A CRITIQUE OF THE REJECTION OF INTELLIGENT DESIGN

AS A SCIENTIFIC HYPOTHESIS BY ELLIOTT SOBER

FROM HIS BOOK *EVIDENCE AND EVOLUTION*

A Dissertation

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the Faculty of

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by

James Charles LeMaster

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APPROVAL SHEET

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To Ruth: In thanks for your patience,

hard work, sacrifice, ideas,

and support in this effort

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PREFACE

I owe many individuals a debt of gratitude for the completion of this dissertation and of my doctoral studies. First, ceaseless thanks are due my wife, Ruth, who has been patient, inspiring, encouraging, and unspeakably sacrificial throughout our marriage, but particularly in this doctoral process. She encouraged me many years ago to pursue this goal and has been willing to accompany me literally halfway around the world to see it to its end. Our three children, Rebecca, Micah and Anna, have also patiently supported me as I have devoted so much time to study and writing, and sacrificially adjusted their lives to move to Kentucky.

My thanks go out to Dr. Elliott Sober for the cordial (albeit limited) correspondence between the two of us. I also want to acknowledge that while he has not been a supporter of intelligent design, he has made obvious efforts at least to consider positive arguments for it, and his objections, in contrast to those of many other recent intelligent design opponents, are remarkably civil and respectful.

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My thanks and my admiration also go to other Discovery Institute fellows. Thanks go to Stephen C. Meyer, for the clear and thorough defenses of intelligent design in his two most recently published books. At points in this dissertation, I drew significant evidential and logical content from parts of those books. Dr. Meyer’s books were also a rich source of scholarly resources for this dissertation. Special thanks are due William Dembski for his courageous and trailblazing writings, which generally defend intelligent design in philosophical and probabilistic terms and at times present specific, critical analyses of Elliott Sober’s ideas. These analyses were a very helpful framework for some portions of this paper. My thanks also go out to Paul Nelson for sending me a key list of scholarly resources that contributed to one portion of the paper. My thanks go out in general to the entire staff at the Discovery Institute which so generously paid for my participation in their 2012 Summer Seminar in Seattle, and so inspiringly shared their knowledge as well as their personal stories with all the attendees.

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Great thanks go to my father, Kelmar LeMaster, for offering the financial help to make sure I completed this program. Thanks, Dad, for countless Tuesday night talks about the Bible and for letting me occasionally share about the specialty that I love.

Lastly, I want to thank and praise our Creator and the Triune God, Father, Son and Holy Spirit for leaving detectable evidence of His intelligent design in creation. I also thank Him for the privilege of focusing on this topic, writing this paper, and making a small application from Romans 1:20, namely to help both theists and skeptics consider why and how "His eternal power and divine nature have been clearly seen, being understood through what has been made."

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Louisville, Kentucky

May 2014

CHAPTER 1

INTRODUCTION

Intelligent Design as Science: A Polarized Issue

Views radically diverge about whether intelligent design qualifies as science. Intelligent design advocates claim that their theory is both a scientific hypothesis and research program. William Dembski insists that a well-developed intelligent design approach is empirical, testable and in fact offers a better explanation for instances of novel specified complexity in biology (macroevolution) than does Darwinism.[1] Philosopher of science Stephen Meyer lists several reasons why intelligent design qualifies as science. For example, it is based on empirical evidence, its advocates use established scientific methods, and it is testable.[2]

On the other side of the controversy, in the past two decades, mainstream academic and scientific circles have built a consensus of rejection toward intelligent design as science. The American Association for the Advancement of Science says, "Individual scientists and philosophers of science have provided substantive critiques of 'intelligent design,' demonstrating significant conceptual flaws in its formulation, a lack

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[1]William A. Dembski, *No Free Lunch: Why Specified Complexity Cannot be Purchased without Intelligence* (Lanham, MD: Rowman and Littlefield, 2002), 365.

[2]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins, 2009), 403-15. Other reasons Meyer lists are as follows: it exemplified historical scientific reasoning; it addresses a specific question in evolutionary biology; it is supported by peer-reviewed scientific literature.

of credible scientific evidence, and misrepresentations of scientific facts"[3] Tufts professor Daniel Dennett comments, "Intelligent Design proponents . . . . have all been carefully and patiently rebutted by conscientious scientists who have taken the trouble to penetrate their smoke screens of propaganda and expose . . . their shoddy arguments. . . ."[4] Robert Pennock of Michigan State says succinctly, "ID fails to meet minimal scientific standards"[5]

Philosopher of Biology Elliott Sober's position generally aligns with Pennock's. In his 2008 book *Evidence and Evolution* Sober concludes that "intelligent design is a sorry excuse for a scientific theory."[6] He critically evaluates its scientific status, not using the tools of empirical scientific research but those of philosophy, and more specifically, probability theory. The general question this paper examines is this: From a philosophical, probabilistic point of view, does intelligent design indeed deserve to be summarily dismissed as non-science, as Sober claims that it does?

Thesis: Sober's Likelihood Rejection of Intelligent Design as Science is not Justified

This paper examines several key aspects of Sober's philosophic and probabilistic case against intelligent design as science as outlined in chapter 2 of

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[3]American Association for the Advancement of Science, "AAAS Board Resolution on Intelligent Design Theory," 2002, http://www.aaas.org/news/releases/ 2002/1106id2.shtml (accessed February 21, 2013).

[4]Daniel Dennett, *Breaking the Spell: Religion as a Natural Phenomenon* (New York: Penguin, 2006), 61.

[5]Robert T. Pennock, "Creationism and Intelligent Design," *Annual Review of Genomics and Human Genetics* 4 (2003): 156.

[6]Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 190.

Evidence, presents defensive responses, and exposes flaws which undermine his negative verdict. The aim of the paper is to show that Sober has not succeeded, from a philosophical or probabilistic standpoint, in reasonably disqualifying intelligent design as a scientific candidate explanation for the specified complexity observable in biology. This paper's primary aim is not to find fault with the neo-Darwinian hypothesis,[7] except when it is necessary to make an appeal to parity when comparing that hypothesis with intelligent design. This paper also does not ultimately aim to show that intelligent design is a superior scientific hypothesis to neo-Darwinism. This paper's goal is more modest: to present reasons why–contrary to Sober's portrayal–intelligent design deserves a seat at the table as a rival scientific hypothesis to neo-Darwinism. Which hypothesis is the superior hypothesis cannot be fairly determined–on both scientific and philosophical grounds–until a fair comparison between the two is allowed.

Overview: Critiquing Sober Regarding Auxiliary Propositions, Likelihood, and Analogy

As will be explained in detail in the second chapter of this paper, in *Evidence*, Sober rejects intelligent design from the grounds of Bayesian likelihood, supplemented by perspectives from both Pierre Duhem[8] and David Hume.[9] Sober claims the intelligent design hypothesis cannot make a claim to scientific status because its most key auxiliary

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[7]This paper universally uses the term 'neo-Darwinism' as a fair general label for what Sober (in *Evidence*) variously labels 'Darwinian hypothesis,' 'Darwinian evolution,' 'evolution,' 'Darwin's theory,' 'evolutionary theory,' etc. Sober, *Evidence*, 270, 127, 162, 122, 190, respectively.

[8]Pierre Duhem, *The Aim and Structure of Physical Theory*, trans. Philip P. Wiener (Princeton, NJ: Princeton University Press, 1954), 183-88. Sober, *Evidence*, 144.

[9]David Hume, *Dialogues Concerning Natural Religion*, ed. Henry D. Aiken (New York: Hafner, 1948); Sober, *Evidence*, 126.

propositions cannot be independently supported. Specifically, there is no independent way of knowing whether the designer implied by a design hypothesis has (or had) the goals and abilities needed to make the observed features of biologically complex and specified structures and systems likely. In other words, there are no indications of what the purported designer would want to do or be able to do, other than inferences gathered through the observed specified, complex features themselves, which Sober claims would be begging the question. He therefore concludes that intelligent design's likelihood is unknowable and thus that intelligent design is not scientifically testable.[10]

Critiquing Sober's Likelihood Assessment and Auxiliary Proposition Requirement

It is reasonable to view appropriate designer goals and abilities as crucial necessary preconditions for intelligent design to happen. However, one shortcoming of Sober's argument is that he never explains why independently supported designer goals and abilities are the absolutely indispensable auxiliary propositions one must *know* in order for a design hypothesis to have a likelihood in the first place. Both scientists and non-scientists legitimately and accurately come to likelihood assessments about human design often even in complete absence of information about designer goals and abilities,[11] a fact which Sober himself has acknowledged.[12] I suggest a much more productive

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[10]Sober, *Evidence*, 142-48. See also Ingo Brigandt, critical notice of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober, *Canadian Journal of Philosophy* 41, no. 1 (March 2011): 168.

[11]William A. Dembski, *The Design Revolution* (Downers Grove, IL: InterVarsity Press, 2004), 192.

[12]Elliott Sober, "Testability," *Proceedings and Addresses of the American Philosophical Association* 73, no. 2 (November, 1999): 73n20.

auxiliary proposition, such as: "from our observations up to this time, only intelligently designed things contain high levels of specified complexity."[13] Day-to-day inferences to design use this kind of auxiliary proposition reliably and more frequently than Sober's "goals-and-abilities" proposition. It can be independently verified, per Sober's demands, and it is not impossible to meet by definition.

A second key shortcoming in Sober's argument is that his demand for independently supported designer goals and abilities turns out to be excessively strict. As will be covered in more detail in the fourth chapter, this is because independent support is also lacking for crucial necessary preconditions for hypothesized neo-Darwinian processes (especially in the case of significant biological events such as the Cambrian Explosion[14]). The result is that if Sober's auxiliary proposition criteria are applied with parity, neither intelligent design or neo-Darwinism should generate an assessable likelihood, and both theories should be rejected as scientific hypotheses.

Critiquing Sober's Approach to Analogy

Another underlying shortcoming of Sober's treatment of likelihoods and of intelligent design is how he handles analogies, both explicitly and implicitly. Sober, like David Hume and others, seems to reject an oversimplified version of an analogy from artifacts and their designers to organisms and their designer(s).[15] These portrayals of

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[13]Restating Meyer's claim: "Experience shows that large amounts of specified complexity or information . . . *invariably* originate from an intelligent source." Meyer, *Signature*, 343.

[14]As discussed in detail in Stephen C. Meyer, *Darwin's Doubt The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), chaps. 1-14.

[15]Sober, *Evidence*, 139-40; Hume, *Dialogues*, 17; Dorothy Coleman, ed., *Hume: Dialogues Concerning Natural Religion and Other Writings*, Cambridge Texts in the History of Philosophy (Cambridge: Cambridge University Press, 2007), 20-21; Helen De Cruz and Johan De Smedt, "Paley's

analogy share a common shortcoming in that they do not accurately represent the tight, dependent causal relationships, or "*isomorphic determining structures*" which characterize strong analogies.[16] It turns out that such isomorphic determining structures exist between key features of both artifacts and organisms (namely specified complexity and design) which are central to both William Paley's watchmaker argument[17] and even more so to intelligent design.

In making his case for intelligent design, design proponent William Dembski says he will not use analogy,[18] yet one can see analogical thinking Dembski's arguments, particularly when he describes the relationship between complex specified information in human artifacts and complex specified information in biological organisms as "isomorphic."[19] In both these domains, such information indeed is isomorphic. This isomorphism is critical because it is what enables one to justifiably bridge an analogical gap between certain human artifacts and certain biological organisms or structures. Waters says isomorphism is what makes an analogy "reasonable."[20] Since Dembski,

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iPod: The Cognitive Basis of the Design Argument with Natural Theology," *Zygon* 45, no. 3 (September 2010): 667.

[16]C. Kenneth Waters, "Taking Analogical Inference Seriously: Darwin's Argument from Artificial Selection," in *Contributed Papers*, vol. 1 of *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* (Chicago: University of Chicago Press, 1986), 503; *Encyclopedia of Cognitive Science* (London: Nature Publishing Group, 2003), s.v. "Psychology of Analogical Reasoning" (the author, Gentner, may be alluding to the same quality, which she calls, "relational connectivity").

[17]William Paley, *Natural Theology: or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*, rev. American ed. (Boston: Gould and Lincoln, 1854), 5-8.

[18]William A. Dembski, *Intelligent Design: The Bridge between Science and Theology* (Downers Grove, IL: InterVarsity Press, 1999), 302.

[19] Dembski, *Revolution*, 230.

[20]Waters, "Analogical Inference," 505.

Meyer and many others (including Paley) have correctly identified such an isomorphism, then by Waters' logic, this makes the analogy of design between human artifacts and biological organisms reasonable.

Although he never addresses it directly, Sober's likelihood case for neo-Darwinism as it applies to macroevolutionary change would also need to involve a mix of analogy and inference to the best explanation. As was asserted above, scientists have never experientially observed macroevolution happening. At best, neo-Darwinism advocates must infer the macroevolutionary process via analogical extrapolation from microevolution.[21] Both intelligent design and neo-Darwinism need independent auxiliary propositions which cannot be supplied via empirical observations. Why then should Sober treat one differently than the other?

When one reads Sober carefully, one can also find him using analogy, both implicitly and explicitly. He seems to use an implicit analogy when he discusses intelligent design's designer, and he acknowledges the legitimacy of Paley's inference that a watch he finds must have had a watchmaker, but affirms this via analogy (albeit a very close one).[22] Sober also makes a case for the likelihood of neo-Darwinism through presenting analogies with lines from Shakespeare, combination locks, and stone arches.[23] In doing so he neglects to state any rules which govern appropriate or inappropriate use

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[21]But there is evidence that extrapolation from traditional microevolution may often be insufficient. D. H. Erwin, "Macroevolution is More than Repeated Rounds of Microevolution," abstract, *Evolution and Development* 2, no. 2 (March-April 2000): 79.

[22]De Cruz and De Smedt question whether if Paley had found an iPod, he would have inferred design. De Cruz and De Smedt, "Paley's iPod," 668. Inspection of an iPod to the degree Paley advocated for the watch would likely leave little doubt, even to an eighteenth-century observer.

[23]Sober, *Evidence*, 123, 162.

of analogy. Sober also acknowledges that legitimate inferences to design can, and should be made (as long as the inferred designers are human), but ironically, he must use analogies himself in order to arrive at such inferences.[24] Thus, without giving standards, when Sober rejects the analogical reasoning of a design argument, yet uses analogy himself, he seems to be utilizing a double standard.

In *Philosophy of Biology* and in *Evidence and Evolution*, Sober tries to reinterpret Paley's design argument as an inference to the best explanation (in the earlier work), or alternatively as a likelihood assessment (in the later work), and nothing more. He claims that neither of these formulations of the argument need to depend in any way upon analogy.[25] In contrast, I see Paley's argument and intelligent design as mixtures of both analogical reasoning and inference to the best explanation.[26] This mixture should be regarded as a strength, and not as a weakness, at least in part because analogical reasoning has abundantly and profitably contributed to scientific advancement, both in the past and in the present.[27] More importantly, Darwin's theory of natural selection itself, as explained in *The Origin of Species*–and regarded for many decades by the mainstream scientific community as a paragon of scientific reasoning–relied largely upon

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[24]Sober, *Evidence*,143, 174-75.

[25]Elliott Sober, *Philosophy of Biology*, Dimensions of Philosophy Series (Boulder, CO: Westview Press, 1993), 30-31, 33; Sober, *Evidence*, 120-22, 134,139, 140. In his 1993 book, Sober calls Paley's argument an "inference to the best explanation" (IBE). In *Evidence and Evolution*, Sober uses the term "likelihood inference," although the essential meaning seems to be the same.

[26]De Cruz and De Smedt and Deming seem to agree with that assessment: De Cruz and De Smedt, "Paley's iPod," 667; David Deming, "Design, Science and Naturalism," *Earth-Science Reviews* 90, nos. 1–2 (September 2008): 64.

[27]Woltering insists that insight can be gained about "non-model" organisms from "model species." Joost M Woltering, "From Lizard to Snake: Behind the Evolution of an Extreme Body Plan," *Current Genomics* 13, no. 4 (June 2012): 289.

analogy.[28]

One of the key points in Sober's argument in chapter 2 of *Evidence* is his dismissal of intelligent design as an inductive argument on the grounds that no one has shown, from Hume's time to the present, that differences between human artifacts and biological organisms are trivial enough to warrant an inference to a similar intelligent cause for both. In other words, Sober claims that from Paley's and Hume's day to the present there has been no evidence for a correspondence between artifacts and organisms[29] As chapters 6 and 7 of this paper detail, however, the progressing technological development and scientific discovery of analogical isomorphisms between artifacts and organisms greatly undermine Sober's claim. Moreover, Sober himself offers a prediction that ultimately strengthens that case for analogy when he anticipates that in the future, humans will succeed in designing and creating living organisms from nonliving components.[30]

The power of analogy between organism and artifact has advanced–and will continue to do so–as discoveries in molecular biology and biochemistry continue to reveal remarkable parallels between biological structures and systems at the molecular level and machines or languages of human design.[31] Meanwhile, breakthroughs in

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[28]Most prominently, domestic breeding; Charles Darwin, *The Origin of Species by Means of Natural Selection or Preservation of Favored Races in the Struggle for Life*, 3rd ed. (London: John Murray, 1861), 4, 47, 64-65, 83-84, http://darwin-online.org.uk/content/frameset?pageseq=437&itemID=F381 &viewtype=image (accessed September 13, 2013). See also Waters, "Analogical Inference," 502.

[29]Sober, *Evidence*, 175.

[30]Ibid., 188.

[31]E.g., Sara Imari Walker and Paul C. W. Davies, "The Algorithmic Origins of Life," *Journal of the Royal Society Interface* 10, no. 79 (2013): 1, 4, 5, http://rsif.royalsocietypublishing.org/content/ 10/79/ 20120869.full.pdf+html (accessed November 19, 2013); Meyer, *Signature*, 12, 23; see also Hubert P.

synthetic biology research are ever-more-closely mimicking living organisms.[32] Intelligent design is not just using a watch analogy anymore.

In summary, Sober argues that intelligent design's auxiliary proposals are not independently supported, that its likelihood is unknown, that it is thus not testable and therefore is not worthy of comparison with other scientific hypotheses of origins and development. This paper first responds that if Sober applied likelihood assessments with parity, and if he used other reasonable, empirical and independent auxiliary propositions–not demanding to know the purported designer's goals and abilities–intelligent design would fare well as a competitor to neo-Darwinism as scientific explanation of biological complexity. What this paper last argues is that allowing the use of analogy regarding isomorphic determining structures would enable Sober to see that the progress of science and technology is shrinking the analogical gap between artifacts and organisms. The shrinking of this gap in turn allows the hypothesis of intelligent design–if the science community will simply permit it–to greatly contribute to science, in both theoretical and practical ways.

Yockey, "Self Organization Origin of Life Scenarios and Information Theory," *Journal of Theoretical Biology* 91, no. 1 (July 7, 1981): 16; Bruce Alberts, "The Cell as a Collection of Protein Machines: Preparing the Next Generation of Molecular Biologists," *Cell* 92, no. 3 (February 6, 1998): 291; Arne Gennerich and Ronald D. Vale, "Walking the Walk: How Kinesin and Dynein Coordinate Their Steps," *Current Opinion in Cell Biology* 21, no. 1 (February 2009): 59; Holger Seelert et al., "Proton-powered Turbine of a Plant Motor," *Nature* 405, no. 6785 (May 25, 2000), 418-19; Tania A. Baker and Stephen P. Bell, "Polymerases and the Replisome: Machines within Machines," *Cell* 92, no. 3 (February 6, 1998): 295; Marco Piccolino, "Biological Machines: From Mills to Molecules," *Nature Reviews: Molecular Cell Biology* 1, no. 2 (November 2000): 149-53; C. Mavroidis, A. Dubey, and M. L. Yarmush, "Molecular Machines," *Annual Review of Biomedical Engineering* 6 (2004): 364.

[32] J. Craig Venter, *Life at the Speed of Life: From the Double Helix to the Dawn of Digital Life* (New York: Viking, 2013), 18-19, 84-95, 119-26; David Deamer, "A Giant Step Towards Artificial Life?" *Trends in Biotechnology* 23, no.7 (July 2005): 336-37; S. S. Mansy and J. W. Szostak, "Reconstructing the Emergence of Cellular Life through the Synthesis of Model Protocells," *Cold Spring Harbor Symposia on Quantitative Biology* 74 (September 4, 2009): 2, 7, http://molbio.mgh.harvard. edu/szostakweb/ publications.html (accessed October 29, 2013).

Background: Why Intelligent Design's Scientific Status Is Important

The issue of intelligent design's claims to scientific status is important for several reasons. First, from the perspective of intelligent design's opponents, it must be refuted because it is dangerous to the progress and integrity of science,[33] because it threatens to harm children's education[34] and because it infringes the principle of separation of church and state.[35] In contrast, intelligent design advocates are just as adamant that allowing intelligent design as an alternative approach to scientific research will greatly benefit and liberate science in its pursuit of truth about the natural world.[36]

Leading intelligent design advocate Phillip Johnson has frequently tried to expose and criticize naturalism–what he calls "an a priori commitment to materialism."[37]

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[33]Robert T. Pennock, "Naturalism, Evidence and Creationism," in *Intelligent Design Creationism and Its Critics*, ed. Robert T. Pennock (Cambridge, MA: MIT Press, 2001), 89-90; Mark Perakh and Matt Young, "Is Intelligent Design Science?" in *Why Intelligent Design Fails*, ed. Matt Young and Taner Edis (New Brunswick, NJ: Rutgers University Press, 2004), 196; Kitzmiller v. Dover Area School District, 400 F. Supp.2d 707, 736, 745 (M.D. Pa. 2005), http://www.bu.edu/lawlibrary/PDFs/research/portals/probonofiles/kitzmiller.pdf (accessed April 24, 2014); National Research Council, *Science, Evolution and Creationism* (Washington, DC: National Academies Press, 2008), 43, http://www.nas.edu/evolution/Intelligent Design.html (accessed January 4, 2014); Barbara Forrest and Paul R. Gross, *Creationism's Trojan Horse: The Wedge of Intelligent Design*, paperback ed. (New York: Oxford University Press, 2007), 10.

[34]Forrest and Gross, *Creationism's Trojan Horse*, 9; Pennock, "Creationism," 143-50, 157-60.

[35]Sober, *Evidence*, 184-85; Kitzmiller v. Dover Area School District, 765-66; Forrest and Gross, *Creationism's Trojan Horse*, 11.

[36]Meyer, *Signature*, 418-38, 456-80, 481-96; Meyer, *Darwin's Doubt*, ix-xii, 339-40, 348-52, 378-81, 385-86, 391-92, 393-403; Phillip E. Johnson, *The Wedge of Truth: Splitting the Foundations of Naturalism* (Downers Grove, IL: InterVarsity Press, 2000), 16-18; Phillip E. Johnson, *Objections Sustained: Subversive Essays on Evolution, Law and Culture* (Downers Grove, IL: InterVarsity Press, 1998), 56; Phillip E. Johnson, *Darwin on Trial*, 2nd ed. (Downers Grove, IL: Intervarsity Press, 1993), 155-56; Dembski, *No Free Lunch*, 314-18, 350-52, 355-71.

[37]Phillip E. Johnson, "How Can We Tell Science from Religion?" Paper delivered at the Conference on the Origin of Intelligent Life in the Universe (July 28-31, 1998), http://www.arn.org/docs/johnson/scirel98.htm (accessed February 26, 2013).

Johnson claims that currently, naturalism is most pervasively exemplified by Darwinism, and clams that naturalism exerts a tremendous and unhealthy metaphysical influence on science in the West. Johnson has seen evidence that scientists who adhere to this metaphysic "might have so strong a wish that materialism be true that they would be willing to set up an a priori philosophical principle as their God, and exempt it from the ruthless scrutiny that science otherwise requires."[38] This brand of science sounds more like a dogmatic religion than an open, circumspect process of following evidence wherever it leads.

Scholars such as Stanley Jaki and Rodney Stark, who have studied the Scientific Revolution emphasize that a theistic worldview–and in this case, a predominantly Christian one–was essential to the birth and rapid development of modern science in Europe.[39] These historical facts naturally raise difficult questions for intelligent design opponents. For example, if a design argument is so inappropriate in science, why then did the notion of a designer so effectively and fruitfully lead to the breakthroughs that characterized the Scientific Revolution. In addition, why was the notion of a designer of nature not a barrier, but in fact a theoretical catalyst in the minds of the early giants of western science? Did they realize a key truth which today's scientific mainstream has neglected? These factors may add valuable merit to intelligent design's claims as a viable scientific hypothesis.

Another general category of reasons for treating intelligent design's claims to

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[38]Johnson, "Science."

[39]Stanley L. Jaki, *Science and Creation* (Edinburgh: Scottish Academic Press, 1986), viii; Rodney Stark, *For the Glory of God: How Monotheism Led to Reformations, Science, Witch-Hunts and the End of Slavery* (Princeton, NJ: Princeton University Press, 2003), 121-97.

scientific status is that such a treatment affects the larger mission of Christian apologetics. First, it helps determine to what degree Christian doctrine can be intellectually and evidentially defended and rationally and observationally undergirded. In other words, it helps clarify the issue of whether Christianity ultimately is a matter of subjective faith, untethered from rational or empirical evidences, or whether there are objective signs, detectible in the biological world around us, which confirm the validity of the rest of God's word? To raise a biblical example, to what do Paul's claims apply regarding God's eternal power and divine nature being "clearly seen" and "understood through what has been made"[40]? Do they only apply to cosmology and astronomy (i.e., the sun, moon, stars, and universe)? Do they apply to both cosmology and biology? To neither? This issue even impacts the concept of general revelation: To what extent does general revelation exist to help support and supplement special revelation?[41]

The issue of intelligent design's scientific status also impacts, albeit somewhat indirectly, how one views Scripture. Can the Bible be relevant in any way to understanding fundamental aspects of the natural world? How should statements in Scripture regarding the natural world be viewed and interpreted? As spiritually inspiring but factually mythological poetry? As historical claims to be trusted literally? And if so, how literally?

In addition, the issue of intelligent design's scientific status can have an effect upon a Christian worldview. This is because if design in biology (especially in human

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[40]Romans 1:20 (New American Standard, 1995).

[41]*Baker Encyclopedia of Apologetics* (Grand Rapids: Baker Books, 1999), s.v. "Revelation, General."

biology) is empirically detectible, this fact may greatly help undergird confidence in the doctrine of humans being created, and in particular, being created in God's image. This doctrine in turn has deep ramification on issues of man's identity, the existence of moral ultimates, mankind's relationship with the environment, life after death, the meaning and ultimate purpose of history, as well as a host of other social issues.[42]

Intelligent design's scientific status is also important because it impacts how both Christians and non-Christians view scientific inference. Does science really require absolute methodological naturalism as many philosophers of science have claimed? What kinds of hypotheses is scientific evidence allowed to indicate?[43]

Finally, successfully defending intelligent design as science is important scientifically, academically and spiritually. Scientifically, it expands science's explanatory scope and power. It helps scientists infer the best explanation of phenomena in this world, not just the best *naturalistic* explanation of those phenomena. Moreover, intelligent design opens the eyes of scientists to consider and search out levels of specified complexity in phenomena that are easily missed when they, by default, assume

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[42]Nancy Pearcey, *Saving Leonardo: A Call to Resist the Secular Assault on Mind, Morals and Meaning* (Nashville: B&H Publishing, 2010), 152-53; John G. West, *Darwin Day in America: How Our Politics and Culture Have Been Dehumanized in the Name of Science* (Wilmington, DE: ISI Books, 2007), 359-75; Benjamin Wiker, *Moral Darwinism: How We Became Hedonists* (Downers Grove, IL: InterVarsity Press, 2002), 20-28.

[43]Pennock, "Creationism,"155-56; Robert T. Pennock, "The Prospects for a 'Theistic Science,'" *Perspectives on Science and Christian Faith* 50, no. 3 (September 1998): 205-7, http://www.asa3.org/ASA/PSCF/1998/PSCF9-98Pennock.html (accessed January 6, 2014); Kitzmiller v. Dover Area School District, 735-36; Eugenie Scott, "Darwin Prosecuted: Review of Johnson's Darwin on Trial," *Reports of the National Center for Science Education* 13, no. 2 (Winter 1993), http://ncse.com/cej/13/2/darwin-prosecuted-review-johnsons-darwin-trial (accessed January 6, 2014); Maarten Boudry, Stefaan Blancke, and Johan Braeckman, "How Not to Attack Intelligent Design Creationism: Philosophical Misconceptions About Methodological Naturalism," *Foundations of Science* 15, no. 3 (August 2010): 227-42; Eugenie Scott, *Evolution vs. Creationism: An Introduction*, 2nd ed. (Westport, CT: Greenwood Press, 2009), 4-6, 19-21; Evan Fales, "Naturalism and Physicalism," in *The Cambridge Companion to Atheism*, ed. Michael Martin (New York: Cambridge University Press, 2007), 123-24.

only neo-Darwinism.[44] Academically, defending intelligent design as science encourages an end to at least one instance of rampant academic discrimination and bullying which has been based in large part on metaphysical or political "group-think" factors.[45] Spiritually (for theists) it provides a friendly atmosphere for their faith to be at least supplemented by evidence in the natural world and it builds their confidence that they need no longer live with what Francis Schaeffer presented as a "two-story" mentality where faith and reason are divorced.[46] For atheists or non-theists, a defense of intelligent design as science provides a healthy challenge to consider expanding their worldview to the possibilities that a cosmic designer exists, and that evidence of his existence can be empirically detected irrespective of one's prior religious commitments or lack thereof. Ultimately, it hopefully will result in some atheists or non theists beginning to discover who this Designer is and to give Him the credit He deserves for all that He has designed.

Methodology

I have approached my research leading up to this dissertation from a number of angles. First, I have deeply familiarized myself with Elliott Sober's likelihood case against ID in the second chapter of *Evidence*. I have needed to separate out the essential topics from the more peripheral topics in that chapter. Chapter 1 of that book has been

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[44] Dembski, *Revolution*, 287-90.

[45] Thomas Nagel, *Mind and Cosmos: Why the Materialist Neo-Darwinian Conception of Nature is Almost Certainly False* (New York: Oxford University Press, 2012), 10; Jerry Bergman, *Slaughter of the Dissidents* 2nd ed. (Port Orchard, WA: Leafcutter Press, 2011); Kaustuv Basu, "Second Thoughts," *Inside Higher Ed* (March 1, 2012), http://www.insidehighered.com/news/2012/03/01/book-intelligent-design-proponents-upsets-scientists (accessed January 6, 2014).

[46] Francis A. Schaeffer, *A Christian View of Philosophy and Culture*, vol. 1 of *The Complete Works of Francis A. Schaeffer* (Wheaton, IL: Crossway, 1982), 83.

helpful (though difficult) in establishing in my mind a basic theoretical groundwork for different approaches to probability.

Naturally, I have spent some time reading reviews and evaluations of Sober's book. Additionally, as Sober unfolds his case, he incorporates the thoughts of a number of key historical figures (e.g., Paley, Hume, Duhem, and Darwin). I have then done some research in both their relevant original writings, as well as analyses of some of their writings by more contemporary scholars.

I have corresponded in a limited way with Elliott Sober himself (I asked him to be my external reader, but he declined), although we have only discussed one narrow topic–the relationship between likelihood and inference to the best explanation. I have also consulted some of Sober's other related writings such as his 1990 book *Philosophy of Biology* and his 1990 article, "Absence of Evidence and Evidence of Absence," finding them quite useful.

Since the issue of analogy is central to this dissertation, I have also delved into the theory behind analogical reasoning and argumentation, consulting the writings of current experts such as Dedre Gentner of Northwestern University and Keith Holyoak and Paul Thagard. I also gained much insight from articles by Kenneth Waters and Julian Weitzenfeld. Of course, David Hume's discussions of analogy as it relates to design arguments, contained in his *Dialogues Concerning Natural Religion*, are centrally important, and I spent time consulting and processing them, along with Sober's treatment of them in *Evidence*.

I spent significant time researching articles concerning the Cambrian Explosion and Burgess Shale fossils and found abundant references to pursue about those topics from the bibliography and footnotes of Stephen C. Meyer's 2013 book *Darwin's Doubt*. Chapter 4 of this paper is significantly indebted to the concepts, arguments and evidence Meyer presents in that book. I have also sought out feedback on some of the arguments I will include in my dissertation from intelligent design advocates and scientists associated with the Discovery Institute such as Casey Luskin and Jonathan McClatchie.

Lastly, I spent significant time and effort researching dozens of current articles in the fields of biochemistry, molecular biology and synthetic biology as I prepared content for chapters 6 and 7 of this paper which focus on molecular machines and synthetic life, respectively. Fazale Rana's 2011 book, *Creating Life in the Lab*, was an extremely helpful and inspiring guide for the seventh chapter.

Chapter Summaries

The introduction (chapter 1) begins by describing how the issue of intelligent design (ID) as a scientific hypothesis and research program has become a seriously polarized issue. It then points out how Elliott Sober's reasons for rejecting ID as science have dramatically shifted in the past twenty years, but how those reasons also directly parallel the two broad reactions of the academic and science communities. The introduction then explains why defending ID as science is important scientifically, academically and spiritually. It then gives the paper's thesis, namely that Sober's likelihood objection to ID as science is not successful. The introduction briefly outlines scholarly literature pertaining to Sober and the likelihood argument and then concludes with an outline of the paper.

Chapter 2 begins by briefly introducing Sober's likelihood approach, including how it is derived from Bayesian probability, but offers a less subjective and more contrastive evaluation of hypotheses. The chapter then describes how Sober defends neo-Darwinism's likelihood, first through a rejection of probabilistic *modus tollens*, and second through an analogy he claims demonstrates why a neo-Darwinian hypothesis would always yield a higher likelihood than pure chance alone.ndependent auxiliary propositions,. The chapter then discusses the critical problems Sober finds with intelligent design. He first introduces the need for independent auxiliary propositions, but claims that intelligent design cannot provide the crucial auxiliary propositions regarding a designer's goals and abilities. Sober then reasons that intelligent design also fails as an inductive argument because there is no legitimate bridge principle between designed artifacts and purportedly-designed organisms. Sober's overall conclusion is that intelligent design has no assessable likelihood, is not testable, and thus is not science.

Chapter 3 is the first of four chapters critiquing Sober's argument. It presents four possible responses to Sober's likelihood requirement that the intelligent design hypothesis provide independent support for designer goals and abilities. This paper will not address the first response–calling on other arguments for God as independent support–because the design argument seems to have a real force of its own which this paper seeks to emphasize. This paper also does not address the second response–that intelligent design theory doesn't need to provide independent auxiliary propositions at all–since it seems to beg the question. The bulk of this chapter focuses on the last two responses: third, that Sober has chosen poor (i.e., overly restrictive) auxiliary propositions and in turn, this paper proposes better ones; and fourth, that Sober's requirements can be met through the use of analogy.

Although more could be mentioned, chapter 4 focuses on five flaws in Sober's argument against intelligent design as science. First, the chapter points out how Sober does not apply his likelihood standards to neo-Darwinism with the same rigor he applies them to intelligent design, at least as they both pertain to so-called macroevolutionary changes. Backed with evidence drawn primarily from Stephen Meyer's 2013 book *Darwin's Doubt*, the chapter shows that if he were to apply his standards consistently, they would eliminate both intelligent design and neo-Darwinism as scientific hypotheses, particularly regarding one major phenomenon in biological history: the Cambrian Explosion. Second, the chapter points out that because natural laws describe not only what must happen, but what cannot happen, that Sober is wrong when he implies that neo-Darwinism is always more likely than chance. Third, the chapter highlights two critical mischaracterizations Sober makes about the purported designer of the intelligent design theory. For one, Sober effectively conflates that designer with the God of theism, and this is flawed since intelligent design theory does not make such a conflation. Moreover, Sober claims that the theistic God he has assumed is utterly inscrutable, which is an unacceptably incomplete theological declaration. Both of Sober's mischaracterizations are foundational to his argument against intelligent design. Therefore, exposing them effectively cripples his final conclusion. Fourth, the chapter describes why Sober's attribution of what he calls a "creationist" view to intelligent design theory is a wrong generalization. Intelligent design theory does not, as Sober implies, claim it is immune from any and all observations of 'sub-optimality' in biological organisms or structures. Last, the chapter explains that Sober's two suggestions in *Evidence* for immunizing the intelligent design hypothesis from potentially damaging criticism, in fact end up eliminating that hypothesis as science. The chapter therefore recommends that intelligent design theorists face critical objections (e.g., those presented by Hume and Gould) head-on, rather than trying to avoid them, as Sober suggests.

Chapter 5 begins by focusing on David Hume's claim that analogy only very weakly supports a design argument. The chapter points out that Hume presents a grossly oversimplified description of analogy and that his presentation of the analogical distance between nature and human artifacts (e.g., machines) is selective and thus critically incomplete. Second, the chapter shows that Sober, very much like Hume, gives an oversimplified description of analogy which makes it largely irrelevant to his likelihood argument. Third, while Sober emphasizes how a rejection of probabilistic modus tollens undermines intelligent design objections to neo-Darwinism on the basis of huge probabilistic barriers, the chapter describes how that very rejection in fact helps the intelligent design hypothesis overcome Sober's likelihood rejection criteria about support for designer goals and abilities. Fourth, the chapter explains why Sober's assumption that God and humans are entirely different is unsupportable. Finally, the chapter describes how, starting with Darwin, Darwinists and Sober himself depend on analogies in making their cases. This implies that a Humean dismissal of analogy as a logical, supporting tool for arguing for the design hypothesis is a double-standard. In many places, chapter 5 bolsters these arguments by giving counterexamples from scholars of analogy and from scientific observation and practice.

Chapter 6 challenges Sober's claim that from Paley's and Hume's day to the present there has been no appearance of evidence of a continuum between artifacts and organisms which would allow for an inductive version of a design argument. The chapter specifically focuses on recent scientific discoveries of systems within organisms which show analogy with humanly designed artifacts. Besides the DNA-computer code isomorphism, cellular biology and biochemistry have continued to discover how the genetic code produces a dazzling array of molecular machines within factory-like cells, machines which perform a variety of highly specialized functions, including molecular kinesin motors which literally walk loads down intracellular microtubules, ATP synthase, with function uncannily similar to hydroelectric turbine generators, and RNA and DNA polymerases, which rapidly produce copies of a complex and specified DNA message string, similar to a teleprinter machine.

Chapter 7 presents more evidence for an analogical continuum between artifacts and organisms, specifically with examples of human technology which increasingly mimic living cells. Experimental progress is discussed that is currently being made in the laboratory in synthesizing fully functioning genomes and toward producing protocells from non-living components. Humans building organisms from non-living materials–something Sober himself predicts–would empirically demonstrate that intelligent beings (or an intelligent Being) could have been responsible both for the origination of life from non-life, as well as the subsequent development of more complex, specified life forms. As the progress of science and technology continues to ever-more-closely mimic life, then the condition of Sober's (and any design opponent's) opposition to intelligent design as a scientific hypothesis is only going to get worse.

The paper's conclusion, chapter 8, summarizes how Sober's argument against intelligent design as science falls short, by affirming that likelihood for intelligent design can be assessed if appropriate auxiliary propositions are chosen, and examined reasonably and equitably for *all* hypotheses on the table. It closes by asserting that Sober has underestimated analogy, that design analogies can be reasonable and compelling, and thus that a probabilistic case can be defended for intelligent design as science.

CHAPTER 2

SOBER'S ARGUMENT

Likelihood, Probability and Probabilistic Modus Tollens

In *Evidence and Evolution,* Elliott Sober addresses the question of whether intelligent design qualifies as science primarily from the perspective of probability theory. The scope of Sober's book, however, is larger than merely an examination of intelligent design. Following his analysis of intelligent design, Sober devotes the remainder of the book to examining neo-Darwinism generally, and common descent specifically, through the lens of probabilities. Consequently, Sober devotes the first chapter of his book to describing several of the prominent approaches to probability theory, in order to lay the groundwork for his subsequent analysis of both intelligent design and neo-Darwinism.

In chapter 1 of *Evidence,* Sober explains one of the concepts most crucial to his examination of intelligent design as science, namely, *likelihoodism*. Sober points out the distinctions between "Bayesian posterior probability" and "likelihood." The former can be expressed by the following formula, namely Bayes' theorem: $Pr(H \mid O) = [Pr(O \mid H) \times Pr(H)] / Pr(O)$.[1] What this means in words is "the probability of a hypothesis H, given observation O is equal to the probability of the observation O, given hypothesis H, times the probability of hypothesis H, all divided by the probability of observation O."

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[1]Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 9.

Sober next points out that applying Bayes' theorem in the context of evaluating certain scientific hypotheses[2] becomes very difficult because Pr(H)–i.e., the probability of a hypothesis in the absence of observations, or "prior probability"[3]–can become highly subjective. Consequently, Sober recommends that when evaluating explanations such as neo-Darwinism and intelligent design, one should use a likelihood comparison, rather than a Bayesian posterior probability approach. Likelihood is expressed in formula as Pr(O│H), i.e., the probability of encountering observation O, given proposed hypothesis H. Sober makes it clear that likelihood assessments are inherently contrastive,[4] meaning that at least two proposed hypotheses (e.g., H_1 and H_2) should be compared. Sober then presents the Law of Likelihood: "The observations O favor hypothesis H_1 over hypothesis H_2 if and only if $Pr(O│H_1) > Pr(O│H_2)$. And the degree to which O favors H_1 over H_2 is given by the likelihood ratio: $Pr(O│H_1) / Pr(O│H_2)$."[5]

Sober says a likelihood assessment differs from a Bayesian probability assessment not only in that the latter can suffer from being subjective, but also in that the two approaches provide different things. Bayes' theorem tells what one's degree of belief should be regarding a given a set of observations, while a likelihood comparison tells "what the evidence says."[6] In other words, from Bayes' theorem, posterior

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[2]Sober mentions, for example "a deep and general scientific theory, such as Darwin's theory of evolution or Einstein's general theory of relativity . . . when we assign prior probabilities to these theories, what evidence can we appeal to in justification?" Sober, *Evidence*, 26. One wonders why he did not also mention intelligent design theory.

[3]Ibid., 8.

[4]Ibid., 33.

[5]Ibid., 32.

[6]Ibid.

probability asks the question, "Given the observed phenomenon, how probable is it that the hypothesized cause produced it?" Likelihood, on the other hand asks, "Given the hypothesized cause, what is the likelihood of that cause producing the observed phenomenon?" By using a likelihood approach, it seems that Sober believes he can realistically compare intelligent design with neo-Darwinism without demanding deductive certainty and without the subjectivity that plagues Bayesian prior probability.[7]

Besides the likelihood approach, there is another key concept which Sober discusses in chapter 1 of *Evidence* which is extremely pertinent to his evaluation of both neo-Darwinism and of intelligent design. This concept is what he calls "probabilistic *modus tollens*." *Modus tollens* is the valid logical syllogism which says: If H, then O; not O; therefore, not H. Sober then asks if a probabilistic version of this syllogism is valid, namely: $Pr(O \mid H)$ is quite high; not O; therefore probably not H.[8] Less formally, Sober describes what one might be able to conclude if probabilistic *modus tollens* were valid:

> If the hypothesis H says that O will very probably be true, and O turns out to be false, then H should be rejected. Equivalently, the suggestion is that if H says that some observational outcome (*not*O) has a very low probability, and that outcome nonetheless occurs, then we should regard H as false.[9]

Sober asserts that, in fact, the probabilistic version of *modus tollens* is not valid because it cannot determine the probabilistic cutoff at which one should reject a hypothesis. Sober specifically cites examples of probabilistic cutoffs used by Richard Dawkins, William Dembski and Henry Morris related to accepting or rejecting theories about how life

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[7]Sober, *Evidence*, 115-16, 120-22, 139-40.

[8]Ibid., 49.

[9]Ibid., 49-50.

emerged on earth. Sober's evaluation is that "Dawkins, Dembski and Morris have all made the same mistake. . . . *there is no such cutoff*. Probabilistic *modus tollens* is an incorrect form of inference."[10]

The illegitimacy of probabilistic *modus tollens* undergirds Sober's repeated emphasis in *Evidence* that there is a fundamental difference between events that are highly improbable and those that are impossible:[11] "The fact that a hypothesis says that a set of observations is very improbable is not a good reason to reject the hypothesis."[12] He asserts that "lots of perfectly reasonable hypotheses say that the observations are very improbable."[13]

Sober's Defense of Neo-Darwinism

Random Processes Still Retain Some Likelihood

Sober applies his principled rejection of probabilistic *modus tollens* as a first step in defending the likelihood of neo-Darwinism Sober first persuades the reader that even when purely random processes are at work, those processes still retain some likelihood of producing specified complex effects, no matter how vanishing the odds, no matter how implausible the resulting phenomenon.

> A mindless random process can produce complex and useful devices. It is possible, as we now would say, for monkeys pounding at random on typewriters to eventually produce the works of Shakespeare. The problem is that this outcome, given some fixed number of monkeys and typewriters and a limited amount of time, is very

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[10]Sober, *Evidence*, 51.

[11]Ibid., 57, 51, 52, 57, 116, 130, 237, 262.

[12]Ibid., 192; see also 57, 51, 52, 57, 116, 130, 237, 262.

[13]Ibid., 51.

improbable. What is true is that monkeys pounding at random on typewriters probably will not produce the works of Shakespeare. For just this reason, it is a mistake for the design argument to claim that complex adaptations cannot arise by a mindless random process.[14]

Sober emphasizes the possibility of highly improbable events, emerging from his rejection of probabilistic *modus tollens*. He does this to counter many currently popular probabilistic arguments against the inherent capacities of purely unguided natural processes. Those arguments claim either that random processes prior to the emergence of life, or neo-Darwinian processes operating after the emergence of life, cannot produce the observable levels of specified complexity in biology within the earth's time limits.[15] Sober argues that even pure Epicurean chance (solely random processes) yields some likelihood, albeit incredibly small, in explaining the origin of biologically complex and specified organisms, structures, and information. Sober then employs an analogy of a combination lock gradually zeroing in on the correct combination to try to show that random mutation plus natural selection similarly would always yield a higher probability

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[14]Sober, *Evidence*, 116. Sober repeatedly emphasizes the vast difference between "cannot occur" and "probably will not occur." Ibid., 50-51; 57, 115.

[15]William A. Dembski, *The Design Revolution* (Downers Grove, IL: InterVarsity Press, 2004), 84-85, 96, 116-26; William A. Dembski, *No Free Lunch*: *Why Specified Complexity Cannot be Purchased without Intelligence* (Lanham, MD: Rowman and Littlefield, 2002), 21-22; Douglas D. Axe, "The Nature of Protein Folds: Quantifying the Difficulty of an Unguided Search through Protein Sequence Space," in *The Nature of Nature: Examining the Role of Naturalism in Science*, ed. Bruce L. Gordon and William A. Dembski (Wilmington, DE: ISI Books, 2011), 423; Murray Eden. "Inadequacies of Evolution as a Scientific Theory," in *Mathematical Challenges to the Interpretation of Evolution*, ed. Paul S. Moorhead and Martin M. Kaplan (Philadelphia: The Wistar Institute of Anatomy and Biology, 1967; repr., New York: Alan Liss, 1985), 6-9; Michael Behe, *The Edge of Evolution: The Search for the Limits of Darwinism* (New York: Simon and Schuster, 2007), 59-62; James W. Valentine, *On the Origin of Phyla* (Chicago: University of Chicago Press, 2004), 79; Stuart A. Kauffman, *Investigations* (New York: Oxford University Press, 2000), 144; Seth Lloyd, "Computational Capacity of the Universe," *Physical Review Letters* 88, no. 23 (June 10, 2002): 237901-1 through 4; Kenneth Dam and Herbert Lin, *Cryptography's Role in Securing the Information Society* (Washington, DC: National Academy Press, 1996), 380n17. Dam and Lin's calculations are relevant to the question of biological origins even though the article's context is computational operational resources available in the universe for cryptographic purposes.

than Epicurean chance.[16] Thus, Sober reasons that even if the likelihoods of either of these hypotheses are very small, one can at least be sure they are not zero.[17]

Neo-Darwinism not Entirely "Random"

Next, Sober claims that natural selection consists of a mixture of a random process (mutation) and a biased process (natural selection). He claims that because of the second, biased process, therefore, the overall process of neo-Darwinism is not a truly random process.[18] The logical implication of Sober's reasoning is that since neo-Darwinism is not fully random, there may be reason to infer that its likelihood exceeds–possibly significantly exceeds–the likelihood of purely random processes alone.

Sober next implies that natural selection, "nonrandom retention of favorable variants,"[19] is *guaranteed* to yield a likelihood which is higher than that of a purely random chance process of producing complex specified biological structures within the limited time constraints: "a *purely* random process takes longer to evolve adaptive configurations than the *partly* random and *partly* nonrandom process of mutation plus selection."[20] The introduction of a bias into the evolutionary process seems to entail that there is now some sort of law, or complex multiplicity of laws, at work in addition to pure chance, ensuring a higher likelihood. Necessity has been added to pure contingency.

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[16]Sober, *Evidence*, 123. However, Sober never specifies how much higher that likelihood is.

[17]See chap. 4 of this paper, which challenges the claim that neo- Darwinism necessarily yields a higher likelihood than Epicurean chance, and that neo-Darwinism is at least certain not to be zero.

[18]Sober, *Evidenc*e, 122-24.

[19]Ibid., 123.

[20]Ibid.

Analogy of Combination Locks with Neo-Darwinism

In order to support his claim that Neo-Darwinism's two-component process of randomness (mutations) plus non-randomness (natural selection) necessarily yields a higher likelihood than pure chance of producing the structures and systems observed in biology, Sober borrows two analogies from Richard Dawkins[21] and mixes them together.

He asks the reader to imagine a nineteen-tumbler combination lock, with twenty-six alphabetic letters to choose from at each tumbler instead of numerical digits, and which will only open when the nineteen choices spell (in order) "METHINKSITIS AWEASEL." Sober presents three scenarios: First, all nineteen tumblers are repeatedly spun at random until the final correct message emerges; second, the tumblers are spun at random, one at a time, in order, and the tumbler "freezes" in place when it lands on the correct letter in the sequence. Third, all the tumblers are spun at once, at random and repeatedly, and any of the tumblers which happen to land on the letter in the sequence which corresponds to the target message are "frozen."[22]

Sober uses this analogy to make the point that only the first scenario is fully random, and it would consequently require a potentially huge number of tries to hit the right target. He emphasizes how this is not the case with the other two scenarios. An additional, non-random factor has been added in either case, which greatly reduces the probabilistic searching required to allow the letters to spell out the correct sequence and

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[21]Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design*, 2nd paperback ed. (New York: Norton, 1996), 7, 8, 44-49. Sober credits Simon as the source for Dawkins' analogy. Herbert A Simon, *The Sciences of the Artificial*, 2nd ed. (Cambridge, MA: MIT Press, 1981), 206.

[22]Sober, *Evidence*, 123.

open the lock. Sober then reasons that neo-Darwinism is much more akin to the second or third scenarios, and crucially unlike the first, because it involves a combination of mechanisms, one random (mutations) and one non-random (natural selection).[23]

Sober presents this analogy for the same reasons that he emphasizes his rejection of probabilistic *modus tollens*: in order to counter the many claims that neo-Darwinism faces insurmountable probability difficulties.[24] This notion of neo-Darwinism's hopelessly infinitesimal odds, was famously illustrated when Fred Hoyle commented that random mutations and natural selection had a similar probability of resulting in advanced forms of life as "a tornado sweeping through a junk-yard might assemble a Boeing 747 from the materials therein."[25] Sober's view of that perspective is that "The misleading analogy between natural selection and a hurricane blowing through a junkyard should be junked. . . . Natural selection is no more a random process than intelligent design is."[26]

Sober's Philosophical and Theological Presuppositions

For the Argument's Sake, Consider the Designer as God

In chapter 2 of *Evidence,* Sober reveals two key philosophical and theological presuppositions which appear to importantly affect how he analyzes and evaluates intelligent design as science. The first presupposition to note regards the assumed

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[23]Sober, *Evidence*, 122-25.

