ARTICLES

PERCEPTIONS OF THE NATURE OF SCIENCE AND CHRISTIAN STRATEGIES FOR A SCIENCE OF NATURE

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WHAT THIS ARTICLE IS ABOUT

Attempts to resolve perceived conflicts between scientific theories and theology often rely heavily upon certain assumed characteristics of science. The author surveys several philosophies of science, noting attractive features as well as limitations.

Baconianism entails the common-sense notion that a methodical collection of facts will eventually lead to the laws of nature. Logical Positivism claims that experience is the basis of all legitimate knowledge, excluding metaphysics and theology. Karl Popper advocates falsification as the crucial means of eliminating error and insuring the progress of science. Thomas Kuhn describes science in sociological terms: a community with a commitment to a collection of shared beliefs, techniques, and goals. Norwood R. Hanson emphasizes the explanatory function of scientific theories: science is the pursuit of patterns. Paul Feyerabend accentuates the human element in science, with concomitant characteristics such as fallibility, and inconclusiveness.

Following a brief discussion of the complexities of observation in science, the author explores some possible strategies for resolving conflict between science and religion, each based upon a viewpoint of the nature of science discussed earlier. None of the strategies is found to be free from difficulty. Since each philosophy of science emphasizes characteristics with overlapping domains of applicability and validity, the author advocates an informed strategy embracing an eclectic approach.

INTRODUCTION

Christians hold certain religious beliefs to be true and cherish them for the meaning they give to their lives. Yet they live in a world shaped significantly by advances of knowledge attributed largely to science and its methodological approach.

When scientific pronouncements and religious beliefs conflict, what options are open to the Christian? The answer depends upon a host of things, but surely upon how science *and* religion are perceived. The present essay is confined largely to a consideration of the potential role played by various views of science, though many of the points made might be adapted readily to views of religion as well.

The caricatures of selected philosophies of science and the subsequent criticisms are intended to emphasize the complexities of the snare-infested quagmire awaiting the naive reconciler of science and religion.

INFALLIBLE INDUCTION [BACONIANISM]

In the nineteenth century, "Baconianism" was a prevalent Protestant, Anglo-American perception of the nature of science.[1] Numerous discussions with students and scientists suggest to the present author that Baconianism, with its appeal to common sense and realism, commands quite a following even at present. Therefore, it is appropriate to begin by enumerating several characteristic beliefs of nineteenth-century Baconianism, *viz.*, beliefs in the certainty of facts and their distinction from reasoning, the power of the inductive method, and the inevitable harmony of science and Scripture.

For the Christian, the "autonomy" of fact followed from its firm basis in human senses, senses that were eminently trustworthy since they were a manifest part of the benevolent design of the Creator Himself.[2] The distinction between fact and inference could be easily and unambiguously discerned.[3] Even the "unbeliever" shared this attitude toward the autonomy of fact, as a letter written by Thomas H. Huxley in 1860 illustrates.

> *Science seems to me to teach in the highest and strongest manner the great truth which is embodied in the Christian conception of entire surrender to the will of God. Sit down before fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing.*[4]

The scientific method was represented as consisting of simple, straightforward steps: begin with an unprejudiced mind, observe a sufficient number of facts, compare them, and the relevant scientific law would emerge, almost as a matter of course.[5] The inevitability of selectivity in the collection of facts was either largely unrecognized or conveniently ignored. Witness the testimony of Charles Darwin, reminiscing on the path leading to his *Origin of Species*:

> *My first note-book was opened in July 1837. I worked on true Baconian principles, and without any theory collected facts on a wholesale scale....*[6]

Contemporary scientists and theologians alike viewed laws and theories of science as simple generalizations of facts.[7] The collection, description and classification of facts of nature would assuredly lead to a deep understanding of nature as its laws progressively unfolded.[8]

Induction was not only a sufficient method in science, but it was a necessary one, and its necessity rested upon the finiteness of man as a part of God's creation. After all, Divine ingenuity must be expected to have produced incredible diversity, complexity and subtlety in nature. Shrewd hypotheses and fallible, human reasoning would be woefully inadequate to encompass the works of the Infinite One. The only reliable method of discovery was a patient, meticulous collection of facts.[9]

As for the efficacy of induction, that was no surprise when one recognized its origin. It was not until men

> *... had fallen back on God's facts in the Bible for the knowledge of ... things divine that...the facts of nature began to be sought for, as the only revelation of the ideas and principles of nature,... Who does not see the*

connection between the restoration of true Christianity and the new era of science...?[10]

If science and theology had a common methodology, what but harmony could result?[11] The Baconian method, in the hands of devout scientists, uncovered "wise designs" everywhere in nature. Theories at variance with Scripture could be counted upon to disagree with the "ablest observations" of nature as well. The inductive method unified all fields of knowledge. It was a method that could be trusted because it was given to man by a benevolent, wise Creator. In turn, its use led to discoveries that confirmed the existence of God. In short, all legitimate spheres of human enquiry proclaimed with one voice the Creator of Scripture.[12] The attractiveness of such an all-encompassing view of the world may well have dulled the sensibilities of its proponents to their own presuppositions and the circularities inherent in their argument.[13]

ERADICATION OF NONSENSE [LOGICAL POSITIVISM]

