sense that it tries to explain biological history. The notion of retrodicting data is another novel, for the time, feature of evolutionary theory. One wonders therefore whether evolution as a science was, for its time, somewhat less objective than physics. How does evolution fit in with Popper's falsifiability criterion for science? Is the theory post-modern in the sense that it happened conveniently to fit with a developing philosophical position of survival of the fittest as found in the contemporary social market place of the industrial revolution? On the other hand, the modern synthesis, with an increased measure of experimental control, especially in molecular biology and mathematical biology, may start to approach the rigor of physics as a science. But evolution has also spread well beyond the laboratory due to its possible philosophical and religious implications. Paradoxically, while the physical sciences seem to provide deep and precise insights, the less-defined biological sciences generate more public interest.

Finally, we turn briefly back to the physical sciences for an example of science that lies somewhere between the controlled laboratory experiments of physics, and the complex, multiple-degree-of-freedom systems of biology, namely, physical cosmology.

As with some aspects of evolutionary study, the controlled experiment in cosmology is not an option. Our knowledge of astronomical events comes to us via various types of light, visible, ultra-violet, infra-red, radio, and x-rays. All of these travel at the speed of light, and given the vast distances involved, the information takes years to arrive at our telescopes, and therefore we witness only historical events.[13] As with the study of historical events in biology we can observe only the history of the cosmos. Furthermore, we have no control over astronomical events and only in a limited way can we predict events. We do, however, assume that the physical processes that happen in controlled laboratory experiments also happen universally. This is a large assumption, but it seems to be one that works well. Therefore cosmologists tend to approach their analyses of astral events with a great measure of confidence if they can ground their predictions in the physical sciences. In this venue (and perhaps in some aspects of evolutionary thought) the scientist is looking for consistency and simplicity of explanation (Occam's razor) and not so much the prediction of new astronomical events. With a strongly consistent picture, the practicing cosmologist tends to feel that his or her data is objective and accurately represents reality, and that theories are rational and objective, and therefore not particularly susceptible to the vagaries of social custom or cultural influences.

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[13] Actually, there is quite a bit that we can predict. Orbits of planets and many of the stars, are predictable. We can make intelligent guesses about aspects of the future of the universe based upon observations of expansion, mass density, and so forth. We have a fairly good idea about the possibilities for the universe, but not the certainties.

Some Limitations of Science

Benedictine priest, physicist, and philosopher of science, Stanley L. Jaki (1924-) states that ". . . for a proposition or reasoning to qualify as science, it must be subject to being tested in the laboratory. . . " and later, "Science . . . is synonymous with measurement." Jaki goes on to illustrate the degree of science in certain areas of human thought by quoting Robert Mayer, one of the pioneers of statistical mechanics: "In physics numbers are everything, in physiology they are a little, in metaphysics, they are nothing."[14] In other words, physics is the most "scientific" of knowledges and other "sciences" are sciences only so far as they deal with measurable laboratory quantities. This is certainly one limitation of science.

Science cannot not explain why the universe exists or where it came from or why there is life. Questions of ultimate purpose are not testable. Science cannot truly examine its own presuppositions. For example, the principle of uniformity may seem true and workable, and scientists receive feedback from their observations that suggest it is true. But no one has ever been to the outer reaches of the universe(s) to scientifically test its veracity.

Science is not capable of deciding questions of ethics, morality, value, theology, philosophy, and so forth. All of these deal with the human capability of free choice and the issue of responsibility. One can do certain kinds of statistical tests dealing with human behavior, but such tests are more helpful to the advertising industry than they are to understanding the mind of a single human being.

We have seen, through the work of Karl Popper, that science cannot, ultimately, prove anything to be true. But, on the other hand, Pierre Duhem and Willard Quine showed that science could not always prove a scientific theory to be false.

Furthermore, science does not definitively deal with the issue of the appropriate correspondence between a scientific theory—with mathematical symbols—and what, in nature actually might correspond to the theory. The appropriate interpretation of quantum physics or perhaps string theory

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[14] Stanley L. Jaki, *The Limits of a Limitless Science and other Essays* (Wilmington DE: ISI Books, 2000), 1-4.

are cases in point. A similar problem can develop for the reading on a voltmeter and its meaning for the "stuff" of nature. How do we know that a reading of a certain number of volts on a meter corresponds to elementary particles having a certain velocity in an electron tube? These sorts of questions are part of the discussion about *realism* in science. What do scientists really find out about nature, or do scientists only project their own ideas onto the readings of the meters and thereby create an "imaginary" view of nature?

It should be emphasized that science deals with natural quantities and since, in the Swedenborgian view reality is dualistic—both spiritual and natural—science cannot legitimately claim to test or explore spiritual reality. An example may help to clarify this statement. For over a century the question of whether prayer for the ill helps recovery has been the subject of scientific study. Here is an area where science seems to be testing something spiritual. But on closer examination we see that everything in the methodology is objectively natural. The protocol is natural; the act of praying (as observed) is natural; and the recovery rate is natural. The fact that the results of experiments are mixed does not tell us so much about spiritual reality but that the complex of human factors are at work which overwhelm the simplicity of the experiment. Thus the scientific method is applied to an inappropriate medium. In the larger view there may also be spiritual reasons why the results are mixed. We will return to this important question in section IV.