[24]Ibid., 123-25.

[25]Fred Hoyle, quoted in "Caltech Kellogg Birthday: Hoyle on Evolution," *Nature* 294, no. 5837 (November 12, 1981): 105. Paraphrased in Sober, *Evidence*, 122.

[26]Sober, *Evidence*, 125.

identity of the designer implied by the intelligent design hypothesis. Sober gives assurances in a few places in chapter 2 of *Evidence* that his core objection to the design argument does not require assuming that the designer is the God of theism any more than "some other intelligent designer."[27] Yet, the notion (or even the unspoken assumption) that the designer of design arguments is identified as God richly pervades the chapter.[28] Most importantly, in two key passages where Sober reveals his most stringent objection to intelligent design as science, the default designer he discusses gravitates back to the God of theism,[29] which lays a stronger foundation for his objections. This assumption has critical consequences for the logic of his entire case, which chapter 4 of this paper addresses in more detail.[30]

Following Descartes: God's Plans are Inscrutable

Following closely upon his first presupposition that the designer is effectively the God of theism, Sober reveals a second presupposition, emphasizing a specific characteristic of that God, and referencing a philosopher, Renee Descartes, whose notions of God were clearly indebted to Christian theism. Sober comments that "the criticism I have made of the design argument is one that Descartes endorses in the *Principles of*

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[27]Sober, *Evidence*, 115, 127, 128, 140-41, 145.

[28]Ibid., 109, 110, 111, 112, 113, 128, 145-46, 147, 148-49, 154, 164, 165, 166, 167, 184, 186, 187, 188. Sober also only seems to give passing or trivial mention of distinctions between Paley's natural theology, the design arguments of "creationists," and those of current intelligent design theory. In Sober's treatment, the three all-too-easily seem to run together.

[29]Ibid., 127-28. Sober asserts Gould does not know God's goals in the case of the panda's thumb; 145-47, Sober asserts Paley, and by extension design theorists, do not know God's goals either.

[30]It makes Sober's assertion of the designer's inscrutability (see below) sound much more convincing, if that designer is seen as the God of Judeo-Christian theism.

Philosophy."[31] The characteristic which Descartes emphasizes, and which Sober utilizes in his argument is the inscrutability of God's goals:

> Concerning natural things, we shall not undertake any reasonings from the end which God or nature set Himself in creating these things, {and we shall entirely reject from our Philosophy the search for final causes}: because we ought not to presume so much of ourselves as to think that we are the confidants of His intentions.[32]

Elsewhere, when claiming that intelligent design lacks the independent support for designer goals and abilities, Sober links that claim to (and apparently agrees with) comments by Philip Johnson that God's purposes might be "inscrutable" and "mysterious."[33] This emphasis on God's inscrutability, like Sober's tendency to identify the designer of intelligent design with God, crucially affects the rest of Sober's case.

Sober builds upon these philosophical-theological presuppositions to analyze whether design arguments can generate an assessable likelihood with which to compare them to neo-Darwinism, whose likelihood he has already at least cursorily defended.

The Failure of Design Arguments in Likelihood Terms

Sober's Focus is Mainly on Paley

When analyzing design arguments through the lens of likelihood in chapter 2 of *Evidence*, Sober focuses the bulk of his attention and critique on William Paley's famous watchmaker argument, and devotes much less attention to contemporary intelligent

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[31] Sober, *Evidence*, 146.

[32] Renee Descartes, *Principles of Philosophy,* trans. Valentine Rodger Miller and Reese P. Miller, Synthese Historical Library 24 (Dordrecht, The Netherlands: Kluwer Academic Publishers, 1991), 14.

[33] Philip E. Johnson, *Darwin on Trial*, 2nd ed. (Downers Grove, IL: InterVarsity Press, 1993), 71, 67, quoted in Sober, *Evidence*, 154n29. Sober interprets Johnson as saying that "God's purposes *are*' inscrutable' and 'mysterious'" (italics mine). In context, Johnson sounds less absolute.

design formulations of the design hypothesis by advocates such as William Dembski[34] and Stephen Meyer.[35] Sober's most substantial mention of contemporary intelligent design theory (about ten pages) focuses on Michael Behe's concept of irreducible complexity.[36] That section is more of a defense of what neo-Darwinism can conceivably do, rather than a critique of intelligent design's claims to scientific status.[37] For this paper's purposes, the most important aspect of that section is Sober's use of an analogy of a stone arch as a means of defending neo-Darwinism, and what that implies about scientific hypotheses which employ analogy to support them.

Standing with Hume, Design Arguments are Fundamentally Flawed

Sober does not try to show that design arguments have been surpassed in likelihood or explanatory power by the advent of neo-Darwinism. Rather, he believes that his likelihood critique of design arguments reveals crucial, inherent shortcomings which eliminate them entirely from consideration as scientific rivals to neo-Darwinism. In this perspective, he explicitly agrees with David Hume's general conclusion (as voiced in Hume's *Dialogues*) that there are fundamental flaws in design arguments.

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[34]William A. Dembski, *The Design Revolution* (Downers Grove, IL: InterVarsity Press, 2004), 64-165; William A. Dembski, *Intelligent Design: The Bridge between Science and Theology* (Downers Grove, IL: InterVaristy Academic, 1999), 97-183.; William A. Dembski, *No Free Lunch:Why Specified Complexity Cannot be Purchased without Intelligence* (Lanham, MD: Rowman and Littlefield, 2002), 1-177, 279-310.

[35]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins, 2009), 349-75; Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), 337-81.

[36]Michael J. Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Simon and Schuster, 1996), 39-40.

[37]Sober, *Evidence*, 154-64.

> Dialogues present a number of serious criticisms of the design argument. . . . If any of these criticisms are correct, they show that there are flaws in Paley's argument that we can recognize without knowing anything about Darwin's theory. . . .
>
> . . . I stand with Hume. Although I think that some of Hume's criticisms of the design argument are off the mark, I do think there is a devastating objection to Paley's argument that does not depend in any way on Darwin's theory.[38]

Sober's "devastating objection" to design arguments is that they generate no assessable likelihood. This objection itself, however, springs from one additional required component of scientific hypotheses which Sober addresses in chapter 2 of *Evidence*.

Duhem and Auxiliary Propositions

From Sober's perspective, what standard(s) should one use to conclude that a certain hypothesis is "more likely" than another–or even has any assessable likelihood–to produce a given empirical observation (e.g., the specified complexity in a human eye, or the specified and complex body plan of a novel Cambrian phyla)? Alluding to Pierre Duhem's discussion about theories in physics,[39] Sober asserts that auxiliary propositions (or "auxiliary assumptions")[40] are the tool for effectively comparing rival hypotheses:

> It is here that a point that Pierre Duhem (1914) emphasized . . . becomes relevant: Theories rarely make predictions on their own; rather, auxiliary assumptions need to be brought to bear. . . . Duhem's point holds for most of the hypotheses that the sciences consider, . . . Duhem's idea is that the usual pattern in science is that the hypothesis H does not entail whether the observation statement O will be true; rather it is H&A that will have this kind of entailment, for suitably chosen auxiliary assumptions A.[41]

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[38]Sober, *Evidence*, 126. While Sober might seem somewhat hesitant about embracing Hume's particular approach, in fact, as discussed in Chapter Five of this paper, he gives tacit approval of Hume's rejection of design arguments on analogical and inductive grounds.

[39]Ibid., 144; Pierre Duhem, *The Aim and Structure of Physical Theory*, trans. Philip P. Wiener (Princeton, NJ: Princeton University Press, 1954), 183-88. Duhem does not seem to use the term "auxiliary propositions." This may be Sober's verbiage.

[40]Sober uses the two terms interchangeably in *Evidence*.

[41]Sober, *Evidence*, 144.

Sober then raises the next logical question, "What makes an auxiliary assumption 'suitable'?" His answer is that "in testing H1 against H2, you must have a reason to think that the auxiliary proposition A is true that is independent of whatever you may already believe about H1 and H2."[42] For Sober, independently supported auxiliary propositions are thus the ultimate criteria through which likelihood assessments are made, which consequently help one at least provisionally compare likelihoods between competing hypotheses, or, as in the case of intelligent design, help one eliminate certain explanations from consideration as scientific hypotheses.[43]

Finding Fault with Gould Regarding the Panda's Thumb

In chapter 2 of *Evidence*, Sober's criticism of biological design arguments begins to take concrete shape in his discussion of Stephen Jay Gould's opposition to inferring a divine designer in light of what appear to be seriously inefficient adaptations like the panda's thumb.[44] Gould's case is framed as an inference to the best explanation, or what Sober calls a likelihood argument:

> Gould's point is that no designer worth his salt . . . would have given the panda this device for preparing its food. A truly intelligent designer would have done better. On the other hand, Darwin's theory of evolution by natural selection says that inefficient devices of this kind are not surprising. . . .
>
> . . . I hope that it is clear that Gould's argument is a likelihood argument. He

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[42]Sober, *Evidence*, 144-45.

[43]Ibid., 128, 154n29, 165, 189; Chong Ho Yu, "Testability of Intelligent Design Argument in the Perspective of Quantitative Methodology," *Jian Dao Journal of Bible and Theology* 20 (2003): 94; Elliott Sober, "The Design Argument," in *Debating Design: From Darwin to DNA*, ed. William A. Dembski and Michael Ruse (Cambridge: Cambridge University Press, 2004): 109-14.

[44]Stephen Jay Gould, *The Panda's Thumb: More Reflections in Natural History* (New York: W.W. Norton, 1980), 20, 24; Stephen Jay Gould, "The Panda's Thumb," in *Intelligent Design Creationism and Its Critics*, ed. Robert T. Pennock (Cambridge, MA: MIT Press, 2002), 669-76.

> claims that the hypothesis of intelligent design makes the panda's thumb very improbable, whereas the hypothesis of evolution by natural selection makes the result much more probable.[45]

While Gould's argument seems to weaken confidence in the case for detecting a divine designer through biological structures, Sober unexpectedly takes the side of 'creationists' in claiming that Gould's argument is fatally flawed: "Creationists have a serious objection to Gould's argument." The flaw is that Gould does not know "what God would have had in mind if he had built the panda."[46] Sober speculates about some alternative goals God might have had in mind for intentionally making the panda's thumb an inefficient mechanism. He reasons that Gould has no independent support for his auxiliary assumptions about God's goals and abilities (as unconsciously held as they might be) which are meant to undergird his argument against a design inference.

> Gould adopts assumptions about the designer's goals and abilities that help him reach the conclusion he wants–that intelligent design is implausible. . . . But it is no good simply inventing assumptions that help one defend one's pet theory. Rather, what is needed is independent evidence concerning what God (or some other intelligent designer) would have wanted to achieve if he had built the panda. And this is something that Gould does not have. I think creationists are right to object in this way to Gould's argument.[47]

Sober thus concludes that Gould's likelihood argument against inferring a divine designer from observing biological structures fails. In Sober's estimation, Gould has not supplied any independent reason to think that God is motivated to create a highly efficient structure rather than a highly inefficient one. To use terms more familiar to the intelligent design debate, Gould has failed to show why God is more likely to create an object rich

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[45]Sober, *Evidence*, 127.

[46]Ibid., 127-28.

[47]Ibid., 128.

in specified complexity than one totally lacking it. Thus whether a panda's thumb or any other biological structure fits the common notion of efficiency is irrelevant to a design argument. God could have had the motivation to directly design any observed object, and thus the panda's thumb apparently does not hurt claims of divine design being manifest in the biological world.

Applying the Same Criticism to Paley and Intelligent Design

At first glance, then, Sober's response seems to immunize the case for intelligent design from elimination, at least as an explanation for problematic biological structures like the panda's thumb, where what one normally conceives as typical indications of design seem much less obvious. However, Sober later uses the same "creationist" lens by which he critiqued Gould's argument against divine design to examine William Paley's famous argument that watches imply watchmakers, as well as his parallel argument that complex biological structures (e.g., the eye) imply a divine designer. Sober claims that both arguments contain underlying auxiliary propositions about the goals and abilities of the respective designers and which critically affect the success or failure of each argument. In either case, Sober claims that "for intelligent design to have a higher likelihood than chance. . . . all Paley needs is an assumption that ensures" that there is a greater-than-miniscule likelihood that a designer would and could produce the object in question (e.g., either a watch or an eye).[48] At first consideration, Sober's requirement of requisite goals and abilities might seem quite lenient, as he adds, "This can be true even if there is *considerable uncertainty* as to which goals and abilities

[48]Sober, *Evidence*, 142.

the designer would have."[49]

Sober thinks that, even though the maker of the watch on the heath is not directly observed, the watch/watchmaker argument (and presumably any other inferential argument from a complex specified artifact to a human designer) succeeds because its auxiliary assumptions about the watchmaker's goals and abilities are independently justified.

> Although Paley's argument about the watch requires assumptions about the goals and abilities the designer would have had if there were such a being, I don't think this leaves the argument in the lurch. Paley is aware that there are many human designers not far from the heath on which he is walking and that these designers know how to make watches and have every inclination to do so. Provided that there is even a small chance that the designer of the watch is a human being of this sort, his argument goes through.[50]

In contrast, however, Sober thinks that the eye/divine designer argument (and presumably any other inferential argument from a complex specified biological phenomenon to a non-human designer) fails because its auxiliary propositions about the eye-designer's goals and abilities cannot be independently supported. With Paley's eye argument for a divine designer, Sober brings up the same problem he noticed with Gould's argument *against* a divine designer in the case of the panda's thumb:

> My criticism of Paley is that his discussion of the eye makes the same mistake that Gould made. Paley assumes that if an intelligent designer created the human eye, the designer would have wanted to give us eyes with features F1 . . . Fn and would have had the ability to do so. Paley is no more entitled to adopt these favorable assumptions than Gould is entitled to embrace his unfavorable assumptions. What is required, whether we are talking about the panda's thumb or the vertebrate eye, is

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[49] Sober, *Evidence*, 143 (italics mine). It is not clear from Sober's previous sentence why he demands that Paley's assumptions must *ensure* a likelihood greater than "tiny," since under either intelligent design or macroevolution, it is conceivable that some circumstance could obtain which would yield a probability of zero.

[50]Ibid.

an independent reason for believing assumptions about goals and abilities.[51]

Paley may have been aware of human watchmakers through his life's experience, but Sober is claiming that Paley has no similar experience with divine designers of eyes. By Sober's standards then, Paley has no independent support for auxiliary propositions about the goals and abilities of the eye-designer. Sober claims therefore that while the watch/watchmaker argument succeeds, the eye/eye-maker argument does not.

No Independent Support for Designer Goals and Abilities

It may help to restate the principles of Sober's argument as they apply to intelligent design arguments in general. In a process involving intelligent design, the goals and abilities of the designer are indeed causally important. In order for a hypothesized designer to design something, that designer would need to possess, as necessary preconditions, goals and abilities adequate to producing that phenomenon. For example, in order for intelligent designers to have designed and built Stonehenge, those designers would have needed to have been sufficiently motivated to design and build it as well as sufficiently capable of designing and building it.

Sober investigates whether the likelihood that an intelligent designer would design and produce a given structure or system is greater than "tiny." He concludes that it depends upon what assumptions (auxiliary propositions)–favorable (A_f) or unfavorable (A_u)–one makes about the goals and abilities of the purported designer. In the case of A_f, one might propose that the designer was both highly motivated and highly capable of designing and producing the observed structure. In the case of A_u, one might propose that

[51]Sober, *Evidence*, 143-44.

the designer was highly motivated and capable of not designing and producing the observed structure.[52] Sober's claim is that with independent evidence as to which proposition regarding the purported designer's goals and abilities one should choose, such as in the case of a watch, one may reasonably choose the favorable proposition and assess a likelihood less than zero. However, without such independent evidence, such as in the case of a biological organism, there is no way of knowing whether the favorable or the unfavorable proposition applies, and thus the likelihood of such a purported designer actually designing and producing anything is not assessable.[53]

For Sober, in the case of apparently man-made objects like watches, people are familiar with the motives and abilities of watchmakers who design and produce watches very similar to the one observed.[54] Sober claims, however, that what is lacking in the case of biological design arguments "is an independent reason for believing assumptions about goals and abilities" of the designer.[55] A good summary of his central objection is that

> auxiliary propositions can be invented about the putative designer's goals and abilities that insure that the likelihood of the intelligent-design hypothesis is very high, but it is equally true that auxiliary propositions can be invented that insure that the likelihood of the intelligent-design hypothesis is zero. What is needed is not the invention of auxiliary propositions . . . but the identification of auxiliary information

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[52]Sober, *Evidence*, 141-42.

[53]Ibid., 143-44.

[54]Ibid., 143. Sober seems to be somewhat mischaracterizing Paley's example, by taking it for granted that everyone knows instantly that the object discovered in the field is indeed a watch, for all intents and purposes identical to other watches with which we are already abundantly familiar. This scenario is different in important ways from the one Paley actually presented in *Natural Theology*. William Paley, *Natural Theology: or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*, rev. American ed. (Boston: Gould and Lincoln, 1854), 5-8.

[55]Sober, *Evidence*, 143-44, 145-46, 168.

> that is independently supported. Paley did not provide this information, and the same is true of modern defenders of the design argument.[56]

Since he cannot recognize any independently supported auxiliary propositions regarding the designer's goals and abilities, Sober therefore concludes that the likelihoods of design hypotheses (whether Paley's or that of intelligent design) are presently unknowable and thus that, given the current level of knowledge and evidence, intelligent design is not scientifically testable,[57] and thus does not qualify as science.

The Failure of Design Arguments in Inductive Terms

In the latter part of chapter 2 of *Evidence*, after rejecting intelligent design as science on likelihood grounds, Sober also concludes that it also fails when considered as an inductive argument. In other words, he argues that though people have abundant experiences of intelligent designers creating complex and useful artifacts, it is not reasonable to conclude that complex and useful biological structures were caused by an intelligent designer. Sober concludes this because he claims that there has never existed, from Hume's day to the present, a gradual range or continuum of phenomena between humanly-made artifacts and biological organisms which justifies inferring a common, analogous cause (i.e., intelligent design) for all of those phenomena.

Sober justifies his reasoning by referring to an alternative example (albeit a hypothetical one) which David Hume raised in *Dialogues*, which in Sober's thinking, does warrant making an inductive inference to corresponding causation. Hume's raised

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[56]Sober, *Evidence*, 168.

[57]Ibid., 143-49. See also Ingo Brigandt, critical notice of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober, *Canadian Journal of Philosophy* 41, no. 1 (March 2011): 168.

the question of whether if a voice from the clouds was heard all over the world at the same time, perceived by each listener in his or her own language, one could reasonably infer that its source was intelligent.[58] In order to achieve a valid case of induction in cases where the cause is unseen, Sober reasons that a "bridge principle" is required, where two causes, one of which is observed and one of which is unseen, are similar enough to justify approximately the same probability of both causes producing a very similar kind of effect.

In Hume's case of the voice from the clouds, where the source of the voice is unseen, Sober concludes the bridge principle is justified because in such a case, "in other cases in which we do see where voices come from, we see that they almost always come from intelligent beings."[59] Further, Sober says that the fact that the voice is coming from high above the ground also does not render the bridge principle unjustified because people have experience observing "that the frequency with which English sentences come from intelligent beings is not affected by how high off the ground the sound is."[60] Sober mentions that in Hume's day, people on the ground might have had the chance to hear voices coming from passengers of hot-air balloons. Sober continues,

> And before hot-air balloons, people were accustomed to hearing speeches delivered and songs sung from balconies, towers, and windows above the ground floor. There was ample evidence that elevation above the surface of the Earth does not matter–regardless of elevation, sound that constitute sentences, always, or almost always issue from the mouths of human beings. The bridge principle . . . is reasonable.[61]

When evaluating the inductive case for biological design however, Sober

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[58]David Hume, *Dialogues Concerning Natural Religion*, ed. Henry D. Aiken (New York: Hafner, 1948), 26-28.

[59]Sober, *Evidence*, 173.

[60]Ibid., 175.

[61]Ibid.

insists that people have no such range of similar samples forming a bridge (or continuum) between human artifacts and biological organisms. Therefore, one cannot know whether the differences between artifacts and organisms do not radically affect the frequencies with which their respective causes (one if which is unobserved) produce their respective effects. This uncertainty therefore undermines a reliable bridge principle.[62] Sober comments, "My point here is not that the bridge principle" proposed for linking artifacts to organisms "is false but that there was no sampling evidence in the eighteenth century, nor is there any now, that it is true.[63] From Sober's analysis, the design hypothesis as a cause of biological organisms is left without a sample size and it is clear that Sober thus concludes that an inductive inference will not work to undergird that hypothesis.

The Rest of *Evidence*

As mentioned above, following chapter 2 of *Evidence*, Sober examines both Neo-Darwinism and common descent from the perspective of probabilities. In the former case, he chooses to focus on examples of "microevolution" (primarily polar bear fur length). In the latter case, he does not include intelligent design in his comparison of competing hypotheses. Consequently, apart from chapters 1 and 2, *Evidence and Evolution* has extremely limited relevance to the issue of this paper, namely whether intelligent design qualifies as a scientific hypothesis.

Literature Review

With an overview of Sober's main arguments from *Evidence* against intelligent

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[62]Sober, *Evidence*, 174-75.

[63]Ibid., 175.

design as science in hand, it will now be useful to briefly survey both what Sober has written elsewhere related to this topic, and how other key scholars have responded to his arguments.

In a number of his other writings, Elliott Sober discusses arguments or ideas similar to those he presents in *Evidence.* He raises topics such as likelihoodism,[64] testability,[65] the inadequacy of probabilistic modus tollens,[66] Pierre Duhem and independent "auxiliary assumptions,"[67] the need for knowledge about a designer's goals and abilities,[68] criticism of Michael Behe's notion of irreducible complexity,[69] discussion of Paley's watchmaker argument,[70] discussion of Hume's case against design arguments,[71] and others. Given these similarities, it may be that *Evidence and Evolution* is an integrated and expanded compilation of many of these previous writings, which Sober edited, revised and arranged into what he sees as a logical, holistic treatment. The bibliography of *Evidence* lists over 30 articles or books, which Sober either wrote himself

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[64]Elliott Sober, "Intelligent Design and Probability Reasoning," *International Journal for Philosophy of Religion* 52, no. 2 (October 2002): 71; Branden Fitelson, Christopher Stephens, and Elliott Sober, "How Not to Detect Design: A Review of William A. Dembski's The Design Inference–Eliminating Chance Through Small Probabilities," *Philosophy of Science* 66, no. 3 (September 1999), 475-83; Elliott Sober, *Philosophy of Biology*, Dimensions of Philosophy Series (Boulder, CO: Westview Press, 1993), 31-36.

[65]Elliott Sober, "Testability," *Proceedings and Addresses of the American Philosophical Association* 73, no. 2 (November 1999): 47-76; Elliott Sober, "What is Wrong with Intelligent Design," *Quarterly Review of Biology* 82, no. 1 (March 2007): 6-7; Sober, *Philosophy*, 46.

[66]Sober, "Testability," 14; Sober, "Probability," 68-69.

[67] Sober, "Testability," 9; Sober, "What's Wrong," 5-6; Sober, *Philosophy*, 48-52.

[68]Sober, "Testability," 19-20; Sober, "Probability," 75.

[69]Sober, "What's Wrong," 7-8; Sober, "Probability," 72-77.

[70]Fitelson, Stephens, and Sober, "How Not to Detect," 472, 486-87; Sober, *Philosophy*, 30-35.

[71]Sober, *Philosophy*, 33-36.

or co-authored, which he used in putting this volume together.

There are a number of reviews or evaluations of the arguments Sober presents in *Evidence and Evolution*. While differing in the details, most of those reviews or evaluations which I surveyed had a generally favorable response. For example, Ingo Brigandt seems to heartily agree with every aspect of Sober's argument against intelligent design as science except one. He voices great concern that Elliott Sober limits his argument primarily to logical issues and does not attack intelligent design for what to Brigandt concludes are surreptitious and corrupt motives: In Brigandt's mind, design proponents are "focused on their social-political goals, and use any means — no matter how depraved — to achieve them."[72] Brigandt seems disappointed in Sober for not extending opposition to intelligent design on logical grounds further into the social realm where Brigandt apparently sees intelligent design as a threat to society.[73]

William Provine praises Sober for the first two chapters of *Evidence*, but then scolds Sober for claiming in his third chapter that using a "teleological version of natural selection," as a heuristic does not harm science: "After stating that natural selection is a 'mindless process' he treats it as mindful for the next two chapters."[74] Like this paper, in his article treating a portion of Sober's argument in *Evidenc*e, Roger Sansom recommends adjustments to Sober's choice of auxiliary propositions. Unlike this paper, however, he proposes folding favorable assumptions about "goals and abilities" into the design hypothesis itself, thus avoiding having to defend such assumptions

[72]Brigandt, critical notice of *Evidence*, 180.

[73]Ibid., 183.

[74]William B. Provine, review of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober, *Evolution* 63, no. 4 (April 2009): 1101-2.

independently.[75]

Sahotra Sarkar is bothered that Sober's case against intelligent design is more one of elimination and not demolition: Sarkar would have preferred that Sober had shown how neo-Darwinism is explanatorily superior to intelligent design, not merely that design is off the table as a candidate. Sarkar also seems to reason that when assessing design arguments, in order to have a "coherent account of either design or intelligence," he–and most importantly Sober–both assume "that we can construe ID creationism as positing a conscious designer in the required sense," i.e., a designer "with its consciousness similar to that of humans."[76] Sarkar also points out how radically Sober's view toward intelligent design versus Darwinism has changed since 1993. The bottom line, however is that Sarkar still agrees with Sober that likelihood for intelligent design "cannot be computed."[77]

Without much discussion, E. O. Wiley simply agrees with Sober that intelligent design "lacks any independent justification for the auxiliary propositions that would render the design hypothesis testable."[78] In his positive review of *Evidence*, David Hull succinctly summed up the current academic judgment: "intelligent design. . . . is anything but a well-established scientific theory. It is instead a paradigm example of

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[75]Roger Sansom, "Auxiliary Hypotheses in *Evidence and Evolution*," *Philosophy and Phenomenological Research* 83, no. 3 (November 2011): 676.

[76]Sahotra Sarkar, "Sober on Intelligent Design," *Philosophy and Phenomenological Research* 83, no. 3 (November 2011): 686. Although Sarkar's wording is not perfectly clear, it strongly appears that this is an analogy which chapter 3 claims causes Sober a crucial problem.

[77]Ibid., 691.

[78]E. O. Wiley, "Why Philosophy Matters to the Working Biologist," review of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober, *The Quarterly Review of Biology* 85, no. 1 (March 2010): 83.

pseudoscience."[79]

Understandably, the one scholar who is generally unfavorable toward Sober's argument is William Dembski. Although Dembski has not written a full, formal review of Sober's likelihood argument, he has responded in a number of his writings to individual arguments by Sober which are repeated systematically in chapter 2 of *Evidence*. Dembski seems to write approvingly of Sober's 1993 reformulation of Paley's arguments as abductive reasoning (inference to the best explanation) rather than analogy.[80]

Other than in this aspect, many instances exist of Dembski strongly disagreeing with Sober, a thorough sample of which appear in Dembski's book *No Free Lunch*. One major objection he raises there has to do with Sober's assertion that the likelihood method of evaluating hypotheses is inherently contrastive (i.e., requires comparing two or more rival hypotheses). Dembski does not think that before rejecting a given hypothesis because it is highly improbable, a substitute hypothesis with higher probability must be available to take its place.[81] It seems that Dembski is not asserting that in order to properly evaluate proposed theories or hypotheses, that evaluative approach must not be contrastive, but rather he is asserting that the evaluative approach may not necessarily need to be contrastive.

Dembski points out a problem for the likelihood approach which might arise in

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[79]David L. Hull, "The Logic Behind the Science," review of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober," *BioScience* 59, no. 4 (April 2009), 349.

[80]Dembski, *Intelligent Design*, 273-76. In *Evidence*, Sober calls what seems to be inference to the best explanation a "likelihood inference".

[81]Dembski, *No Free Lunch*, 101-2.

some cases. The approach might be misleading if it forces one into granting "most likely" status"[82] to one hypothesis over another, when in fact, both are exceptionally, or even prohibitively unlikely.[83] Another way of putting this is that sometimes in science the absolute value of a hypothesis' likelihood is just as important, or even more important than the relative likelihood it has in comparison to another hypothesis.

Dembski also says it is unrealistic to try to cast all hypotheses (whether neo-Darwinism or intelligent design) into the form of chance hypotheses about which probability comparisons can be made. "hypotheses like 'Natural selection and random mutation together are the principal driving force behind biological evolution' or 'God designed living organisms' . . . do not induce well-defined probability distributions."[84] Dembski therefore concludes that "likelihood analyses regularly become exercises in rank subjectivism."[85] He views Sober's ranking of probabilities to Epicurean chance, intelligent design and neo-Darwinism as examples of such subjectivism with no mathematical rigor to back them up.[86]

Dembski claims that an intelligent design hypothesis ought to be viewed in a fundamentally different way than hypotheses based on inductive accumulation of past observations. From Dembski's perspective, the method of predicting likelihood drawn from inductive experience does not fit a design hypothesis well because designers have

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[82]Dembski, *No Free Lunch*, 103-4.

[83]Ibid.

[84]Ibid., 105-6.

[85]Ibid., 106.

[86]Ibid.

free wills and can be creative. As causal agents, they are unlike natural laws derived from repeated observations. "Sober's likelihood approach puts designers in the same boat as natural laws, locating their explanatory power in an extrapolation from past experience. . . . Yet unlike natural laws, which are universal and uniform, designers are also innovators. Innovation . . . eschews predictability."[87]

Dembski addresses a deep problem he finds with "a Humean inductive tradition in which all our knowledge of the world is an extrapolation from past experience."[88] Dembski questions how anyone could have, by inductive experience alone, recognized design in the very first instance it occurred (and thus began building an inductive sample size regarding instances of design). One cannot know deliberate design is happening by observing the actions of the purported designer, but only through the effect of those actions. Dembski's point is that people recognize design by what is produced, not by the assumed goals of the purported designer.[89]

In one of his final points in *No Free Lunch* relevant to Sober's approach, Dembski says that the process of detecting design in practice works according to an order, namely "we start with objects that initially we may not know to be designed. Then by identifying general features of those objects that reliably signal design, we infer to a designing intelligence responsible for those objects."[90] In other words, design detection in practice reasons from object to design hypothesis, or symbolically represented, Pr(H/O).

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[87]Dembski, *No Free Lunch*, 109.

[88]Ibid.

[89]Ibid., 109-10; Dembski, *Revolution*, 229-30; Dembski refers to Reid raising this same point, Thomas Reid, *Lectures on Natural Theology*, ed. Elmer H. Duncan (Washington, DC: University Press of America, 1981), 52.

[90]Dembski, No Free Lunch, 110

Dembski says this order is precisely backward of the order Sober recommends. Dembski paraphrases that order as “from design hypothesis to designed object, with the design hypothesis generating predictions or expectations about the designed object,” or Pr(O/H).[91] Thus Sober’s approach, according to Dembski, uses a method of assessing intelligent design’s scientific status which scientists do not regularly use in practice.[92] In contrast to Sober’s requirement for independent support for designer goals and abilities, Dembski asserts, “We infer design regularly and reliably without knowing characteristics of the designer or being able to assess what the designer is likely to do.”[93]

Summary

This chapter presented the major components of Elliott Sober’s argument against intelligent design as a scientific hypothesis, and presentated a sampling of scholarly responses to Sober’s views. For the purposes of this paper, Sober’s main objections boil down to two main issues. First, intelligent design fails as a likelihood assessment. Second, intelligent design fails as an inductive argument. The remainder of this paper will critically examine these two major issues and show why Sober is mistaken on both counts. This paper argues that the intelligent design hypothesis can generate just as much of a likelihood as the neo-Darwinian hypothesis, and by inductive inference, the intelligent design hypothesis is a reasonable scientific rival (and indeed, is becoming an ever-more-formidable scientific rival) to the neo-Darwinism hypothesis.

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[91]Dembski, *No Free Lunch*, 110.

[92]Ibid., 108-9.

[93]Ibid., 108.

CHAPTER 3

CHALLENGES TO SOBER'S REJECTION CRITERIA REGARDING DESIGNER GOALS AND ABILITIES

At first glance, it might appear that intelligent design theorists could offer any of four defensive responses to Sober's dismissal of the design argument on the grounds that it lacks independent support of auxiliary propositions regarding designer goals and abilities. This chapter will address each of these potential responses in turn, devoting the most attention and emphasis to the last two.

Response 1: Using Other Arguments for God as Independent Support

As a first response, a proponent of a design hypothesis could begin by recognizing that advocates of either neo-Darwinism or intelligent design unconsciously carry with them "Bayesian prior probabilities"–estimates of how probable a hypothesis was prior to consideration of the observed effects needing explanation.[1] A design theorist could supply any number of reasons for holding a prior probability that the hypothesis of design is true. For example, a design advocate who is a Judeo-Christian theist could assert that the designer is the God of the Bible, and could then supply independent support for that hypothesis through a cosmological argument,[2] thus arriving at a prior

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[1]Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 8.

[2]William Lane Craig, *Reasonable Faith: Christian Faith and Apologetics*, 3rd ed. (Wheaton, IL: Crossway, 2008), 111-54.

probability that the God being proposed as the design argument's designer exists. One could also supply Bayesian priors through the moral argument for God,[3] the argument from reason,[4] miracle reports,[5] an argument from religious experience (both his own and countless others'),[6] or an account of a rough match between biblical accounts of a creator or creation and the features or history of nature.[7]

Sober would likely respond to this approach by claiming that Bayesian priors for a design hypothesis are too subjective to be used to generate a probability.[8] In one sense, however, using alternative reasons for believing in a moral, loving, supernaturally powerful God has considerable merit, if for no other reason than it seems to provide Sober with exactly what he asks for: some independent support for designer goals and abilities. Nevertheless, this response would require analysis far exceeding both the claims of intelligent design theory and the scope of this paper.[9]

Response 2: No Need for Independent Auxiliary Propositions

As a second response, an intelligent design proponent could simply deny that

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[3] Craig, *Reasonable Faith*, 172-83. See also Richard Taylor, *Ethics, Faith, and Reason* (Englewood Cliffs, NJ, Prentice-Hall, 1985), 78, 82-84.

[4] C. S. Lewis, *Miracles: A Preliminary Study* (New York: Macmillan, 1947), 26-37.

[5] Craig S. Keener, *Miracles: The Credibility of the New Testament Accounts*, vols. 1 and 2 (Grand Rapids: Baker Academic, 2011).

[6] Richard Swinburne, *The Existence of God,* 2nd ed. (New York: Oxford University Press, 2004), 293-327.

[7] Hugh Ross, *The Fingerprint of God* (Pasadena, CA: Reasons to Believe, 1989), 161-70.

[8] Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 121.

[9] This response may deserve rigorous attention, relevant to the design-Darwinism debate.

any independent auxiliary propositions are needed in certain cases (including this case). In his book *Inference to the Best Explanation*, Peter Lipton claims that in certain cases, there are legitimate "self-evidencing explanations."[10] He gives the example of noticing tracks in the snow and immediately inferring that a person on snowshoes recently walked by. Lipton claims that "the phenomenon that is explained provides an essential part of the reason for believing that the explanation is correct."[11] If Lipton is correct, then the empirically observed marks in a biological organism themselves can provide an essential part of the reason for believing that a design explanation is correct, or at least has a non-negligible likelihood. This would relieve the design advocate of the responsibility to provide any independent support for assumptions about designer goals and abilities.

Of course, regarding Lipton's example of tracks in the snow, Sober would protest, with justification, that such an explanation is not truly self-evidencing. He would argue that several background facts, or auxiliary propositions, known independently of the marks in the snow, undergird the explanation that a person has recently passed by on snowshoes. For example, although one may never have witnessed a person walking in snow on snowshoes, one may have seen photos or television programs of such activity. One also may have seen snowshoes hanging on the wall at Cabela's, which uncannily match the shape of the marks in the snow. One also may unconsciously remember that the area in question is not remote from human civilization, making quite plausible the explanation that some person recently has passed by.

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[10]A term he borrows from Hempel. Carl G. Hempel, *Aspects of Scientific Explanation* (New York: Free Press, 1965), 370-74, quoted in Peter Lipton, *Inference to the Best Explanation*, paperback ed. (London: Routledge, 1993), 26.

[11]Lipton, *Inference*, 26-27.

In addition to the above auxiliary proposals, one may have observed human footprints in the sand on a beach, or in the mud along a trail, or may have previously seen footprints left by animals in the snow. These other footprints, while not precisely matching the marks observed in the snow in the case needing explanation, help to narrow down plausible explanations (e.g., the marks seem to mimic those which a two-legged animal would make and they do not look anything like the tracks any known non-human animal would make). Closely analyzing most of these auxiliary propositions–especially this last cluster related to footprints–helps support a hypothesis via analogy. This illustrates a central claim of this paper, namely, that analogy is central both to design arguments in general and to Sober's criticism of them. Chapters 5, 6 and 7 devote special attention to developing this claim.

As the above discussion about tracks in the snow shows, Duhem (and by extension Sober) seem to be correct in saying that hypotheses about unseen causes need additional, independent auxiliary propositions to support them. Therefore, the second response to Sober's challenge, that no independent support for designer goals and abilities is needed, seems inadequate.

Response 3: Better Auxiliary Propositions for Assessing Likelihood of Design

As a third response, a design theorist could agree in principle with Duhem and Sober that independent auxiliary propositions are needed, but then could question whether Sober's chosen auxiliary propositions–support for designer goals and abilities–are the only propositions, or even the ones most relevant to a design hypothesis as an explanation of observed evidence from biology. If Sober's required propositions are not as relevant as other propositions, perhaps they are not needed to establish likelihood for a design hypothesis.

Reasoning Methodology for Design Arguments

At first glance, arguments proposing design as an explanation for biological specified complexity might seem to be less persuasive than arguments about regular laws of nature that emerge from countless, repeatable laboratory experiments (e.g., the predictable production of carbon dioxide and water from burning the mixture of natural gas and oxygen)[12] or countless observations of invariant natural processes that always produce the same effects (e.g., the orbits of planets and their moons). By the same token, the other main rival hypothesis to design for explaining biological specified complexity, neo-Darwinian macroevolution, also suffers from the same apparent disadvantage.

Because of the subject matter they study–events in the distant past whose causal details largely remain only indirectly available to empirical observation–scientists such as evolutionary biologists, paleontologists, forensic pathologists, archaeologists and intelligent design theorists must use a reasoning method which diverges from the method chemists most commonly use in the lab or astronomers use when observing orbits. The former group most frequently uses the method of *abduction*, which is also commonly referred to as *inference to the best explanation*. This method employs reasoning from empirically observed effects back to potential causes of those effects. Stephen Jay Gould captured the essence of these two approaches to scientific argumentation by pointing out

[12]Steven S. Zumdahl and Donald J. Decoste, *Basic Chemistry*, 7th ed. (Belmont, CA: Brooks/Cole Cengage Learning, 2010), 147.

the distinction between what he calls "historical" and "experimental-predictive" styles of science.[13] Charles Thaxton, Walter Bradley and Roger Olsen chose the labels "origins science" and "operations science," respectively, to highlight the same distinction.[14]

Design theorists like William Dembski and Stephen Meyer emphasize inference to the best explanation (a comparative form of abductive reasoning) as the argumentation approach used both in intelligent design arguments as well as in other hypotheses formed in the other historical sciences.[15] Dembski and Meyer show how theorists concerned with the historical sciences both in the past (e.g., William Whewell,[16] Charles Darwin,[17] Thomas Chamberlin,[18] Charles Sanders Peirce[19]) and in the present (e.g., Thaxton, Bradley and Olsen,[20] Peter Lipton,[21] Stephen Jay Gould[22]) have used,

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[13]Stephen Jay Gould, "Evolution and the Triumph of Homology, or Why History Matters," *American Scientist* 74, no. 1 (January-February 1986): 64. Gould describes a historical scientist as one "who works with the complex, unrepeated phenomena of history." Ibid. Gould also outlines three strategies for historical science which Darwin used in building and defending his theory. Ibid., 62-63.

[14]Charles B. Thaxton, Walter L. Bradley, and Roger L. Olsen, *The Mystery of Life's Origin* (1984, repr., Dallas: Lewis and Stanley, 19924), 6-8, 202-4.

[15]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins, 2009) 59, 154; Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), 346.

[16]Meyer, *Signature*, 152, 156.

[17]William A. Dembski, *The Design Revolution* (Downers Grove, IL: InterVarsity Press, 2004), 287-88.

[18]Meyer, *Darwin's Doubt*, 346.

[19]William Dembski, *Intelligent Design: The Bridge between Science and Theology* (Downers Grove, IL: InterVarsity Press, 1999), 200; Meyer, *Signature*, 156.

[20]Thaxton, Bradley and Olsen, *Mystery*, 6-9.

[21]Meyer, *Signature*, 155, 156; Lipton, *Inference*, 1, 57-58.

[22]Meyer, *Signature*, 150, 156; Gould, "Evolution," 62-65; Stephen Jay Gould, *The Panda's Thumb: More Reflections in Natural History* (New York: Norton, 1980), 27-28.

defended or developed inference to the best explanation (or something closely akin to it). Meyer details the differences between inductive, deductive and abductive arguments, showing how abductive arguments in the form of inferences to the best explanation are a commonly-used scientific argumentation method for undergirding explanations concerning historical events and processes.[23] They are commonly used because those historical events and processes (causes) are no longer observable, while the primary evidence that can inform us about those causes still exists in the form of detectable effects. This seems to indicate that inference to the best explanation is the most fruitful scientific reasoning method for all hypotheses regarding the origin of highly specified and complex biological organisms and structures, whether those hypotheses propose intelligent design or blind natural processes like neo-Darwinism. Advocates of both intelligent design and various forms of Darwinism thus seem to agree on broad methodology, while differing greatly in the explanatory causes they propose.

In the same vein, in his 1993 book, *Philosophy of Biology*, Elliott Sober claimed that classic design arguments of the past–most specifically Paley's–have more inherent strength if they are recognized as inferences to the best explanation: "The design argument is intended by its proponents to be an inference to the best explanation (an 'abduction,' in the terminology of C. S. Peirce)."[24] Sober says that given biological features that are intricate, well-adapted and which contribute to an overall function, Paley must evaluate and compare two distinct explanations:

> The first is that organisms were created by an intelligent designer. God is an

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[23]Meyer, *Darwin's Doubt*, 343-51.

[24]Elliott Sober, *Philosophy of Biology*, Dimensions of Philosophy Series (Boulder, CO: Westview Press, 1993), 30.

> engineer who built organisms so that they would be well suited to the life tasks they face. The second possible explanation is that random physical forces acted on lumps of matter and turned them into living things. Paley's goal is to show that the first explanation is far more plausible than the second.[25]

In fact, in his 1993 book, Sober characterizes the arguments which Paley included in *Natural Theology*[26] as two separate inferences to the best explanation–the watch-to-watchmaker inference and the "works of nature-to-design" inference–which are not analogically, nor inductively, but heuristically linked:

> "Although the subject matters of the two arguments are different, their logic is the same. Both are inferences to the best explanation in which the Likelihood Principle [a statistical principle which says that for a set of competing hypotheses, the hypothesis that confers maximum probability on the data is the best explanation] is used to determine which hypothesis is better supported by the observations."[27]

An interesting development since Sober's 1993 book is that in *Evidence* (2008), he now no longer suggests framing design arguments as "inferences to the best explanation" at all, but favors formulating them as "likelihood arguments." Sober's terminology has changed, although in other respects, his suggested formulation of Paley's argument (and its role in skirting Hume's objections) seems virtually identical.

Whether one uses inference to the best explanation or a likelihood assessment, a pivotal question is this: How does one assess which hypothesis is more likely to produce the specified complexity observed in biology, or what standard does one use to evaluate which explanation is best?[28] Stephen Meyer addresses this question in

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[25]Sober, *Philosophy*, 31.

[26]William Paley, *Natural Theology: or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature*, rev. American ed. (Boston: Gould and Lincoln, 1854), 5-13.

[27]Sober, *Philosophy*, 33.

[28]Lipton, *Inference*, 23; Meyer, *Darwin's Doubt*, 348.

significant detail in two recent books: *Signature in the Cell* (2009) and *Darwin's Doubt* (2013). Meyer claims that *causal adequacy* is the essential criterion most commonly used in historical science.[29] For example, Meyer paraphrases Charles Lyell's criterion, namely that historical scientists "should cite causes that are known from our uniform experience to have the power to produce the effect in question. . . . *'causes now in operation*.' This was the idea behind his uniformitarian method and its famous dictum: 'the present is the key to the past.'"[30]

As Meyer points out, William Whewell also alluded to this same way of evaluating proposed causes in the past: "Our knowledge respecting the causes which actually *have* produced any order of phenomena must be arrived at by ascertaining what the causes of change in such matters *can* do."[31] Meyer also says that Darwin himself effectively used the same criterion of causal adequacy in his defense of his theory of evolution by natural selection:

> Darwin adopted this methodological principle as he sought to demonstrate that natural selection qualified as a *vera causa*, that is, a true, known, or actual cause of significant biological change. In other words, he sought to show that natural selection was 'causally adequate' to produce the effects he was trying to explain.[32]

Recognizing that several proposed hypotheses could be causally adequate to explain one

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[29]Meyer, *Darwin's Doubt*, 348.

[30] Charles Lyell, *Principles of Geology: Being an Attempt to Explain the Former Changes of the Earth's Surface by Reference to Causes Now in Operation* (London: Murray, 1830-1833), 75-91, quoted in Meyer, *Darwin's Doubt*, 349; Charles Lyell, *Principles of Geology*, 11th ed., (New York: Appleton, 1889), 1:76-126.

[31]William Whewell, *Philosophy of the Inductive Sciences, Founded upon their History* (London: John W. Parker, 1840), 2:101; Meyer, *Signature*, 160.

[32]Meyer, *Darwin's Doubt*, 349. See also Vincent Carl Kavaloski, "The Vera Causa Principle: A Historico-Philosophical Study of a Metatheoretical Concept from Newton through Darwin" (PhD diss., University of Chicago, 1974), 100-103.

given phenomenon, Meyer also stresses the comparative (and competitive) nature inherent in the search for the best explanation, something nineteenth-century naturalist Thomas Chamberlin addressed in his "method of working hypotheses."[33]

Remember from the previous chapter that Sober's criterion for what makes a hypothesis "likely" is the presence or absence of independent auxiliary propositions which support it. One must also surmise that since the likelihood method is inherently contrastive, determining which hypothesis among two or more rivals is more likely depends upon which hypothesis has better, or more, independently supported auxiliary propositions.

Meyer's and Sober's respective criteria for comparing hypotheses seem reasonable, and in fact, in crucial conceptual ways they seem to overlap (i.e., they seem to be saying effectively much the same thing, while using differing terminology). However, a third concept needs to be added at this point. Even the notions of "causal adequacy" or "independent auxiliary propositions" have not fully zeroed in on what makes an explanation best, or a hypothesis more likely than another in the case of unobservable past events. When engaging in "historical" or "origins" science, analogy appears to be the crucial factor undergirdins the evaluation of which explanation is better or more likely.

Over 250 years ago, Joseph Butler observed something that helps tie together the concepts of likelihood (and "best explanation") and analogy:

> That which chiefly constitutes Probability is expressed in the Word Likely, i.e., like some Truth, or true Event; like it in itself, in its Evidence, in some more or fewer of

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[33]Meyer, *Darwin's Doubt*, 346. See also T. C. Chamberlin, "The Method of Multiple Working Hypotheses," *Science*, n.s., 148, no. 3671 (May 7, 1965): 754-59.

> its Circumstances. For when we determine a thing to be probably true, suppose that an Event has or will come to pass, 'tis from this Mind's remarking in it a Likeness to some other Event, which we have observed has come to pass. And this observation forms, in numberless daily Instances, a Presumption, Opinion, or full Conviction, that such Event has or will come to pass; according as the observation is, that the like Event has sometimes, most commonly, or always so far as our observation reaches, come to pass at like distance of Time, or Place, or upon like Occasions.[34]

For Butler, "likelihood" inherently springs from "likeness," which is essentially synonymous with similarity or analogy. Applying Butler's concept, analogy would then seem tightly linked to (or even inherent in) Sober's likelihood criterion. This is because people infer the likelihood (or causal adequacy) of a hypothesized past, unobservable cause (a hypothesis H) of present observations, by the degree to which those observations (effects) are "like" (i.e., similar to, or analogous to) observations (effects) whose causes they presently observe and know.

This analogical thinking also seems inherent in Meyer's paraphrase of Lyell urging scientists (in Lyell's case, geologists) to only invoke "causes that are known from our uniform experience to have the power to produce the effect in question." One can "know" the same, or highly similar, causes were at work in both the present and in the past only because of the high similarity or analogy in the effects. Indeed, a search of Lyell's usage of the word 'similarity' in his *Principles of Geology* repeatedly reveals that his confidence in the causal geologic explanations he gives comes through observation of features in ancient environments analogous to those whose causes are now observed.

Similarly, when Whewell urges inquiry into "what the causes of change in such matters can do," he is implying that "such matters" are, in fact similar, or analogous

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[34]Joseph Butler, *The Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature* (London: Printed for James, John and Paul Knapton, 1736; Ann Arbor MI: University Microfilms, 1967), ii.

matters. Darwin felt that similarities (analogies) he saw between the varying products of domestic breeding and differences in wild species were sufficient to help undergird his theory as the best explanation. Therefore, analogy's role in design arguments–and in this critique of Sober's rejection of them as science–is crucial, and it appears again and again in this dissertation, and chapters 5 through 7 devote almost exclusive attention to it.

In a recent email, Sober said that for some time he has not thought "that IBE [inference to the best explanation] is a very good theory of evidence and inference."[35] This paper still asserts however, that the standard of independently supported auxiliary propositions, when used to establish which hypothesis is most "likely," effectively boils down to the same standard as contained in Meyer's criterion of "causal adequacy," the criteria one uses to know which explanation is "best." This is at least in part because both are fundamentally dependent upon analogy and because both are essentially contrastive.

Comments by Michael Scriven from two articles he wrote close to fifty years ago, seem to confirm the claim that Sober's and Meyer's standards essentially reduce to the same thing. Among other characteristics, Scriven says that a qualified candidate for "best explanation" is a cause which "has on other occasions clearly demonstrated its capacity to produce an effect of the sort here under study."[36] This sounds like the essence of Meyer's 'causal adequacy' criterion, and when Scriven says, "an effect of the sort here under study," he can be interpreted as meaning, "an effect *analogous to the one* here

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[35]Elliott Sober, e-mail to author, July 23, 2013. Sober also attached a draft of a forthcoming paper: William Roche and Elliott Sober, "Explanatoriness is Evidentially Irrelevant, or Inference to the Best Explanation meets Bayesian Confirmation Theory," to be published in *Analysis*. Sober said the article "describes some reasons for a Bayesian (or a likelihoodist) to be skeptical of IBE."