Developing in the early part of the twentieth century, and flourishing especially in the thirties, logical positivism saw itself as the natural development of a philosophy of science espoused in the 1880's by the Austrian scientist/ philosopher Ernst Mach. To the logical positivist, the touchstone which legitimatizes science and unifies knowledge is experience. Science is fundamentally a description of experience; metaphysics is excluded, including such disciplines as theology and ethics.[14] The rejection of metaphysics was not unprecedented; the strategy employed was. Since no experiential observation can verify the truth or falsity of a statement that asserts the existence of a reality transcending the realm of experience (i.e., a metaphysical reality), the statement itself is nonsensical — meaningless![15]

The most distinctive doctrine of logical positivism is the principle of verifiability, which may be stated several ways: the meaning of a proposition is identical with the method of verification; anyone uttering a sentence must know in which conditions he calls it true or false — otherwise he doesn't know what he has said.[16] To illustrate the principle, let us apply it to the following statement: The paper on which the words you are now reading are printed is "ordelatious." Suppose that ordelatious is defined as: smoothness, coupled with a whitish color, a temperature below 50 degrees Celsius, and a slightly salty taste. The statement is meaningful, since by touching, viewing, probing with a suitable thermometer, and tasting, one could readily establish its truth or falsity in this case. If, however, ordelatious is defined as above, with an additional characteristic that transcends possible experience, then that transcendent quality is meaningless since its presence or absence makes no detectable difference. The application of this principle to statements about the transcendence of God or His participation in the world has been made by logical positivists in a straightforward manner.[17]

The initial appeal of logical positivism was undoubtedly due in part to the prospect of escaping the subjectivity that seems to plague philosophies that embrace the metaphysical.[18] Nonetheless, the sharp categories and dichotomies originally set up by logical positivism have all come under sharp attack.[19] Predictably, some of the sharpest attacks have been directed against the verifiability principle itself.

In the first place, the principle is a metaphysical one; that is, the verifiability principle itself is not meaningful, given the criterion for meaning that derives from the principle. In other words, one cannot verify by sense experience the statement that all meaningful statements are verifiable by sense experience.[20] To respond to this criticism by relegating the principle to a "useful convention" is to engage in question-begging on the one hand, and to open the door to metaphysical philosophies on the other hand. A further difficulty for logical positivism resides in the very concept of verification. In the case of scientific statements about the world, the validity of inductive inference is generally assumed, a problematic issue since David Hume allegedly showed that all attempts to validate inductive inference utilize inductive reasoning, and hence entail circularity.[21] The response of logical positivists to this criticism has been to relegate the problem to the realm of metaphysics, where (for them) it becomes a fictitious problem.[22]

REJECTION OF ERROR [POPPERIANISM]

A radically different approach was taken by Karl Popper.[23] Though never a member of the "Vienna Circle," from whence logical positivism arose, Popper felt a strong affinity for the "rational attitude" the philosophy promoted.[24] But he refused to accept the "solution" offered by logical positivists to Hume's problem of induction. Rather than accept induction, without rational justification, he insisted that induction is not necessary, nor is it used to gain knowledge of the unknown — in short, it is *not* a fact.[25]

If induction is not the method of science, one of the questions that arises is whether there are *any* characteristics to distinguish science from myth. Youthful encounters with Marxism, Freudian psychoanalysis and Einstein's general theory of relativity led Popper to note a remarkable contrast in attitude in these fields: the propensity of Marxists and psychoanalysts to interpret any conceivable event as a verification of their respective theories, and the expressed willingness of Einstein to abandon his theory should it fail certain crucial tests.[26]

Thus, Popper came to emphasize falsifiability as a crucial line of demarcation between science and pseudoscience. Consider the simple "theory": All swans are white. To conclusively verify this theory entails the exhaustive inspection of *all* swans; to falsify the theory requires only a single counterinstance, *viz.*, one non-white swan. While the scientist cannot hope to verify what *is* the case, he *can* hope to discover what is *not* the case. Hence, he should construct theories that entail specific predictions. Given the incompleteness of knowledge, at least some of these predictions will *not* be borne out by experience; hence, the particular theory will be refuted. But rather than looking upon a refutation as a failure of the theory, it should be perceived as a triumph of scientific methodology. Indeed, the goal of the scientist becomes the refutation of theories instead of their defense, since rapid refutation of successive theories leads to progress in an inverted sort of way, *viz*., the discovery of error, or a backing away from error. This methodology utilizes shrewd guessing and a relentless search for discrepancies between these guesses and experience — in short, knowledge grows by trial and error.[27]

A scientific theory that is specific and falsifiable, yet has survived many attempted refutations, is said to be "highly corroborated." This is simply an appraisal of its success up to a specified time and under specified circumstances and is not (Popper insists) logically equivalent to asserting that it is true. Although

> *...the striving for knowledge and the search for truth are still the strongest motives of scientific discovery....Science is not a system of certain, or well-established statements;...it can never claim to have attained truth, or even a substitute for it, such as probability....*[28]

Popper's philosophy of science is a direct response to what he terms "insurmountable difficulties" associated with inductive logic.[29] Yet his critics claim that by introducing the concept of corroboration he has sneaked back into science inductive inference, the logical process he sought to banish. What is the essential difference between justifying a theory by confirming instances or by absence of falsifying ones? they ask.[30]

