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Is Science Scientific? Affinities between Theologians and Scientists as Interpreters in the Search for Truth

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"Is science scientific?" The question may seem as ridiculous as asking whether 2 + 2 = 4. Yet most scientists, I contend, would shudder at some of the notions of what "scientific" often means to the general public.[1]

> Scientific study of the universe uses repeatable procedures and experiments to discover facts and verify theories that reflect the truth about the way things really are. Because science distances the scientist as subject from the observed object, its data, methods, and knowledge are objective, value-neutral, and certain. This objectivity, evident largely in the mathematical concepts and quantitative methods it employs, distinguishes science from all other disciplines and modes of expression. The phenomenal predictive power and success of science since the Enlightenment suggest that science will eventually be able to solve any problem it considers.[2]

The preceding paragraph is full of misconceptions about science. It ignores many of the following questions: How are facts related to values? What are the

[1]I would like to dedicate this article to the memory of Paul Sonnack, my former professor of church history at Luther Northwestern Seminary, who first encouraged my theological study, especially in the areas of science and religion. I also appreciate many helpful comments of several colleagues on an earlier draft of this essay.

[2]This paragraph is entirely contrived to encapsulate misunderstandings of science. Unpacking it may be a good way to start a conversation.

roles of intuition, imagination, and creativity in science? Does truth mean correspondence with reality? Is mathematical knowledge certain? How are theories related to data? Do subjects and objects influence one another? Are the political views of a scientist at all relevant to her work? Are there any limits to science?[3]

If misunderstandings about the nature of science exist, as I contend they do, there is still much work to be done in bridging C. P. Snow's two cultures.[4] Using some of the history of mathematics and science, I hope to build one bridge by making science less intimidating. Specifically, my goals are, first, to show that science is *not* "scientific" in the way described above; second, to explain why science *is* interpretation; and finally, to suggest affinities between scientists and theologians.[5] If along the way you learn a little history of mathematics or overcome some fear or dislike of math, of course, as a mathematician, I would be delighted.

I. ASSUMING REALITIES: THE SUCCESS OF SCIENCE

When the Royal Academy in England and the Académie Française were founded in the 1660s, the possibilities for science seemed boundless. In some ways, late seventeenth-century Europe was even more of a scientific community than the United States three centuries later. Science was regularly the topic of conversation in salons and coffee houses, occupying the minds of women and men, amateurs and professionals, and inspiring both poetry and satire.

In contrast to the previous two millennia, after the scientific revolution the whole scientific enterprise was based largely on mathematics. Galileo had changed the key scientific question from the metaphysical "why?" of Aristotle to a physical "how?" that was answered using quantities and mathematical formulations. Quantification, Newton's new calculus, and the logical reasoning of Euclid's geometry were the pillars of scientific methodology. In the centuries after Newton, science enjoyed phenomenal success. The mathematically based physical sciences became the model for economics, political science, and other developing social sciences. Since the predictability of quantified data and deterministic mathematical models was the goal, the more mathematical a discipline, the better it was.[6]

While Newton and his cohorts pursued their mathematically based science in the praise and service of their Creator, in less than a century Laplace was able to dispense with the hypothesis of God.[7] In addition, by the late 1800s, cracks had begun to appear in the scientific edifice, and the worst of these, perhaps, was at its foundation—Euclidean geometry.

[3]Similar questions could be asked about theology.

[4]Snow's two cultures are scientific and nonscientific. See *The Two Cultures and the Scientific Revolution* (New York: Cambridge University, 1959).

[5]F. W. Norris has similar goals in "Mathematics, Physics and Religion: A Need for Candor and Rigor," *Scottish Journal of Theology* 37 (1983) 457-70.

[6]The occasional labeling of physical sciences as "hard" and social sciences as "soft" suggests that such hierarchies persist. Feminist critics of science note that language about "hard" and "soft" science or computers that are "up" or "down" is revealing.