In summary then, we see that science deals with natural phenomena that are more or less measurable. It develops theories which may or may not be true and may or may not correspond to the reality of nature. Science makes assumptions about uniformity and order and thereby predicts and, where possible, controls nature—through curing disease or designing airplanes. Some sciences, especially physics and chemistry, are very active in the prediction and control aspect of science. Other sciences, such as cosmology and geology, tend to be more passive, providing explanations of what has happened with only limited abilities to predict future events. Genetic engineering exemplifies an aggressive science of prediction and control, whereas evolutionary paleontology is a more passive science, seeking to support evolutionary theory but limited in control and predictive capabilities. One might insist that scientific endeavors must include strong components of prediction and control as say physics does, but others could reasonably argue to include in science those disciplines which study physical materials at least systematically and analytically. We might call such sciences retrodictive rather than predictive.

In this section we have briefly looked at some of the characteristics of science and some of the perceived limitations of science and the scientific method. While philosophers might argue that little can be proved by science, and that the scientific method is not foolproof, the working scientist probably takes the view that the scientific method does produce a valid and usefully approximate objective picture of nature. Furthermore, the application of pure science to real world situations seems to lend credence to the idea that science theories and models do represent a visible and tangible natural reality. While the choice of methodology and the choice of which parts of nature to study and how to apply that science may be culturally conditioned, the knowledge from science and its applied consequences do seem grounded in objective reality. Yet, we note that the while the working scientist has a confident attitude about scientific objectivity that is perhaps more suited to the eighteenth century, the contemporary philosopher of science could be said to have a more critical view of both the methodology and achievements of science.[15]

III. RELIGIOUS RESPONSE TO SCIENCE

Early Design Arguments

Science explores nature with its methodology while religion, through revelation tells us that God created nature. How have theologians seen the reflection of Divine qualities in nature and ultimately responded to the seeming incursion of scientists into this realm? The issue is then the relationship between science and religion. For this journal one may be

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[15] Science also provides its own set of limitations with multiple scientific consequences. Important examples include, Heisenberg's uncertainty principle in quantum mechanics, the finite speed of information transmission in relativity theory, Gödel's undecidability theorem in logic, the halting problem in computer science, and the event horizon of a black hole. See, for example, *Impossibility: the limits of science and the science of limits* by John D. Barrow (Oxford University Press, 1998).

tempted to try a simple overlaying of Swedenborgian religious thought on to the previous discussion. Yet the theology of the Writings of Swedenborg was given in a context, and it seems important to understand that context since we, as thinking beings, are burdened with many philosophical and religious preconceptions that are not distinctly Swedenborgian. It is important for us to see where our ideas come from. Therefore we continue with ideas and persons selected from history—but now with the more philosophic and religious response to science or science-related ideas.

The question of the relationship between religion and science is predominantly a question of both metaphysics and epistemology. Who decides what is real, and what is our methodology for determining reality? Prior to modern science, sources of metaphysical truth were Scripture admixed with Greek thought. The important metaphysical questions (facts) were the existence of God, that creation was an act of God, and that man was created in the image of God. Each of these issues would be affected by science.

One of the first philosophic (pre-scientific) arguments for the existence of God is attributed to Anselm of Canterbury (*c.*1033-1109). Anselm was born in Italy and, as young man , left home and crossed the Alps to the monastery at Bec, in Normandy. He rose to various administrative posts, and the monastery grew in stature and wealth under his guidance. There he developed a connection with Canterbury and, in brief, after several problems with King William II, was appointed Archbishop of Canterbury. Anselm had already established himself as a scholar and is sometimes called the founder of Scholasticism. He is famous for his ontological (having to do with "being") argument for the existence of God. As with all such arguments, critics have found flaws. Nevertheless, this was the first such argument and the fact that it was a serious effort suggests that clerics believed that God's existence could be proven logically if not empirically.

In a similar vein Thomas Aquinas (c.1225-1274) also presented proofs for Divine existence. Aquinas was born in Italy and became the most influential theologian of the middle ages. His *Summa Theologica,* although not completed, is his most profound work. He argued that there were "five ways" in which creation or nature points to the existence of a creator. Just as an artist is often known by his style, composition, technique, and so forth, so also is the Creator known by his creation.[16] There is the argument from motion. Surely the motion in the world requires a creator. There is the argument from causation. Nature is full of cause and effect relations, and all cause must then go back to God. There is the argument of contingent beings—such as people. People are not necessary to creation but can be traced back to God's good pleasure. There is the argument from values. What is the origin of morality, truth, and goodness if not God as the original cause? And finally there is the teleological argument of design. Many objects in creation have purpose and therefore are the result of design by a Creator. The point is not to debate Aquinas' philosophic logic but to exemplify a certain type of thinking that connects nature to God or gives considerations about nature a religious dimension.