Popper's central concept of falsifiability of refutability has also come under fire. In the first place, it goes against the grain of a common-sense narrative of the historical development of science. Does it not seem artificial and forced, to recount the story of the discovery of capillaries as the falsification of some contradicted conjecture(s) rather than the confirmation of a hypothesis entertained by William Harvey?[31] Secondly, existential statements such as "There are molecules" are not refutable in that one can always change the properties of the postulated entities to agree with experiment, yet these sorts of statements have proved fruitful in the development of scientific thought.[32] Finally, may not "falsifiability" be a superfluous concept? Though "all swans are white" is falsifiable, this formulation of the scientific theory would probably have little impact upon the research activities of scientists encountering the "first" non-white swan.[33]

SOCIOLOGICAL COMMUNITY [KUHNIANISM]

An influential viewpoint of the nature of science has been developed by Thomas S. Kuhn.[34] As a graduate student in physics assigned to assist in the preparation of a series of lectures on the development of modern mechanics, Kuhn was surprised to learn that the transition from ancient to modern ideas was not as straightforward, logical and inevitable as he had assumed.[35]

Kuhn's account of the growth of knowledge emphasizes the sociological aspects of science. "Normal" science involves a community of participants sharing a constellation of values, beliefs, and techniques. An accepted paradigm (example par excellence) serves to focus community interest. Commitment to the paradigm frees the scientific community from a continual (unproductive) preoccupation with fundamentals and channels research in a way that at once narrows the scope and increases the depth. For example, Newton's *Principia* posed a set of puzzles in a mathematical setting that included theoretical problems, the measurement of specified parameters and constants, the refinement of techniques of measurement, and a variety of predictive implications — in short, a set of scientific activities with reasonable assurance of success.

Increased specialization of research and sophistication of theory are accompanied by a precision of expectations which sometimes results in anomalies — discrepancies between prediction and observation. Should an anomaly persist, despite all efforts to solve the puzzle it creates, a crisis is likely. Symptoms include a proliferation of versions of the theory in question, debates over fundamentals, a preoccupation with philosophy, and an open questioning of accepted rules. As "abnormal" scientific activity increases, a new point of view may come to predominate, often promoted by charismatic scientists who are either young, relatively new in the field, or exceptionally creative. The new paradigm gains ascendancy by processes analogous to political persuasion and religious conversion, with incommensurable viewpoints frequently leading to encounters in which advocates of opposing sides "talk through" each other. After the "revolution" scientists share a new paradigm, which not only influences the way they view a given set of phenomena, but also (often) gives to them a different set of significant problems. Even the textbooks are rewritten in such a way that precursors of the new paradigm are carefully incorporated into the sketchy "history" of the discipline.

The normal-abnormal dichotomy that Kuhn emphasizes for science has been criticized for being artificial, misleading and unilluminating,[36] while his emphasis upon the role of non-rational processes during times of scientific crisis has been attacked for the relativism it seems to encourage.[37]

EXPLANATORY APPEAL [HANSONIANISM]

The late Norwood Russell Hanson has characterized scientific theories as "conceptual gestalts." They provide "patterns within which data appears intelligible."[38] Indeed, an important function of science is to provide explanatory models for the phenomena found in the world. Following the philosopher Charles Pierce, Hanson claims that the actual process used in the growth of knowledge is a quasi-logical one termed retroduction. Retroduction combines substantial knowledge with brilliant insight in an imaginative leap towards what *may be* the case.[39] An example is the discovery of the law of gravitation.[40] The law does *not* follow deductively nor can it be obtained inductively from Kepler's three laws of planetary motion. But *if* Newton's law of gravitation is correct, Kepler's three laws, several motions of the moon, the ocean tides, and the motion of falling objects are all explained as a matter of course. Although Newton's gravitational law (or theory) is empirical, it is more than simply that.

It is more than a refutable statement like: All swans are white. It does more than summarize a cluster of prior observations. It is a theory from which those observations are explicable as a matter of course.

A more current example of the explanatory appeal of a theory is that of plate tectonics. Given the theory, one can place a wealth of data into a plausible scenario that makes sense, for example, of the global distribution of earthquakes, volcanoes, heat flow, crustal thickness, ocean floor topography, and sea floor magnetism. To the question, Why should one accept the theory of plate tectonics? a persuasive answer for many is simply, Because it makes sense of a whole string of otherwise disparate observations about the earth.

The objection might be made that a plausible explanation has been mistaken for the truth of the matter. A likely rebuttal is that science is no longer preoccupied with truth but with models, and the concept of truth in science no longer refers to certainty but to probability.[41]

EPISTEMOLOGICAL ANARCHY [FEYERABENDIANISM]

Underlying all of the philosophies of science discussed thus far is the belief that the progress of science depends crucially on some distinctive methodological rule or procedure. For the Baconian, a careful induction from patiently-collected facts will inevitably lead to truth. For the logical positivist, metaphysical elements must be weeded out, so that scientific theories are confined to an ever-growing cluster of verifiable statements about the world. For Popper, theories are created by bold conjectures; they must be refutable by design and will be ruthlessly eliminated (and/or modified) as their predictions deviate from observations. For Kuhn, specialization in research will lead to an increased precision of prediction, the subsequent discovery of anomalies, an eventual paradigm-switch and a new theory with more finely-honed problem-solving capabilities. For the follower of Hanson, intelligibility provides a goal that will (presumably) become increasingly difficult to achieve unless the explanatory theory corresponds rather well with the reality of the world.