[36]Michael Scriven, "Causes, Connections and Conditions in History," in *Philosophical Analysis and History*, ed. William H. Dray (New York: Harper and Row, 1966), 250, quoted in Meyer, *Signature*, 161.

under study." Additionally, Scriven asserts that for such a hypothesized cause, "independent evidence supports the claim that it can produce this effect,"[37] which closely parallels the essence of the auxiliary proposition standard in Sober's likelihood approach. Moreover, the contrastive, comparative nature which Sober's likelihood approach (using auxiliary propositions to compare competing hypotheses) and the inference to the best explanation (comparing causal adequacy between explanations) both share indicates the two are conceptually equivalent.

If Meyer's 'causal adequacy' standard and Sober's 'independent auxiliary proposition,' standard are conceptually equivalent, then the general reasoning method favored by Meyer, Whewell, Lyell and Darwin should meet Sober's standards of independently supported auxiliary propositions in a straightforward way. That method calls for one to hypothesize causes similar to (i.e., analogous to) ones observed and understood today. More specifically, that method calls for one to use as auxiliary propositions the empirical facts of intelligent causes producing effects highly analogous to the observations in of complex, large-scale change biology. With such auxiliary propositions in hand, one is not necessarily required to *also* supply independent support for propositions about necessary preconditions to design, namely assurance that the purported designer possessed some requisite level of goals and abilities.

In objecting to intelligent design as a scientific hypothesis, Sober claims that there is no available independent information about a purported designer's goals and abilities, and that consequently, one cannot make a likelihood assessment for the design

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[37]Michael Scriven, "Explanation and Prediction in Evolutionary Theory," *Science* 130, no. 3374 (August 28, 1959): 481. Meyer, *Signature*, 161. Again, Meyer's wording seems to contain an implicit analogy.

hypothesis. Since, as pointed out above, goals and abilities are necessary preconditions for design, they can be considered "prior" (either chronologically or logically) to the cause of design itself. In trying to assess likelihood, Sober thus seems to be using an approach more akin to operations science or experimental science, rather than origins science or historical science (mentioned above). Sober is depending upon what one might call "cause-side" reasoning to assess likelihood, rather than "effect-side" reasoning,[38] which was shown above to have been more effectively used in the history of modern science when seeking to explain past events (especially unique ones, where direct empirical evidence or observation of the cause itself is either scanty or unavailable).

As a challenge to Sober's cause-side reasoning, the fact is that people make countless design inferences in their everyday experience, just as many scientists do in the course of their research. For example, people's reactions to the first and second World Trade Center tower impacts show that while they may have speculated inconclusively about the goals and abilities of the pilot after the first crash, after the second crash, those considerations became secondary. Moreover, their epistemic shift was not caused by more independent knowledge about goals and abilities, but by unmistakable signs of design. Their strong sense of design rightly refined and clarified their assumptions about the goals and abilities of the planes' pilots, and not vice versa.[39] Cases like this

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[38]Chong Ho Yu calls Sober's approach "hypothesis-driven," in contrast to "data-driven." Chong Ho Yu, "Testability of Intelligent Design Argument in the Perspective of Quantitative Methodology," *Jian Dao Journal of Bible and Theology* 20 (2003): 99.

[39]For example, see Jill McCracken, "A Firefighter's Story," The National 9/11 Pentagon Memorial, 4, http://pentagonmemorial.org/sites/default/files/educational- resources/ 9.11%20Day %20of % 20Service_Firefighter%27s%20Story.pdf (accessed April 25, 2014); Samuel C. Baxter, "More Than a Decade After 9/11: What Should We Remember?" *The Real Truth*, September 11, 2013, http://www.realtruth.org/ articles/110907-002.html (accessed April 25, 2014); Jim Picht, "9/11 and the Rage of America: a Coda," *The Washington Times*, September 18, 2011, http://

(undoubtedly abundant) should cause us to doubt Sober's strict preclusion of design hypotheses on the basis of the goals and abilities standard. In cases of unobserved causes like designers, cause-side reasoning seems exactly the opposite of what is needed.

Besides people in the general public reliably using effect-side reasoning in seeking explanations for phenomena they experience, scientists–especially those in the historical sciences–regularly reason *back* to otherwise unknown goals and abilities of designers on the basis of close examination of observable items or artifacts. In other words, they often reason back to goals and abilities with an already-existing certainty or at least suspicion that design has taken place. Moreover, that certainty or suspicion has obviously not come from independent support for designer goals and abilities, but from the empirical, observed evidence which needs explanation (effect-side reasoning). This clearly shows that providing independent support for designer goals and abilities is not an inviolable standard without which a design hypothesis cannot proceed. It shows to the contrary, that designer goals and abilities sometimes may be, at best, of secondary importance in a design argument.

Why is Sober so sure that goals and abilities are indispensable, and why do design theorists completely disagree with him? Sober does not go into great detail about this question. It appears, however, that because he correctly recognizes how absolutely essential those preconditions of sufficient goals and abilities are for design to occur, he therefore insists that having some independent cognitive support for their existence is the

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communities.washingtontimes.com/neighborhood/911-we-remember-how-terrorism-changed-us/2011/sep/18/911-and-rage-america-coda/ (accessed April 25, 2014); Marisa Guthrie, "George W. Bush Recalls His First Reaction to the 9/11 Attacks," *The Hollywood Reporter*, http://www.hollywoodreporter.com/live-feed/george-w-bush-recalls-his-216640 (accessed April 25, 2014); Neal Conan, "The Second Plane Hit, and All Doubts Vanished," *NPR*; http://www.npr.org/blogs/thisisnpr/2011/09/11/140345582/the-second-plane-hit-and-all-doubts-vanished (accessed April 25, 2014).

only way by which one can gain some knowledge that a design hypothesis is plausible (i.e., has some likelihood as a cause). However, while sufficient goals and abilities are ontological prerequisites (necessary preconditions) for the occurrence of design, that fact does not necessarily entail that independent informational support for sufficient goals and abilities is an epistemological prerequisite (necessary precondition) for even considering a hypothesis of design as a candidate explanation. It seems that Sober has turned an ontological precondition into an epistemological precondition.

Inferring Design in Practice Without Known Designer Goals and Abilities

As claimed above, forming design arguments by hypothesizing causes analogous to ones humans observe and understand today (just as many practitioners and theorists of science in the past have urged) should mitigate the need to supply independent support for designer goals and abilities. Certain practices common in science support the claim that the ontological necessary precondition of sufficient designer goals and abilities does not require a parallel epistemological precondition of knowing (to at least some degree) what those designer goals and abilities might be. Practitioners in certain scientific fields regularly infer design by using abductive arguments, and they use empirically detectable effects as their starting point. In fields like crime investigation and archaeology, just as in intelligent design research, effects–in the form of observed, empirical evidence–are used first to reason to a design inference, then possibly to reason *back to* plausible goals and abilities, not the reverse.[40]

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[40]William Dembski, "Introduction: Mere Creation," in *Mere Creation: Science, Faith and Intelligent Design*, ed. William A. Dembski (Downers Grove, IL: InterVarsity Press, 1998), 17; Thaxton, Bradley and Olsen, *Mystery*, 6-9; Meyer, *Signature*, 340, 351; Meyer, *Darwin's Doubt*, 98, 397.

Forensics. No one demands that a detective first come up with independent support for an alleged murderer's goals and abilities before homicide is legitimately proposed as the manner of death. On the contrary, forensic pathologists DiMaio and DiMaio claim,

> The manner of death as determined by the forensic pathologist is an opinion based on the known facts concerning the circumstances leading up to and surrounding the death, *in conjunction with the findings at autopsy and the laboratory tests*. The autopsy findings may contradict or agree with the account of how the death occurred. Thus, if the story is that an individual shot himself and the autopsy reveals a gunshot wound to the back inflicted from a distance, obviously the account is incorrect. (emphasis mine)[41]

In the DiMaios' example, if empirically detectable features in the observed effects indicate that someone else shot the deceased person, those features would trump the hypothesis that he shot himself, along with its associated auxiliary propositions about goals and abilities (whether independently supported or not). This illustrates that in a scientific field like forensics, which regularly resorts to design hypotheses to explain effects, independent propositions about designer goals and abilities may often, or even consistently, *not* be primarily important factors in initial investigations. In fact, they may even be irrelevant to the likelihood of a design inference in comparison to the more important factor of empirically detectable details in the observed effects and the design-related causes which those effects indicate. Sober would likely claim that a criteria he calls "a bridge principle"[42] (an inductive inference undergirded by analogy) renders design hypotheses in forensics categorically different from design hypotheses in biology.

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[41]Vincent J. DiMaio and Dominick DiMaio, *Forensic Pathology,* 2nd ed. (Boca Raton, FL: CRC Press, 2001), 4.

[42]Sober, *Evidence*, 173.

Chapters 5 through 7, however, explain and illustrate how ongoing scientific discoveries and experiments are indeed increasingly supplying evidence for just such a bridge principle between organisms and artifacts. Consequently, his requirement about designer goals and abilities therefore cannot necessarily be as relevant, much less as absolute as Sober claims it to be for assessing the likelihood of a biological design hypothesis.

Archaeology. Regarding the practice of making inferences and developing explanations in the field of archaeology (which is generally regarded as a science), Sober himself makes a revealing admission in a separate article. He makes an allowance (or perhaps more accurately, an exception) to his own strict requirement that independent support for designer goals and abilities are indispensible for assessing the likelihood of design arguments:

> To infer watchmaker from watch, you needn't know exactly what the watchmaker had in mind; indeed, you don't even have to know that the watch is a device for measuring time. Archaeologists sometimes unearth tools of unknown function, but still reasonably draw the inference that these things are, in fact, tools.[43]

In this case, archaeologists lack independently supported auxiliary propositions about the purported designer's motives, as well as about that designer's ability to produce the purported tool. Yet in stark distinction to his own strict requirements of intelligent design in *Evidence*, Sober claims here that one can still draw a reasonable design inference (i.e., a likelihood of design is assessable even without independent support for a designer's goals and abilities).

Sober can make such an allowance because he is familiar with real-life field

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[43]Elliott Sober, "Testability," *Proceedings and Addresses of the American Philosophical Association* 73, no. 2 (November 1999): 73n20. Interestingly, Paley similarly claimed that design can be inferred, even if functions of certain components are unclear, Paley, *Natural Theology*, 7.

practice of archaeologists, and he knows that such practices of inferring design without necessarily knowing designer goals and motives have born abundant and accurate epistemological fruit. In this instance, holding archaeologists to the same strict standards as he sets before intelligent design in *Evidence* would put Sober in direct conflict with scientific practice. As with the case in forensics, unless the logical structure of design arguments in archaeology differs materially from the structure used in biological design arguments, Sober's requirement about designer goals and abilities may be regarded as interesting, but not crucial, for assessing the likelihood of a biological design hypothesis.

Considering Other Auxiliary Propositions:
The Importance of the Product

When evaluating Paley's watch/watchmaker argument,[44] while emphasizing designer goals and abilities, Sober neglects another crucial auxiliary proposition: Watchmakers also exist who actually *do* produce watches. The point is subtle but important. Even if Paley were aware of watchmakers with requisite goals and abilities (as Sober crucially claims that he was), if Paley had no independent support for the additional, and more crucial proposition that they actually produced watches, how could he infer at all that a watchmaker in fact produced the watch he found? A whole factory full of highly motivated and highly skilled watchmakers could still fail to produce a single watch (for example, due to a nationwide watchmaker's strike). It would be more important if Paley possessed well-supported evidence that those designers actually produced watches, evidence such as the watches themselves.

Although an auxiliary proposition that watchmakers do make watches is

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[44]Sober, *Evidence*, 141-47.

helpful for the watch/watchmaker design argument, how does this help the argument for design in biology? After all, isn't it begging the question to claim as an auxiliary proposition for a biological design argument that a designer does indeed make biological organisms? The answer is that this kind of proposition helps by getting the focus back in the right place: the empirical product, or in more Bayesian language, the observed effect. It illustrates that one only ultimately infers abilities and goals of others from what they produce. The college graduate who moves back to live with his parents may tell them of strong goals he has to get a job, but if day after day he simply sits on the couch and plays video games, they have very little reason to believe that he truly possesses such goals.

Sober's auxiliary proposition requirements have exposed the valuable point that intelligent design does indeed require adequate goals and abilities in the designer as necessary preconditions, just as fire requires fuel, heat and oxygen as its necessary preconditions.[45] Yet a designer's goals and abilities cannot be detected, much less assessed unless that purported designer in fact produces something. As Dembski puts it, "The only way to assess intelligence is to test it and see what it does."[46] In other words, goals and abilities of designers are opaque to humans until they are manifested in tangible effects. Dembski comments, "We do not get into the mind of designers and thereby attribute design. Rather, we recognize their intelligence by examining the effects of their actions and determining whether those effects display signs of intelligence."[47] Thomas

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[45]In fact, fire requires a fourth precondition, an oxidation-reduction reaction requiring the simultaneous presence of both oxidizing and reducing substances. Firesure, "Theory of Fire: The Fire Tetrahedron," http://www.firesure.ie/fire_safety_ guidance/ theory_of_fire.html (accessed June 27, 2013).

[46]Dembski, *Revolution*, 194.

[47]Ibid., 229.

Reid, in a remark aimed directly at Hume, emphasized that the most crucial factor for recognizing design are the effects which design produces: "From the marks of wisdom and intelligence in effects, a wise and intelligent cause may be inferred."[48]

Inferential Precedence

The insight that one can only detect design by what it has produced, means that there is a logical precedence of order in a design inference: first, one observes the phenomenon to determine its basic features; next, if empirical signs of design are present, one makes an inference to design in general and makes the parallel inference of design's preconditions (some kind of goals and abilities on the designer's part sufficient to produce the phenomenon); and last, one investigates further to try to determine more specific details about the characteristics of the designer and his methods of design. Of course, this whole process should take place within the larger context of a comparison with other explanations to determine if design is the best explanation to infer. Michael Behe strongly emphasizes the precedence of inferring design before inferring anything about the designer: "As a matter of procedure, the design must first be apprehended before there can be any further questions about the designer."[49]

As a refinement to Behe's claim, suggest that once one apprehends a likelihood of design, one can also infer with equal likelihood at least two things about the hypothesized designer's characteristics: namely that he does (or did) possess some kinds of goals and some kinds of abilities sufficient to lead him to design the observed

[48]Thomas Reid, *Lectures on Natural Theology* (Washington, DC: University Press of America, 1981).

[49]Michael Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Simon and Schuster, 1996), 197.

phenomenon. One can do this because events (whether effects or causes) automatically entail their necessary preconditions. As Stephen Meyer puts it,

> If a postulated cause is known to be a necessary condition or cause of a given event or effect, then historical scientists can validly infer that condition or cause from the presence of the effect. If it's true that where there is smoke there is always first fire, then the presence of smoke wafting up over a distant mountain range decisively indicates the prior presence of a fire on the other side of the ridge."[50]

Scientists can therefore infer sufficient goals and abilities in an unobserved designer because and to the same degree that they can infer the designer. This inference is justified because they know through their vast experience with human designers that sufficient designer goals and abilities are necessary preconditions for design to happen. As Behe correctly asserts however, specific details about those goals and abilities, need not be known or independently supported before a design inference is justified.

Interestingly, Sober and Dembski seem to agree that design inferences may have very limited scope. Sober acknowledges that "Paley. . . makes it clear in Chapter 5 of *Natural Theology* that his argument about the watch and the eye is intended to establish only the *existence* of a designer and that the question of the designer's *characteristics* must be addressed separately." (emphasis his)[51] For his part, Dembski recognizes highly similar epistemological limitations of intelligent design arguments, but applies them to specifics about designer goals (purposes):

> Intelligent design resists speculating about the nature, moral character or purposes of this intelligence. . . . Intelligent design . . . distinguishes design from purpose. We can know that something is designed without knowing the ultimate or even proximate purpose for which it was designed.[52]

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[50]Meyer, *Darwin's Doubt*, 351.

[51]Sober, *Evidence*, 140.

[52]Dembski, "Introduction," 18.

Sober is right about the need for independent support. But for historical sciences, which seek long-past unobservable causes, it is not the right strategy to begin the search for that independent support by demanding evidence of necessary preconditions. As chapters 5 and 6 will discuss in much greater detail, the better place to look is analogy. Analogy is crucial to forensics, archaeology, and other historical sciences. In historical sciences there often may be even less available, observable evidence for the necessary preconditions than there is for the cause itself. To illustrate, if there are ashes and scorch marks over a large area in the forest, is it the best strategy to first demand independent evidence for a heat source before one is permitted to reasonably infer that a fire has occurred? In contrast, should one use experiences with similar detectable marks and infer by analogy that a fire has occurred and then later look for possible heat sources? In fact, one's knowledge of other similar effects can help to narrow down good places to start looking for details about the missing heat source.

I claim that in the formation of hypotheses about intelligent agency in the historical sciences, and in assessing their likelihood, independent support of auxiliary propositions about designer goals and abilities often may be of secondary importance. One can illustrate this claim by linking a hypothesis about a biological designer with Lipton's example of the snowshoe walker. It seems apparent that goals and abilities are necessary preconditions both for a person in snowshoes to walk by and leave tracks in the snow as well as for an intelligent designer to produce biological organisms or organs and leave marks of specified complexity. Therefore, whether the hypothesized cause is a snowshoe walker or a biological designer, justifiably inferring the non-zero likelihood of the cause also automatically and simultaneously includes justifiably inferring the non-zero likelihood of the preconditions necessary to that cause.

What goals and abilities can one conceivably attribute to a hypothesized person affecting whether he walked by on snowshoes? In terms of goals, the person would have to have some sort of motives driving him/her to walk by (wanting to go somewhere? wanting to get exercise?). Call this goal set A. But one can surely also imagine a person having *not going anywhere* as their controlling motive. Call this goal set B. By Sober's logic, how can one supply independent support to ensure that the purported snowshoe walker's goal set could not have been B (i.e., motives that would absolutely prevent the person from going anywhere at that particular time)? Just like goal set A and B, in chapter 2 of *Evidence*, Sober sets forth both kinds of auxiliary assumptions (both favorable and unfavorable) to a design hypothesis.[53]

Regarding abilities, from a favorable point of view, the person would have to have the ability to walk. But again, one can easily imagine people who cannot walk (infants, handicapped people, etc.). Is there independent support that the purported snowshoe walker was not an infant or handicapped? Importantly linked to abilities, the person would need have at least the use of snowshoes at that period of time (she owned them; she borrowed them; she rented them). Is there independent support that the purported snowshoe walker had access to snowshoes?

The observer of the snow tracks is not in a position to provide any independent support for any of these auxiliary propositions about necessary preconditions. It would seem that by Sober's method, the hypothesis that a snowshoe walker passed by and caused the tracks can yield no likelihood and therefore must be eliminated from

[53]Sober, *Evidence*, 142.

consideration, not because it is inferior to some other explanation, but because it cannot count as an explanation at all.

Of course, this is an example of *reductio ad absurdum*. Sober would let the inference to a snowshoe walker go through without independent support of auxiliary propositions about the person's goals and abilities. On the contrary, given how the tracks in the snow bear an uncanny resemblance to snowshoes and how the spacing of the tracks seems to match the distance of a human stride, not only would one justifiably infer that a person on snowshoes just walked by, but one would consequently and automatically infer that the person had requisite goals and abilities to walk by on snowshoes. One could then use this information as a springboard to entertain hypotheses about what those goals and abilities might be (e.g., Was she training for a marathon? Was she out hunting?).

This last point shows that allowing the design inference to proceed further, rather than cutting it off due to Sober's criteria, enables further, potentially useful analysis and discovery to take place. This is also an advantage of letting the design inference to go through rather than jettisoning it due to Sober's criteria. Learning and discovery can take place as to the possible characteristics, goals, abilities of the purported designer of biological organisms, just as of the purported snow walker.

Why would Sober and any other rational person let the snowshoe walker inference go through? Apparently there are other auxiliary propositions (other considerations or background knowledge) which trump the need for independent support for goals and abilities, even though requisite goals and abilities are necessary preconditions. Response 2 above mentioned some of those other auxiliary assumptions. Consequently, one should also allow alternative auxiliary propositions which trump the need for independent support for goals and abilities in the case of a biological designer. Sober has not mentioned, or shown anywhere in *Evidence* why other propositions, besides designer goals and abilities, in principle should not be allowed when seeking support for a design hypothesis.

As this paper will claim and illustrate repeatedly, analogy is the key which provides the independent auxiliary propositions for design hypotheses regarding observations produced by unobserved phenomena. Another illustration will show how analogy resolves the issue which Sober raises regarding designer goals and abilities. Is Sober reasonable in demanding independent support for a designer's abilities to produce observation O before he can make any assessment of whether that hypothesized designer makes O likely? There is dark black writing high on some ceilings of Kentucky's Mammoth Caves, well out of arm's reach. The guides at the caves inform tourists that the writing was produced by smoke from candles held by cave visitors many years ago. Yet even without such information, when observing those marks, would it be legitimate for visitors to demand independent support for a hypothesized person's ability to produce them before they could make any assessment of whether such a hypothesis would make those marks likely? On the contrary, they could immediately hypothesize a human cause because of analogy. People have seen somewhat similar writing many times before (say on pieces of paper), and they have also seen a person in the act of writing similar things on paper. That analogy (and indeed it is an analogy) is close enough to supply sufficient independent support before they have independent support for how the person might have done it, or what his motives might have been.

In chapter 2 of *Evidence*, Sober certainly has discouraged, or judged ineffective, the use of analogy and induction as means of producing auxiliary propositions.[54] Chapter 5 of this paper addresses Sober's treatment of both analogy and induction in much greater detail.

To summarize response 3, independently supported auxiliary propositions, other than those Sober requires, are available and do undergird a non-zero likelihood for a design hypothesis. Analogy with existing causes and effects can play a major role in providing such auxiliary propositions. A major shortcoming in Sober's argumentation in chapter 2 of *Evidence* is that he has not presented alternative auxiliary propositions like these for consideration. In contrast, with the help of analogy, intelligent design theory can make use of such alternative auxiliary propositions, using effect-side reasoning, and consequently presents a design hypothesis which has at least as much causal adequacy, is at least as good a candidate for best explanation, and is at least as likely as any other 'scientific' hypothesis on offer relevant to the origins and major developments of specified complexity in biological history.

Response 4: Independent Support for Designer Goals and Abilities Through Analogy

As a fourth and final response to Sober's argument against intelligent design as science, a design theorist could agree with Sober that the design hypothesis needs to supply independently supported auxiliary propositions about sufficient designer goals and abilities, and then proceed to supply independent support for those goals and abilities. While the third response denies that design proponents need to supply exactly what Sober is demanding, the fourth response supplies what Sober demands, directly disputing his

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[54]Sober, *Evidence*, 139-40.

conclusion that intelligent design cannot supply it.

As mentioned above, design theorists like Dembski and Meyer make connections between the kind of reasoning which historical scientists use in fields like forensics and archaeology and the kind of reasoning they propose as best for formulating and evaluating hypothesized causes of complex, specified features in the biological world. Now, if purported designers are unobserved, either because they are trying to avoid detection or because they have long since passed away, where do forensic scientists and archaeologists respectively gain the independent support for requisite designer goals and abilities needed to make a design hypothesis likely? They get such independent support from analogies from other cases of design where the designers and their goals and abilities are observable, and thus well-known. Therefore, I propose that an effective way to independently support auxiliary propositions about the goals and abilities of a purported biological designer is to use analogy from observable design by observable designers. Such designers have known goals and abilities, and the proposal is that the unobserved designer(s) of biological organisms and structures are (or were) likely to have highly corresponding, or at least somewhat similar goals and abilities. Further, I believe that everyone who has proposed some form of design argument (from Aristotle to Paley to Meyer and Dembski), has either explicitly or implicitly used analogical reasoning as at least one crucial component in the formation of that argument.

Ontology of the Proposed Designer

What kind of designer are design hypotheses proposing? Intelligent design theorists have repeatedly asserted that at most, they make minimal claims about the identity and characteristics of the designer(s) logically inferred from their hypotheses.[55] In keeping with that assertion, I suggest that there are three broad options regarding who or what that designer might essentially be: 1) "They" were an ancient species of intelligent biological creatures indigenous to planet earth; 2) "they" were intelligent aliens; 3) "he" was a divine Being or beings. As far as anyone has yet discovered, none of these designers, if they existed and did design life on earth, is currently embodied and present. In the first two cases, the creatures very possibly would long since have gone extinct. If they existed, they also did not leave any fossil evidence indicating their presence.

Sober's Inconsistent Stance on Analogy

When one suggests the use of analogy from human designers as even a portion of the underpinning of a design hypothesis, he can expect the immediate response that David Hume long ago (at least reputedly) fatally undermined the analogical version of the design argument.[56] Chapter 5 below will address in detail Hume's objections not only to analogy versions but also to induction versions of design arguments. What is pertinent here is that Sober implies in chapter 2 of *Evidence* that it would be unadvisable for design advocates to try to use analogy from human artifacts and their intelligent designers to infer that biological organisms also have a comparable designer or set of

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[55]Dembski, "Introduction," 17, 21; Willliam A. Dembski, *No Free Lunch: Why Specified Complexity Cannot Be Purchased without Intelligence* (Lanham, MD: Rowman and Littlefield, 2002), xiv; Meyer, *Signature*, 440, 442.

[56]Sober, *Philosophy*, 30; James R. Peters, *The Logic of the Heart: Augustine, Pascal and the Rationality of Faith* (Grand Rapids: Baker Academic, 2009), 52, 153; Jonathan Loesberg, "Kant, Hume, Darwin, and Design: Why Intelligent Design Wasn't Science Before Darwin and Still Isn't," *The Philosophical Forum* 38, no. 2 (Summer 2007): 96; J. C. A. Gaskin, "The Design Argument: Hume's Critique of Poor Reason," *Religious Studies* 12, no. 3 (September 1976): 331.

designers.[57] In short, Sober implies that it is better to avoid Hume's criticisms and keep analogy off the table for use in helping establish likelihood for a design hypothesis. However, key fragments of Sober's arguments in chapter 2 of *Evidence* indicate that he himself is using analogy, and indeed must do so, in the very efforts he makes to show how intelligent design has no assessable likelihood and is not a scientific hypothesis.

Sober justifiably claims that the goals and abilities of the purported designer are crucially important factors in any instance of design. Yet how does anyone, including Sober, know that they are crucially important? They know this because (using Humean terminology) they have seen a constant conjunction[58] in countless instances between certain goals and abilities in human designers and the complex, specified things they design and produce. People know through vast experience observing human behavior that if a human being is going to design and produce something with specified complexity in it, that human being must have a requisite level of certain kinds of goals and abilities, and if those goals and abilities do not match the requisite level, no specified, complex artifact will result. People have rich, observed experience that goals and abilities are especially critical to design. This is because humans are free agents and therefore can freely choose their design goals, and can manipulate or even mask how their abilities are manifested in the things they design. It is notoriously difficult to predict the particulars of what humans may design,[59] although it may be much easier at least to

[57]Sober, *Evidence*, 126, 139-40.

[58]David Hume, *An Enquiry Concerning Human Understanding*, ed. Tom L. Beauchamp (Oxford: Clarendon Press, 2000), 37, 39, 59, 63; David Hume, *A Treatise of Human Nature*, ed. L. A. Selby-Bigge (1896; repr., London: Oxford University Press, 1946), 87, 94, 128.

[59]Dembski, *Revolution*, 228, 287; Dembski, *No Free Lunch*, 109, 362.

predict that most humans will produce some design (even if superficially disguised).

As discussed above, Sober claims that one cannot know where the goals and abilities of the purported biological designer fall on the continuum between A_f and A_u (A_f being the favorable assumption that the hypothesized designer would have both desired, and had the ability to produce the object in question, and A_u being the unfavorable assumption that the designer both desired and had the ability not to produce the object in question).[60] Yet doesn't Sober only know this inherent, underlying unpredictability about the hypothesized designers through his experience of human designers and thus through an analogy from them? It seems that Sober is subtley, and perhaps unconsciously using analogy from human designers to infer qualities of an unobserved biological designer. Sahotra Sarkar, in his review of *Evidence*, likewise seems to recognize and affirm the inherent similarity which Sober assumes between the design argument's designer and human designers. Sarkar reasons that one"cannot evaluate ID creationism as a substantive intellectual doctrine, scientific or non-scientific" unless one posits "a conscious designer (*with its consciousness similar to that of humans*)."[61] Sarkar then asserts "Here, I will assume—*as does Sober*—that we can construe ID creationism as positing a conscious designer in the required sense."[62]

In addition, Sober's source analogue–human designers and the things they design–is a vast inductive sampling pool available to bolster his claim that the necessary

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60Sober, *Evidence,* 142-43.

61Sahotra Sarkar, "Sober on Intelligent Design," *Philosophy and Phenomenological Research* 83, no. 3 (November 2011): 686 (italics mine).

62Sarkar, "Sober," 686 (italics mine). Sarkar is somewhat hard to follow here. As Sarkar asserts, Sober seems to posit a human-like designer in terms of consciousness. Yet he also posits an inscrutable designer (atypical of humans). Chapter 4 addresses the inscrutability issue in more detail.

preconditions of requisite goals and abilities binds all designers, including the purported biological designer. Thus, Sober's strict criteria for independent support for designer goals and abilities in the case of the unobserved, hypothesized biological designer depends, to at least some degree, on a process of analogical, inductive reasoning.[63]

If Sober uses analogical, inductive reasoning, even implicitly, when forming the design hypothesis which he criticizes, parity demands that design theorists also be allowed to use analogical, inductive reasoning in mounting a defense of that hypothesis. Specifically, design theorists should be allowed to use that same vast pool of experience with human designers. From this vast pool, they first can glean evidence of intelligent humans designing complex, specified things and thus infer that complex, specified things in nature are also the products of intelligence. Second, they can also present evidence that those human designers also have an overwhelming tendency to possess the requisite goals and abilities to produce those designed things, and infer that the hypothesized designer of nature also has analogous goals and abilities. Forensic scientists and archaeologists, as discussed above, rightly infer that design emerges from designers with the requisite goals and abilities, based upon vast pools of experience with other human designers. They do this, and indeed must do this, via analogy. Design theorists should be allowed to infer designer goals and abilities via analogy, just as forensic scientists and archaeologists do.

The fact that Sober has made such an implicit analogy is not wrong or illogical in itself. In fact such an analogical assumption seems entirely reasonable, given that the

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[63]Sober's inference that the hypothesized designer must be a goal-contingent free agent seems reasonable. If indeed he is implicitly using analogy from human designers to arrive at that inference, which it appears he is, that analogy also seems reasonable.

overwhelming majority of cases of design, for which investigators already know the designer, are indeed produced by intelligent human beings whose goals and abilities may run along a continuum. Yet, this reasonable appeal by analogy to human designers should also be extended to design theorists to attribute to that same designer an approximately similar likelihood of his goals and abilities being akin to the goals of human designers.

How could a design theorist use experience of human design to estimate the likelihood of sufficient designer goals and abilities? The goals and abilities of human designers along this continuum is not completely unknown or at least in principle not unknowable. There may be a very small percentage of humanity which is both able to and willing to produce things utterly lacking in specificity and complexity (e.g., mathematicians trying to create truly random number sequences, designers of artificial mountains or landscapes for theme parks). There also may be a very small percentage of humanity which is both *unable* or *unwilling* to produce *anything* specified and complex (e.g., infants, comatose patients, the elderly with dementia, or others with severe mental or physical handicaps). Yet, extensive experience also demonstrates that the vast majority of humans are almost universally and continually involved in designing things–from drawing up daily schedules or vacation itineraries, to inventing new labor saving devices or new business strategies. The vast majority of humans find it very difficult *not* to produce some degree of specified complexity.[64] Design researchers could conceivably

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[64]For example, researchers are debating whether humans are even capable of creating truly random strings of numbers. See Navindra Persaud, "Humans Can Consciously Generate Random Number Sequences: A Possible Test for Artificial Intelligence," *Medical Hypotheses* 65, no. 2 (2005): 212-13; Małgorzata Figurska, Maciej Stanczyk, and Kamil Kulesza, "Humans Cannot Consciously Generate Random Numbers Sequences: Polemic Study," *Medical Hypotheses* 70, no. 1 (2008): 183-84; William Bains, "Random Number Generation and Creativity," *Medical Hypotheses* 70, no. 1 (2008): 189.

carry out empirical surveys, examining large swaths of the human community, in order to get a rough idea of the general level of goals and abilities in humans related to producing complex, specified things. The fact that the vast majority of that community consistently does have the requisite goals and abilities favorable to designing things means the likelihood of favorable goals and abilities is assessable for human beings in general, at least in principle.

To summarize, if fundamental notions about the contingencies of the purported biological designer's goals and abilities come analogically from human designers, which in Sober's case they seem to, then it seems the biological designer's goals and abilities have an assessable likelihood as well, also derived analogically from human beings. Design theorists ought to be allowed to use analogy (just as Sober does) to assume similar, relevant qualities between humans and the purported biological designer. Therefore, the design hypothesis has an auxiliary proposition which ensures that[65] the likelihood is not negligible nor zero that that designer will also possess the requisite goals and abilities to produce the specified, complex things investigators observe in biology. Notice that this use of analogy satisfies Sober's demand that support for the goals and abilities auxiliary proposition be *independent of* whatever biological features investigators observed and whose cause they are seeking to explain (e.g., the human eye). Analogy always supplies this independence, thus avoiding the circularity which Sober rightly warns against.

What if Sober were to protest that he does not know that goals and abilities are essential to design via analogy from vast experience of human designers, but rather that

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[65]Sober, *Evidence*, 142.

design requires the goals-and-abilities prerequisite by definition? In other words, designers cannot even be labeled as designers unless they possess the requisite goals and abilities that impel them to design something.

First, while the very meanings of design and designer include notions of goal-contingency by definition, one must ask where humans developed their definitions of "design" and "designer" from. They likely derived the meanings of those words through the very process of frequent, repeated experience of the purposeful, goal-oriented actions of human beings.

Second, as response 3 stated above, while the requisite goals and abilities *are* necessary preconditions to design (and to designers), they may either be irrelevant to, or of secondary importance in assessing if a design hypothesis is likely. Again, if one uses other auxiliary propositions to infer some likelihood for the design explanation, the goals and abilities of a designer necessarily must have been present. Therefore, whether knowledge of the importance of designer goals and abilities comes through analogy or by definition, the ultimate conclusion is the same: contrary to Sober's main point in chapter 2 of *Evidence*, intelligent design does have an assessable likelihood and in fact does not necessarily have any less of a likelihood as a scientific hypothesis to explain large-scale biological complexity than neo-Darwinism does.

Summary

In this chapter I have presented four possible responses to Sober's claim that design theory's inability to provide independent support for requisite goals and abilities in the hypothesized designer undermines any likelihood assessment of design, and thus eliminates design as a scientific hypothesis. I discarded two of the four responses: 1) using other arguments for God as independent support and 2) asserting that a design hypothesis is a self-evidencing explanation. I devoted the bulk of the chapter to the other two responses: 3) proposing a better kind of auxiliary proposition than designer goals and abilities, namely that design has repeatedly made itself detectable through complex, specified effects and 4) independently supporting designer goals and abilities through analogy. I focused on these two responses because they seem more effective and more pertinent to the purposes of overcoming Sober's specific objections. These four responses to Sober's core objection primarily have been defensive. But more needs to be said. The next chapter takes a more *offensive* look at some problems in Sober's argumentation which are detrimental–or potentially fatal–to his case against intelligent design as science.

CHAPTER 4

FLAWS IN SOBER'S ARGUMENTS AGAINST INTELLIGENT DESIGN AS SCIENCE

This chapter shifts from defending the intelligent design hypothesis from Sober's objections to pointing out flaws in Sober's argumentation. The first, and most lengthy section discusses how Sober's standards undermine neo-Darwinism just as much as they do intelligent design, and therefore concludes that those standards are inappropriate for analyzing hypotheses about origins of biological specified complexity. This chapter also points out a flawed claim Sober makes about the likelihood of neo-Darwinism; how in order to erect a key pillar of his argument, Sober attributes to intelligent design a viewpoint it does not necessarily include; how Sober makes unjustified or self-defeating theological assumptions; and finally why intelligent design theorists ought not follow Sober's suggestions for how to strengthen the likelihood assessment for the design hypothesis.

By Sober's Standards, Neo-Darwinism Also Lacks a Likelihood in this Case

In chapters 3 and 4 of *Evidence*, in an apparent effort to apply his standards with parity, Sober sets forth versions of likelihood assessments of "natural selection" (or "evolutionary theory"). A major problem with his efforts, however, is that in both chapters, for all intents and purposes, Sober fails to assess neo-Darwinism as a hypothesis to explain so-called macroevolutionary developments in biology (for example, the sudden appearance of numerous new body plans during the Cambrian period). Sober's third chapter merely focuses on an example of microevolutionary change (the length of polar bear fur), comparing the neo-Darwinian process with random genetic drift. This discussion is largely irrelevant to the theme of this paper since explanations for microevolutionary change are not at issue in the debates between intelligent design and neo-Darwinism . Supporters of various forms of design arguments have repeatedly affirmed mutation and natural selection as the best explanation for microevolutionary changes[1] (such as variations in moth coloration, changes in finch-beak size, antibiotic or insecticide resistance, etc.).

In Sober's fourth chapter, Sober presents a likelihood comparison between hypotheses of common ancestry and separate ancestry. His comparison, however, does not pit neo-Darwinism head-to-head with intelligent design, which he seems to regard as already eliminated from competition by his arguments in chapter 2. Rather, Sober's concern in chapter 4 is "the question of whether two or more species have a common ancestor . . . *within* evolutionary theory" (emphasis his).[2] It seems Sober has not dealt adequately with the likelihood of the existence of a common ancestor, because he has limited himself within the evolutionary paradigm where mutation and natural selection are presupposed. Moreover, it seems that Sober does not deal at all with the deeper issue of auxiliary propositions about neo-Darwinism's capabilities and speed for producing

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[1]Sober may admit this when he says, "creationists usually say that they are talking about the separate origins of the 'fundamental kinds' of organism, not about species in the biological sense." Elliott Sober, *Evidence and Evolution: The Logic Behind the Science* (New York: Cambridge University Press, 2008), 274; William A. Dembski, *No Free Lunch* (Lanham, MD: Rowman and Littlefield, 2002), 246; Phillip E. Johnson, *Reason in the Balance* (Downers Grove, IL: InterVarsity Press, 1995), 15, 74; Michael Denton, *Evolution: A Theory in Crisis*, paperback ed. (Chevy Chase, MD: Adler and Adler, 1996), 85-86.

[2]Sober, *Evidence*, 274.

macroevolutionary change in the first place (whether by common descent or separate descent), and he certainly does not include intelligent design for consideration in his discussion of descent in chapter 4.

In summary, throughout *Evidence,* Sober never gives neo-Darwinism, as an explanation of the major changes in biological specified complexity around which the debate truly revolves, the same rigorous critical likelihood evaluation to which he subjects intelligent design. This seems like an imbalanced or inconsistent treatment of the issues.

Neo-Darwinism's Auxiliary Proposals about Necessary Preconditions

The likelihood of neo-Darwinism as a hypothesis deserves examination, especially in explaining novel, specified and complex structures (proteins, cells, tissues, organs, body plans). A sizeable number of biologists and philosophers have either been very hesitant about, or have outright doubted neo-Darwinism as an explanation for these levels of biological change since Darwin's time. In 1874, based upon lack of evidence in both the fossil record and in embryology, Louis Agassiz called into question large-scale Darwinian changes, saying "Darwin's theory, like all other attempts to explain the origin of life, is thus far merely conjectural. I believe he has not even made the best conjecture possible in the present state of our knowledge."[3]

Over one hundred years later, the skeptical voices are still heard. In 2009,

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[3]Louis Agassiz, "Evolution and the Permanence of Type," *Atlantic Monthly* 33 (1874): 96, 101, http://digital.library.cornell.edu/cgi/t/text/pageviewer-idx?c=atla;cc=atla;rgn=full%20text;idno=atla0033-1;didno=atla0033-1;view=image;seq=107;node=atla0033-1%3A14;page=root;size=100 (accessed September 5, 2013). More specifically, Agassiz said, "The law of evolution, . . . so far as its working is understood, is a law . . . keeping types within appointed cycles of growth." Ibid., 95.

Genetics professor Gunter Theissen wrote, “while we already have a quite good understanding of how organisms adapt to the environment, much less is known about the mechanisms behind the origin of evolutionary novelties, a process that is arguably different from adaptation.” Theissen also noted that “Despite Darwin’s undeniable merits, explaining how the enormous complexity and diversity of living beings on our planet originated remains one of the greatest challenges of biology.”[4]

In a 2002 book, the late geosciences professor Lynn Margulis and her co-author Dorion Sagan wrote, “Mutations, in summary, tend to induce sickness, death, or deficiencies. No evidence in the vast literature of heredity changes shows unambigious evidence that random mutation itself, even with geographical isolation of populations, leads to speciation.”[5] In a 2008 *Nature* article, evolutionary development researcher Scott Gilbert said, “Evolution needs a theory of body construction and change, as well as population construction and change. . . . The modern synthesis is remarkably good at modeling the survival of the fittest, but not good at modelling the arrival of the fittest.”[6] In that same article, developmental biologist Stuart Newman commented “You can’t deny the force of selection in genetic evolution, . . . but in my view this is stabilizing and fine-tuning forms that originate due to other processes.”[7]

In 2012, philosopher Thomas Nagel voiced his own “incredulity” toward neo-

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[4]Gunter Theißen, “Saltational Evolution: Hopeful Monsters are Here to Stay,” *Theory in Biosciences* 128, no. 1 (March 2009): 44.

[5]Lynn Margulis and Dorion Sagan, *Acquiring Genomes: A Theory of the Origins of Species* (New York: Basic Books, 2002), 29.

[6]Scott Gilbert, quoted in John Whitfield, “Postmodern Evolution,” *Nature* 455, no. 7211 (September 18, 2008), 282.

[7]Stuart Newman, quoted in Whitfield, “Postmodern Evolution,” 283.

Darwinism:

> It is prima facie highly implausible that life as we know it is the result of a sequence of physical accidents together with the mechanism of natural selection. . . . What is lacking to my knowledge, is a credible argument that the story has a nonnegligible probability of being true. . . . In the available geological time since the first life forms appeared on earth, what is the likelihood that, as a result of physical accident, a sequence of viable genetic mutations should have occurred that was sufficient to permit natural selection to produce the organisms that actually exist?"[8]

Notice that Nagel phrases his doubt in terms of "likelihood," hopefully using that concept in a way similar to that with which Sober uses it. It is clear that serious doubts persist to this day as to whether independent evidence exists for auxiliary propositions in support of neo-Darwinism as a likely cause of macroevolutionary change.

Applying Elliott Sober's standards from *Evidence and Evolution* with parity, if the hypothesis of intelligent design requires independently supported auxiliary assumptions about designer goals and abilities, then any alternative hypothesis for biological specified complexity should *also* be required to supply independently supported auxiliary assumptions regarding *its* necessary preconditions. Obviously, each alternative hypothesis will likely require its own unique auxiliary propositions. In Sober's mind, and probably in the mind of most of the scientific establishment, the most acceptable explanation for appearances of major biological specified complexity (e.g., appearances of novel body plans or phyla, complex molecular machines, the human eye, etc.) is neo-Darwinism: natural selection working on random mutations. The discussion above asserted that designer goals and abilities are reasonable, necessary preconditions to the occurrence of design. In the same vein, what are some necessary preconditions to the

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[8]Thomas Nagel, *Mind and Cosmos: Why the Materials Conception of Nature is Almost Certainly False* (New York: Oxford University Press, 2012), 6.

neo-Darwinian process, as a cause for macroevolutionary changes?

Parallel to the preconditions of design for which Sober demands independent support (namely, designer goals and abilities), I propose that proponents of neo-Darwinism ought to supply independently supported propositions about three things: 1) a plausible common ancestor and intermediate transitional animal forms, 2) sufficient speed with which neo-Darwinism can produce the high level of specified complexity required, and 3) the fundamental capability of neo-Darwinism to produce those observed effects. By Sober's standards then, in order to properly assess any likelihood of random mutation and natural selection to produce specified biological complexity, one needs to have independent reason to believe, not just conceive, that there existed a plausible common ancestor and intermediates tying together the major phyla body plans, and that the combined process of mutation and natural selection has the capability of producing that all those complex body plans,[9] *within the given time constraints* of the earth's biological history and the currently accepted durations of various life forms (whether their phyla, class, order, family, etc.). If Sober applied tight scrutiny to these auxiliary propositions for neo-Darwinism (the theory of origins which Sober and the majority of biologists prefer) he would likely discover that its likelihood fares no better than intelligent design's likelihood.[10] David Hume's skeptical standards regarding design arguments, when more generally applied, can be seen as eliminating far too many

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[9]Dembski comments, "There are plenty of complex biological systems for which no biologist has a clue how they emerged. I'm not talking about handwaving just-so stories. Biologists have plenty of those. I'm talking about detailed, testable accounts." Dembski, *No Free Lunch*, 276.

[10]David L. Hull, "The Logic Behind the Science," review of *Evidence and Evolution: The Logic Behind the Science*, by Elliott Sober," *BioScience* 59, no. 4 (April 2009): 349. Hull apparently thinks that Sober avoids this problem, but I claim the Humean tendency to overreach troubles Sober's reasoning as well.

reasonable scientific explanations,[11] and Sober's standards seem to suffer from the same problem.

Currently, there is a growing body of evidence that hurts the likelihood that neo-Darwinism has either the capability to produce, within the available timeframes, the major complex, specified information jumps in biology indicated by the fossil record. The most glaring example of these problems seems to pertain to an explanation of the so-called Cambrian Explosion. Additionally, for many paleontologists, there is presently no clear, non-question-begging evidence of a plausible common ancestor and intermediate types of creatures leading to the phyla that appear in the Cambrian Explosion. These problems are described in detail in Stephen Meyer's 2013 book *Darwin's Doubt,* and most of the discussion for the remainder of this section is indebted to that book.

The majority opinion that I have encountered in the paleontology and biology literature is that the Cambrian radiation was a highly unusual event. Scientists are described as "perplexed"[12] by this "conundrum. . . . whose origin seems to defy explanation,"[13] while the fossil data seem "surprising"[14] or "extraordinary"[15] when viewed from a neo-Darwinian perspective. Such expressions arguably imply that neo-

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[11]H. O. Mounce, *Hume's Naturalism* (New York: Routledge, 1999), 110.

[12]Martin Hughes, Sylvain Gerber, and Matthew Albion Wills, "Clades Reach Highest Morphological Disparity,"" *Proceedings of the National Academy of Sciences* 110, no. 34 (August 20, 2013): 13875.

[13]Kevin J. Peterson, Michael R. Dietrich, and Mark A. McPeek, "MicroRNA's and Metazoan Macroevolution: Insights into Canalization, Complexity and the Cambrian Explosion," *Bioessays* 31, no. 7 (2009): 736.

[14]Stephen Jay Gould, *Wonderful Life: The Burgess Shale and the Nature of History* (New York: Norton, 1989), 49.

[15]Roger Lewin, "A Lopsided Look at Evolution." *Science* 241, no. 4863 (July 15, 1988): 291.

Darwinism poorly explains that data, or in likelihood terms, that the neo-Darwinian hypothesis does not make those fossil observations very likely.

Fossil evidence, accumulated and analyzed over the course of the last 150 years has, if anything, reduced independent support for the existence of a common ancestor and intermediate radiating forms leading to the Cambrian phyla. Darwin himself acknowledged a glaring problem in accounting for distinct break between the abundant and distinctively complex fossilized Cambrian life forms and the relatively few, simple and seemingly unrelated fossilized pre-Cambrian creatures, a problem which he acknowledged as "inexplicable," and "a valid argument" against his theory.[16]

Cambrian fossil discoveries, such as the Burgess Shale and the Chengjiang fossils, have exacerbated the problem which Darwin noticed. Hughes, Gerber and Wills comment,

> From Charles Darwin onward, evolutionary biologists have been perplexed by the apparently instantaneous first appearances of numerous phyla (a highly disparate sample of species) in the Cambrian fossil record. The subsequent discovery of hitherto unknown fossil groups from the Cambrian Burgess Shale and similar localities added to the enigma.[17]

In describing the historical perspective granted by the Burgess Shale, Roger Lewin remarks, "evolutionary innovation appears to have been in high gear, generating a wide range of marine organisms where previously there had been few."[18] That range was so wide that "the Cambrian explosion established virtually all the major animal body forms–Bauplan or phyla–that would exist thereafter, including many that were quickly 'weeded

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[16]Charles Darwin, *The Origin of Species by Means of Natural Selection or Preservation of Favored Races in the Struggle for Life*, 3rd ed. (London: John Murray, 1861), http://darwin-online.org.uk/content/frameset?pageseq=437&itemID=F381 &viewtype=image (accessed September 13, 2013). 334.

[17]Hughes, Gerber and Wills, "Clades," 13875.

[18]Lewin, "A Lopsided Look," 291.

out' and became extinct."[19] Lewin later adds, "The fact that all existing (and many extinct) phyla arose during that burst of evolutionary activity at the Precambrian/ Cambrian boundary is striking."[20] One reason Lewin might find the "burst" of Cambrian innovation "striking" is that neo-Darwinian processes normally should have produced numerous transitional forms ancestral to each of (or shared by) the Cambrian phyla gradually radiating from one substantially-more-ancient common ancestor.[21] The fossil record reveals little, if any evidence of such gradually radiating intermediates or of a common ancestor.[22]

In addition, the appearance of disparity between phyla before diversity among lower taxonomic levels, is another observed trend in the fossils from the Cambrian period which is highly anomalous to the standard neo-Darwinian paradigm.[23] Using his famous tree diagram, Darwin theorized that one animal at the trunk would gradually branch into increasingly diverging species, genera, families and orders.[24] In Darwin's diagram, the

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[19]Lewin, "A Lopsided Look," 291.

[20]Ibid.

[21]Richard Dawkins, *Unweaving the Rainbow: Science, Delusion and the Appetite for Wonder* (New York: Houghton-Mifflin, 1998), 201.

[22] Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), 101; Graham E. Budd and Sören Jensen, "The Limitations of the Fossil Record and the Dating of the Origin of the Bilateria," in *Telling the Evolutionary Time: Molecular Clocks and the Fossil Record*, ed. P. C. J. Donoghue and M. P. Smith (London: Taylor and Francis, 2003), 168, 183, quoted in Meyer, *Darwin's Doubt*, 96; Simon Conway Morris, "Darwin's Dilemma: The Realities of the Cambrian 'Explosion'," *Philosophical Transactions of the Royal Society* B 361, no. 1470 (2006): 1069; James W. Valentine, "Late Precambrian Bilaterians: Grades and Classes," in *Tempo and Mode in Evolution: Genetics and Paleontology 50 Years After Simpson*, ed. Walter M. Fitch and Francisco J. Ayala (Washington, DC: National Academy Press, 1995), 90; Sören Jensen, S. M. L. Droser, and J. G. Gehling, "Trace Fossil Preservation and Early Evolution of Animals," *Palaeogeography, Palaeoclimatology and Palaeoecology* 220, nos. 1-2 (May 2, 2005): 19-20.

[23]Meyer, *Darwin's Doubt*, 39-40.