[7]Mary Hesse points out in "Criteria of Truth in Science and Theology," *Religious Studies* 11 (1975) 391, that the thought of an intervening God rendered science untestable.

II. SHAKING FOUNDATIONS: NON-EUCLIDEAN GEOMETRIES

For centuries, scholars thought Euclid's geometry was true because it reflected the way the world really was. One sticky point, though, was Euclid's fifth postulate, known in its modified form as the parallel postulate, which says that through a point not on a given line there is exactly one line parallel to the given line.[8] Euclid and later mathematicians tried unsuccessfully to prove the parallel postulate. In order to prove it, Gerolamo Saccheri, a Jesuit who lived nearly 2000 years after Euclid, dared momentarily to suppose that the postulate was wrong. He considered the two alternatives to Euclid's postulate: suppose there were *no* lines parallel to the given line, or, alternatively, suppose there were *two or more* lines parallel to the given line. The first alternative, as he had hoped, led to a contradiction, but the second one, supposing the existence of two or more parallel lines, led only to unbelievable results. Mathematicians were not to consider Saccheri's options again for a hundred years, but when they did in the 1820s, they were willing to pursue the results to their logical conclusion—non-Euclidean geometries.

Now if this discussion of geometry is making you a bit queasy, bear with me a little longer. Euclid's geometry was designed with tabletops (affectionately known as "planes" in geometry) in mind. There, every triangle has exactly 180°. On an orange, however, the geometry is different. In fact, on an orange you can draw a triangle with three right angles,[9] so the sum of its angles is 270°, considerably more than the 180° allowed by Euclid. Clearly, a number cannot be exactly 180 and simultaneously more than 180, so only one of these geometries can be true, right? Legends tell that Karl Friedrich Gauss, one of the discoverers (creators?) of non-Euclidean geometries, attempted to determine empirically which geometry was true by measuring the angles of a triangle formed by three mountain tops. Of course, measurement uncertainty prevented him from reaching a conclusion on this basis. Eventually, mathematicians decided each geometry was true within its own system.

The advent of non-Euclidean geometries unleashed a surge of creativity on the part of mathematicians. No longer bound by the insistence that mathematics reflect the world's reality, mathematicians were set free to ask "what if...?" and "what if...not...?" questions. Mathematicians invented new sets of numbers and created new arithmetics. They studied abstract algebras enthusiastically, without concern for the practical applications that these algebras eventually developed.

[8]In Euclid's *Elements* (New York: Dover, 1956) 155, Thomas Heath translates the cumbersome fifth postulate: "That, if a straight line falling on two straight lines make the interior angles on the same side less than two right angles, the two straight lines, if produced indefinitely, meet on that side on which are the angles less than the two right angles."

[9]Briefly, draw from the top (as the North pole) to the equator, then one quarter of the way around, and finally back to the pole. Lines on the sphere are redefined as great circles (circles that cut the sphere precisely in half). These are what airlines use to determine the most economical flight path between two cities. Every triangle on an orange will have more than 180°. In a second non-Euclidean geometry, any triangle on the outside of a trumpet would have less than 180°.

They explored and compared infinitely large sets and found paradoxes.[10] Since mathematicians, like theologians, admire order and harmony, they also united the non-Euclidean geometries in a single coherent scheme of projective geometries. Not all mathematicians, however, were satisfied with these unifying efforts.

Scurrying to set mathematics on a firm, logical foundation, Bertrand Russell and Alfred North Whitehead spent years writing *Principia Mathematica*, which took hundreds of pages to prove that $1 + 1 = 2$.[11] Such length and the use of new, uncomfortable logical axioms were required to avoid a paradox. Russell's paradox had to do with sets, but it is based on the problem of self-reference evident in the liar paradox: "This sentence is false."[12] So, Russell and Whitehead's scheme to set mathematics on a sure foundation foundered on a paradox. But mathematicians dreamed that someday someone would find a way to construe mathematics so that paradoxes, if they arose, could be overcome.