While each of these philosophies offers useful insights into the nature of science, Paul Feyerabend has offered some provocative criticism of the assumption of some unique, identifying principle or rule as defining science.[42] Insisting that science is a creative, human activity, he refuses to allow it to be hampered by "stultifying, unimaginative rules." Given any rule, sometimes its opposite should be adopted, he urges, suggesting the appropriateness at times of hypotheses which, in turn, are ad hoc, contradict accepted experimental results, embrace a smaller collection of facts than their rivals, and are even self-contradictory. He characterizes his pluralism in methodology with the motto "Anything Goes"!

Against Popper, Feyerabend advocates the *retention* of theories that *have already been refuted*, for the following reasons.[43] First, because criticism based upon abandoned theories has often proved fruitful in the past (Copernicus' study of the "ancients" contributed to his innovation in astronomy). Second, because "no idea is ever examined in all its ramifications and no view is ever given all the chances it deserves." Third, because the critical examination of a prevailing viewpoint is best done from outside the system. Fourth, because the evidence adduced to refute a theory may itself be theory-contaminated and potentially refuting evidence may be excluded from consideration by the prevailing theory. Fifth, because "there is not a single interesting theory that agrees with all the known facts in its domain" so that to reject refuted theories is to reject all theories.

As for the progress of science, as manifested by Newtonian concepts and the achievements of the space program or by molecular biology and the advances of modern medicine, Feyerabend claims that we've been duped. The progress of science, in whatever sense one wishes to define it, is not a valid argument for some infallible method of science; that progress has occurred precisely because the "rules" of scientific methodology have been violated.[44]

Feyerabend's philosophy is appealing because of its explicit recognition of the humanness in science — it permits scientific decisions to be based upon personal judgment rather than upon a rigid set of rules. It allows Buffon to react to a discrepancy by a factor of two between observation of the movement of the line of the moon's apsides and Newton's theory thusly: So many facts support Newton's theory that this single discrepancy must be explained away.[45] It allows Einstein to react to the report that measured values for the bending of light near the sun and for the red shift disagreed with his predictions with this remark:

> *My gravitational equations are convincing because they avoid the inertial system (the phantom which affects everything but is not itself affected). It is really strange that human beings are normally deaf to the strongest arguments while they always are inclined to overestimate measuring accuracies.*[46]

An unattractive feature of epistemological anarchy for some is its undiscriminating attitude toward an almost infinite number of possible methodologies for practicing science. Limits of acceptability seem so broad that there remains no discernable distinction between delusion and knowledge, whim and reason, fantasy and truth. Feelings of uneasiness are reinforced by assertions such as the following.

> *The task of the scientist, however, is no longer 'to search for the truth,' or 'to praise God,' or 'to systematize observations,' or 'to improve predictions.' These are but side effects of an activity to which his attention is now mainly directed and which is 'to make the weaker case the stronger' as the sophists said, and thereby to sustain the motion of the whole.*[47.]

THEORY-LADEN OBSERVATIONS

A common-sense philosophy might suppose that science begins with the simple collection of sense data — observation being one of the most elementary and unproblematic aspects of science. The following examples have been chosen to display the inadequacy of this common-sense view of science.

Consider the discovery of the planet Uranus.[48] In March 1781, William Herschel recorded in his journal the sighting of a "curious either nebulous star or perhaps a comet." Subsequent sightings over the next few days indicated that the "comet" moved with respect to the fixed stars. After several months of unsuccessful attempts to calculate the orbit of this "comet," the astronomer Lexell suggested that it might be a planet. Further computations confirmed his suggestion. A subsequent search of available astronomical records uncovered at least seventeen sightings of this planet in the ninety years prior to Herschel's observation. In all of these previous sightings, the object was referred to as a star. It seems clear that scientific advancement requires more than simply seeing!

For illustration, consider a command to record what you are *now* experiencing. If you take this command seriously, you may still be puzzled. Should you include your rhythmic breathing, the pressure of the chair on your posterior, the background noises, the light in the room...? Supposing you somehow succeeded in recording the totality of your present experiences, you would still not be doing science. Science necessitates a point of view, a theoretical mind-set, if you will, to ensure selectivity in data collection, not to mention an imaginative creativity.[49]

The difficulties associated with early telescopic observations are not generally appreciated.[50] There is the general problem of the unfamiliar. Who has not experienced the bewilderment of that "first look" through a microscope, with all the blurry, wiggly globs that became clear only after consulting the textbook drawings which accentuate what it was that one was supposed to see? The early telescopes undoubtedly were of poor quality, and the images produced possessed a liberal amount of distortion. If one views a familiar building through such an instrument, compensation can be readily made, but how can one apply analogous corrections to the images of celestial objects only seen previously from far away by the naked eye? A further problem facing early observers was that of reliability and consistency. The magnifying power of the instrument seemed dependent upon the object (its nature? its distance? its size?), being greatest for the moon and much less for the stars. Viewed through the telescope, the moon's terminator (the boundary between light and dark portions) displayed an unevenness suggesting topographic relief, yet the outer boundary appeared perfectly round and smooth. Is it any wonder that one of Kepler's students reported a session with the telescope in these words:

> *...I tested the instrument...in a thousand ways, both on things here below and on those above. Below it works wonderfully; in the heavens it deceives one....*[51]

In light of the foregoing points, Galileo's assertion that the telescope works in the same way everywhere seems less than convincing. On the other hand, it is highly significant that Galileo had a cause to promote, *viz.*, the Copernican system, and he saw early telescopic observations as providing arguments in favor of Copernicanism. Seen from the twentieth century, it seems that Galileo's predisposition towards Copernicanism affected his judgment as to the significance (or insignificance) of otherwise puzzling instrumental distortions.

