Does the Success of Mathematics Defeat Naturalism?

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Many ACMS members will remember that, at our 1991 conference, Bill Dembski gave a talk entitled "Revising the Argument from Design."[1] Since then, the term "Intelligent Design" has become well-recognized in academic circles. In fact, those holding an opinion of the idea usually do so with zeal. Dembski's epistemological model is surely valid for everyday encounters, and at times he has used the movie *Contact*, based on a novel by Carl Sagan, to illustrate his theory: Radio astronomers inferred an extra-terrestrial intelligence because they detected a series of binary signals matching the pattern of prime numbers. This phenomenon exhibited the three features Dembski argues are needed to infer design: contingency, complexity, and specification. Contingency guarantees that the signals were not the result of an unintelligent process. Complexity rules out, on probabilistic grounds, that the signals could be explained by chance. Specification ensures that the signals exhibited a pattern associated with intelligence.

It seems to me that few would argue against the validity of the above inference. The controversy with Intelligent Design often comes, rather, when its proponents argue that the design inference method should be applied to the life sciences. Using the analogy of a mousetrap, for example, Michael Behe argues that many biological systems—those that are "irreducibly complex"—must have been designed.[2] Just as a mousetrap will not work if any one of its parts is missing, so, too, are certain biological systems—vision, flagella, etc.— built. As there is no survival advantage in having just one of the parts missing in these systems, the probably that they assembled randomly is so small that Dembski's epistemological model drives the conclusion that they are, in fact, designed.

At some level design conclusions are oddities for Christians, for we believe that God is the creator—designer if you will—of all there is. What would something that is *not* designed look like? Of course, Dembski would agree with this statement. His point is that there are certain things that leave an unmistakable mark of design, and his model can detect precisely those things. Now, this paper is not about taking sides on the Intelligent Design debate, but it does concern itself with the idea of design in a more global sense. And rather than argue directly for some type of design in nature, it asks whether aspects of mathematics cause difficulties for a naturalistic worldview. Several thinkers have indirectly raised these issues when looking at the field of mathematics itself from a meta-level. Let's briefly examine three such contributions.

In 1960 the physicist Eugene Wigner published an essay in *Communications in Pure and Applied Mathematics*. The issue implied by Wigner's title, *The Unreasonable Effectiveness of Mathematics in the Natural Sciences*, received a good amount of verbal discussion, but written responses seemed to lie dormant within the mathematical community until 1980. At that time R.W. (Richard Wesley) Hamming reacted to Wigner's essay with a piece in the *American Mathematical Monthly* bearing the title *The Unreasonable Effectiveness of Mathematics*. Hamming was chair of computer science at the Naval Postgraduate School in Monterey, California, though he is perhaps best recognized for his work in error correcting codes. Finally,

[1]Dembski, William A. "Revising the Argument from Design." *Proceedings of the ACMS* (1991): 101ff.
[2] Behe, Michael J. *Darwin's Black Box*. New York, NY: Touchstone, 1996.

in 1998 the philosopher Mark Steiner published *The Applicability of Mathematics as a Philosophical Problem* with Cambridge University Press in 1998. Steiner is currently at The Hebrew University of Jerusalem working in the area of mathematical knowledge. His book has received considerable attention, and was reviewed by Michael Liston in *Philosophia Mathematica* (2000), by Bill Dembski in *Books and Culture* (February of 2001), by Garrett DeWeese in *Philosophia Christi* (November, 2002), and by others.

Wigner begins his paper with a story about two friends talking about their jobs. One of them, a statistician, was working on population trends. He showed a paper to his friend. It started, as usual, with the Gaussian distribution, and the statistician explained the meaning of the symbols. His friend was a bit incredulous and was not quite sure whether the statistician was pulling his leg. "How can you know that?" was his query. "And what is this symbol here?" "Oh," said the statistician, "this is pi." "What is that?" "The ratio of the circumference of a circle to its diameter." "Well, now you are pushing your joke too far. Surely the population has nothing to do with the circumference of the circle."