III. DASHING DREAMS: GÖDEL'S THEOREM, UNCERTAINTY, AND CHAOS

This dream, it turned out, was impossible. In 1931, Kurt Gödel shocked the mathematical community by using logic to undo logic. He showed that any system as simple (and sophisticated) as arithmetic of the whole numbers, 0, 1, 2, 3, ... , was either incomplete or inconsistent. Gödel's theorem said, basically, that (for sufficiently interesting systems) there are statements that are true, but which *can never be proved* to be true (within the system). And, when Gödel said never, he did not mean simply that mathematicians had not yet come up with the answer. He meant that no individual or group, however brilliant, would ever be able to prove one of these true-but-unprovable propositions.[13]

As if the existence of such unruly propositions were not bad enough, Gödel and his followers went on to prove that there are some theorems whose truth or falsity we cannot even determine. They are undecidable, logically. That is, mathematicians will never be able to prove that these undecidable propositions are true or that they are false. Mathematics, thus, has moved in the last 150 years from being the sure foundation of the scientific method, emulated by numerous disciplines, to being forced to admit that not only does it not have all the answers, but that it has proven to itself that it never will.[14]

[10]For example, a mathematician would claim there are as many even numbers, 2, 4, 6, ... as counting numbers, 1, 2, 3, ... Edwin A. Abbott captures some of the excitement and consternation of these times in his humorous satire, *Flatland* (New York: Dover, 1952).

[11]See Morris Kline, *Mathematics: The Loss of Certainty* (New York: Oxford, 1980) 218-30.

[12]The rule "All rules have exceptions" is another example. The author of Titus 1:12-13 unwittingly included a similar paradox.

[13]Self-reference is the core of the problem. The most enjoyable treatment of Gödel's theorem is Douglas R. Hofstadter, *Gödel, Escher, Bach: An Eternal Golden Braid* (New York: Vintage, 1979).

[14]The mathematical story I have just told is essentially that of AUGMENT Mathematics, Augsburg College's new, historically based first-year mathematics curriculum, developed collaboratively with FIPSE funding under the able leadership of my colleague and mentor, Larry Copes, to whom I owe much more than the subhead "Shaking Foundations." Morris Kline's *Mathematics in Western Culture* (New York: Oxford University, 1953) is probably the best generally available survey of the influence of mathematics on western culture.

Still, we live the majority of our lives as if Euclid's geometry were true, because a plane is a decent approximation to the relatively flat daily world. Newton's science, too, in spite of Einstein's relativity theory, is still useful as a predictor for human scale interactions. But even the predictive power of deterministic mathematics has recently come into question.

Chaotic[15] dynamical systems, a newly investigated form of mathematics, is based on deterministic equations like $y = kx(1-x)$. The amazing feature of this new mathematics is that although the models are deterministic, the results can be completely unpredictable. One might expect that what happens in a deterministic system to two fairly close input values should be similar, but this is not the case. Unless the two values are precisely the same, a chaotic dynamical system may take them on wildly different paths.[16] So, for chaotic systems, even predictability is lost.

IV. CHANGING SCIENCE

Perhaps the grandest lesson in the recent history of mathematics is that the persistence of a particular theory does not guarantee its correctness or truth. Euclid's geometry remains a marvelous synthesis, but its claim to truth is now tempered. Science, too, has changed over the centuries. Most of us know about the Copernican revolution in astronomy, and that Einstein's theory of relativity has replaced or at least expanded upon Newton's physics (though we may be less certain about what Einstein's theory means). We may even have heard of the new physics of quantum mechanics. We are probably less familiar, however, with notions that science has abandoned, for example, bleeding as a means of healing in medicine, or ether as the substance through which objects move in space.