By the time of the counter reformation and the Council of Trent (1545–1563) the Catholic Church had a fairly well defined view of cosmology that would include Aristotelian geocentricism, and a philosophy of creation such as that of Thomas Aquinas. While the early scientists such as Galileo were personally religious, they often saw the role of theology somewhat differently. For example, Galileo put forth two principles that state his view of the correct relationship between the respective authorities of Scripture and science. He cited Augustine in saying that Scripture does not teach us about matters that do not pertain to salvation. He also quoted Cardinal Baronius: "The intention of the Holy Ghost is to teach us how one goes to heaven, not how heaven goes."[17] Second, Galileo stated a criterion for those situations where Scripture and science seemed to conflict. If science had an ironclad explanation or fact—supported by data and good logic—that conflicted with Scripture, then Scripture was to be interpreted metaphorically. Otherwise Scripture was to be literally interpreted. It is well known history that Galileo was eventually condemned by the inquisition in 1633 for not obeying the 1616 injunction "not to hold, teach, or defend in any way whatsoever that the earth moves." History also records that the church eventually came to see that the 1633 judgment was an error. In 1992, Pope John Paul II said that the original judgment transposed

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[16] This argument also occurs in modern design theory, in that the "agent" of design is said to leave behind "footprints" in the design.

[17] Quoted in *Religion and Science* by Ian G. Barbour (San Francisco: Harper, 1997), 14.

" into the realm of the doctrine of the faith a question that in fact pertained to scientific investigation."[18] The fact that the church relied on Aristotelian ideas, ideas that were part of the contemporary, but conventional, wisdom contributed to the erroneous judgment. And this is an error that the religiously-inclined tend to repeat—the appropriation of current scientific or philosophic ideas to support religious doctrine, when such ideas are only contingent and are susceptible to replacement through new discoveries and the resulting new theories.

Galileo might be characterized as a religion/scientist separatist in that he recognized the validity of both areas but seemed to award them separate domains. Yet like others Galileo felt that God could be seen in the Book of Nature and the Book of Scripture.

René Descartes (1596-1650) was a different kind of separatist. Descartes saw existence as a dualism of mind and body. The body or natural world was mechanistic and susceptible to scientific discovery whereas the mind existed in a different realm. It was through the mind that one could contemplate God and the mind had an *a priori* idea of God. Yet despite his view that nature was mechanical, Descartes was not a deist who saw God as only necessary for the moment of creation. Descartes was a theist, believing that God's will was necessary to the continual renewal and sustaining of creation. Cartesian dualism was a formative idea for Swedenborg's philosophy.

Deism grew to be a prominent philosophy for religious scientists. The notion of a clockwork universe that, once created, ran autonomously gained currency as more natural phenomena were explained in mechanistic terms. (Until roughly the twentieth century miracles were considered to be an exception to the clockwork.) Yet deism strongly implied a minor role for God in nature and ultimately human affairs. Providence, the action of God in human affairs, became an endangered doctrine. Perhaps the consequences of pure deism were too drastic to contemplate. Naturalists and scientists gradually turned to a different approach, one which goes back to the concept of the two books of revelation: Scripture and nature. The question became, "What can we see in nature that points to

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[18] Ibid., 15.

God?". The answer apparently was that one should be able to see the divine plan in nature, one should be able to see *design.*

Robert Boyle (1627-1691) stated that science was a religious task and is, ". . . the disclosure of the admirable workmanship which God displayed in the universe."[19] As well as admiring God's creation in the beauty and symmetry of nature, scientists also noted a pattern of divine benevolence—that the world was created for people.[20] The argument for design goes back to Aquinas but finds prominent nineteenth-century expression in the work of English theologian William Paley in his book *Natural Theology* (1802). Paley was impressed with the clockwork universe of Newtonian mechanics, although he was also concerned by the fact that it had become an image invoked by those who saw no further need of the Creator after creation. Paley attempted to turn the clock into a positive image for Divine creation. He compared the perception of a person who, on a deserted heath, finds a stone with that of a person who finds a watch. The position and character of the stone have aspects of randomness, whereas the watch raises a variety of questions and commands closer attention. Paley contends that the watch suggests design to a much stronger degree than the stone. The watch has a level of complexity and an inherent sense of purpose well beyond that of the stone. Similarly, certain structures found in nature, such as the eye or the human heart, display a degree of complexity and purpose such that the observer cannot help inferring the existence of a plan or design in their manufacture. Thus the design feature is situated in the artifact itself. Philosophically, the design argument may have problems as earlier noted by the Scottish philosopher David Hume (1711-1776). Yet, as we will see, it continues to be of interest in the twenty-first century.

We have seen that up to the early nineteenth century, scientists and those who thought about related issues, such as those in the British school of "natural" philosophers tended to see the hand of God in nature. Some were theists, who believed that God must continually sustain His creation.

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[19] Ibid., 19.

[20] This is an early statement of the anthropic principle—that the universe is uniquely fitted for humans. In the twentieth century this idea finds sophisticated expression in *The Anthropic Cosmological Principle* by John Barrow and Frank Tipler (Oxford: Oxford University Press, 1986).