Further evidence of the interplay between theory and observation comes from Galileo's account of what he found on the surface of the moon.[52] When he pointed his telescope toward the moon, he *saw* discontinuities which he *reported* as craters. This suggests a commitment to a specific model for their origin. Craters might be produced by artillery explosions, falling meteors or volcanoes, but surely not by erosion, subsidence, or digging!

As a final instance of the complexity of observation, one might cite experiments in which subjects were fitted with inverting spectacles, causing the world to be seen upside-down. After a time, compensation was made spontaneously by the subjects, and the world was seen right-side up. When the spectacles were subsequently removed, the subjects again saw the world upside-down, for a time.[53]

The nineteenth-century Baconian would say that "seeing is believing." The preceding examples suggest that things are not quite that simple. In some cases, a more appropriate statement might be: "believing is seeing."[54]

TENSION RESOLVED?

With this background, let us explore several strategies open to the Christian when he perceives a conflict between a scientific pronouncement and a scriptural doctrine. The first two place science "above" theology; the final three place theology "above" science.

SCIENCE: INDEPENDENT DISCIPLINE [LOGICAL POSITIVIST]

Science deals with sense data that are observable and experiential; religion deals with the *a priori* and the metaphysical. Therefore, do your science; keep it separate from your theology; don't expect to get clues from Scripture about nature.Advocates of an approach to this sort of independence of science from religious doctrine include Galileo,[55] who wrote

> *...in discussions of physical problems we ought to begin not from the authority of scriptural passages, but from sense-experiences and necessary demonstrations.*[56]

One objection to this approach is that it misses the point of the distinction between science and religion as seen by logical positivism.

> *...there is no logical ground for antagonism between religion and natural science. As far as the question of truth or falsehood is concerned, there is no opposition between the natural scientist and theist who believes in a transcendent god. For since the religious utterances of the theist are not genuine propositions at all, they cannot stand in any logical relation to the propositions of science.... His assertions cannot possibly be valid, but they cannot be invalid either...*[since he] *says nothing at all about the world....*[57]

Another objection relates to a point raised when logical positivism was discussed above, *viz*., science is *not* devoid of the metaphysical. Themes such as conservation, quantification, atomistic discreteness, hierarchical structure, and the principle of uniformity in nature are not empirically verifiable (or falsifiable), but they have been immensely fruitful.[58] Thus, the line separating science from religion is not as well-defined as this position asserts. If the metaphysical were to be strictly excluded, science would be severely restricted.

A further objection to the strategy arises from a recognition that Scripture speaks of nature. Though surely not a central theme of Scripture, statements about nature do occur as they impinge upon the themes of Scripture. To insist that any subject must be treated centrally or exhaustively in order to be treated truly is surely wrong.[59] To treat the cosmic and historical statements of Scripture as so much irrelevant baggage — to look exclusively for the "religious" truths in Scripture is analogous to ignoring Lewis Carroll's cat and insisting that the grin can stand alone. It is worse than reducing Scripture to a skeleton that won't support its own weight. It is taking away the skeleton, the historical and physical framework which Scripture presupposes.[60]

Finally, treating science as an independent discipline is a defeatist approach. It is to surrender the concept of the unity of truth, without which the whole world view of the Christian loses much of its appeal.[61]

SCIENCE: EXEGETICAL TOOL [BACON]

An alternative strategy is epitomized by the exclamation: "So that's what the Bible means!" A passage written by Galileo may be cited in support of this approach:

> *...it is the function of wise expositors to seek out the true senses of scriptural texts. These will unquestionably accord with the physical conclusions which manifest sense and necessary demonstrations have previously made certain to us.*[62]

In this mode, interpretations of Scripture must conform to current scientific knowledge. This often results in naturalistic explanations for miraculous events with concomitant restrictions on the literalness of the passage in question. This strategy has been applied to the Scriptural stories of the Creation, the Flood, the Egyptian plagues, and the conquest of Jericho, to mention just a few.[63]

Understandably, this approach has a special appeal to the Christian who chooses science as a profession. Ironically, arguments used to support this strategy also raise issues that lead to objections. Proponents may point out the tendency of the naive "believer" to equate his *interpretation* of Scripture with Scripture itself. The folly of this tendency will be easily recognized if science is used explicitly as an exegetical tool. Furthermore, the procedure is completely justified by the fact that God is the Author of both nature and Scripture. One of the problems with this argument is that it easily blurs an equally crucial distinction between nature and *its* interpretation, science. To insist that science holds the key to Scripture is merely to exchange one interpretation for another, to trade naivety about Scripture for naivety about nature, to replace one form of arrogance with another.