While some passé notions were fairly harmless, other debunked scientific ideas were more influential and more dangerous. For example, Aristotle's mistaken reproductive theory, like the one assumed by biblical writers, helped convince prominent thinkers for 2000 years that women were inferior.[17] Recent science was also influenced by values. In the nineteenth century, craniometry measured head sizes in an attempt to show that women and non-whites were inferior to white men.[18] Scientific concerns coupled with racism persuaded leaders in Nazi Germany to slaughter millions in an attempt to eliminate inferior races and peoples. Given these precedents, one might wonder what prompts researchers today

[15]Given the deep mythological meanings of "chaos," it is perhaps an unfortunate term. Mathematical "chaos" involves a very structured randomness.

[16]Interested readers may observe this "sensitive dependence on initial conditions" by considering iterations of $f(x) = 4x(1 - x)$. John C. Polkinghorne considers some philosophical implications of chaos in "The Nature of Physical Reality," *Zygon* 26 (1991) 221-36. James Gleick's *Chaos: Making a New Science* (New York: Viking, 1987) provides a good general introduction.

[17]Aristotle thought the fetus in miniature was contained in the man's sperm and that the woman was simply a fertile field. The essence of his theory was not replaced until the nineteenth century. See Nancy Tuana, "The Weaker Seed: The Sexist Bias of Reproductive Theory," in *Feminism & Science*, ed. Nancy Tuana (Bloomington: Indiana University, 1989) 147-71.

[18]Zuleyma Tang Halpin, "Scientific Objectivity and the Concept of the Other,'" *Women's Studies International Forum* 12 (1989) 288.

to investigate gender differences or to seek a genetic basis for homosexuality and how such results could be misused. To borrow a biblical metaphor, what we might call "bad" science, like false prophecy, is only easy to identify in hindsight. Thus, all science, like all prophecy, runs the risk of being discredited.

This means that facts and values are no longer clearly separated. Scientists now readily admit that most data are theory-laden. That is, what you observe is based upon what you hope or expect to find, what the theory predicts; the net you fish with determines what you catch.[19] In fact, many scientific discoveries are not made until researchers look in a particular manner. Theories determine which datapoints can be ignored as anomalous and which require modification of the theory. Interpretation, thus, mediates the connection between science and reality.

Quantum physics has also modified how scientists view reality. Scientists no longer claim to say, for example, what the *real* nature of light is. Rather, most are satisfied with the complementary model of saying it is like particles and like waves. Heisenberg's Uncertainty Principle has also affected the subject-object split in science, showing that science like mathematics has its limits, and challenging a deterministic reality. The principle says that the more precisely one knows a particle's position, the less precisely one knows its momentum, so one cannot know both precisely at the same time. Moreover, by observing the particle the scientist affects it; so the subject-object dualism of science can no longer be maintained.

V. CONTROLLING PERSPECTIVES: SCIENCE AS INTERPRETATION

Both scientists and biblical interpreters may recognize the role of their respective texts, the world and the Bible, while also admitting that their own paradigms or worldviews affect the interpretations they give. One of the reasons many people look to contemporary western science for truth and certainty, like the reason that some Christians turn to fundamentalism, is their fear that any breach in the objectivism of science will drown them in a chaotic sea of relativism.

However, there is an option beyond objectivism or relativism and beyond fundamentalism or scientism.[20] All interpretations are *not* acceptable; some *are* better than others. As in biblical interpretation or theology, so in science it is possible to judge among the various perspectives, theories, or paradigms scientists propose in order to understand and interpret the data they observe. Scientific interpreters, like biblical interpreters, have criteria for what makes a good interpretation. Thus, the way out of the objectivism/relativism dichotomy is by controlling perspectives.

In part, scientific perspectives are controlled because science is a public

[19]The metaphor is from Holmes Rolston, *Science and Religion: A Critical Survey* (New York: Random House, 1987) 19.

[20]Objectivism and relativism are really two sides of the same coin. One is certain there is a single truth; the other is certain there are none, or only those of human construction. See Richard J. Bernstein, *Beyond Objectivism and Relativism: Science, Hermeneutics, and Praxis* (Philadelphia: University of Pennsylvania, 1988).