Others were deists who saw God's hand only in the moment of creation and felt that nature, once created, was a marvelous stand-alone perpetual motion machine. The most prominent science of the time, physics—although reductionist and mechanical, was seen as supportive of religion in a general way and useful to society as the applied science of engineering. In terms of a relationship between science and religion, classical physics was non-confrontational to religious thinkers. Such was not the case with the new theory of evolution.

Evolution

On the face of it, evolution purported to explain the history and development of the plant and animal kingdoms—including humans—without reference to any ongoing, purposeful, direction. The Bible as a key resource for understanding human history and ethical behavior, the special place of man in the chain of being, the prominent cultural role of contemporary churches, were factors that guaranteed that the new theory of naturalistic evolution would provoke a much stronger response. Evolution raised questions about almost every religious and cultural issue: ethics, teleology, providence, scriptural authority, eugenics, and slavery. Darwin himself, who initially seems to have been religious in his earlier days and accepted Paley's writings as persuasive, gradually became more agnostic as he became convinced of the apparently encompassing explanatory power of the evolutionary hypothesis.

While on the surface the tenets of evolution seemed inimical to religious belief, many felt that evolution provided a mechanism that freed religion from some serious problems. Evolution seemed to provide a perfect mechanism to explain suffering. If, through the contingent nature of survival of the fittest, many did not survive and indeed suffered in the process, then God was freed of being the immediate cause of the individual suffering. Evolution could also be seen as a teleological device that could lead the world to a better existence. Asa Gray (1810-1888), the American botanist, Calvinist, and Harvard professor, is quoted as having said, "Darwinian teleology has the special advantage of accounting for the imperfections and failures as well as the successes . . . if [a theist] cannot recognize design in Nature because of evolution, he may be ranked with those of whom it was said 'Except ye see signs and wonders ye will not believe.'"[21] Later teleological thinkers also seemed to welcome evolution as a means of enriching our understanding of God's creation. For example, the Anglo-American philosopher Alfred North Whitehead (1861-1947) saw natural history as a developing rather than static situation. This process was subject to some overall direction and guidance.[22] Similarly, the French Jesuit and paleontologist, Pierre Teilhard de Chardin (1881-1955) viewed creation as a process that constantly worked toward greater perfection and complexity. He saw the beginning moments of life and the emergence of human consciousness as critical transition points. Eventually this evolutionary/perfectionist process proceeds to the spiritual and will lead to the consummation of the world as promised in Colossians 1: 15-20 and Ephesians 1: 9-10.[23] Finally we note the gradual development in the work of these and other thinkers of the idea of *process theology*. God becomes somewhat of a partner in the evolution of the world and actually develops and perfects even more in time as His interaction with the world improves and deepens. In process theology, God's being seem contingent upon his creation.

Meanwhile, others found evolution to be lacking as a scientific theory for reasons either of religious conviction or problems with the science itself, or both. In the latter category, James Clerk Maxwell (1831-1879), the English synthesizer of electricity and magnetism, and the American biochemist Lawrence Henderson(1878-1942), both felt that there were invariance principles in molecular structure and behavior that put limits on evolution. Lord Kelvin (William-Thomson, 1824-1907) felt that the age of the earth was too short to accommodate an evolutionary approach to complex biological structures. (We note that his estimate of 100 million years falls well short of the today's estimate of about 4.54 billion years.)

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[21] Quote in John D. Barrow and Frank J. Tipler, *The Anthropic Cosmological Principle* (Oxford: Oxford Univ. Press, 1986), 85.

[22] See p. 105 Alistair McGrath, *Science and Religion: an introduction* (Oxford: Blackwell, 1999).

[23] Ibid., 224.

But the earth's age is still felt by some to be a critical limitation on evolutionary processes.

Evolution received spirited opposition from fundamentalists who were scriptural literalists. Again the age of the earth (reckoned at a few thousand years from Scripture) was not sufficient. And the issue of the special creation of man in the image of God was seen as inimical to man being a descendent of lower animals. The most dramatic example of confrontation between fundamentalism and evolution occurred at the Scopes trial in Dayton, Tennessee, 1925. A high school biology teacher, John Scopes, taught evolution and was brought up on charges for violating state laws against teaching evolution. This episode illustrates the high emotional content associated with evolution. More recently creationism or "creation science" has emerged as an attempt by some theologians and scientists to debunk evolution or to provide an alternative scientific explanation that will include God as a final cause. While this writer's understanding of the scientific basis of evolution is very limited, it nevertheless seems that with the advent of molecular biology an evolution interpretation of much of the biological world seems consistent with the scientific evidence. In some sense evolution seems to be a minimalist theory in that it only looks to probabilities and natural environment as explanatory of physical data. The real question is, "What, if anything, is at another level of causation; what might be beyond evolution?" This question can be explored on both the scientific and philosophical/religious levels.