[24]Darwin, *Origin*, 145.

large body-plan-level disparities between higher taxonomic levels (e.g., phyla) should have only become apparent in times closer to the present, at the tips of the tree's ever-more-numerous branches.[25] Darwinian and neo-Darwinian orthodoxy expect evolution to build disparate body plans "from the bottom up." Yet, as numerous paleontologists now point out, the fossil record reveals a top-down pattern: disparity preceding diversity.[26] Cambrian fossil discoveries have, as both Meyer and Gould have phrased it, turned the Darwinian tree-model "on its head."[27]

The fossil record regarding the Cambrian explosion also severely hurts the likelihood of the neo-Darwinian hypothesis by exhibiting a time span for the appearance of numerous novel body plans which is drastically shorter than one would expect on neo-Darwinian grounds. Darwin himself felt that his theory required vast periods of gradual evolution prior to the beginning of the "Silurian age" (i.e., the Cambrian), and he offered "no satisfactory answer" as to why the rocks gave no evidence confirming such an expectation.[28] One hundred and fifty years of paleontology have not revealed the long periods of biological evolution Darwin expected. Valentine, Jablonski and Erwin highlight the shortness of that time span that is evident in the fossil record:

> The Cambrian explosion is named for the geologically sudden appearance of

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[25]Meyer, *Darwin's Doubt*, 40.

[26] Meyer, *Darwin's Doubt*, 40-44 ; Gould, *Life*, 49; Lewin, "A Lopsided Look," 292; Derek E. G. Briggs, Douglas H. Erwin, and Frederick J. Collier, *The Fossils of the Burgess Shale* (Washington, DC: Smithsonian Institution Press, 1994), 40; Stuart Kauffman, *At Home in the Universe: The Search for the Laws of Self-Organization and Complexity* (New York: Oxford University Press, 1995), 13; Douglas H. Erwin, James W. Valentine, and J. John Sepkoski, Jr. "A Comparative Study of Diversification Events: The Early Paleozoic Versus the Mesozoic," *Evolution*, 41, no. 6 (November 1987), 1183.

[27]Meyer, *Darwin's Doubt*, 42; Gould, *Life*, 47.

[28]Darwin, *Origin*, 332.

> numerous metazoan body plans (many of living phyla) between about 530 and 520 million years ago, only 1.7% of the duration of the fossil record of animals. . . . All living phyla may have originated by the end of the explosion.[29]

Peterson, Dietrich and McPeek also emphasize the suddenness of the explosion: "numerous animal phyla with very distinct body plans arrive on the scene in a geological blink of the eye, with little or no warning of what is to come in rocks that predate this interval of time."[30] Ohno expresses the same perspective, "It now appears that this Cambrian explosion, during which nearly all the extant animal phyla have emerged, was of an astonishingly short duration, lasting only 6-10 million years."[31] Scholars also often contrast the suddenness of the Cambrian explosion with the much longer time span standard Darwinian theory predicted would be observed. Hughes, Gerber and Wills note that, "From Charles Darwin onward, evolutionary biologists have been perplexed by the *apparently instantaneous* first appearances of numerous phyla (a highly disparate sample of species) in the Cambrian fossil record."[32] If so many disparate body plans appear far, far faster than standard neo-Darwinian gradualism would predict, then in likelihood terms, the auxiliary proposition of an adequate time span needed to undergird that hypothesis lacks independent support, and neo-Darwinism's likelihood is severely damaged.

As Stephen Meyer brings out in *Darwin's Doubt*, since the fossil record

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[29]James W. Valentine, David Jablonski, and Douglas H. Erwin, "Fossils, Molecules and Embryos: New Perspectives on the Cambrian Explosion," abstract, *Development* 126, no. 5 (March 1, 1999): 851.

[30]Peterson, Dietrich, and McPeek, "MicroRNA's," 736.

[31]Susumu Ohno, "The Notion of the Cambrian Pananimalia Genome," abstract, *Proceedings of the National Academy of Sciences* 93, no. 16 (August 1996), 8475.

[32]Hughes, Gerber, and Wills, "Clades," 13875 (italics mine). See also James W. Valentine, *On the Origin of Phyla* (Chicago: University of Chicago Press, 2004),4; Briggs, Erwin, and Collier, *Burgess*, 40.

regarding the Cambrian explosion has proven to be so unhelpful, evolutionary biologists have turned to molecular phylogenetics, which compares differences and similarities in the genomes of living representative of phyla that first appear in the Cambrian fossils. They do this in an attempt to independently verify that neo-Darwinian processes did in fact cause the appearance of the animal phyla during the Cambrian.[33] As with the fossil record, the key evidence which phylogenetics would need to supply would be data confirming, (1) the existence of a common ancestor, (2) clear transitional branching patterns, and (3) a definite, ancient origin of the common ancestor relative to the Cambrian radiation, and long time spans for the transitional branchings to occur.

Many evolutionary biologists claim that phylogenetic studies have confirmed not only the existence of a common ancestor, but have shown that the first divergence from such a common ancestor happened long enough ago to allow neo-Darwinian gradualism plenty of time to produce the Cambrian phyla.[34] Many biologists and paleontologists also claim that there is also abundant evidence from phylogenetic studies which shows matching of ancestral origins between genetic and anatomical homology.[35] Nevertheless, some severe problems seem to plague the molecular phylogenetic approach. Due to space limitations, I will only address two of those major problems.

The first problem is that the use of molecular clocks yields widely varying estimates of when the first divergence from the purported common ancestor happened.

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[33]Meyer, *Darwin's Doubt*, 98-101, 114-17.

[34]Ibid., 104.

[35]Peter Atkins, *Galileo's Finger: The Ten Great Ideas of Science* (New York: Oxford University Press, 2003), 15-16; Donald Prothero, *Evolution*: *What the Fossils Say and Why it Matters* (New York: Columbia University Press, 2007), 140.

Different genes yield widely differing molecular clock calibrations. Therefore, depending upon the genes chosen for study, estimates of initial divergence (or "branching") vary by many hundreds of millions of years. Valentine, Jablonski and Erwin report, "Various attempts to date those branchings by using molecular clocks have disagreed widely."[36] At the end of a critique of one set of molecular estimate studies which they conclude are "without merit", Grauer and Martin advise that "whenever you see a time estimate in the evolutionary literature, demand uncertainty!"[37] In fact, uncertainty, in the form of dramatically wide timespan estimates for divergences, seems to be rampant. Depending upon which genes are chosen for calibrating the molecular clock, calculations of the time that has passed since divergence from the purported common ancestor are 1.2 billion years,[38] 800 million years,[39] between 274 million and 1.6 billion years,[40] between 452 million and 2 billion years,[41] or even any time within a

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[36]Meyer, *Darwin's Doubt*, 106; Valentine, Jablonski, and Erwin, "New Perspectives," 851.

[37]Meyer, *Darwin's Doubt*, 107; Dan Grauer and William Martin, "Reading the Entrails of Chickens: Molecular Timescales of Evolution and the Illusion of Precision," *Trends in Genetics* 20, no. 2 (2004): 85.

[38]*Meyer, Darwin's Doubt*, 103; Gregory A. Wray, Jeffrey S. Levinton, and Leo H. Shapiro, "Molecular Evidence for Deep Precambrian Divergences Among Metazoan Phyla," *Science*, New Series, 274, no. 5287 (Oct. 25, 1996), 570.

[39]*Meyer, Darwin's Doubt*, 104; Douglas H. Erwin et al., "The Cambrian Conundrum: Early Divergence and Later Ecological Success in the Early History of Animals," *Science* 334, no. 6059 (November 25, 2011): 1092.

[40]Meyer, *Darwin's Doubt*, 106; Gu Xun, "Early Metazoan Divergence Was About 830 Million Years Ago," *Journal of Molecular Evolution* 47, no. 3 (September 1998): 370.

[41]Meyer, *Darwin's Doubt*, 106; Stephane Aris-Brosou and Ziheng Yang, "Bayesian Models of Episodic Evolution Support a Late Precambrian Explosive Diversification of the Metazoa," *Molecular Biology and Evolution* 20, no. 12 (December 2003): 1949. When Aris-Brosou and Yang "relaxed" the molecular clock approach, and instead implemented a Bayesian approach, their divergence date fell very close to ones estimated from fossils alone, prompting them to conclude that evolutionary "bursts" do occur. They attribute such bursts to environmental causes which "remain unclear." Ibid., 1947, 1952.

14.2 billion-year range.[42] In another molecular study, Ayala, Rzhetsky and Ayala criticize an earlier molecular study, claiming its estimate of the divergence date is about 600 million years too early.[43] Given the gross imprecision of the estimates, Meyer concludes,

> If . . . comparative sequence analyses generate divergence times that are consistent with nearly all possible evolutionary histories, with the divergence event ranging from a few million to a few billion years ago, then clearly most of these possible histories must be wrong. They tell us little about the actual time of the Precambrian divergence, if such an event really happened.[44]

The second major problem with the attempt to use molecular phylogenetics to independently support the neo-Darwinian hypothesis regarding the Cambrian explosion is that in practice, the molecular phylogenetic approach begs the questions it is intended to answer. Apparently, phylogenetic analyses start by assuming not only that the common ancestor existed, but also that divergence from such an ancestor happened sufficiently long ago to allow neo-Darwinian processes to gradually form the diverse body new body plans apparent in the Cambrian fossils. Meyer warns that "This assumption (of universal common descent) raises the possibility that the ancestral entities represented by divergence points in these studies are artifacts of the assumptions by which molecular data are analyzed."[45] He adds that the molecular sequence-comparison software used in

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[42]Meyer, *Darwin's Doubt*, 107; Graur and Martin, "Entrails," 80. The authors of the original report calculated a much narrower divergence date range, but Graur and Martin assert that "calibration and derivation uncertainties [were not] taken into proper consideration." Ibid. Correcting for those flaws, Graur and Martin arrived at the absurd range of 14.2 billion years.

[43]Francisco José Ayala, Andrey Rzhetsky, and Francisco J. Ayala, "Origin of the Metazoan Phyla: Molecular Clocks Confirm Paleontological Estimates," *Proceedings of the National. Academy of Sciences* 95, no. 2 (January 20, 1998): 606-7.

[44]Meyer, *Darwin's Doubt*, 108.

[45]Ibid., 110.

phylogenetic analysis has "been written to produce trees showing common ancestors and branching relationships regardless of the extent to which the genes analyzed may or may not differ."[46] These procedures thus assume throughout "that the nodes and divergence points existed in the past."[47]

For example, Valentine describes some of the non-independent assumptions frequently used in reconstructing phylogenies:

> Many of the classical phylogenetic hypotheses are based on some overarching concept imposed as a principle from which relationships may be deduced; the assumption that evolution has always proceeded from the simple to the complex, for example, would greatly constrain the possible phylogenetic patterns. Many hypotheses combine such (often tacit) assumptions with attempts to trace in some logical way the evolution of particular, presumptively homologous features (including developmental features) or organs.[48]

Under the subheading titled "Only orthologous genes should be used to construct species phylogenetic trees," one bioinformatics textbook instructs the reader, "The key assumption made when constructing a phylogenetic tree from a set of sequences is that they are all derived from a single ancestral sequence, i.e., they are homologous."[49] Orthologous genes are defined as "genes that have evolved directly from an ancestral gene."[50] Therefore, the phylogeneticist is expected to regard as givens both that a common ancestor existed and that there is a lineage system linking the genes

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[46]Meyer, *Darwin's Doubt*, 110.

[47]Ibid.

[48]Valentine, *Phyla*, 115.

[49]Marketa Zvelebil and Jeremy O. Baum, *Understanding Bioinformatics* (New York: Garland Science, 2008), 239.

[50]Holmgren Lab, "Othologous Genes," Northwestern University, http:// groups.molbiosci.northwestern.edu/ holmgren Glossary/Definitions/Def-O/orthologous_genes.html (accessed August 19, 2013).

in question back to that ancestor.

Wray, Levinton and Shapiro sound a hopeful note about what molecular phylogenetics can tell us: "The hypothesis of deep Precambrian divergences makes specific testable predictions."[51] However, they then seem to reverse that assertion with the subjective caveat "new estimates of divergence times should not violate well-corroborated phylogenetic relationships."[52] As documented above, the fossil record does not corroborate Precambrian divergences or phylogenetic relationships. One wonders where Wray et al. expect to find such corroboration, when it is the phylogenetic studies themselves that are supposed to supply it.

In chapter 2 of *Evidence*, Sober strongly warns against using question-begging arguments to try to support an intelligent design hypothesis. One must not begin by simply assuming that a designer produced the observed biological phenomena:

> This is just what the design argument is trying to establish. . . . What is needed is information about goals and abilities that we can know is correct without already needing to have an opinion as to whether the intelligent design or the chance hypothesis is true.[53]

Likewise, it seems that molecular phylogenetic studies need to supply information about the existence of a common ancestor that one can know is correct (or at least have some confidence is correct) without such information being fundamentally dependent upon the assumption that a common ancestor existed. Unless phylogenetic studies can supply the same kind of independent support that Sober demands of intelligent design, it seems

[51]Wray, Levinton, and Shapiro, "Molecular Evidence," 572

[52]Ibid..

[53]Sober, *Evidence*, 144. Meyer echoes Sober's objection to question-begging, Meyer, *Darwin's Doubt*, 111.

those studies will not contribute to the likelihood of the neo-Darwinian hypothesis.

To summarize the discussion of the first two preconditions for neo-Darwinism, using Sober's standards, without independent support for the necessary preconditions of an adequate time span, or a common and transitional ancestors, the likelihood of the neo-Darwinian hypothesis, at least as an explanation for the Cambrian explosion, is just as unknown as Sober claims that the intelligent design hypothesis is: it could be assigned either a very favorable or very unfavorable likelihood. Without independent support, it even could conceivably have a likelihood of zero. Thus, Sober's criterion, applied with parity, not only eliminates intelligent design as a scientific hypothesis, but simultaneously eliminates neo-Darwinism as a scientific hypothesis (for the Cambrian explosion) as well.

The third necessary precondition linked to the neo-Darwinian hypothesis which needs to be independently supported is capability. Are there independent reasons to believe that neo-Darwinian mechanisms (genetic mutation and natural selection) are capable of producing the diverse, complex and specified forms evident in biological history, such as the fauna of the Cambrian explosion? Just as Sober asked if there was independent support that the purported designer of intelligent design theory had the necessary abilities to produce these complexities, so a crucial question is whether independent support exists that neo-Darwinian processes have the necessary capabilities to do the same. There appears to have been a long-standing, and recently-growing perspective in the biology community that they cannot.

Meyer addresses one critical reason for this growing skepticism toward neo-Darwinian capabilities related to the macroevolutionary appearance of body plans. He quotes fellow design-advocate Paul Nelson regarding the dilemma between the macro-level mutations needed in embryos and what embryos can tolerate.

> To evolve any body plan, mutations expressed early in development must occur, must be viable, and must be stably transmitted to offspring. . . .
>
> Such early acting mutations of global effect on animal development, however, are those *least likely* to be tolerated by the embryo and, in fact, never have been tolerated in any animals that developmental biologists have studied.[54]

In other words, to change a body plan, the embryo must undergo large-scale mutation early in its development. Yet embryos in the early stages of development are either destroyed by such large-scale mutation or will perish long before being able to reproduce. According to John and Miklos, the only sensible context for the starting point of macro evolutionary change is "in very early embryogenesis."[55] Yet, Wallace Arthur describes mutations in early development as "extremely disadvantageous,"[56] echoing what R.A. Fisher noted about them several decades ago: "these are, I believe, without exception, either definitely pathological (most often lethal) in their effects,"[57] a trend which Louis Agassiz noticed as early as 1874.[58]

Comments by two of Paul Nelson's mentors confirm the dilemma he mentions above, namely, "that the scientific literature offers no examples of viable mutations affecting early animal development and body-plan formation . . . and also that the

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[54]Paul Nelson, quoted in Meyer, *Darwin's Doubt*, 262; Meyer does not give a reference, but Nelson makes essentially the same points in an online lecture (23 minutes into the lecture). Paul Nelson, "Darwin or Design" Saddleback Church (November 25, 2012), You Tube, http://www.youtube.com/watch?v=0snNuOiZF_k (accessed 31 August 2013).

[55]Bernard John and George L. Gabor Miklos, *The Eukaryote Genome in Development and Evolution* (London: Allen and Unwin, 1988), 309.

[56]Wallace Arthur, *The Origin of Animal Body Plans: A Study in Evolutionary Developmental Biology* (Cambridge: Cambridge University Press, 1997), 14.

[57]Ronald A. Fisher, *The Genetical Theory of Natural Selection* (New York: Dover, 1958), 44.

[58]Agassiz, "Evolution," 99.

macroevolution of novel animal form requires just such early-acting mutations."[59] This paradox leads Nelson to the conclusion that a neo-Darwinian process fails as "an adequate mechanism for producing new animal body plans."[60] It turns out that mutations later in development which prove non-lethal to organisms, are not of the magnitude to bring about novel body plans, revealing what embryonic biologist John McDonald calls

> a great Darwinian paradox: Those loci that are obviously variable within natural populations do not seem to lie at the basis of many major adaptive changes, while those loci that seemingly do constitute the foundation of many, if not most, major adaptive changes apparently are not variable within natural populations.[61]

This paradox seems to be at least one reason behind a growing number of claims that in key respects, microevolution and macroevolution are functionally distinct processes. For example, while Gilbert, Opitz, and Raff call neo-Darwinism "a remarkable achievement," they raise a serious qualification: "However, starting in the 1970s, many biologists began questioning its adequacy in explaining evolution. . . . Microevolution looks at adaptations that concern only the survival of the fittest, not the arrival of the fittest."[62] Biology professor Brian Goodwin comments, "The large-scale differences of form between types of organisms that are the foundation of biological classification systems seem to require another principle than natural selection operating on small

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[59]Meyer, *Darwin's Doubt*, 263. For example, in Nüsslein-Volhard and Weischaus' famous study of fruit-fly embryo mutation, mutations to what they feel are the majority of body plan genes were lethal. Christine Nüsslein-Volhard and Eric Weischaus, "Mutations Affecting Segment Number and Polarity in Drosophila," *Nature* 287, no. 5785 (October 30, 1980): 795. See also Nelson, "Darwin and Design" online lecture, 24:27.

[60]Nelson, paraphrased in Meyer, *Darwin's Doubt*, 263.

[61]John F. McDonald, "The Molecular Basis of Adaptation: A Critical Review of Relevant Ideas and Observations," *Annual Review of Ecology and Systematics* 14 (1983): 93.

[62]S. F. Gilbert, J. M. Opitz, and R. A. Raff, "Resynthesizing Evolutionary and Developmental Biology," *Developmental Biology* 173, no. 2 (February 1, 1996): 361.

variations."[63] Biologist Rudolf Raff echoes a similar perspective: "Macroevolutionary events lie beyond the short-duration processes of development of an individual or microevolution in a small population."[64] Other similar comments could be added.[65]

If macroevolution is not the equivalent of extended microevolution, it raises the question of what purely materialistic mechanism can produce large-scale biological changes like novel body plans. Wallace Arthur admits the answer is elusive: "One can argue that there is no *direct* evidence for a Darwinian origin of a body plan — black *Biston betularia* [peppered moths] certainly do not constitute one! Thus in the end we have to admit that we do not really know how body plans originate."[66] Goodwin says, "despite the power of molecular genetics to reveal the hereditary essences of organisms, the large-scale aspects of evolution remain unexplained, including the origin of species."[67]

Returning to the larger issue of auxiliary propositions, it thus seems that at least in terms of large biological changes as exemplified by novel body plans that appear in the Cambrian explosion, the neo-Darwinian hypothesis lacks independent support for perhaps its most important necessary precondition: the capability to produce such

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[63]Brian C. Goodwin, *How the Leopard Changed Its Spots: The Evolution of Complexity* (New York: Scribner, 1994), viii-ix.

[64]Rudolf A. Raff, *The Shape of Life: Genes, Development, and the Evolution of Animal Form* (Chicago: University of Chicago Press, 1996), 30.

[65]E.g., Lewin, "A Lopsided Look," 291. Lewin quotes David Jablonski and David Bottjer: "Different patterns imply different processes." Ibid.; D. H. Erwin, "Macroevolution is More than Repeated Rounds of Microevolution," *Evolution and Development* 2, no. 2 (March-April 2000): 78.

[66]Wallace Arthur, *Theories of Life: Darwin, Mendel and Beyond* (New York: Penguin, 1987), 180.

[67]Goodwin, *Leopard*, ix.

changes. By Sober's own standards, the likelihood of the neo-Darwinian hypothesis regarding the major examples of specified complexity–the very phenomena on which intelligent design focuses its attention–is no more certain than Sober's assessment of the likelihood of an intelligent designer producing those phenomena. Applying Sober's standards strictly and fairly, both hypotheses should be eliminated as science. The other option is to loosen Sober's standards and not demand independent support for necessary preconditions unobserved due to their operation in the distant past. This option, however, would allow both neo-Darwinism and intelligent design to be regarded as legitimate scientific hypotheses, and would enable them to be compared as rival explanations on impartial grounds.

Evaluating neo-Darwinism on the basis of *all three* of the chosen necessary preconditions (an adequate time span, a common ancestor along with transitional lineages, and the capability of producing novel body plans), and unless some form of analogical argumentation is allowed (which Sober strongly recommends against), independent support is lacking on all three counts. By Sober's standards, neo-Darwinism fares no better than intelligent design in generating an assessable likelihood for the kinds of macro-level biological changes which are of key interest in the debate between the two explanations. Unless some other means to gaining independent support can be found, Sober's "necessary preconditions" standard apparently eliminates *both* the intelligent design *and* the neo-Darwinian hypotheses as they pertain to the specified, complex Cambrian body plans. Using a method Sober employed in *Evidence* to eliminate intelligent design,[68] one can choose either favorable or unfavorable auxiliary propositions

[68]Sober, *Evidence*, 142-44.

for the neo-Darwinian explanation of the Cambrian phyla, just as Sober asserts one can do with respect to intelligent design, without any independent way (among those discussed above) of choosing between them, and thus there remains a possibility of a likelihood of zero.

Elsewhere in his writings, Sober has discussed an issue which may be relevant to this lack of independent support, at least support sought from the fossil record. In a 2009 article, Sober asks, "If finding intermediate fossils is evidence for common ancestry, isn't failing to find them evidence against?"[69] In simple terms, isn't absence of evidence tantamount to evidence of absence? Sober, approaching this question in likelihood terms concludes that "The other reason the motto ['absence of evidence isn't evidence of absence'] persists is that when it is false, it is often close to being true—it involves an exaggeration that is slight."[70] This section has highlighted three 'absences': the absence of fossil evidence for a common ancestor and intermediates to the Cambrian phyla; the absence of sufficient time; and the absence of evidence that neo-Darwinian processes have the capability to produce new body plans. By Sober's reasoning, however, absence of those three lines of evidence might provide only weak evidence of absence of those three necessary preconditions.

There are several shortcomings in Sober's evaluation concerning lack of evidence. First, Sober does not adequately take into account that for over one hundred and fifty years, paleontologists have tirelessly and urgently sought fossil evidence for

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[69]Elliott Sober, "Absence of Evidence and Evidence of Absence: Evidential Transitivity in Connection with Fossils, Fishing, Fine-Tuning, and Firing Squads," *Philosophical Studies* 143, no. 1 (March 2009): 69.

[70]Ibid., 89.

transitional fossils and yet, in the case of the Pre-Cambrian fossil evidence for a common "urbilaterian" (original bi-lateral) ancestor as well as the lineages linking that ancestor to the Cambrian phyla, they have failed miserably. In a century and a half, those paleontologists have indeed found plenty of fossils, yet scarcely any would even remotely be interpreted as intermediates. Second, this long-term failure despite great effort seems amplified by the fact that the majority of those paleontologists fully assume the truth of the gradualistic Darwinian paradigm. This assumption could easily induce a bias toward interpreting the fossils they do find as true intermediates, when such might not actually be the case. Finally, another personal factor could also add bias, namely that finding key intermediates could bring paleontologists professional prestige, increased publishing material ad career advancement.

Given these factors, and Sober's evaluation notwithstanding, the fact that there is still a glaring absence of fossil evidence in the case of Cambrian ancestors seems to indicate both that personal and professional integrity in paleontology is still substantially intact, and more importantly, that the absence of fossil ancestors and intermediates really does offer much more than "weak" or "slight" evidence of their genuine absence. More pertinent to his rejection of intelligent design on likelihood grounds, Sober dismissed intelligent design as a scientific hypothesis because it purportedly fails to provide independent support for what the designer's motives and abilities might be. Sober formulated this demand on the basis of Duhem's claim that independently supported auxiliary propositions are what help undergird scientific hypotheses.[71] If absence of

[71]Pierre Duhem, *The Aim and Structure of Physical Theory* (Princeton, NJ: Princeton University Press, 1954), 183-88.

evidence is only weak evidence of absence, then perhaps Sober's claim that independent evidence for the designer's (i.e., God's) goals and abilities is absent should be counted as at most a weak basis for denying that intelligent design has an assessable likelihood.

On the other hand, absence of the three kinds of evidence for the necessary preconditions of neo-Darwinism (as described above) sounds suspiciously like a lack of independent support. So while according to Sober's estimation in his 2009 article absence of evidence might not be significant evidence of absence, Sober–and any proponent of the neo-Darwinian hypothesis–needs non-circular evidence for an auxiliary proposition of urbilateria and the intermediates that ensures that Pr(Disparate Cambrian Phyla/neo-Darwinism)>tiny ("the probability of observing disparate Cambrian phyla, given the hypothesis of neo-Darwinism, is greater than tiny"), just as Sober demanded of Paley such non-circular evidence relevant to his design hypothesis.[72] In other words, absence of evidence is absence of evidence, which is equivalent to an absence of independent support for the auxiliary proposition of urbilateria and intermediates, which are required to give neo-Darwinism some likelihood. By the specific likelihood and Duhemian standards Sober sets forth in *Evidence*[73] (especially regarding his choice of required auxiliary propositions) such absence of such crucial fossil evidence still ought to count strongly against assessing any likelihood for neo-Darwinism and thus, as in the case with intelligent design, ought to be at least part of the grounds for dismissing it as a scientific hypothesis.

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[72]Sober, *Evidence*, 142.

[73]In his "Absence" article of 2009, while addressing and commending the likelihood approach at many points, Sober makes no mention of Duhem or the importance of independent support for auxiliary propositions.

In pointing out the ways Sober's standard eliminates both hypotheses, the goal is not to demonstrate that neo-Darwinism in the end is not a scientific hypothesis. As mentioned above, perhaps one can find some other means to gaining independent support. Perhaps Sober's standards are too high. It seems that Sober's choice of auxiliary propositions is where his argument against intelligent design as science breaks down. Perhaps to qualify as a scientific hypothesis, one in fact does not need to provide independent support for auxiliary propositions about necessary preconditions (such as the existence of bilateria and the intermediates), but one only needs to use the observed evidence in hand to form other auxiliary propositions (including using analogy and induction), in order to produce an assessable likelihood by which to compare competing hypotheses (i.e., infer the best explanation). Following this course of action, however, intelligent design reemerges as a viable rival scientific hypothesis.

Neo-Darwinism is not Necessarily Always More Likely than Chance

Recall from chapter 2 that Sober invoked his rejection of probabilistic *modus tollens* to support the claim that even purely random processes have a non-zero (albeit extremely small) likelihood of causing the changes scientists observe in biology. Sober then asserted that because in the neo-Darwinian process, law-like mechanisms (natural selection) operate in conjunction with purely random events (mutations), therefore neo-Darwinism's likelihood must necessarily be higher than that of purely random processes alone. Is Sober right? Is the combination of random and law-like processes of neo-Darwinism *guaranteed* to be more likely than a purely random process?

A factor which can instill some doubt about Sober's conclusion is that natural laws not only tell us what must happen under certain conditions, but also what *cannot* happen. From a purely theoretical point of view, random chance could conceivably accomplish anything, given enough time. However, when laws come into play, there will inevitably be certain things which cannot happen no matter how much time is available. This will even be true even in the illustrative cases of "random events" frequently appealed to in probability literature: flipping coins (say, if the coin is a two-headed coin: you are prohibited by the law of the nature of the coin to never see a tails), throwing dice (if you put five dots on two faces and don't put six on any of the sides), or drawing balls from urns (if you weld the one black ball to the side of the urn, making it impossible for anyone to draw it out).

Turning to natural selection, it is certainly possible to conceive of different levels of favorability in variants: for example short-term favorability and long-term favorability. It could be that the kinds of variants which would ultimately, gradually lead to a favorable adaptation such as a new body plan, are prohibited from gaining a hold due to other "laws" of biology: that body-plan level mutations can only happen early in development, and are always lethal.[74] As pointed out above, Sober implies that in a purely random system, any outcome never has a likelihood of zero. When laws come into the evolutionary mix, however, it seems that this assurance of non-zero likelihood could now be precluded by the presence of such biased laws. In fact, it is very possible that certain phenomena are truly impossible, not merely highly improbable.

In a mixed system such as Sober presents neo-Darwinism to be (a mix of a random and a biased components) it now seems that one cannot ensure that certain

[74]As mentioned above, see McDonald, "Molecular Basis," 93; Meyer, *Darwin's Doubt*, 262.

outcomes do not have a likelihood of zero[75] Thus, I claim that Sober has failed to demonstrate that neo-Darwinism, as a mixed system of both random and biases elements, *always* yields a likelihood higher than a system of pure chance (e.g., Epicureanism). I also claim that he has failed to ensure (at least in chapter 2 of *Evidence*) that the likelihood of neo-Darwinism producing complex, specified structures such as the Cambrian phyla display is not zero.

Sober Crucially Mischaracterizes the Designer of Intelligent Design Theory

Sober's claim that intelligent design cannot provide independent support for any certain auxiliary proposition about designer goals and abilities, rests crucially upon assumptions about the identity and qualities of the purported designer. As chapter 2 pointed out, Sober seems effectively to identify that designer with the God of theism. Moreover, given that identification, a crucial quality which Sober assigns to that designer is his inscrutability. With these two philosophical-theological assumptions in place, it seems much easier for Sober to come to the conclusion that the goals and abilities of that designer which are relevant to any biological design he may have undertaken or considered are incapable of estimation (by Gould, Paley, an intelligent design theorist, or anyone).

The following syllogism summarizes the flow of logic of Sober's argument:

1. The default designer in the biological design argument is effectively identified as God.

2. God is inscrutable, especially in terms of his goals.

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[75]Sober, *Evidence*, 142.

3. Therefore the default designer in the biological design argument is inscrutable; his goals and abilities relevant to any biological design he may have undertaken or considered are incapable of estimation.

Given his conclusion in step 3, Sober takes four additional logical steps in order to disqualify intelligent design as science:

4. Assessable likelihood for intelligent design is impossible since it lacks independent support of designer goals and abilities.

5. Without assessable likelihood, intelligent design is not testable.

6. Scientific hypotheses must be testable.

7. Since it is not testable, therefore intelligent design is not scientific.

There are two major flaws in the first premise of effectively equating the biological designer with God. First, whether advertently or inadvertently, Sober is misrepresenting the views of intelligent design. Representatives of the intelligent design movement have repeatedly insisted that their theory does not suppose, nor assume that the designer is God. Moreover, they also insist that the kind of design inference they are promoting does not necessarily lead to the specific God of Christian theism. Dembski comments, "intelligent design resists speculating about the nature, moral character or purposes of this intelligence (here is a task for the theologian–to connect the intelligence inferred by the design theorist with the God of Scripture)."[76] Stephen Meyer likewise voices the limitations of intelligent design inferences: "Intelligent design does not answer questions about the nature of God or even make claims about God's existence. . . . It simply argues that an intelligent cause of some kind played a role in the origin of life."[77]

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[76]William Dembski, "Introduction: Mere Creation," in *Mere Creation: Science, Faith and Intelligent Design*, ed. William A. Dembski (Downers Grove, IL: InterVarsity Press, 1998), 18.

[77]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins, 2009), 442.

Michael Behe claims that "The inference to design can be held with all the firmness that is possible in this world, without knowing anything about the designer."[78] This implies that the inferred designer need not be God. By effectively identifying the purported designer as God, and thereby erroneously associating such identification with the views of intelligent design theory Sober begins to erect a straw man.

The second problem is that Sober needs this first premise (illegitimate from an intelligent design point of view) in order to move on to the second premise. A choice of a designer who is not God makes asserting that such a designer's goals are inscrutable much more difficult. Sober seems to be of the point of view that the God of theism is categorically different from human designers, and as such is fundamentally unknowable. This perception has been widely promulgated in theological literature for millennia, so it is no surprise that Sober declares it as an essential characteristic of God, almost as a matter of course. From there, the step from God's total "otherness" to God's inscrutability is a very short one. Again referencing Descartes, Sober reasons, "Apparently, invoking *human* purposes to explain a set of observations is one thing, invoking *God's* purposes is another. The failure to heed this distinction is the mistake that undermines Paley's argument."[79] By association, intelligent design's argument has presumably made the same mistake and is likewise undermined. However, Sober's own mistake is that intelligent design theory never insists that the designer be God, and therefore never insists that the designer be inscrutable. The second premise of

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[78]Michael Behe, *Darwin's Black Box: The Biochemical Challenge to Evolution* (New York: Simon and Schuster, 1996), 197.

[79]Sober, *Evidence*, 147. Of course, in the case which Sober is presenting, if Paley made this mistake, then intelligent design has also made this mistake and is likewise undermined.

inscrutability cannot be made without Sober illegitimately assuming in the first premise that intelligent design's designer must be the God to whom Descartes and Paley are apparently referring: the God of theism. The straw man has grown.

What about aliens or "an otherwise unspecified designer"? Given the fact that the Search for Extraterrestrial Intelligence program (SETI), a well-known group of presumably recognized scientists, claims that detecting certain specified and complex patterns from outer space will serve as scientific evidence for the existence of intelligent alien life, it is curious as to why Sober never mentions SETI and whether the goals of hypothesized aliens are or are not inscrutable. Despite his repeated assurances to the contrary, Sober supplies no evidence to show that analyzing the design argument with a non-divine designer makes no difference to his argument's persuasiveness. The reason Sober's propensity to identify the designer as God is flawed is that it is a critical oversight which I claim makes a great difference to the logic of Sober's entire case against intelligent design as science.

Regarding the second premise, one main flaw is that the claim that God, which Sober assumes is the designer of the design hypothesis, is unknowable and utterly inscrutable is a shallow and selective mischaracterization of all that the Bible and Christian theology (or broader theistic theology) has to say about human knowledge of God.[80] Since Sober has chosen to delve into theology in order to make his case, I feel it is legitimate on this particular point to respond in kind.

One can find statements in the Bible emphasizing that God or His will are in

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[80]Sober is probably not assuming the "God" of Hinduism, Buddhism, or even Islam. Paley's argument, on which Sober focuses much of his critique in chapter 2 of *Evidence*, was concerned with the God of the Bible.

some sense unknowable. Isaiah 55:8-9 is a well-known example. In that passage, God declares: "as the heavens are higher than the earth, so are My ways higher than your ways, and My thoughts than your thoughts" (NAS). In Job 11, one of Job's friends asks rhetorically if one can discover and know the depths and limits of God (Job 11:7-8), and in Romans 11 Paul praises God, saying, "Oh, the depth of the riches both of the wisdom and knowledge of God! How unsearchable are His judgments and unfathomable His ways," and then asks, "For who has known the mind of the Lord . . .?" (Rom 11:33-34).

On the other hand, the Bible contains an abundance of passages indicating that at least some knowledge of God and His will is not only available, but sometimes unavoidable. For example, Jeremiah says, "Thus says the Lord, 'let him who boasts boast of this, that he understands and knows Me'" (Jer 9:23-24). The apostle John records Jesus saying, "This is eternal life, that they may know You, the only true God, and Jesus Christ whom You have sent" (John 17:3). Both the Old Testament and the New claim that it is possible to know God's existence and some degree of His nature through observing the natural order around us. The Psalms assure us that "The heavens are telling of the glory of God; and . . . declaring the work of His hands" (Ps 19:1). This psalm says that these indications are constant in duration ("day to day" and "night to night") and universal in scope ("through all the earth" and "to the end of the world") (Ps 19:2, 4). In a passage with central relevance to the design argument, the apostle Paul claims, "that which is known about God is evident within them [humans]; for God made it evident to them. For since the creation of the world His invisible attributes, His eternal power and divine nature, have been clearly seen, being understood through what has been made, so that they are without excuse" (Rom 1:19-20).

The Bible also more specifically indicates that it is possible to know at least something about God's goals. Paul writes, "we have not ceased to pray for you and to ask that you may be filled with the knowledge of His will in all spiritual wisdom and understanding" (Col 1:9). Moses assured the Israelites that God's commandment–which reveals certain aspects of His goals–"is not too difficult for you, nor is it out of reach. It is not in heaven, that you should say, 'Who will go up to heaven . . . and make us hear it, that we may observe it?' . . . But the word is very near you, in your mouth and in your heart, that you may observe it" (Deut 30:11-14). The Bibler also claims that people can know God most clearly through observing and knowing Jesus Christ. John the apostle says, "No one has seen God at any time;" but then adds that "the only begotten God who is in the bosom of the Father, He has explained Him" (John 1:18). Jesus Himself claimed, "He who has seen Me has seen the Father" (John 14:9). Countless Bible references describe God directing individuals and groups to do certain things and go certain places, or revealing truth to them, all of which reveal important aspects of God's goals.

Many Christian theologians through the centuries have commented that while God and His goals remain beyond complete or utterly transparent apprehension, humans can know some limited degree of His nature and will. For example, John Calvin echoes Paul's views in Romans above, saying, "Indeed, His essence is incomprehensible; hence his divineness far escapes all human perception. But upon his individual works he has engraved unmistakable marks of his glory, so clear and so prominent that even unlettered and stupid folk cannot plead the excuse of ignorance."[81]

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[81]John Calvin, *Institutes of the Christian Religion*, ed. John T. McNeill, trans. Ford Lewis Battles, Library of Christian Classics 20-21, ed. John Baillie, John T. McNeill, and Henry P. VanDusen (Philadelphia: Westminster Press, 1960), 1.5.1.

Of central importance to this paper, many theologians, from Origen to Norman Geisler, have concluded that such partial knowledge of God's nature and will comes through analogy,[82] a topic which the next chapter will expand further. Thus, there has been, and remains substantial disagreement with the position–which Descartes expressed and which Sober crucially relies upon in his case against intelligent design as science–that God's goals are utterly inscrutable.

Besides biblical and theological reasons, some have asserted for logical reasons that a premise like Sober's–that God's nature or goals are inscrutible–is self-refuting. Harold Netland critiques the claim, "No meaningful and informative statements about God can be made."[83] He asserts that "it does express a statement about God–namely that the nature of God being what it is no meaningful statements about him can be made."[84] Netland then evaluates the slightly broader claim, "No concepts at all can be applied to God."[85] This would then include properties such as God's nature, His actions, His likes and dislikes, and presumably His goals as well. But this claim is also self-refuting because, "If the thesis were true, we could never know that it is true."[86] The reasonable

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[82]See Origen, *On First Principles*, trans. G. W. Butterworth (London: Society for Promoting Christian Knowledge, 1936), 10; Jacob Arminius, *The Writings of James Arminius*, trans. James Nichols (Grand Rapids: Baker, 1956), 2:33; William G. T. Shedd, *Dogmatic Theology*, 2nd ed. (New York: Charles Scribner's Sons, 1889), 1:152; Norman Geisler, *Systematic Theology* (Bloomington, MN: Bethany House, 2003), 2:246.

[83]Harold A. Netland, *Dissonant Voices: Religious Pluralism and the Question of Truth* (Grand Rapids: Eerdmans, 1991), 138.

[84]Ibid., 138.

[85]Ibid.

[86]Ibid., 138-39. See also Geisler, *Systematic Theology*, 246; For another paraphrase of Netland's evaluation, see John S. Feinberg, *No One Like Him: The Doctrine of God*, Foundations of Evangelical Theology Series, ed. John S. Feinberg (Wheaton, IL: Crossway, 2001), 76.

conclusion is that while humans cannot know God exhaustively, this doesn't preclude them knowing Him (and presumably his goals) to some degree.[87] Paul seems to have encapsulated a notion very similar to this when he states, "now we see in a mirror dimly, but then face to face; now I know in part, but then I will know fully" (1 Cor 13:12; see also 1 Cor 13:9-10).

The implications for Sober's case against intelligent design as science are that his first premise is a clear mischaracterization, and that his second premise is a critically incomplete and ultimately self-defeating theological declaration. There is no good reason for accepting either his premise that the designer of intelligent design necessarily must be equated with the God of theism, or that the goals of that designer are utterly inscrutable. Without these key premises and with the prospect of supplying independent support for the design hypothesis via analogy, I claim that Sober's case against intelligent design as science retains little, if any persuasive strength.

Sober Wrongly Conflates a "Creationist" Position with Intelligent Design

Stephen Jay Gould put forth a rather famous objection against biological design arguments in his discussion of the panda's thumb. If one observes that digit closely, Gould claims that one will find it is not "[a]n engineer's best solution. . . . [but rather] a somewhat clumsy, but quite workable, solution."[88] Gould's broader conclusion, drawn from examples in nature like the panda's thumb is that "Odd arrangements and

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[87]Feinberg, *No One Like Him*, 76. Note: Netland points out that lack of exhaustive knowledge is our common and workable epistemological state, even with such a trivial as a writing desk. Netland, *Voices*, 141.

[88]Stephen Jay Gould, *The Panda's Thumb: More Reflections in Natural History* (New York : Norton, 1980), 24.

funny solutions are the proof of evolution–paths that a sensible God would never tread but that a natural process, constrained by history, follows perforce."[89] In short, Gould feels that the panda's thumb provides very good evidence of non-intelligent design.

Gould seems to have come up with a formidable challenge to intelligent design on observational, scientific grounds. One might think that someone (like Sober) seeking to critically evaluate whether intelligent design qualifies as a scientific hypothesis, would seize upon Gould's point and use it as a forceful piece of evidence against intelligent design. In chapter 2 of *Evidence*, however, Sober unexpectedly sides with 'creationists' in objecting that Gould's reasoning contains a fundamental flaw which, when exposed, seems to render a design hypothesis immune from Gould's form of criticism. These creationists, along with Sober, respond that inefficient mechanisms in biology raise no obstacle to design inferences since God could have designed them that way for what to us are inscrutable reasons.[90] Sober asserts,

> Gould adopts assumptions about the designer's goals and abilities that help him reach the conclusion he wants–that intelligent design is implausible and Darwinian evolution is plausible as an explanation of the panda's thumb. But it is no good simply inventing assumptions that help one defend one's pet theory. Rather, what is needed is independent evidence concerning what God (or some other intelligent designer) would have wanted to achieve if he had built the panda. And this is something Gould does not have.[91]

While Sober's response to Gould might at first glance seem to be good news for the design argument, there is a fundamental problem which Sober already anticipates. If God's goals are inscrutable (not independently supported), literally anything could be

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[89]Gould, *The Panda's Thumb*, 24. Gould's default designer is God. Again, intelligent design theory does not demand this assumption.

[90]Sober, *Evidence*, 127-28.

[91]Ibid., 128.

interpreted as being "designed," irrespective of what characteristics it has. Design as a hypothesis thus would explain both everything and nothing. In Sober's terms, it would prevent us from knowing what likelihood to assess, thus undermining Paley's claim that the eye displays more evidence for a designer than a stone does.[92] Sober, while seeming to defend design inferences in these types of objections to design inferences on empirical grounds, claims that his refutation of Gould will ultimately undermine intelligent design's likelihood as a theory.[93]

Could Sober's rejection of Gould's panda's thumb argument end up fatally undermining intelligent design as science? There are several problems which need to be pointed out. The first problem is that Sober does not say who the 'creationists' are to whom he refers. Second, Sober seems to illegitimately conflate the 'creationist' view with the views of entire intelligent design community regarding examples from biology where specified complexity (including "efficiency") is lacking or absent. For example, in direct contrast to the so-called 'creationist' view, William Dembski, referencing the panda's thumb, comments,

> The first question that needs to be answered about the panda's thumb, and indeed about any biological structure, is whether it displays clear marks of intelligence. The design theorist is not committed to every biological structure being designed. Naturalistic mechanisms like mutation and selection do operate in natural history to adapt organisms to their environments. Perhaps the panda's thumb is such an adaptation.[94]

Intelligent design theorist Stephen Meyer gives another response to apparent

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[92]Sober, *Evidence*, 147-48; William Paley, *Natural Theology: or Evidences of the Existence and Attributes of the Deity, Collected from the Appearances of Nature* (Boston: Gould and Lincoln, 1854), 5.

[93]Sober, *Evidence*, 128.

[94]Dembski, *Revolution*, 63.

sub-optimality or design inefficiencies observed in biology. He asserts that intelligent design "predicts that the study of supposedly . . . 'poorly designed' structures will reveal either (a) functional reasons for their design features or (b) evidence of . . . decay of an otherwise rational and beneficial original design."[95] Meyer then refers to research on the human retina indicating some potential functions behind what initially seemed to be sub-optimal design of the human eye.[96] Notice that contrary to the 'creationist' response, neither Dembski nor Meyer invokes God's inscrutability to preserve a design hypothesis from the challenge of sub-optimality. Rather, their responses either affirm the possibility that processes do explain phenomena better (are more likely explanations) in some cases, or that further scientific observation and research sometimes do reveal empirical features which might indicate more 'optimality' than scientists initially noticed.

Dembski elsewhere announces what he calls a "fundamental claim" of intelligent design: that "there exist well-defined methods that, on the basis of observational features of the world, are capable of reliably distinguishing intelligent causes from undirected natural causes."[97] Under the 'creationist' claim of God's inscrutability, intelligent design theory would lack a method of distinguishing design from non-design. Therefore, the 'creationist' perspective which Sober conflates with intelligent design theory differs diametrically from the stated position of two of intelligent design's leading theorists.

Sober claims that his point about God's inscrutability which neutralized

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[95]Meyer, *Signature,* 490.

[96]Ibid., 490-91.

[97]Dembski, "Introduction," 16-17.

Gould's objection "comes back to haunt the theory of intelligent design."[98] It cannot haunt that theory if this is an inaccurate generalization of intelligent design's position. Sober seems to be trying to undermine intelligent design on a point which at least two of its most prominent spokesmen do not hold. In fact, several pages after criticizing Gould for attributing to God goals and abilities which one cannot know without independent support, Sober uses this point as perhaps the most fundamental premise in what he calls "the Achilles Heel" of the likelihood argument for intelligent design.[99] However, using Dembski and Meyer's standards, rather than the purported 'creationist' standards, then Sober has not rightly characterized the intelligent design position on how to interpret sub-optimal "design." Therefore, pointing out that mischaracterization and clarifying the actual position voiced by Dembski and Meyer undermines Sober's most fundamental premise and critically weakens his overall case against intelligent design as science.

Gould claims that "odd arrangements and funny solutions" more strongly support (or in Soberian terms are made more likely by) evolution as a hypothesis than divine creation. This is counterbalanced by another claim he makes: "ideal design is a lousy argument for evolution, for it mimics the postulated actions of an omnipotent creator."[100] For Gould, it seems there is an objective, empirical standard with which to assess the likelihood, or unlikelihood, of a design hypothesis. By contrast, Sober's goal seems to be to make the case that there is no such empirical standard.[101] Intelligent

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[98]Sober, *Evidence*, 128.

[99]Ibid., 141.

[100]Gould, *The Panda's Thumb*, 20.

[101]Though they both seem to identify–I will argue illegitimately–the designer with God.

design theory, however, seems to have one important thing in common with Gould: they both assert that typical characteristics of design (if design exists in biology) ought to be detectable.

Intelligent design proponents (with whom Sober ought to be familiar), numbering far more than Williams Dembski and Stephen Meyer, focus their attention on determining if certain structures or phenomena in nature display the kinds of features which are typical and observable indicators of design. Using those indicators as observational standards, Gould’s objection has force against a design inference in the case of the panda’s thumb. Yet, by the same token, Paley’s argument about seeing more evidence for design in an eye than in a stone has force as well. Moreover, since Paley’s day, by that same standard, an ever-growing plethora of claims of design inferences emerging from empirical observations in science–specifically, observations of biological structures–also also have force, adding weight to intelligent design’s claims to status as a scientific hypothesis.

Sober’s Strategies for Immunizing the Design Argument Actually Render it Irrelevant

The previous section pointed out that intelligent design theory is committed to the principle that typical characteristics of design, if design exists in biology, ought to be detectable. An implication of this principle is that intelligent design proponents must squarely face sub-optimality objections, like Gould’s panda’s thumb example, even though such objections may show that design in such cases is not the best explanation (or does not have the highest likelihood of producing the phenomenon in question). Yet facing such objections head-on effectively shows that intelligent design is a scientific hypothesis, subject to empirical confirmation or refutation. This issue of how intelligent design should respond to objections is centrally relevant to critiquing Elliot Sober's argument against intelligent design as science.

Sober seemed to offer a defense of design inferences when he rebutted Gould's objection about inefficiencies in the panda's thumb. Later in chapter 2 of *Evidence*, Sober makes a similar move, appearing to immunize Paley's famous watchmaker argument against David Hume's previous, and equally famous objections to design arguments in general.[102] Sober accomplishes this immunization by reformulating–in fact greatly narrowing–the reasoning method Paley is purported to have used in his argument. Sober says that by viewing Paley's argument exclusively as a likelihood argument (a special kind of inference to the best explanation), and not as an argument by analogy or induction, the force of Hume's objections can be neutralized. By using this method to try to defend Paley, Sober is implying that other variations of design argumentation (such as intelligent design) can likewise emerge unscathed by Hume's critiques. It seems that according to Sober, the key to successful immunization from Hume's attacks is to make sure that a design argument does not make use either of analogical or inductive reasoning. If those two methods are avoided, Sober says, the design argument is safe. Regarding discarding analogy for likelihood, Sober says,

> Even if Hume is right about the analogy argument, his objection does not touch the likelihood formulation of the argument from design. With respect to watches, the only relevant question is whether their observed features are made more probable by the hypothesis of chance or by the hypothesis of intelligent design: with respect to the eye, the same comparative question is the only one that matters. Paley's analogy

[102]From analogy: David Hume, *Dialogues Concerning Natural Religion*, ed.Henry D. Aiken (New York: Hafner, 1948), 17-18, 20-21. From induction: Hume, *Dialogues*, 23; David Hume, *An Enquiry Concerning Human Understanding*, ed. Tom L. Beauchamp (Oxford: Clarendon Press, 2000), 84.

> between watches and organisms is merely heuristic. The likelihood argument about organisms stands on its own.[103]

Sober next claims that using a likelihood approach instead of an argument from induction likewise immunizes the design argument:

> Apparently, the design argument is an inductive argument that could not be weaker: its sample size is zero. This objection also dissolves once we move from the model of inductive sampling to that of likelihood. Observing numerous worlds and seeing how they were brought into being is not essential if the point is just that the two hypotheses about the world we inhabit confer different probabilities on what we observe. . . . for now, it should be clear that the likelihood argument takes the sting out of the fact that none of us has seen an intelligent designer create an organism from nonliving materials.[104]

Is it a good strategy for intelligent design proponents to follow Sober in his method of avoiding appeals to analogy and induction? Is it advisable instead to base the design hypothes, as Sober recommends, purely on likelihood? Indeed, Sober's method appears to shield intelligent design from what have been judged by some to be "devastating" Humean criticisms.[105] The problem is that this method eventually comes back to leave the intelligent design hypothesis devoid of any empirical support.

If a "likelihood assessment" is a narrow version of an inference to the best explanation, the logical question is "what makes one explanation better than another?" If one strips a design argument of all appeals to analogical or inductive substantiation, how can one undergird the inference that design is even a "good" explanation for biological structures, much less a "better" explanation than any other? Divorcing an inference to the best explanation from any way to substantiate why an explanation would be better is

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[103]Sober, *Evidence*, 140.

[104]Ibid.