Proponents may also insist that for Scripture to remain relevant, it must be interpreted in the light of accepted scientific knowledge — that the progressive nature of the growth of scientific knowledge toward the correct understanding of the universe demands a revision of outmoded Scriptural interpretations. Based upon conservative ideas of inspiration, revelation, and truth, opponents might object that, given the changing character of scientific knowledge, the endless adjustments of Scriptural interpretation that the proposed strategy would require are out of harmony with the Judeo-Christian concept of an unchanging God, who has spoken the truth in Scripture.[64]

Finally, what proponents view as the advance of truth, opponents see as one more evidence of a deplorable trend toward the secularization of knowledge. What the proponents call rational explanation, the opponents fear as rationalization and an explaining away. Even in cases where these objections may lack logical foundation, their psychological impact is significant.

SCIENCE: INCOMPLETE INVESTIGATION [BACON]

The first of three strategies in which theology is placed "above" science handles conflicting claims of science and religion by asserting that the scientific data is incomplete. Of course, the assertion is trivially true given the open-endness of science. Therefore, the assertion is normally intended to encompass the stronger claim that the present data is so incomplete that the offending theory is fundamentally wrong. The belief is often expressed that further investigation will vindicate this attitude and also the veracity of Scripture.

The argument from the incompleteness of science is an argument from missing data — an argument from ignorance, in a way. Historically, this ploy has been notably unsuccessful. For example, a long-standing strategy of natural theology was to allege that support for the argument of God's continued action and presence in the world resided precisely in those regions of inquiry that scientific investigation had not penetrated. Subsequent advances of science drove that sort of "God of the Gaps" from His universe.[65] Furthermore, the belief that continued collection of data relevant to an offensive theory will result in substantial modification of that theory assumes (incorrectly) that a theory is merely a summary of data and that data is not theory-dependent. Finally, the above strategy exhibits an unwarranted faith in scientific methodology. To believe that "sufficient" scientific research will inevitably lead to conclusions supporting the reality of the supernatural is to ignore the secular, naturalistic presuppositions of science.

SCIENCE: SUPERFICIAL INVESTIGATION [KUHN]

A variation on the incompleteness argument is this: the apparent disagreement between science and theology arises due to a failure to attend carefully to the presuppositions and/or anomalies associated with the offensive theory. The obvious way to rectify the situation is to concentrate research in the problem area; to refine the measurements, to accentuate the anomalies, and to scrutinize meticulously the presuppositions. After all, the argument goes, it is the focusing of manpower and effort on a problem that leads to a solution. Briefly characterized, this strategy is the search for inconsistencies, and it is fraught with dangers.

In the first place, a sort of uniqueness theorem is invoked, *viz*., only the truth can be consistent. Yet it is a well-recognized logical possibility that, for any finite collection of data, several — perhaps many — theories may be devised. The elimination of an offensive theory may not prove to be easy, or even possible, even if it is *false*!

In the second place, even if an anomaly is discovered and documented and generally acknowledged, rejection or modification of the offensive theory is not assured. A contemporary illustration of this point comes from the field of paleomagnetism.[66] In the early decades of this century, it was established that rocks with a magnetic polarity opposite that induced by the earth's present magnetic field occur worldwide. By the fifties, experts generally interpreted the data to mean that the earth's magnetic field had experienced reversals of polarity in the past. However, in the early fifties, both theory and experiment suggested the possibility of a self-reversal mechanism to account for the direction of magnetization of rocks. About the same time an unexpected correlation between the oxidation state of the minerals and their magnetic polarity was discovered. By the mid-sixties, several investigations had confirmed the existence of polarity-oxidation correlations (suggesting self-reversal), while at the same time evidence was mounting for the reality of field reversal. There were expressions of concern that paleomagnetism might contain internal contradictions, one scientific expert casting the difficulty as "one of the major unsolved problems of Earth science."[67] After about 1972, the problem faded away, *not* because it was solved, but presumably because it defied solution and "all" other data filled the paleomagnetic model of field reversal.

This brings up a third difficulty with the search for inconsistencies. The goal of the endeavor is largely destructive rather than constructive. The search for anomalies and loopholes in a theory cannot compare with the challenge and sense of satisfaction that comes from the construction and refinement of successful scientific models. Thus, it has happened that some who became experts in a particular field for the express purpose of "slaying the fiery dragon" have ended up embracing the paradigm they initially sought to demolish — not in the spirit of a "turncoat" but as they have seen the fruitfulness of the paradigm — not because the prevailing paradigm was flawless, but simply because there seemed no viable, positive alternatives.

In a laudable effort to take a more positive approach, some creationists have insisted that creationism offers the potential for *more* puzzle-solving activity than does the prevailing paradigm. But creationists have often neglected addressing an equally crucial point, *viz*., the puzzle-generating framework must also offer some prospect of success. The concept of "special creation" is, by its very nature, not subject to scientific testing at all at the level of mechanism (at least not as ordinarily represented — i.e., an ex nihilo, fiat series of events).

SCIENCE: UNSCIENTIFIC [POPPER]

A popular strategy among anti-evolutionists is to assert that the offensive theory is irrefutable. The assertion may be based upon two independent considerations which will be taken up in turn: the nature of the subject and the nature of the theory.