Modern Design Theory

One effort that attempts to find a scientifically more complete theory than evolution is modern *intelligent design*. In some ways the modern design movement is a successor to British natural philosophy and other design philosophies of the eighteenth and nineteenth centuries. Many of the historical thinkers that we have briefly discussed were essentially looking for or postulating the existence of design. The modern intelligent design movement carries this tradition further and attempts to codify the likelihood that a given set of data or events (a) follows known regular laws of nature (b) occurs randomly or (c) is the result of design. Yet there are differences between ID and its precursors. For one thing intelligent design is not the same as creationism. ID states that design leads to the notion of an agent, but ID itself makes no philosophic statement as to the nature of the agency. This is an important distinction in that it helps to preserve the scientific/logical platform of ID as opposed to the religious/philosophic underpinnings of creationism.[24] Thus, where the modern design movement most differs from its predecessors is in the effort to use the mathematics of probability and information science to develop explicit scientific criteria for the existence of design.

Most scientists agree that probability and its use in science is common and legitimate. For example the field of statistical mechanics is crucial to understanding molecular dynamics and has shown itself capable of leading to measurement and prediction, both characteristics of the scientific method. Yet in statistical mechanics, most applications lead to overwhelmingly strong probabilities of occurrence and non-occurrence on the macroscopic scale. For example, the existence of huge numbers of molecules in highly probable configurations of position and/or velocity allow us to make quite precise predictions of behavior on the macroscopic level. But in the modern design idea, the probabilistic concepts are used on the opposite end of the scale, the small probability end. This is the domain of cryptography and the scientific search for extraterrestrial life.

One of the most prolific and capable spokespersons for design is Michael Dembski (1960-). With doctoral degrees in both mathematics and philosophy, Dembski is well positioned to contribute to a discussion of the place of design in science. His 1998 mathematical book *The Design Inference*[25] attempts to build a mathematically/logically rigorous methodology for identifying design with an observed event. The proposed ideas are intriguing and may ultimately lead to a paradigm shift in scientific methodology. We give a very abbreviated description, starting with an example of statistical testing.

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[24] David Hume (1711-1776) also felt that while a designer could be inferred to explain order in nature, the nature of the designer was unknowable.

[25] William A. Dembski, *The Design Inference* (NY: Cambridge U. Press, 1998). See also, by the same author a less mathematical treatment, *Intelligent Design: the bridge between science and theology* (Downers Grove, Illinois: InterVarsity Press, 1999).

Several decades ago, there was a strong feeling in some quarters that smoking led to lung cancer. Yet it took a while before a causal link seemed to be supported by data. Part of the reason for this delay was due to the use of statistical testing—a well established scientific methodology. One such test is the χ^2 test which proceeds roughly as follows. The statistician forms the so-called null hypothesis H_0 which, in this case, says that smoking has nothing to do with cancer. Calculations are then done to determine average levels of cancer in the general population. A certain numerical calculation is then done to compare the cancer levels in the general population with levels of cancer in smokers. While there may be some noticeable differences in these levels, the perceived difference may actually be due solely to chance. Therefore a certain statistical criterion is applied to give perspective. If the difference is less than the statistical criterion, then the statistician accepts the validity of H_0, that cancer is unrelated to smoking, and that any calculated difference between cancer levels in smokers and the general population is due to chance only. On the other hand, if the calculated difference is greater than the statistical criterion, the statistician rejects the null hypothesis, H_0. But note that the statistician does not ever say that smoking actually causes cancer. The statistician only judges as to the validity of the null hypothesis. To the lay person, this test looks a bit one-sided. A common sense examination of the numbers would seem to indicate that something—smoking—is actually increasing the incidents of cancer in smokers. Yet the statistical test never actually says that. With enough data about smoking and cancer, it was finally possible—*with high probability*—to reject the notion that the elevated incidence of cancer among smokers was due to chance. This is the sort of anomaly that Dembski addresses with his design methodology. In a rough sense, Dembski's design protocol turns this negative statement into a positive statement—that smoker's are more likely to get cancer.

To make the case clearer, let us consider Dembski's example of the six-sided die. Using the χ^2 test one can check the null hypothesis to see if the die is loaded. We expect that out of 60,000 tosses, approximately 10,000 tosses would show each of the separate faces. But we would also expect that the die would not show *exactly* 10,000 outcomes for each face. In fact the probability of that event is the very small number, less than two chances in one trillion. The most likely outcome is one of the myriad cases where each face shows a number with various degrees of difference in the counts from exactly 10,000 times. The χ^2 test provides a rough estimate of the allowed number of deviations from *exactly equal* numbers for each face, that are consistent with all faces being equally likely, and that any deviations are due to chance. But now consider what we would think if each face came up *exactly* 10,000 times. Our common sense suggests that such an outcome is extremely *unlikely* if chance were operating alone. We would think that someone had rigged or *designed* the die to achieve this too-perfect outcome. The point here is that there are two edges to our credibility regarding a chance outcome. At one edge is the so-called confidence level of the χ^2 test that barely upholds the hypothesis of the unbiased die. At the other edge, where the χ^2 variable is precisely zero (all faces appear 10,000 times each) there must be some way to conclude something—such as an intervention or design—that brought about such an unlikely, yet remarkable, event.