[105]For example, James R. Peters, *The Logic of the Heart: Augustine, Pascal and the Rationality of Faith* (Grand Rapids: Baker Academic, 2009), 52.

equivalent to (using Sober's terminology) divorcing a hypothesis from any independently supported auxiliary propositions. In either terminology, it is an exercise in futility. This is why Sober comes to the conclusion that an intelligent design argument has no assessable likelihood and thus is not scientific. Sober's strategy that at first appears helpful to Paley's design argument (and by extension to intelligent design hypotheses) ends up eliminating scientific consideration of biological design altogether. As with the case of his rebuttal of Gould, attempts to protect intelligent design inferences from sharp criticism end up doing far more harm to the case for intelligent design than good.

It should be clear therefore, in both the case of Sober proposing how to refute Gould's objection and in the case of Sober proposing how to evade Hume's objections, that intelligent design advocates should be very cautious about taking Sober's advice for how to protect the a design argument from criticism. Sober's method in the case of Gould's criticism ends up backfiring on the case for intelligent design. His method in the case of Hume's objections also ends up causing the same destructive result.

The lesson for intelligent design advocates (and creationists for that matter) is to not succumb to the allure of Sober's responses to the objections of Hume and Gould. Those responses are not helpful to a design argument. The key to a strong design argument is not to try to make it immune from criticisms, or to seek to avoid objections. On the contrary, as in the case of Gould's objections, the best strategy for intelligent design theory is to face Hume's objections head on and attempt to refute them.

Summary

This chapter has shown that Sober's case against intelligent design contains several serious flaws. Sober is unfairly lenient on neo-Darwinism and overly sanguine about its capabilities. He misrepresents intelligent design by gratuitously assuming that the designer is God and that He is inscrutable. Additionally, he wrongly conflates intelligent design with "creationism" by erroneously inferring that they both claim that detectibility is unimportant. Finally, Sober unwisely advises intelligent design theorists to avoid Hume's purportedly devastating objections to analogical or inductive design arguments.

Regarding this last point, and directly contrary to Sober's advice, induction and analogy should not be arbitrarily divorced from an inference to the best explanation, nor from a likelihood assessment as they relate to design arguments. This paper claims that induction and analogy work together to supply just the independent support which an inference to the best explanation or a likelihood assessment need. A design hypothesis shows itself to make observations of specified complexity in biology more likely when it is supported with induction which is derived from analogy to cases of design which are abundant in human experience. As the next two chapters explain, analogy is in fact the key to founding strong design inferences, and more broadly, to founding the multitude of the inferences scientists rely upon every day in a wide variety of fields. Upon closer examination, it also becomes clear that Sober himself relies (perhaps implicitly, unconsciously, and inconsistently) upon analogy and the inductive evidence it supplies in order to try to build his case that neo-Darwinism has an assessable likelihood as a scientific hypothesis while intelligent design does not.

CHAPTER 5

PROBLEMS IN HUME'S AND SOBER'S TREATMENT OF ANALOGY IN THE DESIGN ARGUMENT

It is important at the beginning of this chapter to briefly explore some fundamentals of analogy theory. The first reason is that this dissertation recommends the employment of analogy in design arguments as a response to Sober's criticisms of the intelligent design hypothesis as science. The second reason is that both implicitly and explicitly, analogy frequently is critically relevant to, or even underlies some of Sober's arguments in chapter 2 of *Evidence*. Since this dissertation critically responds to those arguments, it must therefore deal with the issue of analogy as well.

David Hume tried to cast severe doubts on the use of analogy in design arguments, as this chapter addresses below. Since Hume's day, others have repeated his criticisms,[1] and have often particularly focused criticism on Paley's famous watchmaker argument.[2] In *Evidence*, Sober himself tacitly accepts the force of Hume's criticism of

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[1]For example, Helen De Cruz and Johan De Smedt, "Paley's iPod: The Cognitive Basis of the Design Argument within Natural Theology," *Zygon* 45, no. 3 (September 2010): 667-68, 676; Antony Flew, *David Hume: Philosopher of Moral Science* (Oxford: Basil Blackwell, 1986), 62-67; Robert H. Hurlbutt III, *Hume, Newton and The Design Argument*, rev. ed. (Lincoln: University of Nebraska Press, 1985), 151-54; Stanley Tweyman, ed., *David Hume's Dialogues Concerning Natural Religion in Focus*, Routledge Philosophers in Focus Series (London: Routledge, 1991), 3-11, 23-60; Peter McLaughlin, "Reverend Paley's Naturalist Revival," *Studies in History and Philosophy of Biological & Biomedical Sciences* 39, no. 1 (March 2008): 29.

[2]For example, Sander Gliboff, "Paley's Design Argument as an Inference to the Best Explanation, or, Dawkins' Dilemma," *Studies in the History of Philosophy of Biology & Biomedical Sciences* 31, no. 4 (December 2000): 590-91; McLaughlin, "Reverend Paley," 27, 36-37.

design analogies, perhaps giving the impression that analogy plays no significant role in his method of analyzing purported scientific hypotheses. Nevertheless, as this chapter will explain, analogy itself has been widely used and proven useful both in science broadly as well as within hypotheses concerning the origins of biological novelty. While Darwin admitted that "analogy may be a deceitful guide,"[3] he nevertheless used analogy as a fundamental tool in both developing and supporting his theory of natural selection.

This raises the question, what standards cultivate the proper use of analogy in scientific hypotheses, to help foster scientific advancement and steer scientific investigation closer to the truth? What are some guidelines to encourage the use of plausible and strong analogies and to avoid frivolous and weak ones?

Basics of Analogy

The Crucial Importance of Higher-Order Relations

In their 2001 article "Metaphor is Like Analogy," Gentner, Bowdle, Wolff, and Boronat summarize the essence of analogical mapping. They say that the two analogues in question (what Gentner et al. call the 'base domain' and the 'target domain') both are assumed to have manifestations of structure at three levels of increasing abstraction and complexity: "objects and their properties, relations between objects, and higher-order relations between relations."[4] In order for a successful analogy to be formed, the two

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[3]Charles Darwin, *The Origin of Species by Means of Natural Selection or Preservation of Favored Races in the Struggle for Life*, 3rd ed. (London: John Murray, 1861), 518, http://darwin-online. org.uk/content/frameset?pageseq=437&itemID=F381 &viewtype=image (accessed September 13, 2013).

[4]Dedre Gentner et al., "Metaphor is Like Analogy," in *The Analogical Mind: Perspectives from Cognitive Science*, ed. Dedre Gentner, Keith J. Holyoak, and Boicho N. Kokinov (Cambridge, MA: MIT Press, 2001), 200.

structures must align in terms of "1) one-to-one correspondence between the mapped elements in the base and target, and 2) parallel connectivity, in which the arguments of corresponding predicates also correspond."[5]

Gentner et al. also add that one chooses a proper alignment through the guidance of "the systematicity principle: a system of relations connected by higher-order constraining relations such as causal relations is preferred over one with an equal number of independent matches."[6] Thus, in Gentner's view, higher-order relations which match across analogues are highly important to good analogies.[7] Holyoak and Thagard explain: "Gentner has emphasized the powerful role of higher-order relations in analogical mapping, as sets of propositions interrelated by higher-order relations can be used to help identify correspondences between two analogous structures."[8] Gentner and Markman emphasize that the sharing of abstract relationships between the two analogues is more important than other, more concrete (or mundane) similarities between them:

> A matching set of relations interconnected by higher order constraining relations makes a better analogical match than an equal number of matching relations that are unconnected to each other. . . . We are not much interested in analogies that capture a series of coincidences, even if there are a great many of them.[9]

The design analogy seems to meet this standard of mapped higher-order relations. A causal relation is required between intelligent design and specified and

[5]Gentner et al., "Metaphor," 200.

[6]Ibid., 200-1.

[7]Dedre Gentner, "Structure-Mapping: A Theoretical Framework for Analogy," *Cognitive Science* 7 (1983): 158, 163, 165.

[8]Keith J. Holyoak and Paul Thagard, *Mental Leaps: Analogy in Creative Thought* (Cambridge, MA: MIT Press, 1995), 29.

[9]Holyoak and Thagard, *Mental Leaps*, 47.

complex features in human artifacts. That same higher-order causal relation is then mapped onto the specified and complex features in biological organisms, suggesting intelligent design as the analogous cause.

As a result of the relative importance of higher-order relations, Gentner and Markman claim that qualitative differences in the individual superficial attributes of the objects being compared may be irrelevant to the strength of the analogy: "analogies must involve common relations but need not involve common object descriptions." They give an example of Kepler's analogy between the forces moving a planet and those steering a boat, commenting, "it does not detract from the analogy that the planet does not look like a boat."[10]

A large quantity of overlapping features also may not matter to the strength of the analogy: "A theory based on the mere relative numbers of shared and non-shared predicates cannot provide an adequate account of analogy, nor, therefore, a sufficient basis for a general account of relatedness."[11] C. Kenneth Waters has pointed out that too often, analogies have been inaccurately portrayed as "enumerative inductions" which are "based upon a random selection of common properties." Perhaps alluding to Hume, Waters laments that these kinds of portrayals

> ignore the very relations that make the arguments analogical. Hence, traditional accounts fail to capture the special pattern of reasoning underlying analogical inferences. No wonder these traditional accounts have prompted philosophers to conclude that analogical arguments are too weak to justify scientific hypotheses and to belittle the justificatory role played by them throughout the history of science.[12]

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[10]Holyoak and Thagard, *Mental Leaps*, 47.

[11]Gentner, "Structure Mapping: Theoretical," 156.

[12]C. Kenneth Waters, "Taking Analogical Inference Seriously: Darwin's Argument from Artificial Selection," in *Contributed Papers*, vol. 1 of *PSA: Proceedings of the Biennial Meeting of the*

Forming a good analogy thus involves the ability to weed out the irrelevant differences from the crucial similarities.[13] Therefore, quantitative and qualitative differences between artifacts and organisms in design analogies may be irrelevant in comparison to the more important, higher-order causal relation between design and specified complexity.

Isomorphism

Holyoak and Thagard state that an ideal analogy contains an *isomorphism*. An isomorphism happens when the two criteria specified above are met: one-to-one mapping and parallel connectivity (what Holyoak and Thagard call "structural consistency"[14]). They say that, "when [the two properties] are both satisfied, the mapping is an isomorphism."[15] A thermometer is thus analogous to air temperature, in that "the relations between different heights of the mercury in the tube are isomorphic to the relations between different air temperatures."[16] Furthermore, when higher-order relations are regular and predictable, and when they map isomorphically between analogues, they form what Weitzenfeld has termed an *isomorophic determining structure*.[17]

William Dembski has claimed that an isomorphism exists between the

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Philosophy of Science Association (Chicago: University of Chicago Press, 1986), 503; Weitzenfeld labeled as "partially defective" analogies based only on "number of properties in common or . . . degree of similarity." Julian S. Weitzenfeld, "Valid Reasoning by Analogy," *Philosophy of Science* 51, no. 1 (March 1984): 137.

[13]Holyoak and Thagard, *Mental Leaps*, 35.

[14]Ibid., 29.

[15]Ibid.; see also Weitzenfeld, "Valid Reasoning," 140.

[16]Holyoak and Thagard, *Mental Leaps*, 32.

[17]Weitzenfeld, "Valid Reasoning," 143.

specified, complex information in both human artifacts and biological organisms.[18] An emphatic comment by Hubert Yockey seems to confirm Dembski's claim. In comparing the organization of amino acid sequences to the properties of language, Yockey writes, "It is important to understand that we are not reasoning by analogy. The sequence hypothesis applies directly to the protein and the genetic text as well as to written language and therefore the treatment is mathematically identical."[19] Contrary to Yockey's claim, when considered materially, the two systems he compares (functional amino acid chains and human languages) may indeed be analogous, not strictly identical . However, the core feature of specified complex information maps identically between the two, justifying an isomorphic analogy for the causes of both, namely intelligent design.

A comment by Gentner may raise an objection at this point. She says,

> although the degree-of-overlap model appears to work well for literal similarity comparisons, it does not provide a good account of analogy. The strength of an analogical match does not seem to depend on the overall degree of featural overlap; not all features are equally relevant to the interpretation. Only certain kinds of mismatches count for or against analogies.[20]

One could well ask, "isn't the intelligent design hypothesis claiming a literal similarity–not merely an *analogical* one (by Gentner's terminology)–between human artifacts and biological organisms?" This reasonable question prompts several responses. To begin with, intelligent design is claiming a literal similarity–an isomorphism–of the most crucial component of both systems, namely specified complexity. Design

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[18]William A. Dembski, *Intelligent Design: The Bridge between Science and Theology*, paperback ed. (Downers Grove, IL: InterVarsity Academic Press, 1999), 160; William A. Dembski, *The Design Revolution* (Downers Grove, IL: InterVarsity Press, 2004), 230.

[19]Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," *Journal of Theoretical Biology* 91, no. 1 (July 7, 1981): 16.

[20]Gentner, "Structure Mapping: Theoretical," 156.

proponents are not, however, necessarily claiming literal similarity in the physical manifestations of the effects of that isomorphic cause. They would admit that tractors are quite different from eyes. In that sense, artifacts and organisms are at best only analogous in the details which don't matter to the hypothesis. In the most important aspect, specified complexity, artifacts and organisms are literally similar, even isomorphic. Weitzenfeld distinguishes between what he calls *homeomorphs* (analogues of the same kind) and *paramorphs* (analogues of different kinds). The analogies used in design arguments are probably paramorphs. In either case, however, Weitzenfeld claims, "As long as there is an isomorphism there can still be reasoning by analogy."[21]

Second, literally similarity is not necessary when comparing certain human artifacts–say, a tractor and a copy of *Hamlet*–in order to justify inferring the same, literal general cause of intelligent design for both. In other words, one may point out all the ways a tractor and *Hamlet* lack "literal similarity" if one wishes, but they both have the same, literal, general cause, intelligent design. Third, Gentner admits there is a continuum between analogies and literal similarities.[22] Moreover, as this chapter addresses below, when evaluating the design argument as an inductive argument, Sober calls for evidence of such a continuum between artifacts and organisms, and chapter 6 will show that as science and technology develop, they increasingly and inexorably reveal evidence for just such a continuum. In other words, unbiased biologists should be growing more and more aware of a much more literal similarity between artifacts and organisms (or their subcomponents).

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[21]Weitzenfeld, "Valid Reasoning," 143.

[22]Gentner, "Structure Mapping: Theoretical," 161.

All this being said, Holyoak and Thagard claim that analogies, even those containing apparent isomorphisms, are not guaranteed to perfectly reflect reality. They conclude only that given isomorphism, analogies drawn from the source "will have some plausibility for the target." Since plausibility falls significantly short of certainty, they claim the best one can do is use the analogy tentatively in order to "to generate inferences about the target, and then check whether these inferences actually hold up when the target domain is directly investigated."[23] Holyoak and Thagard also warn that as a result of such investigation, analogies may in the end turn out to be false, and need to be discarded.[24] In contrast, Weitzenfeld's estimation of the reliability of inferences from analogies containing isomorphic determining structures is much more optimistic. He claims that "conclusions will follow apodeictically from a genuine isomorphism."[25] It may be that in making this claim, Weitzenfeld is demanding perfect isomorphism, or may be restricting analogies to those in mathematics or related field. Nevertheless, if isomorphisms at higher levels can be determined, it may be that analogies used in design are much more than merely 'plausible.'

Analogy and Inference to the Best Explanation

Holyoak and Thagard assert that analogies can play a crucial role in explanations, contributing to the process of inference to the best explanation. First, they point out that "analogy can contribute to showing the explanatory power of a hypothesis

[23]Holyoak and Thagard, *Mental Leaps*, 30.

[24]Ibid., 131; See also Dedre Gentner and Arthur B. Markman, "Structure Mapping in Analogy and Similarity," *American Psychologist* 52, no. 1 (January 1997): 47.

[25]Weitzenfeld, "Valid Reasoning," 139.

if the hypothesis supports explanations analogous to those provided by accepted theories."[26] Second, as stated above, the most important feature of an analogical structure used in an explanation "will be higher-order relations, such as 'explain' and 'cause,' that are intended to carry over from the explanatory source to the target to be explained."[27]

At a general level, Holyoak and Thagard claim that "analogy is part of inference to coherent explanatory theories."[28] They then specifically evaluate the explanatory quality of design arguments undergirded by analogies from human artifacts to biological organisms. By their first standard above, it would seem that such design analogies would greatly enhance explanatory power because they indeed find their source in 'accepted theories' (the 'accepted theory' being the consistently observed fact that the common feature of specified complexity is universally caused by intelligent agency in the domain of human artifacts). By their second standard, it also seems that design analogies help explanations since they are indeed analogies concerned with higher-order relations of cause-and-effect. Holyoak and Thagard at first give high praise to the explanatory value of the kind of analogy presented by Paley, calling it "a sophisticated analogy based on a system mapping."[29] They continue

> The argument from design clearly uses a system mapping, as shown by the presence of the higher-order 'cause' relation in both the source analog (watch/watchmaker) and the target analog (world/God). So there is indeed an analogical explanation that makes the hypothesis of divine creation a legitimate candidate to be evaluated by inference to the best explanation.[30]

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[26]Holyoak and Thagard, *Mental Leaps*, 173.

[27]Ibid., 174.

[28]Ibid., 177.

[29]Ibid., 172.

[30]Ibid., 174.

The only problem with the explanation based on an artifact-to-organism analogy which Holyoak and Thagard raise is that there are other rival explanations available, including Darwinism. From an intelligent design point of view, the fact that the design hypothesis must compete with Darwinism, or neo-Darwinism is not a liability. However, Holyoak and Thagard regard the emergence of Darwinian theory as a decisive watershed in the explanatory competition, supplanting design as the best explanation. Holyoak and Thagard come to the same conclusion that Sober held in 1993, and from which he has fully retreated, namely, that design was the best explanation for biological innovation available prior to Darwin. Holyoak and Thagard reach that conclusion, however, for very different reasons than Sober originally did. Analogy, for them was of crucial supportive value, whereas for Sober, the design argument as presented by Paley should be viewed as a likelihood argument without recourse to analogy, since David Hume had already made the analogical approach untenable.

Hume Regarding Analogy and Induction: Overview and Critique

The subject of David Hume's critique of analogy is an important link between the discussion of analogy theory and Elliott Sober's evaluation of intelligent design as science. There are definite connections between Sober's thinking in chapter 2 of *Evidence* regarding the design argument and Hume's thinking in his *Dialogues Concerning Natural Religion*. The previous chapter's discussion discussed Sober's suggested method of framing the design argument as a likelihood argument in order to avoid the purported Humean pitfalls of analogy and induction. Chapter 4 objected, however, that following this method results not in a stronger design argument, but in an argument without any evidentiary support, even in principle, thus removing intelligent design from consideration as a scientific hypothesis. This would imply that a sensible design advocate would not follow Sober's advice, but would instead fall back on a formulation of the design hypothesis which in fact *is* grounded upon analogy and induction, thus bringing Hume and his criticisms back into play.

The first point to highlight about Hume's criticisms in *Dialogues* of the design argument is a literary one. *Dialogues* is a piece of polemic fiction. In reality, there was no "Cleanthes" or "Philo." They all are fictional characters invented by Hume. Thus, whether the character Cleanthes–i.e., Hume himself–really presented the most persuasive or logically compelling version of a design argument is open to question.

Hume's Criticism of Analogical Design Arguments

Regarding analogy between human artifacts and nature, Hume has his character Cleanthes say,

> The curious adapting of means to ends, throughout all nature, resembles exactly, though it much exceeds, the productions of human contrivance; of human designs, thought, wisdom, and intelligence. Since, therefore, the effects resemble each other, we are led to infer, by all the rules of analogy, that the causes also resemble; and that the Author of Nature is somewhat similar to the mind of man, though possessed of much larger faculties, proportioned to the grandeur of the work which he has executed. By this argument a posteriori, and by this argument alone, do we prove at once the existence of a Deity, and his similarity to human mind and intelligence.[31]

Hume's criticism, through Philo, of this analogical argument, is that "wherever you depart, in the least, from the similarity of the cases, you diminish proportionably the evidence; and may at last bring it to a very weak analogy, which is confessedly liable to

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[31]David Hume, *Dialogues Concerning Natural Religion*, ed. Henry D. Aiken (New York: Hafner, 1948), 17.

error and uncertainty."[32] One of Hume's main criticisms of the machine-world analogy is that as the two analogues become less and less similar, the analogy between them grows weaker, and thus the conclusions one could draw about the similarity of causes between them grows more doubtful.

Hume, through Philo, then asserts that in fact, the natural universe and humanly-built machines bear very little similarity in some crucial respects.

> surely you will not affirm, that the universe bears such a resemblance to a house that we can with the same certainty infer a similar cause, or that the analogy is here entire and perfect. The dissimilitude is so striking, that the utmost you can here pretend to is a guess, a conjecture, a presumption concerning a similar cause.[33]

Therefore, Hume's implied conclusion is that the analogical argument presented by Cleanthes (again Hume himself) is a weak one.

As a first response, one could claim that Hume's Philo is focusing on the wrong things when comparing houses to the universe. As explained above, Waters, as well as Gentner and Markman pointed out that it is a poor or shallow account of analogy which solely or even primarily focuses on the quantity of shared features or the superficial qualitative similarity of those features (these features, namely objects and their properties, Gentner has labeled "attributes").[34] While countless material or even qualitative dissimilarities between houses and the universe could be pointed out, Philo has not addressed the few most important (higher-order) features those two analogues have in common upon which the character Cleanthes based his design argument. He specifically mentions, "the curious adapting of means to ends," and the accurate mutual

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[32]Hume, *Dialogues*, 17-18.

[33]Ibid., 51.

[34]Gentner, "Structure Mapping," 157.

adjustment of parts,[35] a combination similar to what intelligent design theorists now call *specified complexity*. Specificity and complexity are two special features, enabling the analogues to overcome the effects of so many superficial differences between them. They are special because, according to accumulated human experience, intelligent design so far has shown itself to be an indispensible ingredient for producing specificity and complexity together to the high degree so apparent both in nature and in human artifacts.[36] Even Hume would admit that ox carts and symphonies have far more differences than similarities. Yet, in the one broad category of primary concern, namely, whether they share that curious adapting of means to ends and the accurate mutual adjustment of parts, they are perfectly analogous. Simply comparing the number of similarities and differences of the analogues does not allow one to necessarily and accurately evaluate the strength of an analogy, especially when intelligent design is the proposed cause.

Second, when Hume points out that as similarities lessen, analogies weaken, he neglects to mention that the converse is also true: as the two analogues become more and more similar, the analogy grows stronger. Third, Hume's choice of the two analogues might be selectively unfriendly to a close analogy. There are much closer analogies which could be chosen (and which could have been chosen in Hume's day) between artifacts and nature than machines and the entire universe. Fourth, over two hundred years of both technological developments and scientific discoveries have emerged since

[35]Hume, *Dialogues*, 17.

[36]William Dembski suggests this same general notion as a strengthened form of analogy to help overcome Hume's analogy criticism: Dembski, *Intelligent Design*, 302n84; See also Tweyman, *Hume in Focus*, 10-11.

Hume presented this argument. Many of those developments and discoveries since his day have prompted–and arguably are increasingly prompting–analogical inferences between human artifacts and natural structures and systems which are much more plausible than Hume's machine-universe example in *Dialogues*. For example, the similarities between the specified complex information in DNA and that within computer programs, or the similarities between cellular machinery and man-made micro-machinery probably suggest analogically parallel causation more powerfully than anything Hume could have imagined. Chapters 6 and 7 will present more detailed examples of this narrowing analogical gap.

Hume's Criticism of Inductive Design Arguments

Shifting to Hume's criticism of the design argument on inductive grounds, his character Philo asserts,

> When two species of objects have always been observed to be conjoined together, I can infer, by custom, the existence of one wherever I see the existence of the other: and this I call an argument from experience. But how this argument can have place, where the objects, as in the present case, are single, individual, without parallel, or specific resemblance, may be difficult to explain. And will any man tell me with a serious countenance, that an orderly universe must arise from some thought and art like the human, because we have experience of it? To ascertain this reasoning, it were requisite that we had experience of the origin of worlds; and it is not sufficient, surely, that we have seen ships and cities arise from human art and contrivance.[37]

Hume has a good point: no human ever witnessed (or "experienced") the universe in the act of being created by an intelligent designer. It would seem then, that for utterly unique, single-occurrence phenomena in the unobservable past, previous examples of identical phenomena from which to draw an inductive inference do not

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[37]Hume, *Dialogues*, 23.

exist.[38] Yet something seems wrong about this conclusion. Surely there are examples of scientists forming plausible hypotheses about unique, single-occurrence phenomena which nevertheless are unobservable (e.g., the Big Bang). Furthermore, as H.O. Mounce points out, strictly applying Hume's experiential standards would cripple science itself, eliminating the ability to generalize from single, unique events.[39]

Hume's own statements implicitly reveal the key to why scientists are able to hypothesize about singly-occurring, non-observable events. He asserts that the design argument fails because the universe is "without parallel, or specific resemblance." He then expresses incredulity that one would infer that the universe was caused by "some thought and art like the human," and concludes that it is insufficient to attribute to the universe a cause similar to that of humanly-built ships and cities. Analogy is embedded within all these statements (note the use of words such as "parallel," "resemblance," and "like"). He rejects an inductive argument for design ultimately because he feels that the universe has no analogue among humanly-built artifacts. If the universe did specifically resemble–i.e., was analogous to–humanly-built ships and cities, it seems that it would be easier to inductively infer a designer for the universe, since people have abundant experience (i.e., a huge, consistent, inductive sample size) of intelligent agents producing ships and cities.

The Big Bang theory was first proposed as a bona fide scientific explanation for the origin of the universe because the cosmos exhibited features which someone

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[38]Elliott Sober, *Evidence and Evolution: The Logic Behind the Science* (New York: Cambridge University Press, 2008), 140; Antony Flew called this argument Hume's "killing blow." Flew, *David Hume*, 64-65.

[39] H. O. Mounce, *Hume's Naturalism* (New York: Routledge, 1999), 110.

recognized as analogous to the effects of a huge explosion.[40] While no human was present to witness the beginning the universe, nonetheless people have abundant experience of the effects of explosions on the human scale. Using analogy, one need not be an on-site witness to make an inductive argument.

Analogy and induction, then, at least as they pertain to hypotheses about unrepeated, unobservable events in the distant past, are intricately woven together. In such cases, one cannot have induction without analogy and conversely, once one has a plausible analogy, one also has a non-zero inductive sample size. One may even use such an inductive argument as independent evidence to support a likelihood assessment. Further scientific observation may show that the original analogy is imperfect, and likelihood may thus decrease. But even in that case it decreases due to scientific evidence, meaning that the hypothesis must somehow be scientifically testable. Analogy and thus induction allow intelligent design to circumvent Sober's claim that it has no assessable likelihood: high, low or anywhere in between.

The close connection between induction and analogy, which is revealed in Hume's predominantly negative evaluation of design arguments, also implicitly manifests itself in Sober's evaluation of intelligent design as a scientific hypothesis. More

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[40]G. Lemaître, "The Beginning of the World from the Point of View of Quantum Theory," *Nature* 127, no. 3210 (May 9, 1931): 706; Hugh Ross, "Astronomical Evidences for a Personal, Transcendent God," in *The Creation Hypothesis: Scientific Evidence for an Intelligent Designer*, ed. J. P. Moreland (Downers Grove, IL: InterVarsity Press, 1994), 145. Some cosmologists are now claiming that the origin and behavior of the universe as a whole differs in some crucial aspects from our normal experience of an explosion: WMAP Science Team, "Foundations of Big Bang Cosmology," NASA's Wilkinson Microwave Anisotropy Probe, http://map.gsfc.nasa.gov/universe/ WMAP_Universe.pdf, or http://map.gsfc.nasa.gov/universe/bb_concepts.html (accessed December 4, 2013). Yet in at least two important ways the explosion analogy still fits (extremely hot origin and rapid subsequent expansion): WMAP Science Team, "Tests of Big Bang Cosmology," NASA's Wilkinson Microwave Anisotropy Probe, http://map.gsfc.nasa.gov/universe/bb_tests.html (accessed December 4, 2013). In any case, these facts miss the main point here: induction proceeds from analogy.

obviously, Sober's own negative verdict of intelligent design owes at least a significant amount of its support, both indirectly and directly to Hume's perspectives.

Sober Regarding Analogy and Induction: Overview and Critique

Sober's likelihood argument against intelligent design does not directly mimic Hume's criticisms of the design argument's appeal to analogy (and by extension, induction) contained in *Dialogues*. Sober's argument, as was detailed in previous chapters, presents his own, unique type of criticism of design arguments, whether made by Paley in centuries past or by intelligent design advocates of today. Nevertheless, Hume's criticisms are still lingering in the shadows of Sober's second chapter in *Evidence*. How does Sober use Hume's perspectives on analogy (and its relation to induction) in making his case against intelligent design as science? More broadly, what role does Sober give analogy, implicitly and explicitly, as he argues his case against intelligent design as science?

Sober's Tacit Agreement with Hume in Terms of Analogical Design Arguments

First, Sober agrees with Hume that the design argument is fundamentally flawed (i.e., not just inferior to some other explanation such as Darwinism or Epicureanism).

> The *Dialogues* present a number of serious criticisms of the design argument. . . . If any of these criticisms are correct, they show that there are flaws in Paley's argument that we can recognize without knowing anything about Darwin's theory. . . .
>
> . . . I stand with Hume. Although I think that some of Hume's criticisms of the design argument are off the mark, I do think there is a devastating objection to

Paley's argument that does not depend in any way on Darwin's theory.[41]

When Sober says that "some of Hume's criticisms are off the mark," he does not mean that they are logically flawed. Neither does he mean that he thinks they do not have power to devastate a certain version of design argument. Sober occasionally refers back to Hume's criticisms of both analogy and induction almost as warning signs to intelligent design advocates. If they do not reframe their argument as Sober suggests, they risk the specter of Hume's potentially devastating objections.

Second, later in the chapter, Sober reveals an implied, indirect affirmation of Hume's criticisms of design analogies. According to Sober, Hume thinks that "the design argument is an argument from analogy and . . . the conclusion of the argument is supported only very weakly by its premises."[42] Sober, loosely paraphrasing Hume,[43] then adds,

> Hume thinks this argument is undermined by the fact that watches and organisms have relative few characteristics in common: watches are made of metal and glass; organisms metabolize and reproduce, etc. Even if Hume is right about the analogy argument, his objection does not touch the likelihood formulation of the argument from design.[44]

Sober does not directly say that he agrees with Hume that the design argument would be undermined by pointing out the several ways organisms and watches differ. However, he *implies* that he agrees with Hume, because after having shown why Hume would object to it, rather than attempting to refute Hume in any way, he suggests

[41]Sober, *Evidence*, 126.

[42]Ibid., 139.

[43]When Hume wrote *Dialogues*, Paley's watchmaker argument still lay several years in the future. Hume never contrasts differences like metal and glass versus metabolization and reproduction.

[44]Sober, *Evidence*, 139-40.

reformulating design arguments like Paley's to an entirely different means of argumentation which rather than confronting Hume's objection, will avoid it altogether.[45] This avoidance strategy indirectly implies that he agrees with Hume that an argument for design via analogy is a 'very weak' argument.[46]

Problems with Sober's Agreement with Hume

Sober's characterization of analogy, especially analogy presented in design arguments, like Hume's, is overly simplistic. It seems to assert, just as Hume does, that the strength of analogy is measured solely or primarily on the quantitative or qualitative overlapping of attributes (objects and their properties). It seems to completely ignore the role of higher-order relations which analogy theorists have emphasized as crucial for stronger, more reliable analogies. Sober says,

> Think of similarity as the proportion of shared characteristics. Things that are 0 percent similar have no traits in common; things that are 100 percent similar have all their traits in common. The analogy argument says that the more similar watches and organisms are, the more probable it is that organisms were produced by intelligent design.[47]

This is how Sober characterizes Hume's perspective on design argument analogies. If Sober himself thinks that the analogies which ground design arguments are more sophisticated than this, he does not mention it. Sober seems to be perpetuating the same,

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[45]Sober made this same suggestion back in 1993, except using the term 'Inference to the Best Explanation" instead of "Likelihood Argument." See Elliott Sober, *Philosophy of Biology,* Dimensions of Philosophy Series (Boulder, CO: Westview Press, 1993), 34-36; De Cruz and De Smedt claim that Paley also used an avoidance strategy. See De Cruz and De Smedt, "Paley's iPod," 668. Gliboff likewise says that Paley's appeal to induction late in his book canceled the immunity to Hume's criticisms which Paley's previous case via inference to the best explanation had. See Gliboff, "Paley's Design Argument," 595.

[46]Sober, *Evidence*, 139.

[47]Ibid.

oversimplified version of analogy upon which Hume built his criticism of the design argument. As the example above regarding ox carts and symphonies illustrates, strong analogies are often drawn even when the majority of the features of the two analogues differ between them.

Since design arguments use higher-order analogies, the facts that watches are made of glass and metal and that organisms metabolize and reproduce are not central reasons for rejecting the analogical inference that organisms and watches share the same feature of being designed. The analogy in design arguments revolves around the notion of causation, which is a higher-order relation. In both analogues, the same kind of feature (design, or a designer) is proposed to cause the same kind of observed result (complex, specified information and structures). Clearly, this can be a more crucial factor in determining whether the inference of a corresponding cause is legitimate (i.e., that they indeed are both designed) than whether the two analogues share a numerical majority of attributes.

Therefore, since design arguments based on analogies do not fit the oversimplified model presented by Hume and Sober, it may turn out that those arguments are not 'very weak' after all, and design proponents may have little to fear from Hume's objections. Moreover, design proponents have no need to resort to Sober's likelihood version of design argument (which finally results in design being summarily dismissed as a scientific hypothesis) but can formulate an inductive argument based on analogy with other, known, designed systems or structures (as discussed in the next section). On the other hand, design proponents can also follow Sober's method, and use robust analogies to provide the independent support for auxiliary propositions which undergird a likelihood argument. Either way, higher-order analogy such as is typical of design arguments is a crucial tool for overcoming Sober's likelihood objection to intelligent design as science.

Sober's Links to Hume Regarding Inductive Design Arguments

In chapter 2 of *Evidence*, Sober also refers to Hume's objection to inductive design arguments (discussed above). As with Hume's objection to design arguments based on analogy, Sober tacitly agrees that the problems Hume raises about inductive design arguments have great force: Humans have no experience whatever witnessing a designer creating a world. "Apparently," Sober concludes, "the design argument is an inductive argument that could not be weaker; its sample size is zero."[48] Generalizing Hume's argument in terms of the intelligent design debate, Sober acknowledges that "the fact that none of us has seen an intelligent designer create an organism from nonliving materials" produces a problematic "sting" for proponents of a design argument.[49] As he did regarding Hume's objections to analogical design arguments, Sober again advocates avoiding Hume's inductive design objection altogether, by using a likelihood framework instead.

Sober returns to consider inductive design arguments later in his chapter. First, recall that chapter 3 of this paper discussed the possibility that a design hypothesis could be formulated with assessable likelihood without necessarily needing to provide independent support for designer goals and abilities. In chapter 2 of *Evidence*, after

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[48]Sober, *Evidence*, 140.

[49]Ibid.

making his case against intelligent design on likelihood grounds, Sober considers a similar possibility: perhaps a successful design argument can be formulated without needing to know designer goals and abilities "if we formulate the design argument as a *probabilit*y argument based on inductive sampling" (emphasis his).[50] Sober returns to Hume as he considers this possibility.

In *Dialogue*s, Hume's design argument proponent Cleanthes raises hypothetical examples (a voice coming from a cloud and books that reproduce themselves) from which a reasonable person would infer intelligent origination despite the examples being highly dissimilar to observed phenomena. Cleanthes then asks why the same line of reasoning could not be used to infer intelligent origination of actual biological phenomena.[51] Hume did not regard his voice-from-the clouds example to be an argument from analogy. Hume's Cleanthes apparently raised the example as a case where a design argument would be persuasive even while purportedly exemplifying at best a very distant analogy, thus apparently overcoming Philo's previous objection that only with close analogies could one infer similar causes (such as an intelligent designer). Interestingly, Hume's design opponent Philo never responds to Cleanthes' hypothetical examples, leaving the reader to wonder if, despite Hume's analogy objections, the right kind of design argument might not need close analogies.

In fact, however, Hume exaggerates how utterly distant his example of the voice from the clouds is from other observed phenomena. He claims, "this extraordinary voice, by its loudness, extent, and flexibility to all languages, bears so little analogy to

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[50]Sober, *Evidence*, 168.

[51]Hume, *Dialogues*, 26-28.

any human voice that we have no reason to suppose any analogy in their causes."[52] Yet loudness, extent, and flexibility are actually irrelevant when compared to the fact that such a voice, uniquely analogous to a normal human voice, communicates meaningful messages to humans.

Nevertheless, in *Evidence*, Sober claims that he agrees with Hume that analogy is of no help in these examples from Cleanthes.

> I don't see much hope for analyzing these arguments in terms of whether the analogies they use are strong or weak. . . . The voice from the clouds is similar to the terrestrial voices we routinely hear in some ways, and, of course, it differs from them in others. But if the argument is not an argument from analogy, what kind of argument is it?[53]

Critique of Sober's General Approach to Inductive Design Arguments

In response, a first point to emphasize is that, while mentioning both of Hume's examples, Sober then proceeds to analyze only one aspect of one of those examples, namely, the fact that the voice from the clouds is coming from a distance above the ground.[54] In fact, in order to emphasize the uniqueness of the phenomenon in that example, Hume also stated that this voice was heard simultaneously by people all over the globe and was understood by each of them in their own native language. In analyzing whether Hume has put forth a persuasive example that in some cases, analogical distance is unimportant to successful design arguments, Sober not only ignores some important aspects of the voice-from-the-clouds example, but also ignores the entire

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[52]Hume, *Dialogues*, 26-27.

[53]Sober, *Evidence*, 170.

[54]Ibid., 175.

reproducing-books example. He is being very selective and incomplete in his analysis.

As stated above, Sober claims this example is best framed as an inductive probability argument. He asserts it is not an argument from analogy and even claims he cannot see how he could analyze the strength or weakness of any analogies in these examples. I am challenging Sober's position on both of these last two points. This type of argument, as illustrated in Hume's voice-in-the-clouds example, only gains probability as an inductive argument precisely *because of* strong analogies which underlie it. Additionally, far from not knowing how to analyze the strength or weakness of the analogies contained in Hume's example (or in Sober's analysis of the correspondingly framed design argument), Sober fundamentally relies on analogies to make his cases both that the voice-in-the-clouds argument succeeds on probabilistic inductive grounds and that intelligent design does not succeed on those same grounds. Analogy permeates, and indeed is determinative in all these arguments, whether they are presented by Hume or analyzed by Sober.

Analogy's Role in Sober's Rejection of Inductive Design Arguments

To see how analogy plays such a central role in Sober's arguments in this section, those arguments deserve more detailed examination. First, Sober restructures Cleanthes's example (VOICES) into the form of a probabilistic inductive argument. He states as a generally observed rule (f_1) that there is a high frequency of examples where, given that one hears an English sentence and observes the cause of that sentence, that cause is in fact an intelligent designer. He next turns that frequency statement into a probability statement (q_1), namely that it is highly probable that when one hears an

English sentence and observes the cause of that sentence, that cause will turn out to be an intelligent designer. Next, Sober proposes a second probability (p_1), namely that it is also highly probable that when one hears an English sentence and *does not* observe the cause of that sentence (for instance, because it is coming from the clouds), that cause will also turn out to be an intelligent designer.

Is it legitimate to make the second probability claim from the well-established first probability? Sober says it is legitimate providing that one can support what he calls a "bridge principle," which claims $p_1 \approx q_1$.[55] In the case of the voice-from-the-clouds example, Sober claims that the bridge principle is justified "because, in other cases in which we do see where voices come from, we see that they almost always come from intelligent beings."[56] Sober goes into more detail, claiming that even in Hume's day, because of known cases of humans speaking from hot air balloons and high towers, "there was ample evidence that elevation above the surface of the Earth does not matter– regardless of elevation, sounds that constitute sentences always, or almost always, issue from the mouths of human beings. The bridge principle . . . $p_1 \approx q_1$ . . . is reasonable."[57]

Sober then uses the same logical process[58] to analyze whether it is reasonable to conclude that since many complex and useful artifacts are caused by observed intelligent designers, therefore a complex and useful biological structure was caused by an unseen intelligent designer. Though Sober judges that the probabilistic inductive

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[55]Sober, *Evidence,* 173.

[56]Ibid., 172-73.

[57]Ibid., 175.

[58]frequency of an observed cause-effect relationship (f_2), probability of that same relationship (q_2), proposed probability of an unobserved cause-effect relationship (p_2), and bridge principle $p_2 \approx q_2$.

argument succeeded in the voices-from-the-clouds example (What Sober shortens to "VOICES"), he concludes that that kind of argument fails for the inductive hypothesis of biological design ("IND-ID"). He concludes this because "The bridge principle in (VOICES) is reasonable, but that in (IND-ID) is not."[59]

For Sober, what is essential to make the bridge principle justified is that differences in the conditioning propositions (i.e., between the observed and unobserved cases) do not affect the frequency (f_1) and therefore should not cause the probabilities (q_1 and p_1) to differ. Evaluating the (VOICES) example, Sober says that through hearing voices from a range of elevations and recognizing them as human, one knows that these differences in elevation do not affect inferring human causation. For Sober, this observed range–or continuum–of gradually increasing elevations effectively bridges what Hume's Cleanthes insisted was an enormous analogical gap. When evaluating the (IND-ID) case, however, Sober insists that there is no such range of differences forming a bridge (or continuum) between human artifacts and biological organisms and therefore one has no idea whether the differences in (IND-ID) case do not radically affect (f_2), possibly causing wide probability differences between q_2 and p_2. Rhetorically, he asks,

> What evidence do we (or our eighteenth-century predecessors) have that the difference between living organisms and nonliving artifacts does not matter in the case of (IND-ID)? . . . If there were a continuum between 'not being alive' and 'being alive,' and we had sampled along this continuum, it would be no great leap to conclude that what we found in our sample also applies to unsampled objects that are a little more down the line. . . . But the vital processes we and our eighteenth-century predecessors see in living things do not seem to be like this. My point here is not that the bridge principle in (IND-ID) (that $p_2 \approx q_2$) is false but that there was no sampling evidence in the eighteenth century, nor is there any now, that it is true.[60]

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[59]Sober, *Evidence*, 174.

[60]Ibid., 175.

Critique of Sober's Own Use of Analogy in Rejecting Inductive Design Arguments

There are several problems with Sober's argument. First, he has been very selective about the features of the (VOICES) example which allow him to build an analogical bridge between a human voice coming from an observed human on the ground to a voice coming from the clouds. He only focuses on elevation, completely ignoring the features that the voice is being heard simultaneously around the world and in countless languages. Perhaps today technology exists that could conceivably produce such a unique phenomenon, but in Hume's day this was not the case, and would indeed create an enormous analogical gap.

Second, Sober's dissatisfaction with what he claims is a lack of a series of intermediates sufficiently similar to the two analogues in the design hypothesis uncovers a difficult tension which both intelligent design and neo-Darwinism must face: the tension between providing evidence which is sufficiently similar and yet at the same time sufficiently different. Earlier, Sober demanded evidential support which was sufficiently independent, i.e., different from the observations in question. Here, he is asking for evidential support which is sufficiently similar to the observations in question. In fact, what Sober is asking for is analogy: a phenomenon (or continuum of phenomena) distinct from, and thus independent of, the phenomenon needing explanation (or a likelihood assessment), and yet similar to that phenomenon in such key ways as to justify inferring a similar or identical cause.[61]

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[61]Certain things we can know best only through analogy. This is reminiscent of Aquinas' discussion of God and man, univocal, equivocal and analogical. Thomas Aquinas, *The Summa Theologica*, trans. Fathers of the English Dominican Province, rev. Daniel J. Sullivan, Great Books of the Western World 19 (Chicago: Encyclopedia Britannica, 1952), 66-67.

The features of similarity and difference must both be present for one to draw any inductive inference. One cannot justify the inductive conclusion that all ravens are black on the basis of viewing the same black raven over and over again. One's inductive sample must include other ravens: 'other' in the sense of being ontologically distinct from the original raven and from one another. At the same time, there must be similarity in a key feature–blackness of color–across the diversity of ravens in order to inductively conclude that all ravens, no matter their ontological differences, are black. Thus, induction, especially when appealed to in forming scientific hypotheses about unique events in the unobservable past, depends upon the two qualities of both similarity and difference which only analogy can provide.[62]

Is Sober being unreasonable and self-contradictory in asking for both independence and similarity? No, since as discussed above, inductive reasoning, and analogy which underlies it, require both features. Sober's shortcoming here is that he has not delineated how independent is independent enough, and how similar is similar enough to allow an intelligent design hypothesis to qualify as scientific. Without such delineation, it seems subjective and arbitrary for Sober to exclude intelligent design as science, especially since neo-Darwinism must meet the same evidential standards: producing sufficiently similar and yet sufficiently independent supporting examples.

More important for the purposes of this chapter, Sober's bridge principle and the support which that principle either has or lacks all draw their meaning from analogy. Children learn very early in their mathematics class that '≈' means "about the same as," a

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[62]Per Holyoak and Thagard, a complete correspondence may be problematic. The more perfect the similarity between two phenomena being compared, the less informative the comparison becomes. A Chinese parable they mention addresses this same point. Holyoak and Thagard, *Mental Leaps*, 30, 184.

meaning tantamount to "is analogous to." In the (VOICES) bridge principle, Sober judges p_2 to be about the same as q_2 because observed examples along a continuum of elevations were themselves about the same, or analogous. While there were differences along that continuum, those differences made no difference to the central similarity, namely that the voices all proceeded from an intelligent designer.

As shown earlier in this chapter, strong analogies can withstand many superficial differences, as long as deeper, or higher-order relations remain the same. Sober is judging the (VOICES) bridge principle to be reasonable based upon support in the form of a series of what he views to be analogous voices at a continuum of elevations. Without drawing analogies like this, apparently based upon his judgment that they are strong enough, the (VOICES) bridge principle would not be reasonable. Sober thus legitimizes an intelligent designer behind those voices-from-the-clouds on the basis of a probability based on inductive sampling, which in turn is entirely supported by analogy.

Similarly, his rejection of the biological design (IND-ID) bridge principle is based on the very same process, except that Sober claims that a series of analogous entities does not exist on the continuum between humanly-made artifacts and biological organisms. In Sober's mind, analogy is lacking, and therefore the bridge principle in this case is unsupportable. Thus, analogy undergirds Sober's whole analytic process and the conclusions he reaches in this section of his book.

One problem with Sober's implicit reliance upon analogy here is subjectivity. Whether the analogies about voices from people in balloons and towers are sufficiently close is open to considerable interpretation. More importantly, Sober does not support his additional claim that today no sampling evidence exists–and none ever has existed–

along the continuum between organisms and artifacts. He provides no evidence for his claim that "living things do not seem to be like this," a claim (more akin to an opinion) that is wide open to empirical challenge, as chapter 6 will show.

To summarize this section, Sober's links to Hume inevitably lead back to analogy. These links to Hume lead him to reject intelligent design as science twice. First, he rejects intelligent design by avoiding Hume's arguments pertaining to analogy or induction, thus leaving the design argument without independent support. Intelligent design proponents can avoid this outcome by simply refusing to follow Sober's advice, and instead risking facing Hume's criticisms, and arguably defeating them, head on. Second, he judges that intelligent design fails as an inductive argument, basing that judgment on subjective or unsupported reasons why he believes intelligent design does not supply an adequate analogy. Intelligent design proponents can overcome this judgment by continuing to reveal the growing body of empirical evidence showing the isomorphic nature of the analogy between artifacts and organisms (or their complex specified substructures), that the continuum which Sober is seeking is indeed emerging, and thus the inductive sample size is actually huge.

Hume's Analogical Distance Criticism and Sober's Rejection of Probabilistic *Modus Tollens*

As chapter 4 above alluded to, Sober repeatedly asserts that theorized causes which have a very low, but non-zero likelihood should not be eliminated from consideration as viable scientific hypotheses. In other words, Sober claims, there is a fundamental difference between events that are highly improbable and those that are impossible. Sober asserts, "Lots of perfectly reasonable hypotheses say that the observations are very improbable."[63] Moreover, in terms of strict probability, it is not impossible for monkeys to type the entire works of Shakespeare, only very improbable.[64] Sober rephrases his claim by saying that probabilistic *modus tollens* is not a legitimate method of reasoning: "We need to take seriously the fact that there is no such thing as probabilistic *modus tollens*. . . . The fact that a hypothesis says that a set of observations is very improbable is not a good reason to reject the hypothesis."[65]

Sober uses his rejection of probabilistic *modus tollens* in order counteract the many currently popular probabilistic arguments arguing that random mutation plus natural selection cannot produce the levels of specified complexity apparent in biology within the time limitations of life on earth.[66] Sober thus reasons that even pure Epicurean chance yields some likelihood (albeit incredibly small) in explaining the origin of biologically complex and specified organisms, structures, and information. Sober then uses an analogy of a combination lock gradually zeroing in on the correct combination to

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[63]Sober, *Evidence*, 51.

[64]Ibid., 116.

[65]Ibid., 192. See also 57, 51, 52, 57, 116, 130, 237, 262.

[66]Dembski, *Revolution*, 84-85, 96, 116-26; William A. Dembski, *No Free Lunch*: *Why Specified Complexity Cannot be Purchased without Intelligence* (Lanham, MD: Rowman and Littlefield, 2002), 21-22; Douglas D. Axe, "The Nature of Protein Folds: Quantifying the Difficulty of an Unguided Search through Protein Sequence Space," in *The Nature of Nature: Examining the Role of Naturalism in Science*, ed. Bruce L. Gordon and William A. Dembski (Wilmington, DE: ISI Books, 2011), 423; Murray Eden, "Inadequacies of Evolution as a Scientific Theory," in *Mathematical Challenges to the Interpretation of Evolution*, ed. Paul S. Moorhead and Martin M. Kaplan (Philadelphia: The Wistar Institute of Anatomy and Biology, 1967; repr., New York: Alan Liss, 1985), 6-9; Michael Behe, *The Edge of Evolution: The Search for the Limits of Darwinism* (New York: Simon and Schuster, 2007), 59-62; James W. Valentine, *On the Origin of Phyla* (Chicago: University of Chicago Press, 2004), 79; Stuart A. Kauffman, *Investigations* (New York: Oxford University Press, 2000), 144; Seth Lloyd, "Computational Capacity of the Universe," *Physical Review Letters* 88, no. 23 (June 10, 2002): 237901-1 through 4; Kenneth Dam and Herbert Lin, *Cryptography's Role in Securing the Information Society* (Washington, DC: National Academy Press, 1996), 380n17: Dam's calculations are relevant to the question of biological origins even though the article's context is computational operational resources available in the universe for cryptographic purposes.

try to show that random mutation plus natural selection always yields a higher probability/likelihood than Epicurean chance.[67] Thus, Sober reasons that even if the likelihoods of either of these hypotheses are very small, one can at least be sure they are not zero.[68]

If one ignores Sober's advice and purposely frames a design argument as an argument from analogy, the worst one has to fear from Hume's criticisms is that such an analogy will be distant, and the argument will be 'very weak.' This would mean that if the best a design theorist could muster is an extremely distant analogy, his design hypothesis would still yield a likelihood, albeit very low. However, using Sober's own claims against probabilistic *modus tollens*, even an extremely low likelihood is not a zero likelihood. Therefore, even if because of a weak analogy, the design hypothesis renders very improbable the observations of biological change, that fact is still not a good reason to reject the design hypothesis. Just as Sober found fault with William Dembski and others for drawing probability cutoffs regarding the chances of blind processes producing life from non-life,[69] so too Hume's analogy criticism of design arguments has no probabilistic cutoff. Thus, even with a very small likelihood, by Sober's reasoning, an intelligent design hypothesis should be regarded as no less scientific than either Epicurean chance or neo-Darwinism, which may also have extremely low likelihoods.