Theories of origins construct certain sequential events of the remote past alleged to have actually occurred. The evidence from science for such historical events is circumstantial; experiments conducted in the present can show, at best, what is *possible*. Actual occurrences are irretrievably imbedded in the past. Personal testimony — useful in ordinary historical cases — is unavailable (excluding revelation). To leap from the plausible to the possible to the probable to the actual is to abandon accepted rules of logic. It is to confuse speculation with science.

Although this line of argument may be psychologically persuasive, as it stands it simply won't do. Science and scientific theories are not systems confined to the strictures of logical demonstration. As was emphasized earlier in this essay, scientists use not only deduction and induction but also retroduction, which involves a creative, intellectual leap that *suggests* that something *may* be. The resultant theory is accepted because it makes sense out of a wealth of data, not because it "follows" from that data. Scientists are in search of "explanations," not proofs.

Turning to the nature of the theory of evolution, it has been criticized for its logical circularity.[68] Thus, it was the doctrine of natural selection that convinced Victorians that evolution had occurred. Natural selection was then equated with evolution. The chief direct evidence bearing on evolution was the fossil record, which was at the same time, by means of the notorious gaps, a most telling argument *against* natural selection. But, conceiving of evolution as the result of natural selection easily (albeit incorrectly) led to the identification of any evidence for one as evidence for the other.

The objection to this criticism is simply to note that "all comprehensive theories, all fundamental theories ... [including] the corpuscular theory of the Newtonians, [and] the relativity theory of the twentieth-century physicists are similarly circular."[69]

Another possible criticism of the evolutionary dogma is that it is taken for granted. For example, in the sixties the International Union of Biological Sciences organized conferences to address the problems of theoretical biology. A perusal of the first published reports shows that though substantial time was devoted to criticisms of proposed mechanisms of evolution, it was almost invariably assumed that evolution, by whatever means, did occur.[70] But the criticism loses much of its force with the realization that principles have come to be taken for granted in other areas of science as well. For example, the principle of the conservation of energy has proved to be an extremely fruitful one, even though on occasion new forms of energy had to be "invented" in order to retain the principle.[71]

SCIENCE: AN ECLECTIC VIEW

What is science? A summary of facts? A set of verifiable/falsifiable statements about the world? A group of shared beliefs providing fruitful puzzles to solve? A predictive tool? An explanatory system for a series of otherwise disparate phenomena? A fallible, human activity? Each of these suggestions requires qualification, but each provides a helpful insight into the nature of science. A careless disregard for any of these insights will likely lead to misunderstanding and frustration as the devout scientist in our time struggles to resolve the tensions he finds between science and religion and seeks to communicate his position effectively to his fellow Christians and to his naturalistic, scientific peers.

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ENDNOTES

1. (a) Bozeman TD. 1977. Protestants in an age of science: the Baconian ideal and antebellum American religious thought. Chapel Hill, NC: University of North Carolina Press, p xii; (b) Daniels GH. 1968. American science in the age of Jackson. NY: Columbia University Press, p 63.
2. Bozeman, p 11, 54, 55; Daniels, p 66-67.
3. Bozeman, p 105.
4. Quoted in: Hooykaas R. 1963. Natural law and divine miracle: the principle of uniformity in geology, biology and theology. Leiden: E. J. Brill, p 210. Compare Francis Bacon, Novum Organum, Book I, Aphorism 68.
5. Daniels, p 66.
6. Darwin C. 1969. The autobiography of Charles Darwin, 1809-1882: with original omissions restored; edited with appendix and notes by his granddaughter, Nora Barlow. NY: W. W. Norton and Company, p 119. Darwin wrote this work between 1876 and 1882. For a comment on his “Baconian method,” see: Grene M. 1974. The knower and the known. Berkeley, CA: University of California Press, p 191ff.
7. Bozeman, p 64; Daniels, p 121.
8. Daniels, p 192, 66.
9. Bozeman, p 18. Compare Daniels, p 73-77.
10. Bacon L. 1846. Sermon at the ordination. In: Discourses and Addresses at the Ordination of the Rev. Theodore Dwight Woolsey, LL.D. to the ministry of the Gospel, and his inauguration as President of Yale College, October 21, 1846. New Haven: B. L. Hamlen, p 25. Compare Bozeman, p 124.
11. Bozeman, p 110-111, 155; Daniels, p 82.
12. Bozeman, p 50, 108.
13. Daniels, p 200.
14. Passmore J. 1972. Logical positivism. In: Edwards P, editor. The Encyclopedia of Philosophy, vol 5. NY: Macmillan Publishing Co., p 52. Hereinafter referred to as EP.
15. (a) Ayer AJ. 1965. Demonstrations of the impossibility of Metaphysics. In: Edwards P, Pap A, editors. A Modern Introduction to Philosophy: Readings from Classical and Contemporary Sources. Rev ed. NY: Free Press, p 687-688. Hereinafter referred to as MIP; (b) Ayer AJ, Copleston FC. 1965. Logical positivism — a debate. In: MIP:748. Compare Ayer AJ. 1946. Language, truth, and logic. NY: Dover Publications, p 33-45.