Can the measurement of low probability events be used to infer design? Is there some sort of low probability threshold beyond which one can say that such an event could not reasonably have happened by chance, but that there is a strong likelihood that it happened by design? Dembski proposes the use of an *Explanatory Filter* to make the appropriate inferences. A given scientific observation that passes through the filter will be deemed to have been caused by one of three possibilities: a) regular natural law—such as Newton's second law of motion, b) chance—such as a random mutation, and c) by design—the nature of which is not specified.[26]

Dembski argues that many areas of modern life implicitly use the design inference. These areas include cryptography, and all manner of identification such as credit card numbers, social security numbers, internet passwords, the search for extraterrestrial beings, and so forth. In every case, there is design or the search for design or the inverse of design. The credit card number is purposely made a number of very low probability in

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[26] Dembski claims that his method is similar to that used by the biologist Michael Behe who, in a more qualitative manner, introduced the idea of irreducible structures: those which, if they had a single component removed, would not function as originally observed. Thus, such structures suggest design rather than gradual mutation to a more fit structure.

order that thieves are unlikely to discover it. People who make codes attempt to create a very low probability that the enemy will uncover the "design" or message. On the other hand, astronomers and mathematicians who scan the universe looking for communication from other beings are looking for intelligent communication such as prime numbers—design—as the signature of other intelligent beings. Hence validity of the search for design is not really in question. The only issue is whether the criteria, the filter, is appropriately stringent. That is, one does not want to infer design where it does not exist. Hence the use of properly conditioned low probabilities. There must be a certain degree of complexity and certain degree of specification—terms which Dembski discusses exhaustively in his books. The idea of a criterion that indicates design, with a high probability, seems compelling.

IV. A VIEW THROUGH A SWEDENBORGIAN LENS

In this discussion we have taken an historical view. The theosophic writings (the Writings) given through Emanuel Swedenborg fit into this history in the sense that they were Divinely given into the mid-eighteenth-century culture to a person, albeit broadly intellectual, of that time. It has been noted by many writers that Swedenborg was quite familiar with the work of Newton and others through his travels and studies in England and on the continent.[27] Swedenborg also contributed to contemporary science and in certain areas such as his study of the brain, his contributions were unique, and still of interest today. Like most scientists of his era, Swedenborg saw creation as the work of an infinite God. But unlike some, Swedenborg's scientific work was heavily influenced by his philosophic, rationalist approach. Well-versed in the classical thought, Swedenborg looked for purpose and sought to understand and picture the deepest part of nature. Whereas Newton refused to make any hypothesis about the nature of gravity beyond what data and his equations told him, Swedenborg tried to dig as deeply as rational thought would allow. He conceived a

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[27] See, for example, "Science in Swedenborg's Time" by Gregory L. Baker in *Emanuel Swedenborg: a continuing vision* edited by Robin Larsen (NY: Swedenborg Foundation, 1988), 433-442.

whole structure of levels in nature, like a set of elementary particles with various kinds of motion whereby pieces from each level would interact with those of the next level—at least in a functional and purposeful manner. In his world-view then, Swedenborg tended to an earlier mode of thought, firmly grounded in the belief that God made and continually sustained the world, and that each part had function and purpose.

Swedenborg's theosophic works describe two worlds, the natural and the spiritual as co-existing with an intimate and asymmetric connectivity. The natural world is clearly secondary, and its existence is due to the spiritual world. "The things of nature are nothing but effects; their causes are in the spiritual world . . ."(*AC* 5711). The Writings are full of similar statements. Thus it seems only reasonable that Swedenborg would always be trying to look as deeply as possible, by every human device, into the deep parts of nature.

In his earlier pre-theological efforts, Swedenborg constantly looked for the connection between the spiritual and natural worlds. In his *Principia* he sought such a nexus and failed. In his later biological works he looked for the soul and was again unsuccessful in reaching that final goal. Why would this be the case? The answer can perhaps be found in the principle that people are in spiritual freedom, a principle that Swedenborg later describes in his Writings (*AC* 10788, 7877e).

It is of the utmost importance that human response to God not be compelled, that people act with freedom and rationality to freely respond to Divine guidance (*AE* 1155, *AC* 7290). Salvation only comes without external compulsion and therefore it seems plausible that despite his considerable efforts, Swedenborg would be unable to see the precise detailed relationship between the natural and spiritual worlds. Preservation of human freedom requires the existence of a *forbidden zone of knowledge*. One example of this forbidden area would be the very knowledge that Swedenborg tried, in his scientific studies, to garner for his *Principia.* Another example of a forbidden zone of knowledge is foreknowledge in Divine revelation. Swedenborgians sometimes try to infer such foreknowledge of scientific ideas in the theosophic writings. For example, do we find that the Writings predict quantum physics or Einstein's theory of gravity? Of course no such prediction is possible because such predictions constitute foreknowledge which would force belief. The same holds true in even stronger measure for possible scientific ideas given in Scripture. Two millennia ago, people observed things about nature, but they did not practice anything like the scientific method of modern times. If Scripture or the Writings made such predictions of major well-established scientific theories then the doctrines they teach would perforce also be true. Human belief would be forced, and again human freedom would be abridged.[28]

This same principle would seem to apply to scientific studies whether done in the eighteenth century or in the twenty-first century. What does the existence of the forbidden zone tell us?