By Hume's standards, the only way a design argument via analogy would yield a zero likelihood is if the analogical distance between an artifact and an organism is

[67]Sober, *Evidence*, 123. However, Sober never specifies how much higher that likelihood is.

[68]See chapter 4 of this paper, which challenges the claim that neo- Darwinism necessarily yields a higher likelihood than Epicurean chance, and that neo-Darwinism is at least certain not to be zero.

[69]Sober, *Evidence*, 50-51.

infinitely large. This clearly is not the case. First, even at the most minimal level, the majority of human artifacts have a material substance, as do all biological organisms, and thus this material substance is one feature they analogically share. Second, all artifacts have some significant level of specified complexity, as do biological organisms and even an ever growing sample of their components (e.g., proteins, cells, tissues, organs, body plans). The fact that they share this feature of specified complexity means the analogical distance between them cannot be infinite, and thus the likelihood of an argument based upon analogy between artifacts and organisms cannot have a likelihood of zero. Since this conclusion emerges from Hume's criticism of analogy, it reveals another reason why design advocates should avoid following Sober's advice about reframing the design argument so as to entirely avoid confronting Hume's criticisms regarding analogy.

The next few sections of this chapter present additional reasons why analogy is central to determining whether or not intelligent design qualifies as a scientific hypothesis, and why analogy is also central to challenging Sober's reasons for rejecting intelligent design as science on likelihood grounds.

Science Regularly and Successfully Uses Analogies

Despite Hume' extreme caution about using analogies, science uses them frequently as powerful tools in the process of developing and analyzing the plausibility of their hypotheses. Albert Einstein and Leopold Infeld, in their 1938 book *The Evolution of Physics* commented,

> It has often happened in physics that an essential advance was achieved by carrying out a consistent analogy between apparently unrelated phenomena. . . .The association of solved problems with those unsolved may throw new light on our difficulties by suggesting new ideas. . . . To discover some essential common features, hidden beneath a surface of external differences, to form, on this basis, a

new successful theory, is important creative work.[70]

Johannes Kepler wrote, "I cherish more than anything else the Analogies, my most trustworthy masters. They know all the secrets of Nature, and they ought to be least neglected in Geometry."[71] Dedre Gentner lists examples of scientists such as Newton, Galileo and Rutherford using analogies in the development of their theories.[72]

In the late nineteenth century, noted glaciologist T. C. Chamberlin seemed to be alluding to analogy when he wrote that self-consistent explanations for phenomena came from other explanations "for *like* phenomena as they present themselves"[73] (emphasis mine). The result, according to Chamberlin is that "there is soon developed a general theory explanatory of a large class of phenomena *similar to* the original one."[74]

Henri Poincaré felt that "scientific conquest is to be made only by generalization. . . . [By] mathematical induction . . . the analysts have made science progress. . . . They needed a guide. This guide is, first, analogy."[75] More recently, Raimo Anttilo, linguistics professor at UCLA, has claimed that "analogies are utterly essential parts of all theories, crucial for explanation and understanding and all formal

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[70]Albert Einstein and Leopold Infeld, *The Evolution of Physics: From Early Concept to Relativity and Quanta*, 2nd ed. (New York: Simon and Schuster, 1938), 286-87.

[71]Quoted in George Polya, *Induction and Analogy in Mathematics*, vol. 1 of *Mathematics and Plausible Reasoning* (Princeton, NJ: Princeton University Press, 1954), 12.

[72]Dedre Gentner, "Are Scientific Analogies Metaphors?" in *Metaphors Problems and Perspectives*, ed. David S. Miall (Atlantic Highlands, NJ: Humanities Press, 1982), 106. See also Hurlbutt, *Hume*,150.

[73]T. C. Chamberlin, "The Method of Multiple Working Hypotheses," *Science, New Series* 148, no. 3671 (May 7, 1965): 754 (italics mine).

[74]Ibid. (italics mine).

[75]Henri Poincaré, *The Value of Science*, trans. George Bruce Halsted, Library of Philosophy, Psychology and Scientific Methods (New York: The Science Press, 1907), 23-24, 77.

definition. . . . Analogy is the only way to extend a dynamic theory."[76] Even more pertinent to this chapter's discussion, Anttilo claims that analogy "is particularly valuable when the object of investigation is not directly observable."[77] Others have noted that analogy continues to play a crucial role in forming and verifying scientific hypotheses.[78]

Keith Holyoak and Paul Thagard, in their book *Mental Leaps*, provide a long list of analogies which proved eminently fruitful in the progress of science: sound is analogous to water or waves (Chrysippus and Vitruvius), the Earth is analogous to the Moon (Galileo), light is analogous to sound (Huygens), a planet is analogous to a projectile (Newton), respiration is analogous to combustion (Lavosier), Electromagnetic forces are analogous to continuum mechanics (Maxwell), the human mind is analogous to a computer (Turing).[79]

Holyoak and Thagard do sound a note of caution. They warn that analogy is "risky" and "often apt to lead to false conclusions."[80] They therefore suggest that analogy should only be used for the discovery and development phases of the typical scientific process, and not resorted to when doing evaluation, although they note that some well-respected scientists have not met their criterion. They specifically call attention to Darwin, who "was explicit in listing natural selection/artificial selection

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[76]Raimo Anttila, *Analogy*, Trends in Linguistics: State-of-the-Art Reports 10 (The Hague: Mouton Publishers, 1977), 17.

[77]Ibid.

[78]Joost M Woltering, "From Lizard to Snake; Behind the Evolution of an Extreme Body Plan," *Current Genomics* 13, no. 4 (June 2012): 289; Helmar Gust, Ulf Krumnack, Kai-Uwe Kühnberger, and Angela Schwering, "Analogical Reasoning: A Core of Cognition," *Künstliche Intelligenz* 22, no. 1 (2008): 8.

[79]Holyoak and Thagard, *Mental Leaps*, 186-87.

[80]Ibid., 190.

analogy as one of the grounds for belief in his theory."[81]

Darwin's Use of Analogy from Domestic Breeding to Speciation in Nature

Charles Darwin deserves special attention in this discussion of analogy and its relevance to scientific hypotheses. The importance of analogy for undergirding important scientific hypotheses is illustrated in the *Origin of Species*. In that work, analogies which Darwin intentionally proposed between domestic plant and animal breeding in human societies and natural selection in the wild play a central role in the evidential case he tries to build for his theory, as he testifies:

> At the commencement of my observations it seemed to me probable that a careful study of domesticated animals and of cultivated plants would offer the best chance of making out this obscure problem. Nor have I been disappointed; in this and in all other perplexing cases I have invariably found that our knowledge, imperfect though it be, of variation under domestication, afforded the best and safest clue.[82]

In many places in *The Origin*, Darwin returns to this analogy[83] as an attempt to persuade the reader to make the logical inferential step from observing artificial selection to accepting the existence of natural selection.[84] In other writings, Darwin asserted that domestic breeding laid the crucial foundation for his theory.[85] Many scholars have documented how central this analogy to domestic breeding was for Darwin in the

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[81]Holyoak and Thagard, *Mental Leaps*, 190.

[82]Darwin, *Origin*, 4.

[83]Indeed, the first chapter is devoted to laying the groundwork for it and Darwin uses it again in Chapter Four as he makes his case for natural selection.

[84]Darwin, *Origin*, 30, 64-65, 83, 84, 87, 88, 500, 501-2.

[85]Charles Darwin to Asa Gray, July 20, 1857, in Darwin Correspondence Project, http://www.darwinproject.ac.uk/entry-2125 (accessed June 6, 2013); Charles Darwin, *The Variation of Plants and Animals Under Domestication* (London: John Murray, 1868), 3, 10, http://darwin-nline.org.uk/content/frameset?itemID=F877.1&viewtype=text &pageseq=1 (accessed September 25, 2013).

conception and defense of his theory.[86]

While Darwin's analogy has certainly received its share of criticism,[87] generally speaking, his overall theory has not yet been rejected by the science community because of his use of that analogy. Therefore, his example illustrates that analogy is at least at times regarded as a legitimate method for conceiving, explaining and independently supporting scientific hypotheses, particularly hypotheses about biological origins and large-scale change. This provides a precedent for intelligent design proponents to also use analogy as scientifically legitimate, independent support for the design hypothesis.

Darwin's use of analogy can help the case for the scientific legitimacy of intelligent design in another way. Darwin's attempt to connect intelligent agency in domestic breeding with the unconscious mechanisms of nature in natural selection seem to achieve only a weak and distant analogy, and thus one wonders how it would fare in light of Hume's standards. On the other hand, the changes intentional domestic breeding

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[86]Stephen Jay Gould, *The Structure of Evolutionary Theory* (Cambridge, MA: Belknap Press, 2002), 119; Graeme Donald Snooks, *The Collapse of Darwinism: The Rise of a Realist Theory of Life* (Lanham, MD: Lexington Books, 2003), 38-39; Jean Gayon, *Darwinism's Struggle for Survival. Heredity and the Hypothesis of Natural Selection*, trans. Matthew Cobb, Cambridge Studies in Philosophy and Biology (Cambridge: Cambridge University Press, 1998), 22-59; Bert Theunissen, "Darwin and His Pigeons. The Analogy between Artificial and Natural Selection Revisited," *Journal of the History of Biology* 45, no. 2 (May 2012):179-80; Paul R. Thagard, "The Best Explanation: Criteria for Theory Choice," *The Journal of Philosophy* 75, no. 2 (February 1978): 89; Stephen C. Meyer, *Darwin's Doubt: The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), 216-17; L. T. Evans, "Darwin's Use of the Analogy between Artificial and Natural Selection," *Journal of the History of Biology* 17, no. 1 (Spring 1984): 133-34, 136, 138.

[87]Alfred Russel Wallace openly rejected any analogical inferences that could be drawn between variation in animals in the wild variations in domesticated breeds. C. R. Darwin and A. R. Wallace, "On the Tendency of Species to Form Varieties; and On the Perpetuation of Varieties and Species by Natural Means of Selection," *Journal of the Proceedings of the Linnean Society of London. Zoology* 3 (August 20, 1858): 61, 45-62, http://darwin-online.org.uk/content/frameset?itemID =F350&viewtype=text&pageseq=1 (accessed September 25, 2013). For a recent example, see the first several chapters of Snooks, *The Collapse of Darwinism*, chaps. 1-5

have caused may present an analogy which better supports intelligent design. For example, those intelligently-manipulated changes help to justify the bridge principle in the analogical-inductive design argument which Sober criticized. He asked for evidence of a continuum–and then claimed that it has never existed–between human artifacts and biological organisms. Why could one not regard humanly bred animal and plant varieties as examples of entities classified somewhere in the range between humanly designed artifacts and animals completely formed by natural processes? Domestically bred animals and plants are *both* organic *and* intentionally designed entities. The material differences between, say a Yorkshire Terrier and a toy stuffed animal are substantial, but those distinctions make no difference to the shared characteristic of both being the product, at least in part, of intelligent agency. Chapter 6 will explore this problem in greater detail.

Analogies Used in Neo-Darwinian Theory

Neo-Darwinian theory has also made noticeable use of analogy in supporting its hypothesized claims. One of the most widespread representations used in evolutionary biology (first proposed by Sewall Wright) of the neo-Darwinian process of evolution is that of a search or walk through fitness landscapes (peaks and valleys).[88] While labeled a "metaphor" by some, evolutionary biologists try to draw legitimate analogical correspondences between these fitness landscapes and the phenomena in the biological world, including the history of biological change (micro and macroevolution).

Richard Dawkins has popularized this fitness landscape representation, using it

[88]Sewall Wright, *Experimental Results and Evolutionary Deductions,* vol. 3 of *Evolution and the Genetics of Populations*, Paperback ed. (Chicago: University of Chicago Press, 1984), 3-4, 450-52, 455-59; *Encyclopedia of Ecology* (Oxford: Elsevier, 2008), s.v. "Fitness Landscapes."

to try to persuade his readers that the gradual, accumulated steps of neo-Darwinian mutation and natural selection are analogous to the long, steady climb up the backside of Mount Improbable.[89] Even if viewed only metaphorically, Dawkins still uses the representation to try to make his point analogically: if one could make it up to the peak of Mount Improbable by a long series of the gradual steps uphill, there is no reason to imagine that neo-Darwinian processes cannot ultimately result in high levels of specified complexity in biology by a parallel series of gradual steps of increasing fitness. Thus, even if fitness landscapes are just metaphors, they can, and are used analogically to draw reputedly scientific inferences about the processes, capabilities and limitations of neo-Darwinism.

Sara Imari Walker and Paul Davies also use analogy in proposing a significant adjustment to classic neo-Darwinian physio-chemical reductionist mechanisms. They point out the need for evolutionary theory to take into account the realm of information, equally as vital to biological systems as the material composition of those systems. Walker and Davies employ the computer hardware/software interface as an analogy to the updated view they propose, even commenting that biological information has undergone important ‘upgrades’ during its history.[90]

The common neo-Darwinian extrapolation from microevolution to macroevolution may also be viewed as an analogy. As chapter 4 discussed, many evolutionary biologists are dissatisfied with a simple extrapolation from micro to

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[89]Richard Dawkins, *Climbing Mount Improbable* (New York: Norton, 1997), 73, 79, 91.

[90]Sara Imari Walker and Paul C. W. Davies, “The Algorithmic Origins of Life,” *Journal of the Royal Society, Interface* 10, no. 79 (February 2013): 2-4, 7, http://rsif.royalsocietypublishing.org/content/10/79/ 20120869.full.pdf+html (accessed November 19, 2013).

macroevolution, and in some cases are convinced that macroevolution operates, at least in part, by a distinct mechanism. In 1937, Dobzhansky felt compelled only "reluctantly to put a sign of equality between the mechanisms of macro- and micro-evolution,"[91] Although by 1951, Dobzhansky's reluctance had significantly dissipated,[92] further discoveries in molecular and developmental biology in the sixty years since then apparently are validating the merit of his earlier hesitance.

One the most frequently-used examples of microevolution is the development in bacteria of resistance to antibiotics. This phenomenon is touted as good, empirical evidence that evolution is currently happening,[93] that random mutation and natural selection are acting together to cause bacteria to adapt, survive and have a better chance of reproducing and eventually and permanently improve the general populations in respect to its environment. There are good reasons, however, why antibiotic resistance is not a good candidate for an analogical inference that neo-Darwinian mechanisms would render likely macroevolutionary changes. First, antibiotic resistance in bacteria, like other minor observed changes in bacteria, does not cause complex, specified, innovative structures which one would look for in evolution of new genera, families, orders, and

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[91]Theodosius Dobzhansky, *Genetics and the Origin of Species*, Columbia Classics in Evolution, ed. Niles Eldredge and Stephen Jay Gould (1937; repr., New York: Columbia University Press, 1982), 12.

[92]Theodosius Dobzhansky, *Genetics and the Origin of Species*, 3rd ed., rev., Columbia Biological Series 11 (New York: Columbia University Press, 1951), 16-17.

[93]The National Academy of Sciences, *Science, Evolution and Creationism*, (Washington, DC: National Academies Press, 2008), 6-7, 39; Richard E. Lenski, "Bacterial Evolution and the Cost of Antibiotic Resistance," *International Microbiology* 1, no. 4 (1998): 269; Behe, *The Edge*, 51-52; University of California Museum of Paleontology, "Examples of Microevolution," University of California, Berkeley, http://evolution.berkeley.edu/evosite/evo101/IVB1aExamples.shtml (accessed December 5, 2013); P. M. Bennett, "Plasmid Encoded Antibiotic Resistance: Acquisition and Transfer of Antibiotic Resistance Genes in Bacteria," *British Journal of Pharmacology* 153, no. S1 (March 2008): S348; Michael Ruse and Joseph Travis, ed., *Evolution: The First Four Billion Years* (Cambridge, MA: Belknap Press, 2009), Alphabetical Guide, s.v. "Bacterial Evolution."

even higher taxa. Bacteria remain bacteria.[94]

Second, like most mutations in all biological species, those which cause antibiotic resistance are not known for certain to provide long-term benefit, and most are detrimental to overall fitness.[95] Dembski and Wells comment, "Such beneficial mutations . . . provide no evidence for macroevolution. Moreover, when environmental pressure is reduced, the benefit conferred tends to be lost. . . . This is one step forward and one step back."[96] Many researchers, though not all,[97] assert that such mutations may produce more overall harm than good to the organisms that have them.[98]

Third, cases of antibiotic resistance which are given by advocates of neo-Darwinism are not usually examples of truly *natural* selection, but at least partially *artificial* selection. This is because intelligent, purposeful human choices are involved, not only in synthesizing or refining the antibiotics themselves, but in distributing and administering them with intention and forethought. For example, the selection factor in malaria's acquisition of chloroquine resistance was anything but natural. It was affected to a significant extent by rigorous and intentional intellectual effort, as well as strategic

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[94]Pierre Paul Grassé, *Evolution of Living Organisms: Evidence for a New Theory of Transformation* (New York: Academic Press, 1977), 87.

[95]Dan I. Andersson and Bruce R. Levin, "The Biological Cost of Antibiotic Resistance," *Current Opinion in Microbiology* 2, no. 5 (October 1, 1999): 490; Johanna Björkman and Dan I.Andersson, "The Cost of Antibiotic Resistance from a Bacterial Perspective," *Drug Resistance Updates* 3, no. 4 (August, 2000): 239.

[96]William A. Dembski and Jonathan Wells, *The Design of Life: Discovering Signs of Intelligence in Biological Systems* (Dallas: The Foundation for Thought and Ethics, 2008), 38-39.

[97]Bruce R. Levin, Véronique Perrot, and Nina Walker, "Compensatory Mutations, Antibiotic Resistance and the Population Genetics of Adaptive Evolution in Bacteria," *Genetics* 154, no. 3 (March 1, 2000): 985.

[98]Dembski and Wells, *Design of Life*, 38-39; Lenski, "Cost," 265; Behe, *The Edge*, 51-52.

planning, both in terms of the antibiotic itself and of its application.[99]

For all these reasons, it is difficult to justify the claim that microevolutionary changes alone–which scientists observe producing small changes in organisms today–extended over vast periods of time will make the appearance of macroevolutionary changes likely. If macroevolution is neither merely microevolution writ large, nor entirely distinct from it, then the actual relationship between the two may be better labeled analogy than extrapolation.

Thus analogy was a common methodology in Darwinism and continues to be so in neo-Darwinism. Contemporary philosophy of science does not regard either of these two forms of hypotheses as unscientific due to their use of analogy. If analogy is viewed as a helpful, powerful tool in scientifically supporting Darwinism and neo-Darwinism, then analogy should be viewed in the same way respecting intelligent design, unless analogies useful to intelligent design can be shown to be significantly inferior, weaker or more distant than those employed by advocates of those rival hypotheses.

Sober's Other Uses of Analogy in *Evidence,* Chapter 2

This chapter previously discussed Sober's comparison of Hume's example about voices coming from the clouds with claims of an inductive design argument. Sober concluded that the former was a reasonable argument and the latter was not, and based that conclusion in fundamental ways upon analogical adequacy. To further emphasize the

[99]For example, anti-malaria "eradication efforts . . . focused on house spraying with residual insecticides, antimalarial drug treatment, and surveillance, and would be carried out in 4 successive steps: preparation, attack, consolidation, and maintenance." Centers for Disease Control and Prevention, "The History of Malaria, an Ancient Disease," http://www.cdc.gov/malaria/about/ history/ (accessed April 20, 2014). Regarding insecticide resistance, see William G. Brogdon and Janet C. McAllister, "Insecticide Resistance and Vector Control," *Emerging Infectious Diseases* 4, no. 4 (October-December 1998): 610.

importance of analogies in hypotheses concerning biological origins and innovation, this section calls attention to a few more examples of Elliott Sober's own explicit and implicit use of analogical reasoning in chapter 2 of *Evidence*. How does he use analogies, and is his evaluation of analogy in his explicit critique of intelligent design consistent with his own use of analogy as he discusses rival hypotheses, including neo-Darwinism?

Analogy with Goal-Contingent and Ability-Contingent Humans

As discussed in chapter 3 above, Elliott Sober implicitly uses analogy by inferring that the purported designer of the design hypothesis *must* be similar to observed human designers in critically needing some modicum of the right kinds of goals and abilities in order to design a complex specified product. Yet, chapter 3 also pointed out this very analogy should also result in the inference that the hypothesized biological designer has goals and abilities relevant to design which are analogous to those of humans, which in principle have an assessable likelihood. While Sober does not make that inference, design theorists should be allowed to do so. In other words, the analogy between human designers and the biological designer, which Sober utilizes in part, should be allowed and employed to achieve its full inferential force.

Analogy of Combination Locks

Sober borrows two analogies from Richard Dawkins[100] and mixes them together, calling the reader to imagine a nineteen-tumbler combination lock, with twenty-

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[100]Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design*, 2nd paperback ed. (New York: Norton, 1996), 7, 8, 44-49; As the source of Dawkins' analogy, Sober credits Herbert A. Simon, *The Sciences of the Artificial*, 2nd ed. (Cambridge, MA: MIT Press, 1981), 206.

six alphabetic letters to choose from at each tumbler instead of numerical digits, and which will only open when the nineteen choices spell (in order) “METHINKSITISAWEASEL.” Sober presents three scenarios: First, all nineteen tumblers are repeatedly spun at random until the final correct message emerges; second, the tumblers are spun at random, one at a time, in order, and the tumbler “freezes” in place when it lands on the correct letter in the sequence. Third, all the tumblers are spun at once, at random and repeatedly, and any of the tumblers which happen to land on the letter in the sequence which corresponds to the target message are “frozen.”[101]

Sober uses this analogy to make the point that only the first scenario is fully random, and it would consequently require a potentially huge number of tries to happen to hit the right target. He emphasizes how this is not the case with the other two scenarios. An additional, non-random factor has been added in either case, which greatly reduces the probabilistic searching required to allow the letters to spell out the correct sequence and open the lock. Sober then asserts that neo-Darwinism is much more akin to the second or third scenarios, and crucially unlike the first, because it involves a combination of mechanisms, one random (mutations) and one non-random (natural selection).

Sober presumably wants to show that the neo-Darwinian hypothesis makes complex specified structures in biology more likely than a purely random process would. He gives this analogy in order to counter what he considers the myth, presented by intelligent design advocates, that neo-Darwinism has to face prohibitively huge random search spaces and thus has only a vanishingly small probability of arriving at the highly

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[101]Sober, *Evidence*, 123.

complex and specified combinations seen in many biological phenomena.[102] Interestingly, Sober uses one analogy to try to refute another analogy: Fred Hoyle's analogy that "natural selection has the same chance of producing complex adaptations that a hurricane blowing through a junkyard has of assembling scattered pieces of metal into a functioning airplane."[103]

Since this paper affirms the disciplined and proper use of analogy in supporting scientific hypotheses, Sober (as well as Dawkins and others) deserves some credit for helping to present inferences about a less-understood process by analogically mapping similarities from more-understood processes. Two important responses are needed, however. The first is that for parity's sake, Sober's analogy deserves scrutiny by the same critical standards as those by which design arguments are scrutinized. For one, Hume warned that the more dissimilar the two analogues are, the weaker the force of the analogy, and weak analogies are "confessedly liable to error and uncertainty."[104] As discussed above, Hume's standards are too easily interpreted as merely focused on a preponderance of quantitative or qualitative similarities or dissimilarities between individual objects in the analogues. Such standards are usually not as helpful for distinguishing strong analogies from weak ones as searching for the presence or absence of isomorphic determining structures, i.e., higher-order–and especially causal–relations among components of the analogues.

The two analogues in Sober's analogy admittedly do contain the higher-order

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[102]Sober, *Evidence*, 123-25.

[103]Ibid., 122; Fred Hoyle, quoted in "Caltech Kellogg Birthday: Hoyle on Evolution," *Nature* 294, no. 5837 (November 12, 1981): 105.

[104]Hume, *Dialogues*, 17.

relation of an interaction between a purely random process (the spinning of the tumblers) and an ordered process (the freezing of the tumblers when a specified condition is met). However, there also is a key higher-order dissimilarity between the analogues. In the case of the combination lock, intelligent agency, i.e., design, is required at two crucial points: First, in the initial determining of the "right" lock combination sequence, and second in the determining that the tumblers will "freeze" when their letters match one small portion of the larger target sequence (not helping achieve any useful, intermediate adaptive function because the lock still will not open). These factors are higher-order relations because they are crucially causal. In these two ways, the lock analogue and an organism analogue do not have isomorophic determining structures. Those structures are similar in some important ways but different in other important ways.

Interestingly, Sober recognizes one of these crucial differences, but chooses to dismiss it: "In all three of these experiments, the target sentence for the combination lock is set by an intelligent being (the designer of the lock), but that isn't relevant to the present point."[105] An intelligent design advocate, not to mention an advocate of rigorously-structured scientific analogies, would beg to differ. The presence in one analogue, and the absence in the other, of the crucial causal agency of intelligent design significantly weakens the analogy, at least to a noticeable extent. I suggest that while Sober's analogy deserves scientific consideration, nevertheless, using Hume's terminology, it also is liable to error and uncertainty.

There is a second point about Sober's use of this analogy. Parity demands that if neo-Darwinian proponents may use analogies as independently supported auxiliary

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[105]Sober, *Evidence*, 123.

propositions, even if those analogies are less-than perfect (i.e., not fully isomorphic), then intelligent design proponents ought to be allowed to do likewise. Moreover, why then should not such analogically-supported design hypotheses be regarded as equally scientific as an analogically-supported neo-Darwinian hypothesis?

Analogy of an Archway with "Irreducibly Complex" Biological Structures

Sober borrows another analogy in chapter 2 of *Evidence*, in this case to specifically challenge Michael Behe's notion of irreducibly complex structures in biology.[106] When constructing a wall, workers can add stones one by one in a certain order, and if the arrangement of those stones is just right, if certain stones are then removed one by one in a different order, a stone arch may remain which will allow safe passage through the wall. In short, the stones which were removed formed a temporary scaffolding or support for the stones which later would become the arch. Sober presents this analogy to try to show that what seem to us to be irreducibly complex structures could conceivably be formed in a step-by-step manner, without the final target in mind from the start. Sober's conclusion, inferred from analogy, is that despite Behe's claims, there likewise are conceivable ways (such as biological scaffolding) for step-by-step, non-teleological, neo-Darwinian pathways to gradually form irreducibly complex structures or processes in biological organisms.[107]

Sober again deserves credit for using analogy to help build understanding of a

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[106]From A. G. Cairns-Smith, *Genetic Takeover and the Mineral Origins of Life* (Cambridge: Cambridge University Press, 1982), 95-99.

[107]Sober, *Evidence*, 162.

phenomenon in nature which is not fully explained, by drawing out similarities to a much more mundane example from human architecture. This analogy, however, like the one discussed above, also falls short of isomorphism for the same reason. While it is conceivable that workers building and then remodeling a wall could get lucky and unintentionally create an arch in a stone wall, the vanishingly small probability of such an occurrence weakens the analogy. Not only is the source analogue highly improbable, it is conjectural, not drawn from rich experience of how arches are actually formed in walls. I have a background (both education and experience) in the field of building construction. I am not aware of arches ever being formed in walls by *unintentional*, step-by-step processes of scaffolding and removal. The stone arches in Gothic cathedrals, for example, were indeed constructed using bracing which was subsequently removed, but such a process was intelligently planned, and learned through years of methodological honing, as well as through intentional improvements via trial-and-error (some churches collapsed). Furthermore, the stonework was performed by highly skilled and experienced craftsmen who knew well ahead of time the final structure their scaffolding designs were ultimate intended to produce.

Sober calls this analogy "a nice model for a mindless evolutionary process."[108] Yet in Cairns-Smith's version of this analogy, from whom Sober borrowed his, intelligent humans learn how to create arches through scaffolding, one stone at time, and then purposely carry those procedures out.[109] Interestingly, Cairns-Smith himself also uses another analogy–the erection of the stone lintels at Stonehenge–to illustrate what

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[108]Sober, *Evidence*, 162.

[109]Cairns-Smith, *Genetic Takeover*, 95-96.

scaffolding can accomplish.[110] Of course no one questions the power of step-by-step scaffolding, as long as it is performed by intelligent, intentional human builders. Sober has thus speculatively added the quality of "mindlessness," not present in Cairns-Smith's analogy. A feature of good analogy is to map isomorphically from a well-known source analogue to a less-well-known target analogue. Sober's source analogue has a critical feature he is mapping which is not well-known because it is merely conjectural and practically implausible, namely, that builders can *accidentally* include the form of an arch in the stones of a wall and then later *inadvertently* uncover that arch stone by stone. While Sober is to be commended for trying to make both the analogues more similar by attributing mindless causal processes to each, I suggest he may have lost as much analogical strength in divorcing his source analogue from regular human experience as he has gained in increased isomorphism.

There is also a difference between the analogues which could be crucially important. Admittedly, they both possess components contributing to a new overall function. Yet, in the target analogue, namely in the kinds of highly specified and complex biological structures and processes regularly referenced by intelligent design theorists (e.g., molecular machines within the cell), the various components perform highly individualized (or tailored) functions (not just in degree but in essence or quality). In contrast, the components of an arch (or in the wall which preceded it) all individually perform essentially the same function. Individually, they all bear loads, whether their collective function is to prohibit or to allow passage through the wall. Sober does not address this key difference in the stone wall/archway analogy with biological structures..

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[110]Cairns-Smith, *Genetic Takeover*, 97.

The systems being compared are not fully isomorphic. Again, the purpose here is not to claim there is no strength to Sober's analogy, but that the strength may decrease upon deeper inspection.

Another point to notice is that since one would be much more likely to find a stone wall turned into an archway as the result of intentional planning and design, Sober's example arguably could be utilized more effectively as an analogy in support of the design hypothesis than in support of neo-Darwinian processes. Last, just as in the case of the combination lock analogy, if the neo-Darwinian hypothesis need not be regarded as unscientific when using use less-than-isomorphic analogies as support, the same standard should apply to the design hypothesis.

Summary

After establishing a good fundamental foundation in the theory of analogy, this chapter showed that both Hume and Sober use a mischaracterized version of analogy to show that design analogies are weak. The result of this is that Sober ill-advisedly discourages the use of analogy for the parallel purpose of supporting the likelihood of the design hypothesis. This chapter also showed that by interfacing Hume's standards with Sober's rejection of probabilistic modus tollens, even a weak analogy still leaves the design hypothesis with a non-zero likelihood. Therefore, defenders of intelligent design should not fear using analogy as independent support for the design hypothesis. This chapter also illustrated that Sober, like Darwinians and neo-Darwinians before him uses analogy both implicitly and explicitly, for providing support for the hypothesis that random mutation and natural selection makes macroevolutionary changes likely. Moreover, those analogies are not necessarily of any higher level of isomorphism–the most important factor in analogical strength–than analogies used in supporting the design hypothesis. All of these factors indicate that when taking analogy into serious account, as it should be taken, Sober has not shown that the likelihood of specified complex, specified change at macro levels in biology under an intelligent design hypothesis is by any means any less assessable than the likelihood of those observations under neo-Darwinism.

If analogy and induction are centrally linked, as I claim they are, then analogy is critically important to the case for intelligent design as a scientific hypothesis, especially as it is evaluated in likelihood terms by Elliott Sober in *Evidence and Evolution*. When comparing biological specified complexity and specified complexity in human artifacts or systems, strong inductive inference follows analogy as a matter of course. This is because the sample sizes of both the analogues already are immense. There are numerous examples of specified complexity in biology, and more are being discovered year by year. Likewise, there are countless examples of humanly-produced specified complexity. If a legitimate analogical link can be demonstrated between the two realms, vast inductive sample sizes are automatically available to undergird inferences to biological design. The next chapter provides a sample of growing evidence of such legitimate analogical links, the true isomorphism between the specified complexity inherent in human artifacts and that present in living organisms, which is being uncovered, both by the advance of biology and by the development of technology.

CHAPTER 6

ANALOGICAL SAMPLING AND SUPPORT FOR DESIGN: ORGANISMS TO ARTIFACTS

Introduction: New Isomorphisms from Science

This chapter and the next address a crucial theme discussed by Sober in chapter 2 of *Evidence*, and which the previous chapter of this paper briefly touched upon. Are the differences between organisms and artifacts so essential (of such a high order) that they preclude inferring similar types of causation for both of them (i.e., intelligence)? Do such differences disrupt isomorphisms of high order relations (like cause and effect)? For example, a lawn mower is designed by ('caused by') a lawn mower designer, i.e., an intelligent person. What about a symphony? Symphonies, at least in their superficial characteristics (first order relations) are vastly different from lawn mowers. Yet at the high order relation of causation, symphonies, like lawn mowers, are also designed by intelligent people. Therefore, in terms of the high order relation of cause-effect, symphonies and lawn mowers are isomorphically analogous in the sense that they both are produced by intelligent design, emerging necessarily from intelligent designers. Therefore, one can see in the case of the continuum between lawn mowers and symphonies, that the differences between any samples along that continuum make no difference (do not effect) the high order relation shared by them both, namely the feature of being intelligently designed.

Now, do differences between samples along a continuum between artifacts and organisms likewise not affect a high order relationship between complex, specified features of those samples and intelligent agency which is hypothesized to cause those features? First, Sober questions that a continuum even exists between organisms and artifacts. Second, he denies that there are any samples along such a continuum and therefore have no evidence for inferring that a similar cause of intelligence can be justifiably inferred. He further claims that this lack of sampling evidence along such a continuum has not changed from Hume's day to the present.

Sober links this claim to Hume because one of Hume's key strategies in his attempt to cast doubt on design arguments was to claim that the world of organisms and the world of human artifacts (he chose 'the universe' and 'machines' to represent those broad domains) were so categorically distinct, that inferences about them both being intelligently designed were incapable of rising above a guess or conjecture.[1] Since Sober claims no further sampling along an alleged continuum between artifacts and organisms has emerged since Hume's day, Hume's objection therefore should hold the same force it did in the eighteenth century, and therefore Sober can justifiably claim that an inductive argument for design fails.

This chapter presents reasons why Sober's claims are mistaken. This chapter will provide empirical evidence not only that a continuum between artifacts and organisms exists, but that the body of samples along that continuum is growing, that that body of samples is growing from both directions, and furthermore that from the direction of artifacts, the progressive steps along that continuum in many critical ways require

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[1]David Hume, *Dialogues Concerning Natural Religion*, ed.Henry D. Aiken (New York: Hafner, 1948), 51.

intelligent involvement and guidance.

Lack of sampling along a continuum (i.e., along what Sober also calls a 'bridge') can also be termed an 'analogical gap.' The examples in this chapter give clear, empirical evidence that undermines Sober's claim that the analogical gap between human artifact and biological organism has not narrowed in the least from Paley's and Hume's day to the present. This chapter, and the next, will present the case that on the contrary, as a direct result of the developments in both science and technology in the last two hundred years, the power of analogy between organism and artifact has significantly grown and will continue to grow into the foreseeable future. Regarding scientific understanding, this chapter will give examples of discoveries in molecular biology regarding cellular assemblies which reveal remarkable parallels with human design. Regarding technological development, chapter 7 will also give examples of scientifically-devised experimental innovations and approaches yielding products which ever-more-closely mimic natural biological life-forms. The analogical evidence today far surpasses that in Hume's universe-machine example and in Paley's eye-watch example.

The previous chapter explained why intelligent design theorists should not be hesitant to use analogical argumentation for undergirding design hypotheses. That chapter claimed that close or isomorphic analogy is what ultimately allows inductive arguments to work, especially as they are used relative to unrepeatable, unobserved events in the past (such as major biological origins). Regarding analogy, William Dembski comments that "a revamped argument from analogy, to my mind, goes a long way toward addressing Hume's objections to design. Nevertheless, since I cash out the design argument as an inference to the best explanation, I shall not pursue this line of inquiry further."[2] It is this paper's assertion, however, that intelligent design arguments, like neo-Darwinian arguments, as they concern the unobservable events of the past, ultimately owe their persuasive force–indeed, they ultimately owe claims to the status of "best explanation"–to the analogies inherent within them, even if such analogies may not be immediately obvious. This chapter therefore pursues the method of analogy where Dembski chose not to pursue it further. The ever-more-isomorphic analogies emerging from both scientific discovery and technological development along the artifact-organism continuum (of which this chapter presents several cogent examples) serve as evidence which can be used either to present a strong inductive argument for intelligent design, or to serve as independent support for a positive likelihood assessment for the hypothesis of design. On both counts then, the evidence for the shrinking artifact/organisms analogical gap can overcome Sober's objections to intelligent design as a scientific hypothesis to rival neo-Darwinism.

Analogy of DNA with Intelligent Language

One of the most striking and well-documented examples of analogy between the world of biological organisms and the world of intelligent artifacts is what one might call the "isomorphic analogy" between the complex, specified information in biological genomes and that in humanly-designed languages, including computer code. Since others, such as Meyer, have so thoroughly treated the computer language-DNA analogy

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[2]William A. Demski, *Intelligent Design: The Bridge between Science and Theology*, paperback ed. (Downers Grove, IL: InterVarsity Academic Press, 1999), 302. Yet, Dembski may use analogical thinking, while labeling it differently. Elsewhere he writes, "The signs of intelligence that occur in human artifacts and biological systems are not merely analogous. They are isomorphic, for one finds the exact same form of specified complexity in each." William A. Dembski, *The Design Revolution*, (Downers Grove, IL: InterVarsity Press, 2004), 230.

elsewhere,[3] only a few brief comments are necessary here.

Regarding the similarities between DNA and language, James Valentine comments,

> Genes may be said to form a sort of metaphorical language, both of evolution and of development. Indeed, the analogies between aspects of the structure of, say written English, and of the metazoan genome are striking. Both written English and genomes involve methods of preserving and conveying information and both are combinatorial systems which are organized into hierarchies capable of essentially infinite variation.[4]

Valentine uses what he calls "the language metaphor" to point out remarkable parallels at various levels between genes and human languages.[5] He summarizes, "The reason that this analogy works as well as it does is surely no accident. Both the regulatory genome and the usages of grammar and narrative in language are systems to organize information so that it makes sense."[6] While Valentine claims that both DNA and human languages evolved, one must certainly reasonably assume that intelligent agency was critically involved in the emergence and refinement of human languages, and by isomorphic analogy, why not in the emergence and refinement of DNA as well?

The consideration of both biological life and humanly-devised languages as systems of organized information corresponds well with what James Shapiro calls "shift in biology from a mechanistic to informatic view of living organisms."[7] Shapiro notes

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[3]Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: Harper Collins, 2009). See especially 12-23, 100-110, 116-17, 255, 407, 461-64.

[4]James W. Valentine, *On the Origin of Phyla* (Chicago: University of Chicago Press, 2004), 77.

[5]Ibid., 114.

[6]Ibid.

[7]James A. Shapiro, *Evolution: A View from the 21st Century* (Upper Saddle River, NJ: FT Press Science, 2011), 4.

that ironically, "molecular biology, which its pioneers expected to provide a firm chemical and physical basis for understanding life, instead uncovered powerful sensory and communication networks essential to all vital processes."[8] Shapiro believes that it is better to view evolution as a process of "systems engineering" rather than as "a random walk through the limitless space of possible DNA configurations."[9] In common human experience, all systems engineering is carried out by intelligent agents. While Shapiro views the likeness he describes as only metaphorical, why doesn't intelligent agency merit serious consideration in biology, since life's informatic features are in fact emerging from biological research itself?

In a recent article, Sara Walker and Paul Davies[10] analogically liken the physio-chemical mechanisms of life and the complex information which runs them with the hardware-software combination in computers. Walker and Davies still suggest "physical transitions (e.g., thermodynamic phase transitions)" as the ultimate causal mechanism for non-life becoming life.[11] Yet they claim that the hardware-software analogy is a valid scientific strategy. They believe it not only more closely reflects the workings of nature than purely mechanistic-reductionist approaches, but it could also yield some "potential novel research directions."[12] Similarly, in his 2009 book, *Signature*

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[8]Shapiro, *Evolution*, 4.

[9]Ibid., 6.

[10]Walker is a NASA postdoctoral researcher. Davies is director of the Arizona State University Beyond Center for Fundamental Concepts in Science.

[11]Sara Imari Walker and Paul C. W. Davies, "The Algorithmic Origins of Life," abstract, *Journal of the Royal Society Interface* 10, no. 79 (2013): 1, http://rsif.royalsocietypublishing.org/content/10/79/ 20120869.full.pdf+html (accessed November 19, 2013).

[12]Walker and Davies, "Algorithmic Origins," 1, 2, 4, 7.

in the Cell, Stephen Meyer describes how both computer codes and many nucleotide base sequences in DNA contain specific instructional information for carrying out complex tasks.[13] Meyer comments, "both are complex, nonrepeating sequences that are highly specified relative to the functional or communication requirements that they perform."[14]

Notice that the direct similarity of biological information (DNA) to computer software, which stands out so starkly to Davies, Walker and Meyer only has become obvious within the last fifty to sixty years. Electronic computers and the software languages which drive them, as well as the discovery of the genetic code in DNA represent remarkable advancements in technology and biology, respectively, since Hume and Paley's day. One of the results of these advancements is the ability to draw an even closer analogy between living organisms and nonliving artifacts. What Meyer claims explicitly and what Davies and Walker seem to be implying is that the information contained in both computer programs and DNA, in conjunction with functional effects both produce as a result of that information, are not merely similar, but identical.

Hubert Yockey, in comparing the specified amino acid sequence in proteins to written language, comes to the same conclusion:

> According to the sequence hypothesis, the specificity of all proteins is recorded in the exact order in which the amino acid residues are arranged. . . . In the following we will resort to illustrating our points by reference to the properties of language. It is important to understand that we are not reasoning by analogy. The sequence hypothesis applies directly to the protein and the genetic text as well as to written language and therefore the treatment is mathematically identical. [15]

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[13]Meyer, *Signature*, 12.

[14]Ibid., 23.

[15]Hubert P. Yockey, "Self Organization Origin of Life Scenarios and Information Theory," *Journal of Theoretical Biology* 91, no. 1 (July 7, 1981): 16.

This identity then precisely, perhaps even paradigmatically, fits Weitzenfeld's and Waters' descriptions above of an "isomorphic determining structure"[16] typical of "reasonable" analogies.[17] Sober challenged intelligent design to produce evidence that "the difference between living organisms and nonliving artifacts does not matter."[18] It appears that the organism-artifact analogy springing from the isomorphism of DNA coding and computer software meets that challenge, whereas perhaps Cleanthes' analogy between a machine and the world, or Paley's analogy between a watch and an eye perhaps fell somewhat short. Perhaps Sober is right about there not being sampling evidence in the eighteenth century, but it appears that there is reasonable sampling evidence in the twenty-first century. Evidence of coding in DNA would not be quite as compelling if the code did not in turn produce complex, specified products. What the fields of cellular biology and biochemistry have continued to uncover, however, is that the genetic code produces a dazzling array of molecular machines which perform a variety of highly specialized functions, all contributing to the overall health and reproduction of living cells.

Perhaps Hume's Philo had a point in questioning whether Cleanthes' analogy from machines to the world was sufficiently close. However, neither Hume nor Paley had any idea of the factory-like, functional complexity of the cell, nor of the myriad of

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[16]Julian S. Weitzenfeld, "Valid Reasoning by Analogy," *Philosophy of Science* 51, no. 1 (Mar 1984):143-44, 148-49.

[17]C. Kenneth Waters, "Taking Analogical Inference Seriously: Darwin's Argument from Artificial Selection," in *Contributed Papers*, vol. 1 of *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* (Chicago: University of Chicago Press, 1986), 503, 505.

[18]Elliott Sober, *Evidence and Evolution: The Logic Behind the Science* (New York: Cambridge University Press, 2008), 175.

specialized machines operating within it, each contributing to overall cellular function. Were Hume alive today, Philo would be hard-pressed to deny at least enough of a reasonable analogy to consider design as a viable candidate for the best explanation of such machinery. The following section considers that machinery in more detail.

Analogy of Molecular Devices with Human Devices

Molecular Machines: General

The analogical likening of biological component and or processes to machines is not new to western science. Marco Piccolino describes how Marcello Malpighi, a seventeenth-century Italian scientist, likened body functions to the operations of man-made machines.[19] Malpighi even presciently claimed that human bodies contained machine-like components too minute to observe with the naked eye:

> Nature, in order to carry out the marvellous operations in animals and plants, has been pleased to construct their organized bodies with a very large number of machines, which are of necessity made up of extremely minute parts so shaped and situated, such as to form a marvellous organ, the composition of which are usually invisible to the naked eye, without the aid of the microscope.[20]

Piccolino claims that Malpighi, helped by this analogy, furthered a conceptual shift which helped science advance by inspiring both microscopic and macroscopic anatomy.[21] While the machine analogy fell into eclipse for a time, it recently has undergone a dramatic revival, as scientists have discovered that cells contain a host of molecular devices, namely, proteins within those cells which have many sophisticated

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[19]Marco Piccolino, "Biological Machines: From Mills to Molecules," *Nature Reviews Molecular Cell Biology* 1, no. 2 (November 2000): 149, 152.

[20]Marcello Malpighi, *Opera Postuma* (London: Churchill, 1697), quoted in Piccollino, "Biological Machines," 149.

[21]Piccolino, "Biological Machines," 149.

machine-like qualities.[22] Bruce Alberts succinctly summarizes the extent of this cellular sophistication: "Indeed, the entire cell can be viewed as a factory that contains an elaborate network of interlocking assembly lines, each of which is composed of a set of large protein machines."[23] The broad quality of a living cell's makeup which strikes contemporary biologists as "machine-like" is a threefold manifestation of specified complexity: integrated functionality, specified structural dependence and information flux.

Integrated functionality. The machine-like, integrated functionality within biological organisms apparently stood out to Malpighi, because he likened them, for instance, to clocks and mills,[24] which also obviously consist of specified component parts which contribute to an overall function in each case. Alberts highlights the integrated functionality of biological machines, saying, "these protein assemblies contain highly coordinated moving parts." They are complex: "Within each protein assembly, intermolecular collisions are not only restricted to a small set of possibilities," and simultaneously they are specified: "reaction C depends on reaction B, which in turn depends on reaction A."[25] From Alberts' point of view, this integrated functionality permeating the cell, which mimics the same feature in humanly-built machines with which humans are familiar, justifies calling "the large protein assemblies that underlie

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[22]Piccolino, "Biological Machines," 151-52.

[23]Bruce Alberts, "The Cell as a Collection of Protein Machines: Preparing the Next Generation of Molecular Biologists," *Cell* 92, no. 3 (February 6, 1998): 291.

[24]Malpighi, quoted in Piccollino, "Biological Machines," 149.

[25]Alberts, "The Cell," 291. Alberts implies that speed and elegance would suffer if "individual components [involved in DNA replication] . . . acted . . . in an uncoordinated manner." Ibid., 292.

cell function protein *machines*. (emphasis mine)"[26]

Specified structural dependency. While Malpighi claimed long ago that the specified situation and shaping of the minute parts of the numerous machines within organisms were crucial to their "marvelous operations," the importance of the feature of structural dependence has been more recently amplified by the discoveries of twentieth-century biochemists and molecular biologists.[27] Alberts claims it is now universally acknowledged that "conformational changes" (changes in structural shape) allow complexes of proteins to assemble which produce "a high degree of order in the cell."[28] Piccolino asserts that "The idea now is that 'structure' is fundamental to the operation of modern molecular devices." He presents three general examples of where structural dependency manifests itself: "the three-dimensional arrangement of individual molecules; the spatial arrangement of proteins in sequential operations; and the arrangement of different proteins in a given process with respect to the membranes" of intracellular organelles or of the cell itself. It seems that for Piccolino, due to this prevalent structural dependency, "modern biological pathways fully deserve the names 'molecular and supramolecular machines'."[29]

Structure is important to the orderly and successful operations of life, both

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[26]Alberts, "The Cell," 292.

[27]Piccolino, "Biological Machines," 151.

[28]Alberts, "The Cell," 291.

[29]Piccolino, "Biological Machines," 152; Piccolino never uses the word "analogy" in his article. He calls Malpighi's example of the clock and the mill a 'metaphor.' However, Malpighi's direct quotes make clear that he regarded body components not as metaphorical, but actual machines. In this quote, Piccolino himself seems not to view the similarity between the two as merely metaphorical, but isomorphic.

within cells and outside them, and this importance reminds some of humanly-designed structural systems. Goodsell remarks,

> Cells are inventive architects. Using only invisibly small building blocks, cells fabricate tough fibers of protein, providing flexible strength to tendons and cartilage. By embedding mineral crystals in these fibers, cells build bones and teeth–stony structures strong enough to last millions of years. . . . A dense scaffold of protein supports and directs the convoluted inner world of each cell. To build these elaborate structures, some thousands of times larger than an individual cell, one can find examples of any engineering principles in use today. Fences are built, railways are laid, reservoirs are filled, and houses are constructed complete with rooms, doors, windows, and even decorated in attractive colors. Lap joints, buttresses, waterproofing, reinforcing rods, valves, concrete, adhesive–each has a molecular counterpart.[30]

Information flux. Regarding one fundamental feature, biologists have needed to enhance the machine analogy and improve upon Malpighi's merely mechanistic model. They have needed to account for the role which information plays in and between the machines which function in the cell. For example, Piccolino points out that biologists now know that biological information flows within cells, as specific messengers carry the information and influence other systems which recognize the messengers and respond in specifically developed ways. He notes, "Through this complex flux of information, different mechanisms can be organized in more complex systems, resulting in highly integrated and efficient processes."[31] Furthermore, mechanisms within the cell act to minimize errors as this information is copied, and these safeguards ensure a level of

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[30]David S. Goodsell, *Our Molecular Nature: The Body's Motors, Machines and Messages* (New York: Springer-Verlag, 1996), 81.

[31]Piccolino, "Biological Machines," 152; Piccolino's frequent use of both the words "specific" and "complex" highlights what intelligent design proponents have targeted as the most reliable indicator of design in both human and biological contexts–specified complexity. Apparently, complex, specified informational flux is often manifested in regulatory processes in the cell. Piccolino, "Biological Machines," 151, 152.

accuracy “far better than any information system in our computerized world.”[32] In Malpighi’s more primitive analogy, biological machine components were thought to be “cords, filaments, beams, levers, tissues, fluids coursing here and there . . .”[33] His analogy did not foresee the information-rich feedback, regulatory and control processes, now increasingly seen in cellular protein interactions.[34]

The growing appreciation of the importance of integrated functionality, structural dependence and information flux within the cell’s protein assemblies not only seems to confirm the empirical, scientific accuracy of Malpighi’s incipient analogy, but to improve and extend it to higher levels of isomorphic structure.[35] This enhanced analogy is also continuing to prove useful for advancing scientific understanding of the cell, its parts and their interactions and influences. Are there ways by which proponents of the design hypothesis can hone the traditional organism-machine analogy to highlight its enhancements emerging from better and better understanding of the cell and its complex, specified components and processes?

Given the more-recently observed feature of informational flux, perhaps a better term from the realm of human designs through which to map an analogy with biological organisms is “device” rather than “machine.”[36] For example, the global

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[32]Goodsell, *Our Molecular Nature,* 41-42.

[33]Malpighi, quoted in Piccolino, “Biological Machines,” 152.

[34]Piccolino, “Biological Machines,” 152.

[35]Alberts tacitly acknowledges close isomorphism between humanly-designed machines and those in the cell when he suggests that certain engineering methodologies will be fruitful when applied to “the protein machines that underlie the workings of all living things.” Alberts, “The Cell,” 291-92.