I want to come back to that story when looking at Steiner's arguments, because they are slightly different from the points Wigner is making, which concern (1) the surprise phenomenon that we have used mathematics so often to build successful theories and (2) a nagging question: "How do we know that, if we made a theory which focuses its attention on phenomena we disregard and disregards some of the phenomena now commanding our attention, that we could not build another theory which has little in common with the present one but which, nevertheless, explains just as many phenomena as the present theory?" Wigner spends little time on that question, which in1962 was fleshed out by Thomas Kuhn in his controversial book, *The Structure of Scientific Revolutions*. For now, I'll spend some time on the first question, giving an example that I will then connect with Steiner's argument.

Regarding Wigner's first point, he concedes that much of mathematics, such as Euclidean Geometry, has been developed because its axioms were modeled on what appeared to be true of the world. But this is not true for all—in fact most—of higher mathematics. Take my field, complex analysis, as just one example. At first, square roots of negative numbers seemed odd to mathematicians because, in the 1500's, negative numbers themselves were treated with some suspicion. There simply did not seem to be any physical reality corresponding to negative numbers, let alone their square roots. But that didn't stop mathematicians from using their imagination and pressing forward. The process that began the acceptance of complex numbers can legitimately be placed in the mid-fourteenth century when Scipione del Ferro of Bologna, and then later Niccolo Fontana solved the depressed cubic equation, which was later extended by Girolamo Cardano to the solution of the general cubic equation. Real-valued solutions to some cubic equations were then obtained by using these methods, but their solutions only came by using complex numbers as an intermediate step. The story that details the entire development of complex numbers is quite intricate, and it wasn't until the end of the 19^{th} century that complex numbers became firmly entrenched. It is important to note, however, that complex numbers were studied because they were useful for mathematical and not physical purposes.

But complex numbers now play a pivotal role in helping physicists understand the quantum world. According to Wigner,

> Quantum mechanics originated when Max Born noticed that some rules of computation, given by Heisenberg, were formally identical with the rules of computation with matrices. … Born, Jordan, and Heisenberg then proposed to replace by matrices the position and momentum variables of the equations of classical mechanics. … The results were quite satisfactory. However, there was … no rational evidence that their matrix mechanics would prove correct under more realistic conditions. As a matter of fact, the first application of their mechanics to a realistic problem, that of the hydrogen atom, was given several months later, by Pauli. This application gave results in agreement with experience. This was … understandable because Heisenberg's rules of calculation were abstracted from problems which included the old theory of the hydrogen atom. The miracle occurred only when matrix mechanics … was applied to problems for which Heisenberg's calculating rules were meaningless. Heisenberg's rules presupposed that the classical equations of motion had solutions with certain periodicity properties; and the equations of motion of the two electrons of the helium atom, or of the even greater number of electrons of heavier atoms, simply do not have these properties, so that Heisenberg's rules cannot be applied to these cases. Nevertheless, the calculation of the lowest energy level of helium, … [agreed] with the experimental data within the accuracy of the observations, which is one part in ten million.

"Surely," Wigner concludes, "in this case we 'got something out' of the equations that we did not put in."

I will not elaborate on the detail with which Wigner cites other examples including: Newton's law of motion—formulated in terms that appear simple to mathematicians, but which proved to be accurate beyond all reasonable expectations; quantum electrodynamics; or the theory of the Lamb shift—a purely mathematical theory.

Wigner ends his paper with the remarks,

> … The enormous usefulness of mathematics in the natural sciences is something bordering on the mysterious, and … there is no rational explanation for it. … The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve. We should be grateful for it and hope that it will remain valid in future research and that it will extend, for better or for worse, to our pleasure, even though perhaps also to our bafflement, to wide branches of learning.

Hamming takes up the effectiveness issue raised by Wigner, and offers four tentative explanations that account for the applicability of mathematics. Let me review them briefly.

First, *we see what we look for*. Mathematicians craft postulates so that they will produce theories that conform to their prior observations. The Pythagorean theorem, Hamming claims, drove the formation of the geometric postulates and not vice versa.