It has been said that science tells us how things work, but not why. In what sense is this true? Superficially, we can ask some "why" questions in science? Why is the sky blue? The sky is blue because Maxwell's electromagnetic theory predicts that higher frequency light (blue) is scattered more than lower frequency light (red). Electromagnetic theory is a collection of equations that describe the actions of electric and magnetic fields. These fields exist because the presence somewhere of electric charges and currents. The currents are due to the motions of charges. And so it goes through each level of explanation. But these explanations are really "how" answers. And usually "how" answers just lead to further "how" questions.[29] In principle, each "how" question can be subjected to experimental study, the gathering of data, formulation of theory, testing of predictions of the theory, and further revision, even falsifiability. In fact, as we noted earlier, philosophers are not certain that science can tell us any absolute truth, even though the working scientist tends to think that long-standing scientific models do have a meaningful basis in reality.

Because science deals with natural results there is a conservative tendency to look for natural explanations. In fact, scientists are naturally leery of explanations of the sort, "God made it so." The fact that a scientist cannot account for a given result is no reason to adopt a supernatural

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[28] During 2005/6 a series of articles and responses appeared in the Swedenborgian journal *New Church Life*, which debated various aspects of the evolution/design issue. One communication in the Jan. 2006 issue, pp. 36-38, by Allen Bedford, Fredrik Bryntesson, Eric Carswell, and Sherri Cooper, particularly spoke to the issue of the Divine providence acting to preserve human freedom.

[29] Sometimes there really is a "why" question at the end. In this case the question might be, "Why an electron?"

explanation.[30] Since the mid-nineteenth century supernatural explanations of laboratory results are not acceptable in the practice of science. The explanation that "God made it so" does not really forward knowledge about nature, may actually retard the effort to find a deeper (natural) explanation, and loses credibility as science does find a deeper explanation.[31] However, confining one's thinking to only natural explanations can have philosophic or belief system consequences. The skeptical scientist can become, as a whole being, a naturalist—having a tendency to assume that the answers to all the "how" questions and even the non-scientific "why" questions must be found in the material realm. But the fact that the "God made it so" philosophic/religious explanation has not been helpful in the past need not blind us to the probabilities of design.

What about the religious scientist? Most religious scientists live a split life. In the lab they seek answers to natural occurrences from natural causes.[32] This is called *methodological naturalism.* A physicist looks for physical causes; a biologist looks for chemical or biological causes. In life, the religious scientist may see other forms of truth. The non-religious scientist may take a more conservative and limited view of the possibilities using *naturalism* as both methodology and philosophy.

Religious biologists who agree that evolution is a primary mechanism for development of species are often termed *theistic evolutionists*. They believe that God has built his laws into creation, placed certain boundary conditions on the activity of these laws, and has probably created secret

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[30] Logically, the fact that a given result cannot be accounted for within natural science is also not a reason to reject a supernatural explanation.

[31] "Creationism" seems to be an example of a theory that is not scientifically fruitful. While supporting a literal or semi-literal reading of Scripture in regard to natural events, fundamental creationism does not encourage further experimental study of nature and therefore a deeper understanding of reality. Creation "science" seems to expend most of its efforts in trying to debunk evolution.

[32] Strictly speaking, the line between natural causes and philosophical bias can become fuzzy. The biologist may incorporate some level of philosophic evolution in her scientific thinking. That is, the fact that mutation happens is scientific, but the idea that randomness in principle is behind evolution is a philosophical assumption. Each biologist may draw the boundary differently.

places[33] whereby He can subtly guide creation toward a better world.[34] People were gradually made distinct from the primates by some unknown process. *Theistic evolution* or *guided evolution* seems to be a workable modus operandi, although the boundaries between the two parts of one's thinking can be in state of tension. Theistic evolution is a possible consistent position for Swedenborgians.[35]

One wonders whether evolution rapidly gained popularity for reasons other than its purported scientific validity. One commentator contemporary with Darwin noted that the theory of evolution had finally made atheism respectable. The initial version of Darwinism was not without scientific problems, yet it quickly became enormously popular. Several writers have speculated that the political, social, and economic culture of the time was looking for a release from the constraints of religion. A kind of social survival of the fittest rather than charity toward the neighbor seemed more the order of the day. If random mutation, adaptation, and survival, could be viewed as fundamental processes in nature, and therefore scientific, and if the only reliable knowledge was scientific, then evolution gave intellectual respectability and even cachet to atheism. Nature's behavior reflected appropriate human behavior thereby providing a certain symmetry and order to new philosophic underpinnings that we now call "naturalism." (We do emphasize that evolutionary mechanisms certainly need not imply the lack of a Creator or the need for ongoing influx from a Creator, but evolution as a philosophy can, without the need for further hypotheses, lead to a naturalistic philosophy.)