[36]Perhaps even “*smart* devices” in some cases. Alberts calls protein assemblies “remarkable devices.” Alberts, “The Cell,” 291.

positioning systems (GPS) people frequently use in their cars, while certainly qualifying as "machines," also possess the same features increasingly observed in living cells: a flux of "information … carried by specific messengers, which act on systems that recognize them and develop specific responses."[37] A GPS is a device–or perhaps more accurately an interactive set of devices (since the unit in the car interacts with a network of satellites)[38]–which isomorphically shares complex, specified features with biological components of cells: including integrated functionality, structural dependence, and informational flux. Not only do cells and designed devices share these three features, the features seem to be at least somewhat inter-dependent.

Device analogies yield induction and likelihood. Even if an analogy from cellular protein complexes to devices is more isomorphic than one to machines in general, how is such an enhanced analogy relevant to Sober's dismissal of intelligent design as a scientific hypothesis? First, while molecular machines and designed devices vary in material makeup and gross number of components, an analogy between them is isomorphic in the kinds of features which matter most: higher-order relations. Furthermore, if the differences in material makeup and gross number of shared components do not affect the isomorphic features, perhaps designed devices qualify as candidates for the continuum (a bridge principle) between artifacts and organisms which Sober requires as support for an inductive design argument.

Some might complain that at first glance, a GPS is not a very convincing

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[37]Piccolino, "Biological Machines," 152.

[38]Garmin, "What is GPS?" http://www8.garmin.com/aboutGPS/ (accessed October 9, 2013).

intermediate between an artifact and an organism. However, it certainly is a much more isomorphic intermediate than any machine which Hume or even Malpighi put forward. Moreover, an intelligent design proponent could likewise challenge a neo-Darwinist to supply support for why cases of unconscious selection which Darwin put forward, or hypothetical examples of combination locks serve as convincing intermediates between the small-scale, intra-species changes effected by domestic breeding and the large-scale, macroevolutionary changes in biological history which (as chapter 4 above discussed) increasingly seem to require causal mechanisms quite distinct from those of microevolutionary processes. Additionally, recall from chapter 5 that lower-order, or superficial differences between analogues, even if great in quantity and quality, are usually quite irrelevant to analogical reliability when the two analogues share higher-order isomorphisms.

Applying a more conceptually useful version of Hume's standards, the more isomorphic the higher-order features of the analogy are, the more reliable the analogy is, and the more reliably one can infer isomorphic or at least highly-similar causation in the target analogue. Since key higher order features of proteins within the cell have been found to be so isomorphic to machines as to be labeled as such, and are increasingly being found to be isomorphic to intelligently-designed smart devices, independent support exists for a scientific inference to a common cause of them both: intelligent design.

As mentioned above, this paper presents two broad strategies, both utilizing analogy, to affirm intelligent design as a scientific hypothesis in spite of Sober's case presented against it in *Evidence*. Given the isomorphic analogy between intra-cellular machines and humanly- designed devices, one can first argue that if the features point to design as a common cause, it is reasonable also to infer by analogy that there is at least a non-zero likelihood that the designers in both analogues share highly similar tendencies in terms of goals and abilities: they both are generally motivated and able to produce things with high levels of specified complexity (in comparison to non-intelligent beings or forces which empirical experience shows not to possess such goal-directedness and ability). Thus, Sober's requirement for independent support for an assessable level of the requisite designer goals and abilities has been met.

Second, one can also argue that because molecular machines and humanly-designed devices are analogous entities, isomorphic in their key features, they lie on a continuum between the general category of organisms and the general category of artifacts, and their differences don't matter because their key (higher-level) shared features aren't affected by those differences. This line of argument thus supplies a very large inductive sample size from which to infer common causation: intelligent design.

Molecular Machines Specific

Kinesin intracellular transport assembly. Kinesins are a family of highly similar intracellular transport assemblies within cells. They transport cellular cargoes (vesicles and organelles)[39] uni-directionally[40] along "paths . . . similar to rail systems,"[41]

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[39]Sharyn A. Endow, "Kinesin Motors as Molecular Machines," *BioEssays* 25, no. 12 (December 2003): 1212.

[40]Melanie Brunnbauer et al., "Regulation of a Heterodimeric Kinesin-2 through an Unprocessive Motor Domain that is Turned Processive by its Partner," *Proceedings of the National Academy of Sciences*,107, no. 23 (June 8, 2010): 10460.

[41]Roop Mallik and Steven P. Gross, "Molecular Motors: Strategies to Get Along," *Current Biology* 14, no. 22 (November 23, 2004): R971.

called microtubules. A most striking feature of the kinesin assembly is its two protein ‘heads” which act like feet, literally walking along the microtubule by alternately binding and unbinding its heads,[42] all the while pulling the cargo.[43] This motors’ movement is powered by ATP hydrolysis.[44] Mallik calls the kinesin transporter “robust and highly efficient,” while noting a somewhat limited regulatory capacity.[45] Kinesin assemblies are widespread among biological organisms, appearing in all eukaryotes.[46] All versions of the kinesin assembly seem to possess the features discussed above which are isomorphic with all machine systems, both humanly and organically derived: integrated functionality, structural dependency and information flux.[47]

Relevant to integrated functionality, Endow describes the kinesin system as an assembly of several components. One component consists of a two-part “tail” which connects to the cargo being towed. Another set of components includes a slender central chain consisting of two coiled strands which then connects to the “head” domain which includes the two motor units (analogous to feet) which do the walking along the microtubule. Additionally, there are two components which allow the tail to bind (and

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[42]Mallik and Gross, “Molecular Motors,” R971; Endow, “Kinesin Motors,” 1212.

[43]S. J. Green, J. Bath, and A. J. Turberfield, “Coordinated Chemomechanical Cycles: A Mechanism for Autonomous Molecular Motion,” *Physical Review Letters* 101, no. 238101 (December 5, 2008): 238101-1; Arne Gennerich and Ronald D. Vale, “Walking the Walk: How Kinesin and Dynein Coordinate their Steps,” *Current Opinion in Cell Biology* 21, no. 1 (February 2009): 59.

[44]Green, Bath and Turberfield, “Chemomechanical Cycles,” 1; Endow, “Kinesin Motors,” 1212, 13; Gennerich and Vale, “Walking the Walk,” 59; Mallik and Gross, “Molecular Motors,” R971.

[45]Mallik and Gross, “Molecular Motors,” R971.

[46]Endow, “Kinesin Motors,” 1212.

[47]Endow highlights one way kinesin motors differ. They convert energy from ATP “without undergoing an intermediate heat or electrical conversion step, as do man-made machines.” Endow, “Kinesin Motors,” 1213.

unbind) with the cargo load.[48]

According to Mallik and Gross, *processive* molecular motors (ones that directionally change their locations within the cell) like the kinesin assemblies, all perform sub-operations, which may include "ATP hydrolysis, conformational change, filament binding, hydrolysis product release and so forth." Whichever set of these sub-operations a molecular motor performs, each sub-operation has its own individual function. Yet these sub-operations produce "mechanical events that generate processive motion."[49] The collection of each sub-operation's sub-function thus produces the larger function of processive motion. In the case of kinesin assemblies, processive motion, in conjunction with attachment to a molecular cargo, results in intracellular transportation, the ultimate function of the kinesin assembly.

Mallik and Gross admit that determining exactly how the sub-operations link to the mechanical events which cause processive motion is "a formidable problem," which has generated "considerable scientific debate."[50] There is little doubt that further scientific research will help unveil how the sub-operations drive the mechanisms in these machines. However, the component of intelligent agency, so necessary for producing the integrated functionality in the humanly-designed counterparts to these machines, is another component researchers need to consider. This is especially true since they apparently use background knowledge of kinetic and structural features in human machines (i.e., they too are very aware of isomorphic analogies) to uncover the

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[48]Endow, "Kinesin Motors," 1212.

[49]Mallik and Gross, "Molecular Motors," R973.

[50]Ibid. Perhaps this is a formidable problem because mainstream biologists are methodologically required to present strictly naturalistic (e.g., neo-Darwinian) explanations.

mechanisms in molecular machines.

Amidst the debate about the exact mechanical events within the kinesin assembly, Endow proposes "a schematic model" for the motor domain (i.e., the two walking "heads"). She suggests that it consists of

> binding sites for its filament and nucleotide with a spring to enable the protein to change in conformation and to produce force upon recoil to its original position, a lever to amplify the force-producing conformational changes, a hinge to allow the lever to move, and a latch to regulate nucleotide binding or release of hydrolysis products.[51]

Thus, according to Endow's schematic model it seems that in addition to "binding sites for its filament and nucleotide, there are at least four distinct components in the motor (which are likely common to many humanly-designed machines): a spring, a lever, a hinge and a latch. It is apparent that all four components must integrate their individual functions in order to achieve the motor function.[52]

An obvious and related instance of integrated functionality in the kinesin assembly is the ability of the two "heads" to collectively generate a coordinated forward walking motion. The steps in this walk must alternate, which "requires tight coupling between the biochemical cycles of both heads" so that at least one head remains attached to the microtubule road at any given time.[53] According to Gennerich and Vale, proper

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[51]Endow, "Kinesin Motors," 1215.

[52]Under a neo-Darwinian hypothesis, co-option ('exaptation') and/or scaffolding must be posited for a one-at-a-time accumulation of these ultimately-integrated components. See Kenneth Miller, "The Flagellum Unspun: The Collapse of 'Irreducible Complexity,'" in *Debating Design*, ed. William A. Dembski and Michael Ruse (New York: Cambridge University Press, 2004), 85-87; Ernst Mayr, "The Emergence of Evolutionary Novelties," in *Evolution and the Diversity of Life: Selected Essays* (Cambridge, MA: Harvard University Press, 1976), 97-100; A. G. Cairns-Smith, *Genetic Takeover and the Mineral Origins of Life* (Cambridge: Cambridge University Press, 1982), 93-99; Robert T. Pennock, *Tower of Babel: The Evidence Against the New Creationism* (Cambridge, MA: MIT Press, 2000), 267-70.

[53]Gennerich and Vale, "Walking the Walk," 59.

coupling implies the presence of a gating mechanism which "requires that one motor domain can influence the action of its partner."[54]

Interestingly, the two motor heads of the kinesin assembly are not completely identical, and the asymmetry between those heads (what Brunnbauer et al call the KLP11 and KLP20 subunits) actually adds to the kinesin assembly's efficiency and effectiveness of function: "the wild-type KLP11/KLP20 protein combines two kinetic traits: an autoregulated but unprocessive KLP11 subunit and an unregulated but processive KLP20 subunit that come together to yield an autoregulated and processive motor protein."[55] The paragraph below on structural dependence clarifies how autoregulation helps the kinesin transport system.

Kinesin assemblies also exhibit significant structural dependence. For example, Mallik and Gross assert that at least in the case of the motor domains of kinesin and myosin, similar changes in structural conformation will lead to similar functional changes,[56] meaning that for those two types of motors, structure strongly affects function. Moreover, other subunits within such motors apparently amplify such structural changes, causing the assembly to processively move: "For kinesin-1, it has been suggested that structural changes in the neck-linker, a region that links the conserved motor domain to coiled-coil stalk, serves to amplify ATP-hydrolysis-induced conformational changes into mechanical motion."[57] Similarly, Gennerich and Vale suggest a model where those neck-

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[54]Gennerich and Vale, "Walking the Walk," 60.

[55]Brunnbauer et al., "Regulation," 10465.

[56]Mallik and Gross, "Molecular Motors," 973.

[57]Mallik and Gross, "Molecular Motors," 973. See also Gennerich and Vale, "Walking the Walk," 59.

linkers, acting as "control levers," produce structural conformation (specifically, the orientation of the "heads") which cause the alternating stepping motion to remain out-of phase, i.e., coordinated.[58] From certain experimental evidence, they conclude that "the structural elements that interconnect the two motor domains (neck linkers for kinesin . . .) are crucial for head–head coordination. These structural elements are under tension in case of kinesin, allowing a very tight coupling between ATP hydrolysis and forward stepping."[59]

The kinesin assembly includes an autoregulatory function. A change in its structural conformation acts as an "on-off switch" for the motor domain: "For kinesin-1 not bound to cargo, the motor's globular 'tail' domain can fold back onto the head in such a manner that the ATPase activity is blocked."[60] This "autoinhibitory folding" is used "to prevent futile ATP hydrolysis. . . . [but] is thought to be relieved when the tail domain of the motor binds to its cargo."[61] In other words, this on-off switching feature causes the assembly to walk when a cargo is attached, but prevents the assembly from moving when the cargo has yet to be loaded. Not only does this regulatory function make cargo loading more efficient, it also acts as an energy-saving device by inhibiting the use of ATP when it is not needed. This important feature is thus another example of structural dependence, in this case upon the folding action of the tail in conjunction with the connection (or lack thereof) with the cargo.

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[58]Gennerich and Vale, "Walking the Walk," 64.

[59]Ibid., 64-65.

[60]Mallik and Gross, "Molecular Motors," R977.

[61]Brunnbauer et al., "Regulation," 10461.

Endow proposes that structure-related properties of the elements within kinesin motor assemblies are important to function, saying that those elements "are likely to have spring-like or elastic properties that allow them to extend or rotate, then recoil back into their original conformation."[62] The role of structure seems so important that Endow encourages "motors researchers . . . to identify the spring-like or elastic elements of the motor, the force-producing conformational changes, and the steps in the hydrolysis cycle at which they occur."[63] One wonders if experts in humanly-designed motors (e.g., mechanical engineers) could prove useful in this endeavor, because what Endow is urging sounds similar to reverse engineering. If so, analogical inferences to intelligent molecular motor design therefore seem reasonable to pursue. Concisely summing up the overall operation of the kinesin motor, Endow says that ATP processing causes conformational changes in the protein structure "that, under load, create strain. The strain drives movement of the load, and the movement . . . relieves the strain."[64] This explanation, as well as those concerning the autoregulatory on-off switch, are entirely mechanistic. However, for real machines–which kinesin assemblies seem to be–complex, specified information is also needed to ensure the precisely right kinds of structural changes, strains, movements and subsequent release of strains which will result in the entire assembly of kinesin components reliably accomplishing attachment, transportation and final delivery of loads to the destinations where they are needed, while also saving energy when loads are not attached.

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[62]Endow, "Kinesin Motors," 1215.

[63]Ibid.

[64]Ibid., 1231.

The kinesin transport assembly also shows evidence of information flux. One of the clearest indicators of such flux is the repeated claim in the research literature that components of the kinesin assembly frequently require "coordination." Mavroidis and his team say, "coordinated hydrolysis of ATP in the two motor heads is the key to the kinesin processivity."[65] Mallik and Gross claim that an important factor in the assembly's processivity "is coordination between the two heads of the motor. . . . to ensure that both heads do not detach at the same time."[66] Gennerich and Vale assert that kinesin processivity "requires head–head coordination" in order to keep the heads from detaching from the microtubule too early, as well as to avoid wasting ATP energy.[67] For Gennerich and Vale this coordination seems to clearly indicate information flux, since they suggest further research to identify "The molecular basis by which one motor domain might 'sense' and respond to the nucleotide/ conformational state of its identical partner."[68] They elsewhere even use the word "communicate" to represent the interaction between the motor domains.[69]

Information flux could happen through changes in tension (or the conformational strain produced by tension). The variations in tension could provide ongoing regulation or feedback between components within the kinesin assembly. "Motor domains . . . might influence each other without being in direct contact. . . [for

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[65]C. Mavroidis, A. Dubey, and M. L. Yarmush, "Molecular Machines," abstract, *Annual Review of Biomedical Engineering* 6 (2004): 371.

[66]Mallik and Gross, "Molecular Motors," R977.

[67]Gennerich and Vale, "Walking the Walk," 59.

[68]Ibid., 59, 63.

[69]Ibid., 61.

instance, via] intramolecular tension."[70] Brunnbauer may be alluding to a process similar to this as she mentions what she calls "a strain-dependent communication."[71] Gennerich and Vale suggest that "the dimensions and flexibility of the neck linkers are key to tension sensing."[72] Such tension sensing "could facilitate communication" through what they term a 'polymer gate' which enables the two heads to sense changes in tension between them and respond accordingly.[73] While they admit that "deciphering the exact mechanism(s) remains a challenge for the future,"[74] whatever mechanism turns out to be right, it will likely manifest even more complexity and specificity than is already evident.

Besides focusing on individual intracellular transport motor assemblies, Mallik and Gross also discuss the issue of how groups of such assemblies collectively interact and influence broader levels of cellular, extra-cellular and even macroscopic biological operations. In their discussion, one can recognize further examples of the intertwining of integrated functionality, specified structural dependence and information flux. For example, regarding the transport along microtubules, Mallik and Gross comment, "Motor proteins are able to recognize [*information flux*] the microtubule polarity, and so the organization of the rails [*structural dependence*] combined with the specific motor employed determines the direction of transport [*integrated functionality*]."[75]

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[70]Gennerich and Vale, "Walking the Walk," 61.

[71]Brunnbauer et al., "Regulation," 10460.

[72]Gennerich and Vale, "Walking the Walk," 62.

[73]Ibid., 63. This polymer gate, like other gating mechanisms Gennerich and Vale suggest are not literal gates, but seem more akin to switching or signaling mechanisms.

[74]Ibid., 65.

[75]Mallik and Gross, "Molecular Motors," R971.

Beyond the individual motion of the various molecular motor assemblies (including kinesin), Mallik and Gross call attention to the larger system of transport tracks within the cell. Besides the microtubules, there are also actin filaments. Being shorter than the microtubules, actin filaments "have been suggested to bridge the gap between microtubules. . . . In this way, local transport can occur on actin filaments in regions where there are few microtubules."[76] Deeper within the cells the actin network is more randomly oriented and thus is dense enough to "make it a good local transport system."[77] Mallik and Gross conclude, "This random distribution of actin filaments can be used to spread out cargos, enabling the cell to achieve a more uniform distribution of cargos than would be possible by moving on microtubules alone."[78] Thus, there can be "a functional collaboration" between the actin and microtubule networks.[79] These descriptions thus are reminiscent of the broad networks of freeways and local roads, and the functional collaboration between them, with which people are familiar at the human level of cargo transportation.

The different kinds of molecular transport assemblies (kinesin, dynein and myosin) seem to have differing motor strengths, processivity, polarity, as well as the choice of track (actin or microtubule) on which they move.[80] These differences may prove useful for the overall transportation scheme of the cell: "there have been

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[76]Mallik and Gross, "Molecular Motors," R971.

[77]Ibid.

[78]Ibid.

[79]Ibid., R972.

[80]Ibid., R978.

suggestions that motors associated with each network coordinate to achieve the requisite subcellular distribution of cargo. . . . At a global level, therefore, the intracellular transport machinery appears to regulate the relative activity of different classes of motors."[81] In fact, different classes of motor assembly often coordinate by relaying the same cargo between them.[82] Again, these interactions seem reminiscent of humanly-managed distribution systems. Because of the differences between motor types, Mallik and Gross ask how the cell so successfully usually avoids traffic jams on the microtubule. Awareness of problems common to cargo distribution systems at the human level might also motivate that question. They admit no definitive answer exists yet, but they suggest generally that "Motor function and architecture may be adapted to avoid this."[83]

Mallik and Gross analogically encapsulate the higher, coordinated features of the cell's transport system: "Cells are organized with different compartments — the nucleus, the Golgi complex, the endoplasmic reticulum, and so on — that act as factories. Each factory generates a unique set of products, which are then distributed to 'consumers', which could be either end-users or other factories."[84] Yet Mallik and Gross go further, inquiring how ensembles of motors might interact, facilitating functional motion at intermediate and macro biological levels: "we need to clarify the function of small ensembles, where a few motors, possibly of different families, work together."[85]

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[81]Mallik and Gross, "Molecular Motors," R972.

[82]Ibid.

[83]Ibid., R979.

[84]Ibid., R971.

[85]Ibid., R979.

They ask whether there might be “a regulatory mechanism operative at a higher level of control.”[86] At the most general level, they ask,

> How does cellular organization on a global scale arise out of the seemingly chaotic motion of single motors? How is work done at the nanoscale manifested at a macroscopic level? We believe that these issues go beyond the field of molecular motors, and are relevant to biological structure in general.[87]

Clear answers about such higher-level influences and interactions are currently not available. However, since there obviously are higher levels of biological organization, research will almost certainly reveal higher levels in biology of integrated functionality, specified structural dependence and information flux. These three features analogically manifest themselves at various levels in the sectors of human society where aggregates of machines are crucially involved, such as assembly lines, factories, cities and even continental transportation networks.

An interesting, highly isomorphic, albeit archaic, analogue to the operations of the kinesin transport assembly comes from the realm of human transportation systems: horse-drawn canal barges used prior to their eclipse by railroads.[88] In the old canal barge system, barges are tethered by long ropes to the pulling motive force, namely, horses or mules that walk on a road along the bank of the canal, towing the load of the barge down the canal. In the case of kinesin motors, the large load () is tethered to an analogous pulling motive force, in this case the kinesin motor assembly, which, like a horse, literally walks down a microtubule, analogous to a road, towing the large cargo behind it.

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[86]Mallik and Gross, “Molecular Motors,” R979

[87]Ibid.

[88]Dick Hazelwood, “Brief History of Express Canal Boats,” Heriot-Watt University, under “Solitons Home Page, http://www.ma.hw.ac.uk/solitons/HISTORY_OF_EXPRESS_CANAL_BOATS.pdf (accessed October 27, 2013).

The horse-drawn canal barge towing system is unquestionably both designed and controlled by intelligent agency (for instance, old pictures of barge-towing will often show both a person driving the horse team on the shore, and a person on the back of the barge handling a tiller). The barge, the horses' harnesses, the road and the towing rope, as well as the team driver and the barge captain, all crucial components of the system, are functionally integrated. There is structural dependency as well: the horses harnesses, the rope, the connection of the rope to the barge and the road beside the canal, have physical design tolerance limits inherent in their shape, size, and mutual orientation. Lastly, there is informational flux in the barge system. Unquestionably, the horse-team driver and the barge captain needed to communicate with each other frequently in order to make important adjustments due to weather, canal barriers or bridges, problems with the road, fatigue in the horses, etc. in order to ultimately bring the contents of the barge safely to its targeted destination. In highly analogous ways, the kinesin motor system depends upon its integrated functionality, structural dependence and informational flux to bring its cargoes safely to its cellular destination.

These two highly analogous systems, which contain isomorophisms at higher order levels, deserve serious consideration as products of an isomorphic cause, namely intelligent design. The kinesin transport assembly and the horse-drawn canal barge system could be seem as intermediates on the continuum between artifacts and organisms which Sober says are required in order to make a reasonable inductive argument. The analogy between the two systems also supplies independent support, via a close analogy, for drawing an assessable likelihood for a hypothesis of design as the cause of the kinesin assembly.

RNA/DNA polymerase. As discussed above, integrated functionality, structural dependence and information flux are all complex and specified general features manifested in both molecular and humanly-designed devices. Polymerases (protein assemblies which either replicate or transcribe DNA) display those three general features. For example, RNA polymerase displays integrated functionality, as Gelles and Landick remark: "All cellular RNAPs, whether bacterial or eukaryotic, are homologous multisubunit enzymes . . . that execute a remarkable series of choreographed movements while transcribing DNA."[89]

Regarding structural dependence, on a general level, the distinct functions of the vast array of proteins are usually dependent upon their three-dimensional form.[90] More specifically, structural dependence also characterizes polymerase assembly and operations. For example, the placement of a sliding clamp around a strand of DNA by a clamp loader is a crucial element in the larger DNA replication process, according to Turner, Hingorani, Kelman and O'Donnell. Their research indicates that there must be the right structural fit, as well as the right kinds and timing of structural (or conformational) changes resulting from the interactions between the sliding clamp and clamp loader proteins, as well as the DNA strand itself.[91]

Furthermore, both DNA and RNA polymerases display information flux. For example, the operations of RNA polymerase are often affected or regulated by

[89]Jeff Gelles and Robert Landick, "RNA Polymerase as a Molecular Motor," *Cell* 93, no. 1 (April 3, 1998): 13.

[90]Meyer, *Signature,* 96; Meyer, *Darwin's Doubt*, 189-91.

[91]Jennifer Turner et al., "The Internal Workings of a DNA Polymerase Clamp-loading Machine," *The European Molecular Biology Organization Journal* 18, no.3 (1999): 771–83; perhaps somewhat analogous to the structural dependence of installing a clamp around a hose with a set of pliers.

extracellular signaling. Drygin, Rice, and Grummt comment,

> The RNA polymerase I (Pol I) transcription machinery . . . collects and integrates a vast array of information from cellular signaling cascades to regulate ribosome production. . . .
>
> Transcription of rRNA genes is efficiently regulated to be responsive to both general metabolism and specific environmental challenges.[92]

During DNA replication, information flux between components of the DNA polymerase system is vital as well, since the processing of both the leading and lagging strands of the DNA strand being replicated must happen at a coordinated pace to avoid what Baker and Bell call, "disastrous consequences."[93]

Interestingly, there are analogies in the higher order features of integrated functionality, structural dependence and information flux between DNA and RNA polymerases and teleprinter machines (e.g., Teletype, Telex, etc.) popular in the first several decades of the twentieth century. Some early forerunners of these machines allowed the operator to key in a message using letters and numbers, which was then converted into a coded system of holes punched into paper tape. Teletype developers invented mechanical readers which could read the coded paper message and then transmit that message over telegraph (and later telephone) lines. This process would then produce either the original alphabetic messages or identically coded paper tape at the receiving end.[94] The teleprinters could send the message, in either typed letters or punched code, to

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[92]Denis Drygin, William G. Rice, and Ingrid Grummt, "The RNA Polymerase I Transcription Machinery: An Emerging Target for the Treatment of Cancer," *Annual Review of Pharmacology and Toxicology* 50 (2010): 131, 134.

[93]Tania A. Baker and Stephen P. Bell, "Polymerases and the Replisome: Machines within Machines," *Cell* 92, no. 3 (February 6, 1998): 300.

[94]Anton A. Huurdeman, *The Worldwide History of Telecommunications* (Hoboken, NJ: Wiley and Sons, 2003), 301-3, http://books.google.com/books?id=SnjGRDVIUL4C&pg=PA302#v=onepage &q&f=true (accessed October 15, 2013).

a number of locations simultaneously, thus producing multiple, identical copies.[95] In the 1930's telecommunications companies, such as AT&T introduced relay stations where electro-mechanical readers could output the coded messages which workers (and later other machines) could then pass on to various other locations.[96]

One of the higher order features and relations which the DNA and RNA polymerases share with a teletype machine is the processing of coded messages arranged in long, order-dependent chains (i.e., complex, specified information).[97] In both cases, the messages are highly meaningful. In both cases the machines' function is to reproduce (one or more) transcribed copies of the original message. In order to accomplish this function, both a polymerase and a teletype machine have the ability to "read" the code, the ability to produce and multiply copies with a high degree of accuracy, and the ability to produce those copies at high speed. In both the analogues, separate, but integrated sub-functions of a large number of specialized component parts all contribute to the reliable achievement of the complex's ultimate function. Baker and Bell illustrate the integration, the speed and the accuracy of the DNA polymerase:

> Synthesis of all genomic DNA involves the highly coordinated action of multiple polypeptides. These proteins assemble two new DNA chains at a remarkable pace approaching 1000 nucleotides (nt) per second in E. coli. If the DNA duplex were

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[95]Charles F. Marvin, "Communications and Weather Service for Airways," in *Standards Yearbook, 1932*, Bureau of Standards (Washington, DC: United States Government Printing Office, 1932), 6, http://books.google.com/books?id=zNYqAQAAIAAJ&pg=PA5#v=onepage &q&f=false (accessed October 15, 2013); Huurdeman, *Worldwide History*, 302; Teletype Corporation, *The Teletype Story* (1958), 9, 16, http://www.samhallas.co.uk/repository/telegraph/teletype_story.pdf (accessed October 15, 2013).

[96]Teletype Corporation, *The Teletype Story*, 16-17.

[97]Meyer, *Signature*, 12-23, 100-110, 122-27, 197-213. Meyer uses the more contemporary analogy of a fax machine. He notes that while the medium changes (the paper at the sending end is physically distinct from the paper at the receiving end), the message (the information) remains the same. Ibid., 15.

> 1m in diameter, then the following statements would roughly describe E. coli replication. The fork would move at approximately 600 km/hr (375 mph). . . . Replicating the E. coli genome would be a 40 min, 400 km (250 mile) trip for two such machines, which would, on average make an error only once every 170km (106 miles).[98]

In both analogues, there is integrated functionality caused by close coordination of finely-tuned component parts, there is structural dependency (if the structural apparatus is not the right shape and composition, the machine fails at its function)[99], and there is informational flux (in the case of the teletype, this is induced largely by the initial human typist). Given closely aligned determining structures (arguably close to being isomorphic in some crucial higher order relations), since intelligent agency is responsible for the conception, design and construction of the teletype system, by analogy it is not unreasonable likewise to infer intelligent agency as responsible for the conception, design and construction of the RNA polymerase. Moreover, it is especially reasonable, even compelling, to infer intelligent agency as responsible for the origin of the complex, specified information which it is the function of both systems to transcribe. Teleprinter machines also manifested the additional ability to translate (translating from typed English words and sentences to the machine code in the hole-punched paper, and then back again). In the cell, an isomorphic translation function is carried out by a separate machine, the ribosome.

Some might protest to the use of teleprinter technology as an analogy to the

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[98]Baker and Bell, "Polymerases," 295.

[99]Structural dependence in the teleprinter systems went beyond the machines themselves, as even the parameters of the coded paper-tape were crucial, as evidenced by stringent standards required for the dimensions of the paper, the size and placement of the holes, etc. See European Computer Manufacturers Association, "ECMA Standard for Data Interchange on Punched Tape," November 1965, Joseph Myers, http://www.polyomino.org.uk/computer/ECMA-10/ (accessed October 15, 2013).

RNA polymerase on the grounds that teleprinters are archaic, usurped by computer systems and the internet. How intelligent could the purported RNA polymerase designer be if the "best" human technology one can liken it to is the outmoded teleprinter? It is important to remember that teleprinters were the cutting edge of communications technology in their day, enabling messages to be distributed with historically unprecedented speed, accuracy and scope. Great minds such as Charles and Howard Krum, Ernst Kleinschmidt (who obtained 188 patents during his lifetime), Frederick Creed, and Donald Murray worked individually and collectively to produce or improve these devices, and numerous patents were granted along the way.[100] Teleprinters became essential to news providers (e.g., the Associated Press and the British Press Association) as well as to railways, and later to business and industry[101] (e.g., the oil industry, the stock market), the military, weather reporting, emergency response and law enforcement.[102]

Because a biological entity like the RNA polymerase is strongly analogous to an antiquated human technology does not take away from a broader point much more central to the consideration of intelligent design as a scientific hypothesis, namely that both analogues possess extremely high levels of specified, complex information (manifested in the ways described above). Independent support exists for highly intelligent design as a hypothesized cause to make these features of both analogues likely. At the same time, one can reasonably present the RNA polymerase and the teleprinter

[100]Huurdeman, *Worldwide History*, 303-4.

[101]Ibid., 302-4.

[102]Teletype Corporation, *The Teletype Story*, 19-28.

system as elements along the kind of continuum which Sober is seeking between organisms and artifacts. Thus, on both likelihood and inductive grounds, analogy between RNA polymerase (along with many other molecular machines) and humanly designed devices like the teleprinter system helps support intelligent design as a scientific hypothesis, and whether human technology has surpassed the analogue given is immaterial to the central claim which the intelligent design hypothesis is making.[103]

ATP synthase. The ATP Synthase consists of two motors, one of which is embedded in the mitochondrial membrane. A proton gradient causes a ring of subunits in this motor to spin. This motor connects to a shaft at its center and imparts rotary motion to that shaft which extends up into a second large ring of subunits outside the surface of the membrane, but which is stably connected to the membrane by a stator. The interaction of this rotating central shaft and the stationary external ring causes ATP to be produced.[104] The direction of the ATP motor rotation can also be reversed, by "hydrolyzing ATP and utilizing the released energy to pump protons across the membrane."[105] One outstanding feature of the ATP synthase machine is that it is nearly ubiquitous in the biological kingdoms.[106] Another outstanding feature is that it is highly conserved (meaning that it has not changed significantly throughout biological

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[103]Intelligent design theory does not demand optimality before inferring design, Archaeologists and forensics experts regularly make justified inferences to intelligent design without demanding optimality.

[104]Aleksij Aksimentiev et al., "Insights into the Molecular Mechanism of Rotation in the F_0 Sector of ATP Synthase," *Biophysical Journal* 86, no. 3 (March 2004): 1332.

[105]Ibid.

[106]Ibid.; Robert K. Nakamoto , Joanne A. Baylis Scanlon, and Marwan K. Al-Shawi, "The Rotary Mechanism of the ATP Synthase," *Archives of Biochemistry and Biophysics* 476, no. 1 (August 1, 2008): 43.

history).[107]

An ATP synthase exhibits an integrated functionality highly isomorphic to a hydroelectric turbine generator. In both analogues, rotary motion, two motors, a central drive shaft and a stator, along with several subunits,[108] act in concert to convert potential energy to mechanical energy and then to a final, transportable energy form (a generator produces electrical energy, an ATP synthase produces ATP). As noted above, reversing the rotation direction changes the synthase's function from energy generation to proton pumping.[109] While a turbine generator is not normally reversible, another human machine, the outboard motor, operates much like a turbine in reverse, converting electrical energy into rotary mechanical energy, which moves water away rather than drawing it in. Since it seems unable to attain the functions above unless at least its major component parts are all present and in proper place,[110] the ATP synthase seems to be at least partially irreducible, as a turbine generator also is irreducibly dependent on its major functional components. Another structural biology team summarizes the system's integrated functionality: "the action of multiple parts is tightly coordinated to achieve coupling between ion current and ATP synthesis or hydrolysis."[111]

Like the hydroelectric generator, the ATP synthase also displays structural

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[107]Nakamoto, Baylis Scanlon, and Al-Shawi, "Rotary Mechanism," 1.

[108]Nakamoto, Baylis Scanlon, and Al-Shawi claim ATP synthase has "at least 22 subunits," Ibid., 2; See also Steven M. Block, "Real Engines of Creation," *Nature* 386, no. 6622 (March 20, 1997): 217; Holger Seelert et al., "Proton-Powered Turbine of a Plant Motor" *Nature* 405, no. 6785 (May 25, 2000): 418.

[109]Aksimentiev et al., "Insights," 1332.

[110]Nakamoto, Baylis Scanlon, and Al-Shawi, "Rotary Mechanism," 2-3.

[111]Armen Y. Mulkidjanian et al., "Inventing the Dynamo Machine: The Evolution of the F-type and V-type ATPases," *Nature Reviews: Microbiology* 5, no. 11 (November 2007): 892.

dependence. Part of what makes the embedded motor in synthase rotate is "a conformational change in the c-ring binding site upon contact with the stator charge in the a/c interface."[112] In addition, the rotor and stator domains are intrinsically highly stable, allowing the enzyme to maintain its integrity when operational. Indeed, in the human realm, motors seem to need an isomorphic stator to anchor them in order to perform work.[113] The tie between structure and function in the ATP synthase sometimes seems to raise the notion of design in the minds of some researchers:

> The structure found for the MF1 [the motor embedded in mitochondrial membrane] . . . dramatically supports rotational catalysis. The biological novelty of the mechanism and the interest it generated is indicated by the range of perspectives published about this finding. . . . The hydrophobic sleeve surrounding the C-terminus of the γ-subunit appears to be designed to allow rotation.[114]

Structure-related factors, namely, the right kinds and places of contact between subunits, as well as the right mix of stability and rotational motion, are critical to proper function in humanly-designed turbine generators as well. Isomorphic traits in the ATP synthase understandably appear designed as well.

Regarding information flux, Piccolino describes how in the ATP synthase rotary mechanism, "there are the regulatory actions based on information flux which, in this case, control the various phases of energetic metabolism culminating in ATP synthesis."[115] In his article "The ATP synthase – A Splendid Molecular Machine" Boyer

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[112]Christoph von Ballmoos, AlexanderWiedenmann, and Peter Dimroth, "Essentials for ATP Synthesis by F1F0 ATP Synthases," *The Annual Review of Biochemistry* 78 (2009): 655; See also Aksimentiev et al., 1332.

[113]Paul D. Boyer, "The ATP Synthase–A Splendid Molecular Machine," *Annual Review of Biochemistry* 66 (July 1997): 742.

[114]Ibid., 741.

[115]Piccolino, "Biological Machines," 152.

may be alluding to this kind of informationa flux when he points out "the importance of interactions between the β and γ subunits[,]"[116] as well as "between regions of the α and β subunits."[117] He also reports that nucleotide binding can affect signals from amino acids within the synthase.[118] In some hydroelectric turbine generators, information flux happens when a subunit called the Kaplan head adjusts blades on the turbine when water flow or power demands vary.[119]

Given these features, many molecular biologists have candidly likenined the ATP synthase to humanly-designed devices. Ballmoos says, "The F1F0 ATP synthase is a miniature engine composed of two opposing rotary motors."[120] Block says, "when the crystal structure of the F1-ATPase was eventually solved, it looked every bit like a three-piston rotary motor, with a hexagonal ring of α-β pairs surrounding a drive shaft made up of the γ-subunit."[121] Arechaga comments, "In recent years, structural information . . . strongly supports the proposal that the ATP synthase works as a rotary molecular motor."[122] Other examples of such anological comparisons could be multiplied.[123]

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[116]Boyer, "ATP Synthase," 739.

[117]Ibid.

[118]Ibid.

[119]"Inside a Hydropower Generator," The Foundation for Water Energy and Education, http://fwee.org/nw-hydro-tours/generator-tour/ (accessed October 3, 2013).

[120]von Ballmoos, Wiedenmann, and Dimroth, "Essentials," 650.

[121]Block, "Real Engines," 218.

[122]Ignacio Arechaga and Phil C. Jones, "The Rotor in the Membrane of the ATP Synthase and Relatives," abstract, *Federation of European Biochemical Societies Letters* 494, nos. 1-2 (April 6, 2001): 1.

[123]E.g., Daniela Stock, Andrew G. W. Leslie, and John E. Walker, "Molecular Architecture of the Rotary Motor in ATP Synthase," *Science* 286, no. 5445 (1999): 1700, 1704; Nakamoto, Baylis Scanlon, and Al-Shawi, "Rotary Mechanism," 1; Aksimentiev et al., "Insights," 1332; Boyer, "ATP Synthase," 742.

Interestingly, Nakamoto highlights how analogy to human motors may have played a key role in developing understanding the ATP synthase: “The central location the c subunit and its obvious resemblance to a camshaft stimulated investigators to develop approaches that would demonstrate rotation."[124] Others suggest alternative analogies: Goodsell calls ATP synthase “a molecular waterwheel, harnessing a swift flow of hydrogen ions to build ATP,”[125] Seelert et al call it a “proton powered turbine,”[126] while Okuno draws the analogy which inspired the discussion above: “there are other similar man-made systems like hydroelectric generators.”[127]

Researchers sometimes call attention to the remarkable speed and efficiency of the ATP synthase. Goodsell points out that “in a fully charged mitochondrion, the flow of hydrogen ions turns ATP synthase at a speed of 100 to 200 revolutions per second, manufacturing three ATP molecules with each turn.”[128] Boyer mentions a study that showed the synthase converting nearly 100% of the ATP energy to motion.

As a result of the discovery of features like those detailed above, structural biologists have not been shy to express their admiration for the ATP synthase. Okuno praises its “extremely high efficiency,”[129] while describing it as a “supercomplex

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[124] Nakamoto, Baylis Scanlon, and Al-Shawi, “Rotary Mechanism,” 4; Interestingly, Piccolino includes side-by-side illustrations of a water wheel and the ATP synthase, in Figure 3, in his article about molecular machines. Piccolino, “Biological Machines,” 151.

[125] Goodsell, *Our Molecular Nature*, 74.

[126] Seelert et al., “Turbine,” 418.

[127] Daichi Okuno, Ryota Iino, and Hiroyuki Noji, “Rotation and Structure of F_0F_1 -ATP Synthase,” abstract, *Journal of Biochemistry* 149, no. 6 (June 2011): 655.

[128] Goodsell, *Our Molecular Nature* 74.

[129] Okuno, Iino, and Noji, “Rotation,” abstract, 655.

enzyme."[130] In Mulkidjanian and his team's words, "the F-type ATPase is a bona fide rotary dynamo machine,"[131] while Boyer calls the ATP synthase "a splendid molecular machine."[132] In a comment especially pertinent to the issue of comparing hypotheses of design and neo-Darwinism, Mulkidjanian et al say, "Understanding how such machines emerged during evolution is a daunting task."[133]

Molecular machines: Other examples. Besides the RNA polymerase, the kinesin transport assembly and the ATP synthase, there are many other molecular machines which display the three features illustrated above which are isomorphic with humanly-designed machines or mechanized systems. Integrated functionality, specified structural dependence and the presence and flux of complex, specified information likely all appear in the vast collection of molecular machines, presently known to number at least in the hundreds.[134] Space does not permit a detailed look at more than the three above, but specimens such as the bacterial flagellum and calcium pump are other examples of molecular machines which bear striking analogous resemblance to humanly-devised machines.

Some molecular machines bear less intuitive resemblance to humanly-designed

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[130]Okuno, Iino, and Noji, "Rotation," 655.

[131]Mulkidjanian et al., "Dynamo Machine," 892.

[132]Boyer, "ATP Synthase," 742.

[133]Mulkidjanian et al., "Dynamo Machine," 892.

[134]Yeast alone contains over 450 functional "protein complexes" or "core machines," Anne-Claude Gavin et al., "Proteome Survey Reveals Modularity of the Yeast Cell Machinery," *Nature* 440, no. 7084 (March 30, 2006): 631, 635. Mavroidis and his co-authors simply say such machines are "countless," Mavroidis, Dubey, and Yarmush, "Molecular Machines," 363. Over 300 years ago, Malpighi claimed that our bodies contained "a very large number" of machines, Malpighi, quoted in Piccollino, "Biological Machines," 149.

machines, but in cases like the spliceosome, this is at least in part because the biological analogue's complexity exceeds any humanly-devised analogue yet suggested. Nilsen reports that "studies . . . reveal that the spliceosome is composed of as many as 300 distinct proteins and five RNAs, making it among the most complex macromolecular machines known."[135] Other examples of molecular assemblies which may deserve inquiry seeking humanly-designed analogues, even among their subunits include chaperone machines,[136] kinetochores,[137] the ribosome,[138] the mitotic spindle,[139] the helicase/topoisomerase assembly,[140] cohesin,[141] and undoubtedly many others.

Examples like these are not an attempt to present a "designer-of the-gaps"

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[135]Timothy W. Nilsen, "The Spliceosome: The Most Complex Macromolecular Machine in the Cell?," abstract, *BioEssays* 25, no. 12 (December 2003): 1147.

[136]For example, see Bernd Bukau and Arthur L. Horwich, "The Hsp70 and Hsp60 Chaperone Machines," *Cell* 92, no. 3 (February 6, 1998): 351–66; Daniel N. Hebert, Kshama D. Chandrasekhar, and Lila M. Gierasch, "You Got to Know When to Hold (or Unfold) 'Em," *Molecular Cell* 48, no. 1 (October 12, 2012): 3-4; Helen R. Saibil, "Machinery to Reverse Irreversible Aggregates," *Science* 339, no. 6123 (March 1, 2013): 1040-41.

[137]For example, see Gregory Alushin and Eva Nogales, "Visualizing Kinetochore Architecture," *Current Opinion in Structural Biology* 21, no. 5 (October 2011): 661–69; Iain M. Cheeseman and Arshad Desai, "Molecular Architecture of the Kinetochore–Microtubule Interface," *Nature reviews -Molecular Cell Biology* 9, no. 1 (January 2008): 33-46; Ajit P. Joglekar, Kerry Bloom, and E. D. Salmon, "In Vivo Protein Architecture of the Eukaryotic Kinetochore with Nanometer Scale Accuracy," *Current Biology* 19, no. 8 (April 28, 2009): 694–99.

[138]Joachim Frank, "The Ribosome–A Macromolecular Machine Par Excellence," *Chemistry & Biology* 7, no. 6 (2000): R133-41; Xabier Agirrezabala and Mikel Valle, "Structure and Dynamics of the Ribosome as Revealed by Cryo-Electron Microscopy," in *Molecular Machines in Biology*, ed. Joachim Frank (New York: Cambridge University Press, 2011), 117-41; James Gumbart et al., "Viewing the Mechanisms of Translation through the Computational Microscope," in Frank, *Molecular Machines*, 142-57.

[139]For example, see E. Karsenti, and I. Vernos, "The Mitotic Spindle: A Self-Made Machine," *Science* 294, no. 5542 (October 19, 2001): 543-47.

[140]Michel Duguet, "When Helicase and Topoisomerase Meet!," *Journal of Cell Science* 110, no. 12 (June 15, 1997): 1345-50.

[141]Gunjan D. Mehta, Syed Meraj Azhar Rizvi, and Santanu Kumar Ghosh, "Cohesin: A Guardian of Genome Integrity," *Biochimica et Biophysica Acta* 1823, no. 8 (August 2012): 1324–42.

argument, asserting that it is beyond any possibility for random mutation and natural selection to produce the biological machines in question. As stated above, Sober is correct when he asserts that there is no way to demonstrate that neo-Darwinian process could not possibly produce the integrated functionality, specified structural dependence and information flux seen in molecular machines. However, time is limited, and even though Sober's point that neo-Darwinian processes are not exclusively random processes deserves consideration, those processes do require vast amounts of time (Dawkins' problematic combination-lock analogy notwithstanding). Extensive experience with human device-designers, shows that they can produce assemblies displaying the threefold manifestation of specified complexity in vastly shorter periods of time than natural processes even conceivably could do so. Whether one calls an inquiry into potential hypotheses about biological origins a set of likelihood assessments or an inference to the best explanation, a hypothesis of intelligent causation drawn from highly isomorphic, higher-order analogies (which the threefold manifestation of specified complexity shared between the analogues seems to be) either justifies an inductive argument or provides the Duhemian, independent support necessary to at least consider intelligent design as a scientific hypothesis to rival neo-Darwinism.

Summary: Filling in the Machine Continuum from Both Sides

The progressive discovery and understanding of biological molecular machines in recent decades has seemed to inspire researchers to try to build synthetic devices on a nano-scale which mimic or elucidate the functions of their biological counterparts.[142] In

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[142]T. Ross Kelly and Jose Perez Sestelo, "Rotary Motion in Single-Molecule Machines," in *Molecular Machines and Motors*, ed. Jean-Pierre Sauvage, Structure and Bonding 99 (Heidelberg:

this case, then not only are natural components of organisms being discovered to be analogous to machines, in response, intelligent designers are creating artifacts that are analogous to components of organisms. Samples are appearing along the artifact/organisms continuum from the directions of both analogues.

In an example of subcomponents of machine-like operations which bio-molecular researchers have experimentally induced in molecules at the nano-scale, Raehm and Sauvage describe “Electrochemically-driven translation of a ring on the molecular string on which it is threaded.”[143] In fact, protein analogues of many molecular subcomponents like this already exist in natural biology, albeit on a slightly larger scale. There is a sliding clamp on the DNA polymerase (crucial to the polymerase’s transcribing function)[144] which moves (or *translates*) down the DNA molecule on which it is threaded, and which thus analogously mimics the motion which Raehm and Sauvage describe as the result of specified, intentional and intelligent effort in the laboratory.

Another example of highly analogous operations in machine subcomponents is revolution. At the nano-scale, the motion of pirouetting around a molecular axle has been induced in the laboratory,[145] while rotation around an axis occurs naturally on the molecular scale in the ATP synthase (where the rotor is embedded within a stationary

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Springer-Verlag, 2001), 19, 21; Laurence Raehm and Jean-Pierre Sauvage, “Molecular Machines and Motors Based on Transition Metal-Containing Catenanes and Rotaxanes,” in Sauvage, *Molecular Machines and Motors*, 55-78.

[143]Raehm and Sauvage, “Molecular Machines,” 58-66.

[144]Turner et al., “Internal Workings,” 778.

[145]Raehm and Sauvage, “Molecular Machines,” 66-72.

membrane)[146] and in the bacterial flagellum (where the rotor propels the movement of a bacterium).[147]

Raehm and Sauvage's research group seem to have the goal of creating "synthetic molecular ensembles whose dynamic behavior is reminiscent of biological motors."[148] Analogies between the systems they synthesize in the laboratory and natural biological machines are numerous: Both are "multicomponent assemblies;"[149] both undergo "large amplitude geometrical changes"[150] or lead to "the locomotion of one of the components;"[151] and such changes or locomotion occur "under the action of an external stimulus;" which Raehm and Sauvage call "signals," in both analogues.[152] The kinds of signals used to induce changes in both systems frequently are the same, and include: "redox, photonic, . . . pH change, [and] chemical signal (recognition of a molecule)."[153]

These analogues–the synthetic machines and their biological counterparts–are therefore highly isomorphic at many levels: in physical terms, both being molecular

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[146]Boyer, "ATP Synthase," 718.

[147]Behe, *Darwin's Black Box*, 51-73; Robert M. Macnab, "The Bacterial Flagellum: Reversible Rotary Propellor and Type III Export Apparatus," *Journal of Bacteriology* 181, no. 23 (December 1999): 7149–53; Howard C. Berg, "The Rotary Motor of Bacterial Flagella," *Annual Review of Biochemistry* 72 (July 2003): 19-54.

[148]Raehm and Sauvage, "Molecular Machines," 56.

[149]Ibid., 55. 77.

[150]Ibid.

[151]Ibid., 55, 58-73.

[152]Ibid., 56, 77.

[153]Ibid., 77. Compare with signals on p. 56.

assemblies, both undergoing significant shape changes stimulated by similar external energy signals, but additionally accomplishing the higher order purpose of frequently identical motility schemes. With highly isomorphic analogues, it is reasonable to infer another highly analogous cause shared between them: intelligent design. Raehm and Sauvage highlight the crucial, guiding contribution of intelligence in the process of producing synthetic molecular machines or their subcomponents:

> It is now more than 15 years ago that our group published the first templated synthesis of a catenane . . . , following the elegant work previously reported by others. . . . Since the mid 1980's, the field has experienced a spectacular development, with the introduction of more and more complexity and functionality into the molecules. The use of transition metals as templates and of their complexes as electroactive and mobile components turned out to be particularly useful in the construction of *electromechanical molecular machines*.[154]

In other words, at least fifteen years of cutting edge research and experimentation (and that only up to the time of Raehm and Sauvage's 2001 essay) by highly intelligent structural biologists served as a crucial factor contributing to the production of "synthetic molecular ensembles whose dynamic behavior is reminiscent of biological motors."[155] Therefore, it is reasonable to infer that intelligence is a crucial factor contributing to the production of biological molecular machines is reasonable. Consequently, on scientific grounds, these analogues supply both the independent support for likelihood of the design hypothesis, as well as a growing inductive sample size on the continuum between humanly devised artifacts and biological organisms (or at least their molecular machine components), both of which Sober has required, and yet both of which he has incorrectly insisted are lacking.

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[154]Raehm and Sauvage, "Molecular Machines," 75-76.

[155]Ibid., 56.

CHAPTER 7

ANALOGICAL SAMPLING AND SUPPORT FOR DESIGN: ARTIFACTS TO ORGANISMS

Introduction: A Bridge Principle Supplied by Synthetic Life Experiments

This chapter continues the critical examination of Sober's assertion that there is not, and there has never been, evidence of a continuum between the products of intelligent human design and biological organisms which would allow a reasonable bridge principle of a similar likelihood of intelligent causation for both domains of phenomena. Chapter 6 examined evidence contrary to Sober's assertion emerging from biochemistry and microbiology which show startling analogies moving across the continuum from organism to artifact. In other words, biological phenomena such as the genetic code and molecular machines display features–ever-more-isomorphic determining structures–which remarkably seem to mimic devices or systems produced by intelligent humans. This evidence seems to starkly contradict Sober's assertion by presenting science with samples along the organism-artifact continuum which should justify an inductive inference according to Sober's criteria.