Second, *we select the kind of mathematics to use*. By this Hamming simply means that we select the mathematics to fit the situation. The same mathematics simply does not work everywhere. Because we force mathematics onto particular situations, it is not all that surprising that we subsequently find it applicable there.

Hamming's third comment is that *science in fact answers comparatively few problems*. To the extent that this is true, the less of a miracle the success of mathematics would appear to be. Wigner, as a physicist, certainly lived with mathematics as an indispensable tool. But other sciences do not share their reliance on mathematics, at least to the extent that physics does. Biology, it is said, has not been successfully dissected by the mathematical scalpel.

It seems to me, parenthetically, that this position is not obviously correct. A great deal of mathematical effort has been focused as of late on biological questions. A colleague of mine, for example, is currently looking at a Coxeter Groups as a model for DNA similarity. Also, knot theory, a newer branch of mathematics that deals with topological invariants, has had some success in the classification of DNA strands according to how they crinkle up under certain conditions.

Even if we grant the argument, however, the success of mathematics in physics is something that cannot simply be dismissed by pointing to slower progress in other areas, and Steiner readily admits that mathematics has indeed met with many failures.

Finally, Hamming posits that *the evolution of man provided the model*, meaning the model for why humans are able to mathematize the physical universe. This is an interesting claim, but is not fleshed out beyond Hamming's remark that, "Darwinian evolution would naturally select for survival those competing forms of life which had the best models of reality in their minds—'best' meaning best for surviving and propagating." It is interesting to note that Hamming concludes with

> If you recall that modern science is only about 400 years old, and that there have been from 3 to 5 generations per century, then there have been at most 20 generations since Newton and Galileo. If you pick 4,000 years for the age of science, generally, then you get an upper bound of 200 generations. Considering the effects of evolution we are looking for via selection of small chance variations, it does not seem to me that evolution can explain more than a small part of the unreasonable effectiveness of mathematics.

On the one hand, I do not find this refutation compelling. Just as an inclined block needs a critical slope to overcome its friction and begin sliding, and once the sliding starts it precedes rather rapidly, so too one might argue that, once science started it progressed quickly, but the evolutionary development that occurred before this explosion cannot be discounted.

But evolutionary accounts have problems as well. Let's briefly look at three such attempts. The first can be called the *sexual selection hypothesis* as argued by Geoffrey Miller.[3] He claims that excessive capacities or acquisition of resources of any kind is basically a sexual display. If you've got the energy or time or intrinsic capacity to do things that don't have direct adaptive value (carrying around a set of antlers that are so big they are more of a detriment than a defense, or a Peacock walking around with a big colored tail, or possessing artistic or mathematical brains that don't contribute to reproductive success) then that energy or time or intrinsic capacity by itself attracts mates.

Of course, physical attributes may well have some role in mate attraction, and artistic brains may as well insofar as they enable people to make attractive artifacts for display. The argument for mathematical brains, however, does not seem to hold up as well. Miller has some ways of dealing with this problem. For example, he states, "The healthy brain theory suggests that our brains are different from those of other apes not because extravagantly large brains helped us to survive or to raise offspring, but because such brains are simply better advertisements of how good our genes are. The more complicated the brain, the easier it is to

[3] Miller, Geoffrey. *The Mating Mind: How Sexual Choice Shaped the Evolution of Human Nature*. New York, NY: Anchor Books, 2001.

mess up."[4] But how would a larger brain be evident, and how would one somehow deduce that this is evidence of good genes? Such speculation seems to be forcing a theory when there seems to be no good evidence to support the theory.

Next is what we might call the *module approach* as argued by Stephen Mithin.[5] The idea here is that integrative and higher level (meta) cognitive processes grew out of the unification of specific evolutionary modules such as a module for tool use, or a module for interpersonal relations. Mithin further argues that only in humans do we find a structure on top of modules—call it general purpose rationality.