16. (a) Passmore, p 52; (b) Ayer, Impossibility of metaphysics, p 687; (c) Ayer & Copleston, p 742ff; (d) Ashby RW. 1972. Verifiability principle. In: EP 8:241.
17. (a) Stace WT. 1965. Metaphysics and meaning. In: MIP, p 697ff; (b) Ayer, Language, truth, and logic, p 115-119.
18. See, for example, Ayer & Copleston, p 726-756.
19. Passmore, p 56.
20. (a) Ewing AC. 1972. Meaninglessness. In: EP:705ff; (b) Ewing AC. 1962. The fundamental questions of philosophy. NY: Collier Books, p 44-47. A counter argument asserting that all factual propositions are necessarily subject to the principle of verifiability can be found in Ayer, Language, truth, and logic, p 41, 93-99.
21. For a brief introduction to the "problem of induction" and a sketch of several proposed solutions, see: Salmon WC. 1967. The foundation of scientific inference. Pittsburgh: University of Pittsburgh Press, p 5-56.
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23. Popper KR. 1968. The logic of scientific discovery. 2nd ed. NY: Harper & Row. First published in Vienna in 1934 as Logik der Forschung. Compare: Quinton A. 1972. Karl Raimund Popper. In: EP 6:398-401.
24. Popper K. 1974. Autobiography of Karl Popper. In: Schilpp PA, editor. The Philosophy of Karl Popper. LaSalle, IL: Open Court, p 70.
25. Popper, Replies to my critics. In: Schilpp, p 992, 1013-1015.
26. Popper, Autobiography. In: p 24-29.
27. Popper, Logic of discovery, p 39, 315-317, 420-441.
28. Ibid., p 278, 279.
29. Ibid., p 29.
30. Quinton, p 399; Salmon, p 26-27.
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32. Ibid., p 51. Compare Popper, Logic of discovery, p 69-70.
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35. Kuhn, Scientific revolutions, p v; Kuhn, Essential tension, p xi-xii.
36. For example, see: Toulmin S. 1972. Human understanding: volume I: the collective use and evolution of concepts. Princeton: Princeton University Press, p 98-119.
37. For an example of the emphatic rejection of relativism, despite logical difficulties, see Salmon, p 45-46. For specific criticisms of Kuhn, see (a) Toulmin, p 76, 102-105; (b) Popper K. 1970. Normal science and its dangers. In: Lakatos I, Musgrave A, editors. Criticism and the Growth of Knowledge. Cambridge: Cambridge University Press, p 56-58. For Kuhn's response, see Kuhn, Scientific revolutions, p 105-107; Kuhn, Essential tension, p 320-339.
38. Hanson NR. 1972. Patterns of discovery: an inquiry into the conceptual foundations of science. Cambridge: Cambridge University Press, p 72, 87, 90.

39. Ibid., p 72-86. Compare the nineteenth-century idea of William Whewell. See: (a) Blanché R.1972. William Whewell. In: EP 8:288-289; (b) Ruse M. 1982. Darwinism defended: a guide to the evolution controversies. Reading, MA: Addison-Wesley, p 45-46.
40. Hanson, Patterns, p 107-108.
41. Gingerich O. 1982. The Galileo affair. Scientific American 247(2):137, 143.
42. Feyerabend P. 1978. Against method: outline of an anarchistic theory of knowledge. London: Verso Edition. See specifically p 20, 23-24, 28, 29, 49, 65, 68.
43. Ibid., p 31, 49.
44. Ibid., p 304.
45. Hanson, Patterns, p 110.
46, Feyerabend, Against method, p 58.
47. Ibid., p 30.
48. Kuhn, Essential tension, p 171ff.
49. Popper, Logic of discovery, p 106.
50. Feyerabend, Against method, p 119, 123, 127-129.
51. Quoted in Feyerabend, Against method, p 123.
52. Hanson, Patterns, p 56.
53. Cited in: Bohm D. 1965. The special theory of relativity. NY: W. A. Benjamin, Inc., p 201.
54. For a brilliant discussion of the complexities associated with observation, see: Hanson NR. 1969. Perception and discovery: an introduction to scientific inquiry. San Francisco: Freeman, Cooper, and Co., p 59-198.
55. Admittedly, it would be anachronistic to place Galileo among logical positivists. The strategy under discussion, as well as subsequent ones, is intended merely to illustrate a certain type of approach. It must not be thought of as inexorably tied to a particular philosophy of science.
56. Galileo. 1957. Letter to Madame Christina of Lorraine, Grand Duchess of Tuscany: concerning the use of biblical quotations in matters of science. In: Drake S, translator. Discoveries and Opinions of Galileo. Garden City, NY: Doubleday Anchor Books, p 182. The "Letter to Christina" is witty and incisive. It is worthwhile reading for anyone seriously interested in a harmony between religion and science.
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64. Views of inspiration, revelation, and truth play a pivotal role in the entire discussion of the relationship between science and religion, but a treatment of these matters is not within the selected scope of the present essay.

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69. Ibid., p 194. Grene qualifies her criticism of the theory of evolution thusly: its circularity is too narrow.
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71. A startling example of this was Pauli's neutrino hypothesis. See: Fierz M. 1974. Wolfgang Pauli. In: Gillispie CC, editor. Dictionary of Scientific Biography 10:424. NY: Charles Scribner's Sons.