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[33] Examples might include Heisenberg's uncertainty principle, or the apparent randomness of biological mutation.

[34] The precise nature of the better world depends on the particular religion. For the Swedenborgian the better world is the life after death and there is no dramatic or abrupt millennial world in the sense of some Christian beliefs.

[35] In the same series of articles mentioned in reference 25, David Fuller reviews Alfred Russell Wallace's views on evolution. Darwin and Wallace had initially very similar ideas but Wallace, who had read Swedenborg, saw three difficulties for the evolution as an encompassing explanation. He felt that evolution did not explain the transitions (a) from inorganic to organic (life), (b) from plant to animal, and (c) from animal life to the existence of the human soul. Fuller aligns very similar passages from Wallace's writings with passages from Swedenborg's Writings.

What about modern design theory? Has it become a *cause célèbre* because religious people are tired of the scientific establishment promoting a theory which seems to (but not necessarily does) point to a random, unguided universe? Probably.

In its modern mathematical version, design theory seems to remain just barely in the realm of scientific theory by not identifying a designer.[36] It does imply agency *without* specifying the agent(s). One criticism of the design methodology is that it appears to make no predictions. Is this a problem? We have noted that while the scientific method presumably involves prediction of new results, there are respectable scientific theories for the retro-explanations of past events, and that examples of fields that use this methodology include archeology, anthropology, and even evolutionary paleontology. In this limited sense, modern design theory could then be part of the kind of *retrodictive* science that we described earlier. Conservatively, design theory, as a science, uses the design methodology of the filter to separate into the design category only those events with a very miniscule probability (typically $<10^{-150}$) of having occurred by chance.[37] In this sense, it is the other end of the χ^2 test.

The *practical* implementation of the design filter as an experimental technique is difficult, except for relatively simple—but not too simple—systems, because we typically do not accurately know the correct probability of an event. Complex systems are very difficult to understand. There may be complexity bifurcations that we are not aware of. There may be intermediate mechanisms such as Manfred Eigen's (1927-) *order through dissipation* mechanism. In the latter two cases, the relationship between the before and after state may be a many-to-one function so that the relevant past has many possibilities and is therefore unknowable. The latter events are now recognized as common in the newer physics of nonlinear systems. The analysis of these sorts of events are called "inverse problems" and because of the many-to-one relationship, such problems may not have unique solutions. Nevertheless, from a theoretical viewpoint, a strictly

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[36] William A. Dembski, *The Design Inference* (NY: Cambridge Univ. Press, 1998), 222, 62.

[37] Ibid., 209 and following pages discusses what might constitute a reasonable estimation of a very small probability.

constructed version of intelligent design would seem to deserve consideration as part of the theory of the scientific method.

But creationists and others who call for a specific designer are doing so as a matter of philosophic bias or religious belief, not scientific methodology. This is a very fine distinction.

A Swedenborgian might also take a conservative view toward design theory. The natural world is the world of effects, and natural events have spiritual causes. Observation of the natural world therefore can illustrate spiritual concepts but not prove them or even get to the bottom because, as argued above, there exists an epistemic forbidden zone. For example, we can know much about how gravity or electromagnetism work, but we really do not know what these forces actually *are* at the deepest level (wherever that may be.) Stretching across the epistemic forbidden zone is the metaphysical principle that causes in the spiritual world *correspond* to effects in the natural world. Correspondences involve relationships or parallelisms or even metaphors, and the correspondence chain is manifested through influx from one level to another, but all of these concepts are expressed in the Writings as philosophic rather than mechanistic notions. Thus the ideas of correspondence and influx are broad and rather vague, with just enough general guidelines to give some shape to their existence. But the details are not given and, as part of Divine revelation and therefore God's manual for human salvation, probably need not be given. Therefore a Swedenborgian scientist could see nature as acting according to law, primarily in a random fashion, or he or she could see nature as exhibiting much that is designed. The epistemic barrier remains.

Concluding Remarks

In this paper we have attempted to capture the flavor of the growth of scientific methodology, the developing understanding of its limitations, and aspects of the religious response to the scientific revolution. While classical physics and religion seemed possibly compatible, we saw that evolution almost immediately generated hostility from religious literalists, while producing praise from religious liberals as partially solving problems with the interactions between the Divine and the human. We then focused on the modern notion of intelligent design by attempting to understand where its methodology could be interpreted as scientific but noted that design idea could also become a philosophical or religious position. It would seem that, depending on the particular definitions of science and of design, Swedenborgians could see intelligent design as part of the theory of scientific methodology.

But the future may bring new paradigms. Because science is a contingent activity, it is quite possible that neither the design inference nor the random chance explanation is the last word in human knowledge. Philosophical inferences based upon human methods are also similarly contingent. This is true for the Swedenborgian as well as the non-Swedenborgian.

Yet the Swedenborgian has made a particular leap of faith across the forbidden zone to a conviction that an even richer life exists on the other side. Similarly, the naturalist has also made a leap of faith, namely that there is nothing on the other side of the forbidden zone. What they do share is a common interest in exploring deeply the accessible side of the barrier. ❑