The last approach has been extensively debated. For example, Alvin Plantinga's *Evolutionary Argument against Naturalism* argues that rationality is very unlikely a quality produced by survivability. As Plantiga acknowledges, his argument is similar to that found in C.S. Lewis's *Miracles*, whose thinking was recently enhanced by Victor Reppert.[6] Even if there were an evolutionary explanation for rationality, it would explain rationality only insofar as it relates to survivability. On a prima facie level, the capacity to spin out higher mathematical theories appears to have no survivable advantage at all, and it is precisely those kind of theories, coupled with their success in explaining the natural world, that are the focus of our present discussion.

This brings us to the *byproduct hypothesis*, as exemplified by Pascal Boyer, who argues against what I've just said.[7] His main thesis is that many higher cognitive functions (mathematics, art, religion, ethics, etc.) are not evolutionary adaptations at all. Instead, they are byproducts of things that *are* adaptive, and just piggyback on the adaptiveness of these other capacities. Some form of mathematical or quantitative ability *is* adaptive, Boyer argues, and as a byproduct of this we get the capacity to do higher order mathematics, the *naked* capacity of which at the time of its development wouldn't have been adaptive (or evolution wouldn't have known it was adaptive), though it may have turned out to have been adaptive.

But I can't find any compelling evidence that would support Boyer in his contention, try as he might to produce one. His claim reminds me of scaffolding theories that are used to refute design arguments. If one is going to argue against something using an evolutionary framework, it behooves that person to supply a detailed model or story that will support such a refutation. Otherwise, the "God of the gaps" charge normally levied against design theorists can be turned around into, if you will, a "natural selection of the gaps" counter charge against the person arguing for blind chance natural selection.

Even if one were to be convinced that our rationality evolved by means of a natural selection model, I don't think such an outlook would damage Steiner's thesis. Strictly speaking, Steiner's argument attempts to refute "Anthropocentrism" rather than Naturalism. But if Steiner is correct the naturalist should not take comfort. As far as I can tell, and Steiner shares this

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[4] Ibid., p. 104.
[5] Mithin, Stephen. *The Prehistory of Mind: The Cognitive Origins of Art, Religion, and Science.* New York, NY: Thames and Huston Ltd, 1996.
[6] Reppert, Victor. *CS Lewis's Dangerous Idea.* Madison, WI: InterVarsity Press, 2003.
[7] Boyer, Pascal. *Religion Explained: The Evolutionary Origins of Religious Thought.* New York, NY: Basic Books, 2001.

opinion, any form of Naturalism is defacto non-anthropocentric in that it would disallow any privileged status for humans in the scope of the universe. If, as Steiner argues, the success of mathematics can be shown to put humans in such a position, then naturalism has problems.

And just how does the success of mathematics put humans in a privileged position? For Steiner, it is not so much the success of any one particular mathematical theory in an area of science. After all, there have been many, many failures of mathematics in addition to its successes, and in this respect Steiner agrees with Hamming's third point and is thus critical of Wigner's approach in citing specific success examples from physics while ignoring error stories. The use of pi by the statistician in Wigner's opening line ignores all the failures, for example, in attempting to predict population trends. What Steiner is talking about is the success of mathematics as a grand strategy. It is a strategy that takes, for example, the raw formalisms of complex Hilbert space theory and boldly uses them as tools to make predictions about the quantum world, predictions that subsequently seem to be born out via experiment. And how is this phenomenon anthropocentric? Let me give an analogy. Most cultures use a base ten number system. No one is 100 per cent sure why this is the case, but the general consensus is that it has to do with our having 10 fingers. (Note: some primitive cultures use base 20, and to many this confirms the appendage hypothesis.) Now, what if successful theories of how the universe operates were based on, say, multiples of 10? That would be anthropocentric in an extreme, as the only reason the number 10 is special to us is due to how we appear to ourselves.

But this phenomenon is precisely analogous to the tinkering of mathematical formalisms. To support his case, Steiner's book contains some general examples such as the applicability of complex analysis in fluid dynamics, relativistic field theory, and thermodynamics. Indeed, roughly half his book is a litany of case studies taken from what he terms Pythagorean analogies in physics to formalisms in quantum mechanics.