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enterprise. Scientists not only explore and create, they also build consensus. Theology likewise works by consensus. A historical-critical interpretation, for example, which is greatly at odds with the commonly held reconstruction of Israel's history or with the accepted history of composition of the biblical texts, would not immediately be accepted. Instead, as in science, it would require first the acceptance of a rival paradigm.[21] "Normal" science or theology proceeds on the basis of commonly held assumptions. When enough anomalies can be addressed by a competing paradigm, a "revolution" in the discipline may take place.[22] Thus, science is what sociologists call an "agreement reality" and the rules that scientists agree upon change.

Like theology, the practice of science involves interpretation. Scientists observe and interact with their "text"—the world as it communicates to them—in ways similar to those of readers who are affected by and make meaning with written texts. But unlike literary interpreters, scientists (or at least their public) have been slower to admit how their own presuppositions and values necessarily shape their work. The control of perspectives is not achieved simply by maintaining a pose of value-neutrality. Sandra Harding, a feminist philosopher of science, has suggested that the objectivity science seeks "is not maximized through value-neutrality...[rather] it is participatory values—antiracism, anticlassism, antisexism—that decrease the distortions and mystifications in our culture's explanations and understandings."[23]

VI. CONCLUSIONS AND CHALLENGES

Is science scientific? Certainly not in the misunderstood sense suggested at the beginning of this essay. Science, like religion, involves interpretation and commitments. Both theologians and scientists deal with limits and uncertainty and both employ values. Both can go beyond their disciplines to consider and discuss how God is active in the world. Both need opportunities to study and learn together with lay people about how science, technology, and faith can improve the lives of ordinary people.[24] Both would benefit by considering the value systems that undergird science and theology and the claims made about reality, knowledge, truth, and certainty. Scientists and theologians may learn from each other about how each discipline seeks knowledge and truth and learn how each interprets.[25]

Learning together and from one another may help theologians and scientists realize there is little basis for the presumed warfare between science and religion.

[21]Thomas S. Kuhn, *The Structure of Scientific Revolutions*, second enlarged edition (Chicago: University of Chicago, 1970) is the classic introduction.

[22]In biblical studies, a revolution occurred with the adoption of the historical-critical method. Literary methods of interpretation in hermeneutics or Van Seters' proposal of a late date for the Yahwist in composition history of the Pentateuch are examples of competing paradigms.

[23]Sandra Harding, *The Science Question in Feminism* (Ithaca: Cornell, 1986) 249.

[24]See the article by Martha Lindbeck and Ann Pederson in this issue.

[25]See the article by H. Frederick Reisz, Jr. in this issue.

Science is not salvific, but it can learn from religion. The power the church once had in Christendom is now held largely by science. Scientists might learn from the lessons of the church to use wisely the power they have by virtue of the high public esteem in which they are held.[26] Theologians can also learn from science, but they should not be intimidated by science or impressed by a false image of it. Instead, non-scientists might admire and perhaps emulate scientists for defining terms carefully and for stating assumptions precisely, for insisting on logical rigor, for being willing to explore possibilities, for recognizing patterns, structures, and relationships, for nourishing a passion for truth, and for appreciating elegance, beauty, and simplicity. Scientists should not be idolized, however. After all, they may shatter our graven images. For instance, mathematicians are now quite willing to say, even to insist, that $2 + 2$ is not necessarily equal to 4.[27]

[26]Langdon Gilkey argues in "Religion and Science in an Advanced Scientific Culture," in *Knowing Religiously*, ed. Leroy S. Rouner (Notre Dame: University of Notre Dame, 1985) 167-175, that it is incumbent upon scientists to recognize their dominance and power in order to use it wisely.

[27]Those who work a standard eight hour day might recognize that $9 + 8 = 5$. Similarly, $2 + 2$ could equal 1 or 0 on a clock with three or two numbers. This kind of addition is part of "modular arithmetic" and is studied in abstract algebra.

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