First, consider Schroedinger's use of the wave equation. He begins with the equation $E = \frac{p^2}{2m} + V(x, y, z)$, where he makes an assumption that energy is constant so he can eliminate it by differentiating. After a series of manipulations he gets $i\hbar \frac{\partial \Psi}{\partial t} = \left[-\frac{\hbar^2}{2m} \nabla^2 + V(x, y, z) \right] \Psi$, and then successfully uses his solution in situations where Energy is not constant. As Steiner says, this is "a perfect example of allowing the notation to lead us by the nose."[8]

In the interest of time, I will skip the powerful examples from Quantum Mechanics, where the tinkering of raw mathematical formalisms has often led to predictions about the quantum world that have subsequently panned out. Instead, I will focus on what at least one person considers to be Steiner's weakest argument: Maxwell's anticipation of a physical reality. As many of you know, Maxwell noted that the experimentally confirmed laws of Faraday, Coulomb, and Ampere, when put in differential form, contradicted the conservation of electrical charge. By working with Ampere's law and adding a term to it, Maxwell got the laws to be consistent with, and indeed to imply, the conservation of charge. With no other warrant,

[8] Steiner, Mark. *The Applicability of Mathematics as a Philosophical Problem.* Cambridge, MA: Cambridge University Press, 1998, p.80.

Maxwell made the indicated changes and baldly predicted that his new term corresponded to some physical phenomenon. Ten years after his death Heinrich Hertz demonstrated the reality corresponding to this term—electromagnetic radiation.

Richard Carrier, a freelance writer and teacher who received his M.Phil in Ancient History from Columbia University, is unimpressed by this episode, saying that what Maxwell did is entirely consistent with Naturalism.[9] First, Maxwell's putting laws in differential form conforms to the naturalistic observation that nature works in continuous, not broken, processes. Second, Maxwell took a logically sound hypothetical step: if charge isn't being conserved, then it must be going somewhere. Carrier then states, "Maxwell rightly picked the simplest imaginable solution first, which due to human limitation is always the best place to start an investigation, and which statistically is the most likely [as] simple patterns and behaviors happen far more often than complex ones. [Thus] Maxwell's moves [that] anticipated EM radiation [were] therefore a natural conclusion from entirely naturalistic assumptions."

But with such language Carrier plays into Steiner's hands. Picking a *simple* solution in accordance with *human limitations* is precisely analogous to using the number 10 as a means of unlocking secrets to the universe. It is anthropocentrism in the extreme.

I suspect that what leaves many people unpersuaded by Steiner's approach is that he is arguing retrospectively. It is difficult for people who are not physicists to appreciate how absolutely spooky is the physicists' continued use of mathematical formalisms. Steiner's main point is that, at least unconsciously, physicists have abandoned a raw naturalism and have replaced it with some kind of anthropocentric—and thus non-naturalistic—strategy. In doing so this general strategy has been remarkably successful.

Of course, the term *success* is loaded with assumptions. A thoroughgoing Postmodernist could argue that successes came only because humans have invested a great deal of energy into science over the last 500 years. Who is to say that if similar energies had been funneled in a different direction there would be operating today a totally different paradigm yet with the same degree of success? The success is due to effort, not necessarily some magical connection humans have with the way the universe really is. The success of mathematics does not defeat Naturalism at all.

This view is somewhat similar to Wigner's second question, mentioned earlier. How can such a statement be answered, and, how may a Christian assess the thrust of the arguments given in this paper? I would suggest that an approach similar to Reppert's in his defense of C.S. Lewis has much potential. Reppert would say that there are, of course, valid points to be made on the side opposing Steiner, who can either be offered as a final answer or as a spur to think the relevant issues through oneself. From a Christian perspective Steiner's analysis dovetails nicely with a Christian view that humans were created in the image of God, and with a rational capacity reflective of his that enables them to understand and admire his creation. Again, such a view does not claim to be the final answer, only a very plausible one, and an answer that a thinking person can put in the marketplace of ideas with full confidence as to its plausibility.

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[9] Carrier, Richard. *Fundamental Flaws in Mark Steiner's Challenge to Naturalism in The Applicability of Mathematics as a Philosophical Problem.* http://www.infidels.org/library/modern/richard_carrier/steiner.html.