This chapter looks at evidence along that same continuum moving from the opposite direction, by presenting additionally compelling evidence of ever-closer analogies between humanly-synthesized mechanisms and actual living cells (or some of their key components). In other words, it shows progress across the continuum from artifact to organism. Thus, this chapter presents the second half of an evidential accumulation challenging Sober's claim of an absent artifact-organism continuum, and consequently provides justification for a reasonable inductive design hypothesis.

In recent decades, remarkable advances have taken place in the techniques and technology closely related to molecular biology and biochemistry (e.g., bioinformatics). As in the case of molecular machines, examples of such advances, specifically in a field called synthetic biology, supply increasing analogues for undergirding an inductive design argument. Moreover, they alternatively provide a source of independently supported auxiliary propositions for a likelihood assessment of a design hypothesis.

Molecular biologists and synthetic biologists have already made strides toward producing microscopic life in the laboratory. Chemist Fazale Rana[1] discusses significant progress made through two different general approaches in this experimental field: the "top-down" and the "bottom-up" approaches. Rana's treatment provides a framework for this section's discussion. Two characteristics of these synthetic biology experiments deserve special attention. First, the features of the products they produce increasingly resemble those of living bacteria. Second, the component of intentional, intelligent design thoroughly permeates these experiments and the products they produce.

The Top-Down Approach

Rana illustrates the top-down approach to synthetic life research by summarizing the work of teams led by synthetic biologist Craig Venter. Their project is

[1]Rana received a PhD in chemistry from Ohio University, did postdoctoral work at the Universities of Virginia and Georgia, and worked at Proctor and Gamble for seven years as a senior scientist. "Dr. Fazale Rana," Reasons to Believe, http://www.reasons.org/about/who-we-are/fazale-rana (accessed January 30, 2014).

currently focused on reproducing from basic components a minimal version of an existing bacteria's genome, then replacing the natural genome of that bacteria with the simplified, reproduced version to see if the bacteria lives. The bacteria they originally chose is *Mycoplasma genitalium*, a very simple organism that only possesses "about 480 gene products."[2] The team even chose a name for their anticipated, new species of synthesized minimalistic bacteria, calling it *Mycoplasma laboratorium*.

To achieve their final goal of producing *M. laboratorium*, Venter's team has set up a progressive strategy, which first has included determining which set of genes are the bare minimum needed for survival in *M. genitalium*, and which are non-essential. Second, the team has sought to duplicate that minimal genome template by synthesizing an exact copy of it from simple nucleotide components. Third, the team will insert that humanly-synthesized minimal genome into a close relative of the *M. genitalium* bacterium which has had its natural genome completely removed. Last, the team hopes to observe the synthesized organism grow, operate and reproduce in the same way the original, natural bacterium did.[3]

Each of these are stages in the overall strategy itself consists of numerous, rigorously implemented sub-steps. Rana calls attention to the intensive and critical involvement of human intelligence in the project.

> Despite how conceptually simple the steps may seem to reengineer a life-form from the top down, the amount of intellectual effort put forth by Venter's team has been astounding. Each part of the process required careful planning and expert execution of laboratory procedures by highly trained chemists and molecular biologists.[4]

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[2]Fazale Rana, *Creating Life in the Lab* (Grand Rapids: Baker Books, 2011), 35.

[3]Ibid.

[4]Ibid., 45.

Preparing for the Genome Synthesis

Each step in the team's process includes the input of intelligent, intentional information. For example, in one of the first steps, the team had to critically evaluate and identify which bacteria's genome would be best to attempt to replicate. Since their goal was a minimal, functional copy, they chose M. genitalium since it has a very small genome.[5] The team also had to carefully deliberate which bacterium to use as the final host for the synthesized genome.[6] Next, they had to obtain M. genitalium's sequenced genome, and then use knock-out experiments (incorporating both systematic and random mutations) to discover and eliminate from their genome template which genes are not strictly essential to the bacterium's survival.[7] Prior to creating the synthetic genome, the team had to choose enzymes with the needed catalytic properties, design the oligonucleotides [short DNA chains] to be compatible with those enzymes, and "devise a reaction scheme that could yield the desired recombination product."[8]

Synthesizing the Genome

The step of chemically synthesizing the minimalized genome will have to proceed in a piece-by-piece manner. Rana details this ten sub-step process to synthesize and connect the oligonucleotide components leading to a complete genome.[9] This process presumably will repeat the same process used in 2008, when a Ventor team

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[5]Rana, *Life in the Lab*, 35

[6]Ibid., 42.

[7]Ibid., 35.

[8]Ibid., 45.

[9]Ibid., 38-39.

synthesized and assembled a full (i.e., non-minimalized) *M. genitalium* genome.[10] The process used in 2008, consisted of several smaller stages and sub-operations, each of which was highly intelligence-intensive. For example, before even beginning the team had to have access to the full natural M. genitalium genome sequence, which obviously already had required intensive intelligence to achieve. Moreover, the team had to already possess expertise in both gene synthesizing and cloning procedures. The intelligent discovery, mastery and dissemination of these procedures preceded the team's efforts by many years. In terms of the team's own in vitro efforts, the overall process began with chemically synthesizing around 100 oligonucleotides (chains of DNA nucleotides, in this case, each about 6000 base pairs long). They then undertook three stages of in vitro recombination, linking the smaller chains into "cassettes" of about 24,000 base pairs each. At this chain length, current in vitro technology will not allow further lengthening, so the team needed to utilize two final stages of cloning (one in *E. coli* and one in yeast) to assemble the full-length genome.[11] While the details are too extensive to include here, generally speaking, each sub step requires intensive and often meticulous intentionality, expertise and care by the researchers conducting the synthesis, as well as by numerous peripheral biotechnical companies which indirectly contributed to the process.[12] Since

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[10]Daniel G. Gibson et al., "Complete Chemical Synthesis, Assembly, and Cloning of a Mycoplasma genitalium Genome," *Science* 319, no. 5867 (29 February 2008): 1215-20.

[11]Ibid., 1215-16; see Figure 2 for a schematic of the assembly strategy.

[12]For those interested in fuller details richly illustrating the extent of intelligent involvement in the genome synthesis process, see Gibson et al.'s descriptions of "Assembly of synthetic cassettes by in vitro recombination." For example, the use of "Recombinant plasmids bearing the individual cassette DNA inserts;" the use of "phenolchloroform extraction and ethanol precipitation;" or the use of "Polymerase chain reaction (PCR) amplification." Gibson et al., "Complete Chemical Synthesis," 1216-17. Further information related to each of these three intelligence-influenced sub-steps can be found in Anthony J. F. Griffiths et al., *Modern Genetic Analysis* (New York: W. H. Freeman; 1999), http://www.ncbi.nlm.

other organisms are currently required to complete the later-stage assembly of large DNA strands, for completing the synthesis of the genome, the 2008 team had to carefully consider which organisms they would choose to facilitate that assembly (in this case, *E. coli* and yeast).[13]

Transplanting the Genome

Before the Venter team attempts to transplant a humanly-synthesized minimal *M. genitalium* genome, they will need to intentionally and completely delete the chosen host bacterium's natural genome. Toward the goal of successful transplantation, the Ventor team has conducted parallel experiments in gene transplantation. Though ultimately successful, Rana reports that it was "a painstaking process of developing a procedure to do so."[14] Running into problems transplanting other genomes, the team had to then develop an improved methodology for gene transplantation. Regarding this new methodology, Rana comments, " Though conceptually straightforward, this methodology relies on a clever strategy that borders on genius to make it work. It also requires a large team of highly skilled molecular biologists to perform detailed laboratory manipulations."[15] Venter's team, according to their original strategy, is planning to insert the synthesized, minimal genome, originally based on M. genitalium, into the closely-

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nih.gov/books/NBK21407/ (accessed November 1, 2013); Danny S. K. Ng, "Phenol/Chloroform Extraction and Ethanol Precipitation," University of Regina Department of Chemistry and Biochemistry, http://uregina.ca/~ngdann/Bioc422/proj1.htm (accessed November 1, 2013); "Pcr: Polymerase Chain Reaction," Biology Online, http://www.biology-online.org/dictionary/Pcr (accessed November 1, 2013).

[13]Rana, *Life in the Lab*, 46.

[14] Ibid., 42; See Carole Lartigue et al., "Genome Transplantation in Bacteria: Changing One Species to Another," *Science*, n.s., 317, no. 5838 (Aug. 3 2007): 632-38.

[15]Rana, *Life in the Lab*, 43.

related, empty host bacterium.[16] When they do, they must also use previously devised and tested checks and safeguards to assure that none of the original host's genes have remained to react with the new genome.

Case Study: A Synthesized Version of a Bacterium

In 2010, as a significant step along the way toward their goal of synthesizing a new, minimalized cell, Venter's team, "starting from digitized genome sequence information," designed, synthesized and assembled an entire, simple bacterial genome (*Mycoplasma mycoides*) and then successfully transplanted it into a DNA-absent version of another bacterium (*Mycoplasma capricolum*). This achievement only falls short of their ultimate goal by virtue of the fact that the synthesized *M. mycoides* genome was essentially copied verbatim, with no aim of reducing it to the minimal information absolutely necessary for life. Therefore, the resulting product was essentially another *M. mycoides* bacterium, not a new species of life. Nevertheless, the achievement was significant enough for the team, led by Daniel Gibson, to claim that what they had created was a "synthetic cell."[17] Sober claimed that there is no continuum between life and non-life. Yet this synthetically designed, assembled, and ultimately functional *M. mycoides* genome (synthesized from previously non-living nucleotide components) seems to provide at least a significant step along that continuum. Crucial for this chapter's argument, the team openly recognizes the causal role their own intelligent design played

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[16]Rana, *Life in the Lab*, 45.

[17]Daniel G. Gibson et al., "Creation of a Bacterial Cell Controlled by a Chemically Synthesized Genome," *Science* 329, no. 52 (2 July 2010): 55.

in producing this genome: "This work provides a proof of principle for producing cells based on *computer-designed* genome sequences." (emphasis mine)[18] Indeed, they recommend that their methods (i.e., intelligent methods) of "design, synthesis, assembly, and transplantation of synthetic chromosomes" be generalized for further use in synthetic biology research.[19] The team also predicts that "the approach we have developed should be applicable to the synthesis and transplantation of more novel genomes as genome design progresses."[20] This implies that research will make further steps along the continuum, steps also crucially dependent upon the causal agency of intelligent design.

Details of the team's efforts highlight how intelligence permeated this project's process at various levels.[21] In the article describing this experiment, the team mentions "design" over a dozen times. Intelligence had already affected the genome they used as their final design reference: it was a strain of *M. mycoides* "that had been cloned and engineered in yeast."[22] They needed to be intelligently meticulous in their genome synthesis: "This project was critically dependent on the accuracy" of the sequence.[23] Indeed, in the words of Gibson et al., "Obtaining an error-free genome . . . was complicated and required many quality-control steps."[24]

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[18]Gibson et al., "Creation of a Bacterial Cell," 55.

[19]Ibid., 56.

[20]Ibid., 55.

[21]This section includes these details not primarily to criticize the limitations of neo-Darwinian processes. Rather, this description helps highlight what intelligent design *can do* and indeed *has done*.

[22]Gibson et al. "Creation of a Bacterial Cell," 52.

[23]Ibid.

[24]Ibid., 55.

Intelligent judgments and choices were made along the way. For example, many gene “cassettes” (smaller modules of genes) were used which had been previously prepared from another, closely-related bacterial strain, but not before the team selectively corrected them. Differences that “appeared biologically significant” were changed, while those which “appeared harmless” were left alone.[25] Apart from the team’s own purposeful and intellectual resources, intelligence from far beyond their own laboratory influenced the project. For example, the design of these smaller cassettes was not done by Ventor’s team themselves, but was subcontracted out to a biotechnology firm near Seattle, and “each cassette was individually synthesized and sequence-verified by the manufacturer.”[26] Cassette preparation itself was constrained by intentionality and goal-directedness: “To aid in the building process, DNA cassettes and assembly intermediates were designed to contain NotI restriction sites at their termini and recombined in the presence of vector elements to allow for growth and selection in yeast.”[27] During genome assembly, a designed PCR amplified vector was used as part of a test for functionality of large fragments of the genome.[28] This sub-process displays intelligent involvement at three levels: a) PCR amplification is an intelligently managed *in vitro* “molecular biology technique”;[29] the vectors were designed; and the functionality test itself implies intelligent evaluation.

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[25]Gibson et al., “Creation of a Bacterial Cell,” 55.

[26]Ibid., 52-53.

[27]Ibid., 53.

[28]Ibid., 54.

[29]“PCR Amplification,” Sigma-Aldrich, http://www.sigmaaldrich.com/life-science/molecular-biology/pcr/pcr-products.html (accessed November 3 2013).

Top-Down Summary

Reviewing such details of the implementation of the strategy of Venter's team emphasizes the point that each step in that strategy critically requires intelligent aspects such as intensive planning, close attention to detail, thorough collaboration, critical feedback and consultation, evaluation and learning from mistakes, creativity, immense reasoning power, experience, and dedication to a clear end goal. In short, from beginning to end, intelligent involvement (consisting of the presence and flux of complex specified information) is an indispensible component of the process. In addition to the direct involvement of Venter's team, their success to date also has required highly controlled laboratory conditions, as well as specialized equipment which itself was specially prepared by other intelligently guided, purposeful human corporations. Moreover, the team has been building upon the generations of previous researchers whose successes required the very same kinds of intelligence-based resources.[30] Rana summarizes that Venter and his colleagues

> depended on the accomplishments of the scientists who came before them. The technology to chemically synthesize oligonucleotides represents a remarkable technological accomplishment resulting from the dedicated efforts over the last half-century of some of the best scientists in the world (including Nobel laureates). Without these brilliant minds and remarkable achievements, Venter's team would have had no hope to carry out the total synthesis of the *M. genitalium* genome.[31]

Thus, the top-down synthetic biology research of the Venter group has resulted in

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[30]For example, Murray and Szostak comment, "The availability of recombinant DNA technology allows . . . the construction of artificial chromosomes from cloned fragments of DNA." Andrew W. Murray and Jack W. Szostak, "Construction of Artificial Chromosomes in Yeast," *Nature*, 305, no. 5931 (September 15, 1983): 189.

[31]Rana, *Life in the Lab*, 45.

products with key features ever-more-closely resembling natural bacteria. Additionally, this research has succeeded largely by virtue of intensive intelligent involvement at various levels in the synthesis-assembly-transplantation process. The next section shows that synthetic biology research done using a bottom-up approach manifests the same two general characteristics: ever-closer resemblance to life and critical dependence on intelligent agency.

The Bottom-Up Approach

Mirroring the successes experienced by scientists using the top-down approach, other synthetic biologists have used a bottom-up approach. Their goal is to successfully create numerous products in the lab from non-living organic components, which ever-more closely mimic either a primitive version of a living cell (a "protocell"), or an essential sub-system or structure performing a function crucially characteristic of a living cell (e.g., vesicles which can encapsulate proteins or nucleotide chains). These synthetic products seem to represent steps along the continuum between artifacts and organisms.

Continuum

Research professor of biomolecular engineering David Deamer[32] seems to acknowledge progress down such a continuum when he writes, "Step by step, the components of an artificial form of cellular life are being assembled by researchers."[33] Deamer is so impressed with the overall results produced to date by bottom-up synthetic

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[32]David Deamer, Jack Baskin School of Engineering, University of California, Santa Cruz, http://www.soe.ucsc.edu/people/deamer (accessed November 4, 2013).

[33]David Deamer, "A Giant Step Towards Artificial Life?," *Trends in Biotechnology* 23, no.7 (July 2005): 336.

biology, that after listing twelve general stages which a molecular assembly must go through before it can legitimately be called "life," he makes the bold claim that "all but one of the functions in the list have now been reproduced in the laboratory."[34] Similar to the membranes of natural cells, vesicles (bilayer spheres with an open space at their center) produced in the lab can grow and divide,[35] and can encapsulate the two major types of biological macromolecules (nucleic acids and proteins),[36] including a functioning ribosome, and messenger and transfer RNA's.[37] Regarding the implications of such results, Oberholzer et al comment, "This work opens up the possibility of using liposomes as minimal cell bioreactors with growing degree of genetic complexity, thus getting close to the reconstitution of a minimal cell."[38] Not only does their comment indicate the existence of a continuum between natural and synthetic cells, but also that

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[34]Deamer, "A Giant Step," 337.

[35]Ibid.; Martin M. Hanczyc, Shelly M. Fujikawa, and Jack W. Szostak, "Experimental Models of Primitive Cellular Compartments: Encapsulation, Growth, and Division," *Science, New Series* 302, no. 5645 (Oct. 24, 2003): 618-22; Irene A. Chen and Jack W. Szostak, "A Kinetic Study of the Growth of Fatty Acid Vesicles," *Biophysical Journal* 87, no. 2 (August 2004): 988-98.

[36]Deamer, "A Giant Step," 337; Rana, *Life in the Lab,* 199; R. Shew and D. W. Deamer, "A Novel Method for Encapsulation of Macromolecules in Liposomes," *Biochimica et Biophysica Acta–Biomembranes* 816, no. 1 (June 11, 1985): 1–8; David W. Deamer and Gail L. Barchfeld, "Encapsulation of Macromolecules by Lipid Vesicles Under Simulated Prebiotic Conditions," abstract, *Journal of Molecular Evolution* 18, no. 3 (May 1982): 203.

[37]Deamer, "A Giant Step," 337; Ajoy C. Chakrabarti et al., "Production of RNA by a Polymerase Protein Encapsulated with Phospholipid Vesicles," abstract, *Journal of Molecular Evolution* 39, no. 6 (December 1994): 555-59; Thomas Oberholzer, Knud H. Nierhaus, and Pier Luigi Luisi, "Protein Expression in Liposomes," *Biochemical and Biophysical Research Communications* 261, no. 2 (1999): 238–41. Note: The translation machinery in the liposome in Oberholzer, Nierhaus, and Luisi's experiments only functioned for about 20 minutes. Oberholzer, Nierhaus, and Luisi, "Expression," 241. A team led by Wei Yu similarly presents several examples of "experimental approaches" provided by "present technologies" which have already succeeded in producing important aspects belonging to what is theorized to be simple primordial cellular life. Wei Yu et al., "Synthesis of Functional Protein in Liposome," *Journal of Bioscience and Bioengineeering* 92, no. 6 (December 2001): 590.

[38]Oberholzer, Nierhaus, and Luisi, "Expression," 238.

biological research is progressively bridging that continuum.

Researchers have experimentally demonstrated the transcription of nucleic acids and translation of working proteins, sometimes in sequence, within synthesized vesicles (called "liposomes").[39] Liposome permeability is another important step. Noireaux and Libchaber claim that "a critical step in building an artificial cell" is to achieve a semi permeable membrane which allows the "exchange and use of external energy nutrients."[40] They claim that through their work, "Energy nutrients limitations have been solved through the internal expression of a membrane pore and by exchange with the environment."[41] These comments indicate the existence of a continuum (and one which is being increasingly occupied by examples from the laboratory) between natural and artificial bacteria, at least in the minds of the researchers.

Some researchers admit that synthetic liposomes or their potential components still lack some essential features present in natural cells. For example, through their experimental work on enzyme design, Lin Jiang et al., in a 2008 *Science* article report that while new activities for enzymes "can be designed from scratch and indicate the catalytic strategies that are most accessible to nascent enzymes, there is still a significant gap between the activities of our designed catalysts and those of naturally occurring

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[39]Deamer, "A Giant Step," 337; Yu et al., "Synthesis," 590-93; K. Ishikawa et al., "Expression of a Cascading Genetic Network Within Liposomes," *Federation of European Biochemical Societies Letters* 576, no. 3 (October 22, 2004): 387–90. Ishikawa and his team reproduced a two-stage series of macromolecule production.

[40]Vincent Noireaux and Albert Libchaber, "A Vesicle Bioreactor as a Step Toward an Artificial Cell Assembly," *Proceedings of the National Academy of Sciences* 101, no. 51 (2004):17669. Mansy and his team report, "fatty acids and their corresponding alcohols and glycerol monoesters" form vesicles with permeability properties under the right laboratory conditions. Sheref S. Mansy et al., "Template-Directed Synthesis of a Genetic Polymer in a Model Protocell," *Nature* 454, 7200 (July 3, 2008): 122-26.

[41]Noireaux and Libchaber, "Vesicle Bioreactor," 17673; Deamer, "A Giant Step," 337.

enzymes."[42] Nevertheless, Jiang and his team use this "gap" as a motivation for pursuing further progress in synthetic biological design: "Narrowing this gap presents an exciting prospect for future work: What additional features have to be incorporated into the design process to achieve catalytic activities approaching those of naturally occurring enzymes?" The admission that partial progress has been made toward synthetically replicating cellular life, coupled with the resolve to further that progress, is an implicit acknowledgment that the artifact-organism continuum exists and that ongoing research potentially can fill it in.[43]

In a similar vein, Nobel prize-winning synthetic biologist Jack Szostak and his colleague Sheref Mansy also admit that the gap between synthesized products and natural cellular life has only been partially crossed. They point out the progress that has been made: "there do not appear to be major problems associated with the growth and division of model protocell membranes or with the integration of the protocell membrane with the internal nucleic-acid-copying chemistry." They also admit, however, the most challenging accomplishment which still lies ahead: "the design and synthesis of a genetic polymer capable of repeated cycles of chemical (i.e., nonenzymatic) replication; this is the central barrier to the synthesis of a complete protocell."[44]

To this pair of synthetic biologists, heritable variation (via reproduction) seems

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[42]Lin Jiang et al., "De Novo Computational Design of Retro-Aldol Enzymes," *Science* 319, no. 5868 (7 March 2008): 1391.

[43]Yu and his team predict, "experimental evolution even from the prebiotic stages has become a foreseeable reality." Yu et al., "Synthesis," 590.

[44]S. S. Mansy and J. W. Szostak, "Reconstructing the Emergence of Cellular Life through the Synthesis of Model Protocells," *Cold Spring Harbor Symposia on Quantitative Biology* 74 (2009): 7, http://molbio.mgh.harvard.edu/szostakweb/publications.html (accessed October 29, 2013).

to be the key feature which would allow Darwinian selection, and thus adaptive evolution, to begin.[45] Whether this feature is the last step between pseudo-life and life is unclear, but at least in their 2009 article, Mansy and Szostak "refer to a cell-like structure with the as yet unrealized potential to evolve useful functions as a protocell; once the evolution of sequences that encode useful functions has occurred, we refer to such a structure simply as a cell."[46] It seems clear that they believe that "purely physicochemical replication schemes . . . , however artificial," can be accomplished one day in the laboratory.[47] Even if such a self-replicating, synthesized protocell is unlike the first primordial cells on earth in some ways, Mansy and Szostak still feel that synthesis experiments, "do have implications for theories of the origin of life on the early earth."[48] If that is the case, there must be important isomorphic analogies–i.e., steps along a continuum–between the products of their research and natural, living cells.

Depending upon Intelligence

Synthetic biology research indicates that there is a continuum between synthetic and natural bacteria which is being progressively populated by samples from the laboratory. Yet just as important, synthetic biology research also demonstrates that those samples are critically dependent at numerous levels and stages upon training, methods and choices of intelligent researchers, upon intelligently designed equipment and upon intelligently manipulated materials. In short, the causal systems producing the

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[45]Mansy and Szostak, "Reconstructing," 1.

[46]Ibid., 1.

[47]Ibid., 2.

[48]Ibid., 7.

samples along the continuum are intelligence-intensive. While intelligence is clearly not sufficient, it is certainly necessary for the production of these life-resembling products.

In the literature referred to above relevant to the examples of bottom-up synthetic biology, whenever methods and materials are listed, the intense involvement of intelligence becomes glaringly obvious. First, for example, regarding liposome bilayer formation and growth, there are at least two ways in which specific intelligent manipulation helped produce the stable vesicles: the control of a narrow pH range and the addition of fatty alcohols and fatty acid glycerol esters.[49] More telling, in order to produce vesicle division in the laboratory, Hanczyc et al. forcefully extruded the vesicles through a porous membrane, a method they admit is "artificial," and highly unlikely to have a natural parallel.[50]

Second, living cells today have a phospholipid outer membrane which by itself is a largely impenetrable barrier preventing substances from either entering or leaving the cell. This problem is circumvented in today's cells via "sophisticated protein channels and pumps" which penetrate the membrane and selectively allow or disallow entry and exit.[51] Many origin-of-life researchers speculate that primordial cells had not had time to evolve such complicated gating mechanisms, and therefore required a much more permeable type of membrane. Sheref Mansy and his colleagues conducted experiments

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[49]Hanczyc, Fujikawa, and Szostak, "Experimental Models," 618.

[50]Ibid., 621. The addition of certain minerals has been found to speed up vesicle formation. High buffer concentration was required, however, to keep the pH level stable. See Martin M. Hanczyc, Sheref S. Mansy, and Jack W. Szostak, "Mineral Surface Directed Membrane Assembly," *Origins of Life and Evolution of Biospheres* 37, no. 1 (February 2007): 75.

[51]Mansy et al., "Template," 122; David W. Deamer, "Membrane Compartments in Prebiotic Evolution," in *Molecular Origins of Life*, ed. Andre Brack (Cambridge: Cambridge University Press, 1998), 189-91.

which purport to show that fatty acids could have formed vesicles with semi-permeable membranes in a prebiotic environment.[52] Upon close inspection of Mansy and his team's materials and methods, however, one factor upon which these experiments critically depended at many levels and in numerous manifestations is intelligent intervention. For example, the team reports that one primary material they used for forming the vesicle membrane was "pure myristoleic acid (C14:1 fatty acid, myristoleate in its ionized form)." The team began with this specific material "because this compound generates robust vesicles that are more permeable to solutes than the more common longer chain oleic acid."[53] Further, the team included myristoleyl alcohol and the glycerol monoester of myristoleic acid in the chemical reactions because they "stabilize myristoleate vesicles to the disruptive effects of divalent cations."[54]

Another primary material used was decanoic acid, which also displayed higher permeability and stability when mixed with decanol and the glycerol monoester of decanoate.[55] Thus, intelligence and end-goals resulted in a choice of a narrow, specified range of materials and admixtures.[56] Furthermore, myristoleic acid is described elsewhere as "most prevalent in triacylglyceride"[57] (triacylglyceride is apparently synonymous with *triglycerides*, and it is a neutral fat that is the normal storage form of

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[52]Mansy et al., "Template," 122-25.

[53]Ibid., 122.

[54]Ibid.

[55]Ibid., 123.

[56]Though the team did run some iterations of the experiment without the additives.

[57]"Myristoleic acid," Lipomics, https://www.lipomics.com/fatty_acids/9-tetradecenoic-acid (accessed October 31, 2013).

animal lipids).[58] Decanoic acid is also obtained from animals as well as coconuts and other seeds.[59] Purportedly, none of these sources was available in a prebiotic environment, so this raises the question as to how myristoleic acid might otherwise be synthesized.

The fatty acids, alcohols and monoesters for the experiments were obtained from a commercial supplier in Minnesota[60] who presumably obtained the acid from animal or vegetable fats or oils and then purified it "by a final distillation on a hundred theoretical plate high vacuum fraction column," in part in order to remove "extraneous trace impurities."[61] Moreover, the supplier claims,

> The isolation of high purity compounds . . . are always protected under an atmosphere of inert gas (i.e., N_2). The final product, with the exception of high melting saturated compounds, is always flushed with nitrogen, sealed in Pyrex glass ampules under vacuum, and stored under cold conditions of -30°C or lower until ready for shipment.[62]

These are just a few examples, among potentially many more, of important intelligent involvement in the experiments of Mansy and his team. Regarding a broader range of fatty acid vesicle experimentation, Fazale Rana also highlights other manifestations of specified, purposeful intervention

> Each stage of the process from prebiotic amphiphiles to functioning primitive membranes depends heavily on concentration of the lipids, their exact identity, and

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[58]"Triglyceride," The Free Dictionary, Medical Dictionayr, http:// medical-dictionary.thefreedictionary.com/ Triacylglyceride (accessed November 6, 2013).

[59]"Decanoic Acid," The Free Dictionary, Medical Dictionary, http:// medical-dictionary.thefreedictionary.com/ decanoic+acid accessed (November 6, 2013). Se also, "Capric Acid," The Free Dictionary, Medical Dictionary http://medical-dictionary.thefreedictionary.com/capric +acid+8+COOH%29 (accessed November 6, 2013).

[60]Mansy et al., "Template," 126.

[61]"Products and Fatty Acids," Nu-Chek Prep, Inc., http://www.nu-chekprep.com/p.htm (accessed November 6, 2013).

[62]Ibid.

> environmental conditions (including temperature, pH, and salt levels, among others). If it weren't for the chemists' diligence in the laboratory, no primitive membrane vesicles would form, encapsulate materials or grow and divide.[63]

The evidence from vesicle membrane synthesis experiments thus display that success in mimicking this important component of life critically relies upon intelligence at various levels.

Third, in addition to a thin, semi-permeable membrane, another feature which a synthetic bacterial cell needs in order to at least minimally mimic a naturally-occurring cell is functioning proteins encapsulated within that membrane. Synthetic biology research is making some progress on that front as well.

Case-Study: Synthesized Protein-Containing Liposome

In a 2001 article, a team led by Wei Yu reports how they induced the production of a functioning protein by inserting the mutated gene of a GFP (green fluorescent protein) into a liposome which they constructed, and which was supplied with a "cell-free protein synthesis reaction mixture."[64] As one reads the article documenting Yu and his team's experiments, it becomes clear that intelligent agency both intensively and extensively influenced and guided a number of steps the team describes. For example, the team reports that "to highly express the protein, the GFPmutl gene was cloned into the expression vector pET21a(+) (Novagen, USA)."[65] First, intelligence was employed in that the kind of cloning employed described here is not natural cloning, but a humanly-devised technique of intentionally cutting a gene from its original host DNA and then

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[63]Rana, *Life in the Lab*, 194.

[64]Yu et al., "Synthesis," 590.

[65]Ibid.

attaching it "into a suitable 'vector' where multiple copies of it can be quickly reproduced."[66] In a concise online summary of cloning, University of Otago School of Medical Sciences state, "The process of cloning a gene involves many biotechnological techniques. Depending on what information is already available on the gene of interest, various methods can be used to isolate and amplify it."[67] Second, expression vectors like those used in these experiments are commercially produced, as is evidenced by the Yu team's use of the "Novagen" brand of vector.[68] Moreover, the team had an intentional end purpose behind the cloning, namely, "to highly express the protein."

Yu's team also reports that "a His-tag was added to the C-terminal of the protein to facilitate its purification, and the purified GFPmutl-His6 was used as the standard."[69] The method of fusing His-tags to recombinant (i.e., genetically engineered) proteins of interest was introduced by a research team in 1988,[70] and His-tags are available as features in commercially-produced expression vectors.[71] One company that produces and purifies His-tagged proteins says that the tag "provides a means of

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[66]"Cloning a Gene," Biology for High Schools, University of Otago, Otago School of Medical Sciences, http://highschoolbiology.otago.ac.nz/index.php?option=com_content&view=article&id=106 (accessed November 11, 2013).

[67]Ibid.

[68]Novagen is a line of products produced by Merck Millipore, http://www.merckmillipore.com/about-us/c_C_Wb.s1Lxi8AAAEWWcgfVhTo, (accessed April 27, 2014). Their website states, "With a range of more than 40,000 products, Merck Millipore is a top tier supplier of tools and technologies to the life science industry."

[69]Yu et al., "Synthesis," 590.

[70]E. Hochuli et al., "Genetic Approach to Facilitate Purificaiton of Recombinant Proteins with a Novel Metal Chelate Adsorbent," *Nature Biotechnology* 6, no. 11 (November 1988): 1321.

[71]For example, "pTrcHis TOPO® TA Expression Kit," Life Technologies http://www.lifetechnologies.com/order/catalog/product/K441001?CID=%3D%253D%253D%253Dsearch-K441001 (accessed November 11, 2013).

specifically purifying or detecting the recombinant protein."[72] Yu's team also describes that "The GFPmutl gene . . . was amplified by PCR"[73] (polymerase chain reaction). The Sigma Aldrich Company describes PCR as

> a powerful core molecular biology technique. It is an efficient and rapid in vitro method for enzymatic amplification of specific DNA or RNA sequences. . . . A simple PCR reaction consists of a set of synthetic oligonucleotide primers that flank the target DNA sequence, target DNA, a thermostable DNA polymerase and dNTPs. A repetitive series of cycles . . . yields tremendous amounts of DNA.[74]

Yu and his team also report that the vesicle they synthesized to house the production of GFP, was made of a mixture of lipids, which were supplied by a Tokyo company.[75] The team describes the highly stringent methodology for processing of the lipid mixture:

> The lipid mixture (9.6 μmol) dissolved in dichloromethane/diethyl ether (1:1, v/v) was rotary-evaporated in a pear-shaped flask under vacuum at room temperature to yield a thin lipid film. To the lipid film was added at 4°C 80 μl of the reaction mixture for protein synthesis. . . . The solution was transferred into an Eppendorf tube and vortexed after standing for 15 min at 4°C to obtain the liposome dispersion with a final lipid concentration of 120 mM. . . . To initiate protein synthesis, the diluted liposome dispersion was incubated at 37°C. After 1-h incubation, reaction was terminated by placing the tube on ice immediately.[76]

Furthermore, Yu and his team report that, as is commonly required for cell-free protein synthesis, they prepared E.coli S-30 cell extract. Cell extract preparation is another humanly-devised process requiring a number of tightly-controlled, purposeful steps (such as buffering, dialysis, and incubation), as well as the use of specialized equipment and

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[72]"The Histidine Tag," Thermo Scientific, Pierce Protein Biology Products, http:// www.piercenet.com/method/his-tagged-proteins (accessed October 30, 2013).

[73]Yu et al., "Synthesis," 590.

[74]"PCR/Amplification," Sigma-Aldrich, http://www.sigmaaldrich.com/life-science/ molecular-biology/molecular-biology-products.html?TablePage=9619242 (accessed March 10, 2014).

[75]Yu et al., "Synthesis," 591.

[76]Ibid.

chemical components. Zubay and Kigawa et al. are good sources for detailed descriptions of the methods and materials used in both the early version of this process, as well as a more recent version, respectively.[77]

While some portions of experimental process which Yu and his team utilized were humanly and intentionally controlled, synthesized or manipulated, some components still clearly needed to be natural. For example, the cell-free protein synthesis reaction mixture, while indicating imposition of some stringent human controls, also depended critically on the presence of natural translation machinery already existing in *E. coli* (e.g., tRNAs, translation factors and ribosomes)[78] Chiarabelli et al have called this approach "semi-synthetic."[79] Thus, the team's success in producing a functional protein within humanly-synthesized liposome only represents one step down the continuum between artifact and organism. Nevertheless, Yu and his team close their article with a comment that seems to acknowledge progress down such a continuum: "The realization of a minimal cell may allow access to systems akin to that of living cells in nature, which in turn, may be a promising gateway towards effective in vitro protein evolution . . ., in vitro or cell-free protein synthesis and knowing the origin of life as well."[80] Since Yu and

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[77]Geoffrey Zubay, "In Vitro Synthesis of Protein in Microbial Systems," *Annual Review of Genetics* 7 (1973): 273-77; Takanori Kigawa et al., "Preparation of Escherichia Coli Cell Extract for Highly Productive Cell-Free Protein Expression," *Journal of Structural and Functional Genomics* 5, nos. 1-2 (March 2004): 63–68.

[78] James F. Zawada, "Preparation and Testing of E.coli S30 In Vitro Transcription Translation Extracts," in *Ribosome Display and Related Technologies*, ed. Julie A. Douthwaite and Ronald H. Jackson, Methods in Molecular Biology 805, ed. John M. Walker (New York: Humana, 2011), 31-32. http://link.springer.com/protocol/10.1007%2F978-1-61779-379-0_2#page-1 (accessed February 6, 2014).

[79]Cristiano Chiarabelli et al., "Approaches to Chemical Synthetic Biology," *Federation of European Biochemical Societies Letters* 586, no. 15 (July 16, 2012): 2139.

[80]Yu et al., "Synthesis," 593.

his team's experiment required at least significant intelligent involvement in order to reach a pre-determined goal of a functioning protein, and since those who conceived and carried out the experiment see it as contributing to progress toward a minimal cell, scientific evidence exists for inductive samples along the artifact-organism continuum, contributing both to an inductive argument for design, and thus independent scientific support also exists for the likelihood of a design hypothesis.

Case Study: Computer-Designed Enzyme Gene

Another example relevant to synthetic protein synthesis appears in a paper published in 2008, where a team led by Lin Jiang describe the computational design and experimental expression of the genetic coding of an enzyme.[81]

Jiang and his team's first goal was to produce an optimized, yet relatively minimal 'de novo' genetic design (or small set of designs) for a retro aldol enzyme, a type of protein which catalyzes a multi-step reaction which breaks carbon-carbon bonds.[82] The team's second goal was to empirically test and compare the very best designs by having them expressed in *E. coli* bacteria. The design phase of this research was of critical importance and therefore the first section of the team's article presents significant details of what they call the "computational enzyme design protocol"[83] they devised for attaining the best designs. This protocol displays various levels of specified complexity and is clearly goal-oriented (at both local and global levels). As can be seen

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[81]Jiang et al., "De Novo," 1387- 91.

[82]Ibid., 1387-88.

[83]Ibid., 1387.

when it is examined in detail, the design phase is intelligence-intensive.

An early page of the team's article presents a schematic flow-chart graphically summarizing the eight general protocol stages. The use in that flow-chart of terms such as "compute," "identify," "optimize," "design," and "rank" emphasize the abundant and critical involvement of intelligence in the design of these enzymes.[84] Details which the article provides of the first seven of the eight protocol stages further highlight the intelligence-intensive nature of the design phase.

At least two levels of purposeful searches had to be carried out, intentionally gleaning the best out a vast set of possible polypeptide arrangements, according to predetermined parameters important to good enzyme functionality. At the first level, the team searched for arrangements which could plausibly result in a functional protein. While just one motif of protein design contained "1.4×10^{18} possible 3D active sites," this first-level search pared that enormous pool down to "181,555 distinct solutions for the placement of the composite TS [transition state] and the surrounding catalytic residues."[85] It appears that this refining search was carried out by a computer algorithm which pre-emptively weeded out designs deemed unfavorable due to "poor catalytic geometry or significant steric clashes."[86]

A second-level search, also run by a computer algorithm, then narrowed the choices further by seeking the most optimal designs, again according to intelligently-chosen parameters: "the predicted TS binding energy, the extent of satisfaction of the

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[84]Jiang et al., "De Novo," 1387.

[85]Ibid., 1388.

[86]Ibid.

catalytic geometry, the packing around the active lysine, and the consistency of side-chain conformation after side-chain repacking in the presence and absence of the TS model."[87] After these two refining searches, seventy-two designs remained which the team ultimately experimentally characterized in *E. coli* and compared as to function.

These details highlight that the first seven protocol steps (and their associated sub-steps) consist of intentionally gathering and then systematically and progressively refining and narrowing a large pool of potential choices according to purposeful standards. These seven steps thus compose an intentionally-directed process of elimination, or conversely, an intelligently-directed process of culling (gleaning, winnowing) and optimizing ever-more-preferable options. Distinct from a Darwinian evolutionary process, this refining process of design via optimizing choices all had to take place before any actual experimental trials of enzyme designs were undertaken.

Jiang and his team used more than just their own intelligent resources to formulate and implement this highly organized, purpose-driven protocol. The team also relied upon other, externally provided, intelligence-intensive resources, such as a "library of scaffold proteins," from which the team designed four basic "motifs" from which to search and choose. Additionally, two computerized algorithms were intelligently and intentionally used for narrowing the field of candidate designs: the Rosetta Match and a Quasi-Newton optimization method. These algorithms themselves were products of untold hours of intelligent design which long preceded their use by Jiang and his team.[88]

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[87]Jiang et al., "De Novo," 1388.

[88]"Rosetta Commons," Rosetta Design Group http://www.rosettadesign group.com/index.php (accessed November 6, 2013); Jorge Nocedal and Stephen J. Wright, *Numerical Optimization*, 2nd ed., Springer Series in Operations Research, ed. Thomas V. Mikosch (New York: Springer Science+Business Media, 2006): 135-63.

Interestingly, near the end of their article, Jiang and his team admit that their enzyme design method ran into clear limitations. Even when using the Rosetta Match program, dealing with the various potential combinations of molecular structure "become intractable for sites consisting of five or more long polar side chains."[89] As a result of this complexity limitation, they comment,

> It is tempting to speculate that our computationally designed enzymes resemble primordial enzymes more than they resemble highly refined modern-day enzymes. The ability to design simultaneously only three to four catalytic residues parallels the infinitesimal probability that, early in evolution, more than three to four residues would have happened to be positioned appropriately for catalysis.[90]

When the team experimentally tested their various designed enzymes in *E. coli*, some functional retro-aldol enzymes were created, although the team admits that "a significant gap" still exists between the functional capabilities of their designed enzymes and those of modern natural enzymes.[91] Their limited success shows that current synthetic biology methods and technology have not fully bridged the continuum between the humanly designed pseudo-cell and a natural modern cell. Despite this limitation, the Jiang team claims that their results "demonstrate that novel enzyme activities can be designed from scratch and indicate the catalytic strategies that are most accessible to nascent enzymes."[92]

Regarding the question of whether inductive samples exist along a continuum between intelligently designed artifacts and natural organisms, the experimental

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[89]Jiang et al., "De Novo," 1391.

[90]Ibid.

[91]Ibid.

[92]Ibid.

production of even simple, minimally functional enzymes seem to supply an affirmative answer. More importantly for this discussion, this empirically demonstrated progress down that continuum is critically and extensively dependent upon design strategies conceived, organized, implemented and managed by intelligent researchers, along with the additional, critical aid of intelligently-designed computer algorithms. Progress down the continuum exists and is increasing; intelligence is undeniably and crucially responsible for that progress from the artifact side. An inference, by isomorphic analogy, to an analogous intelligent cause critically involved in producing the samples progressing down the continuum from the organism side, is increasingly justified, whether by an argument from induction or through independent support for likelihood of a design hypothesis.

Overlooking Intelligence

Returning to a broader perspective on the bottom-up approach to synthetic biology, a common explicit or implicit goal of researchers in this field is to use their experiments to ultimately provide some empirical evidence about how the earliest cells on earth could have formed from simpler components by entirely naturalistic, unguided physical and chemical processes, i.e., by the earliest manifestations of evolution.[93] Simplicity is the order of the day, since they realize that blind, purely mechanistic evolutionary processes would not have had the time they theoretically need to gradually achieve high levels of specified complexity.[94] Some of these researchers claim that their

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[93]Deamer, "A Giant Step," 336; Chiarabelli et al., "Approaches," 2139; Mansy and Szostak, "Reconstructing," 2.

[94]Deamer, "A Giant Step," 336; Jiang et al., "De Novo," 1391.

experimental results do emerge from sufficiently simple subcomponents, mechanisms and preconditions, at least plausibly analogous to those they posit for a prebiotic environment.[95] As illustrated above, numerous examples exist of extensive influence in synthetic biology experiments of intelligent choices and purpose-driven constraints and methods. Therefore, when researchers claim that their experimental results display a simplicity sufficiently analogous to ancient natural processes theorized to produce the earth's most primitive cells, it seems reasonable to doubt that they are taking the influence of intelligence on their experimental process into adequate consideration.

Building on Intelligent Experimentation in the Past

While synthetic biologists all seem to acknowledge that their results only represent partial steps toward replicating cellular life in the laboratory, they also often seem to view their work as the latest step of a progressive process being undertaken by the science community at large toward that goal. Some acknowledge the critical involvement of intelligent researcher earlier in that process, upon which their bottom-up research is now building, just as similar research in the past laid important foundations for the top-down approach. Mansy and Szostak acknowledge that efforts aimed at replicating a minimal cell from scratch

> build on decades of pioneering work in prebiotic chemistry (Orgel 2004), the self-assembly and replication of membrane vesicles (Hanczyc and Szostak 2004), the nature of potential genetic polymers (Eschenmoser 1999), and the nonenzymatic

[95]D. W. Deamer and J. P. Dworkin, "Chemistry and Physics of Primitive Membranes," in *Prebiotic Chemistry: From Simple Amphiphiles to Protocell Models*, ed. P. Walde, Topics in Current Chemistry 259 (Berlin: Springer-Verlag, 2005), 13-14; Hanczyc, Fujikawa, and Szostak, "Experimental Models," 621; Hanczyc, Mansy, and Szostak, "Mineral," 67, 81; Mansy and Szostak, "Reconstructing," 4, 7; Sheref S. Mansy et al., "Structure and Evolutionary Analysis of a Non-biological ATP-binding Protein," *Journal of Molecular Biology* 371, no. 2 (August 10, 2007): 510.

template directed copying of nucleic acid sequences (Joyce and Orgel 2006).[96]

Needing Intelligent Experimentation in the Future

Despite only partially achieving the replication of minimal cells thus far, there seems to be a widespread attitude of hope that further and more complete steps will be and need to be made, and that perhaps not long from now, the bridge to at least a plausible synthetic version of nascent cellular life will be fully crossed. To date, experimentation has successfully produced synthetic, divisible, permeable, growing liposomes, as well as the encapsulation and even artificial design of functioning proteins within them. As of yet, however, certain other protocell functions mimicking those in natural cells have yet to be artificially synthesized. Nevertheless, some synthetic biologists view these remaining challenges as motivations for future research and development.[97] Moreover, in the current experimental approaches, which consist of a combination (or hybrid) of naturally operating and humanly controlled factors, the involvement of intelligent agency seems significant in achieving a finely-tuned system, whether the goal is to mimic a natural cell or to achieve some new or "improved" function, as predetermined by the research team.

Many other examples of such hybrid approaches could be listed, such as the PURE system (Protein synthesis Using Recombinant Elements),[98] the various combined

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[96]Mansy and Szostak, "Reconstructing," 2.

[97]For example, cell-membrane transport machines, mentioned in Ying Zhang, Warren C. Ruder, and Philip R. LeDuc, "Artificial Cells: Building Bioinspired Systems Using Small-Scale Biology," *Trends in Biotechnology* 26, no.1 (January 1, 2008): 19.

[98] Yoshihiro Shimizu, Takashi Kanamori, and Takuya Ueda, "Protein Synthesis by Pure Translation Systems," *Methods* 36, no. 3 (July 2005): 299-304; Chiarabelli et al., "Approaches," 2139.

methods (some alluded to above) of synthesizing liposomes and then encapsulating natural components to produce proteins or enzymes such as T7 RNA polymerase, a-hemolysin, and others,[99] or the method of "droplet transfer" for giant vesicle (GV) production. Regarding the latter method, Chiarabelli and his team report that by "tuning the volumes" of certain ingredients, they were able to produce GV's in a reproducible way, thus extending "semi-synthetic cell technology."[100] It thus appears that this team moved technology a little further along the artifact-organism continuum toward a more natural cell-like structure. In addition, Chiarabelli and his team assert their plans to "further exploit this method for constructing semi-synthetic minimal cells designed to perform specific functions such as lipid production, DNA or RNA replication, and especially core-and-shell reproduction."[101] They thus believe it is feasible to push synthetic biology even further down that continuum of ever-more-life-like (isomorphic) cellular functionality, and such progress will be critically indebted to the extensive, purposeful involvement of intelligent agency.

Bottom-up Summary

Similar to the Top-Down approach, reviewing details of experimental methods and materials reveals that intelligence crucially and extensively influences the Bottom-Up approach to synthetic biology. Bottom-Up researchers usually implicitly and sometimes explicitly acknowledge what amounts to a continuum between humanly-designed cell-like products and natural cells, which synthetic biology is progressively bridging. These

[99]Chiarabelli et al., "Approaches," 2139; Ishikawa et al., "Expression," 387–90; Noireaux and Libchaber, "Vesicle Bioreactor," 17669–74.

[100]Chiarabelli et al., "Approaches," 2141.

[101]Ibid.

researchers also implicitly (and probably unconsciously) reveal that intelligent control and guidance crucially contribute to the progress across that continuum. They reveal such intelligent control and guidance, even while seeking to mimic–and sometimes claiming to have successfully mimicked–a "simple" process of transformation they believe early life had to undergo.

Conclusions from Synthetic Biology

Products of synthetic biology experiments (whether "top-down" or "bottom-up") increasingly mimic natural bacteria in many key features. These experiments require extensive involvement of intelligent agency at numerous levels, and such involvement appears critical to the close natural/synthetic resemblance. As the features of these synthetic products more and more closely mimic those of natural, living bacteria, those products become step-by-step isomorphic analogues along the continuum between humanly-design artifacts and naturally occurring organisms. Ultimately, if Venter's team succeeds in creating *M. laboratorium*, since it would presumably "function as an autonomous living cell, based on what is known as [a] minimal genome," according to Chiarabelli et al., that product would qualify as being "alive."[102] Likewise, if Jack Szostak or others succeed in synthesizing and combining in the laboratory "an RNA replicase, a self-replicating vesicle, and an RNA-coded linking function, such as a lipid-synthesizing ribozyme," they will have produced "a sustainable, autonomously replicating system, capable of darwinian evolution. It would be truly alive."[103] One could

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[102] Chiarabelli et al., "Approaches," 2139.

[103] Jack W. Szostak, David P. Bartel, and P. Luigi Luisi, "Synthesizing Life," *Nature* 409, no. 6818 (January 18, 2001): 388.

argue that either of these developments would completely fill in the narrowing continuum between life and non-life which Sober asserts is needed (and yet is utterly lacking) for an inductive design argument to reasonably succeed.[104]

Moreover, since these synthetic life experiments and their products critically require the diligent planning, guidance, monitoring, interaction and correction of intelligent researchers through numerous steps in the experimental process, the small differences along the continuum in the products they produce display no diminishing influence on the essential need for that intelligent causation. Since these synthetic life experiments and their products display the critical need for intelligent agency no matter which step along the continuum they represent, they take the role of the inductive samples which Sober insisted have not existed from Hume's time to the present. As synthetic biology experiments continue, this inductive sample size of intelligently-produced products, which increasingly approximate life, continues to grow. A bridge principle fitting Sober's requirements seems to be emerging and growing ever-more-robust. Therefore by isomorphic analogy, it is entirely justified to infer that life–even as simple as bacteria, which purportedly existed for 3.5 billion years prior to the existence of such experiments–also requires the involvement of intentional, intelligent agency to account for the existence of certain, critical features which it isomorphically shares with its synthetic counterparts.

Using a likelihood approach, this same growing continuum of isomorphic analogues also supplies a strong, independently supported auxiliary proposition that natural life (at least bacterial life) requires the same intelligent agency that synthetic life

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[104]Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 175

requires, robustly increasing the likelihood of the intelligent design hypothesis. If Sober protests that this argument still has not shown what the goals and abilities of the purported designer are, the best response would be that since the products are so isomorphic (and increasingly so as research proceeds) it is reasonable to infer the goals and abilities of the producers are highly comparable: they are motivated to produce bacterial life and have the ability to do so. To insist at this point that one simply cannot know anything about what the purported designer of natural bacteria had in mind or was able to do is purely gratuitous, most probably based upon an unjustified, theologically-related assumption. The support is independent because it does not present observed features of the naturally occurring bacteria as their own evidential justification, but looks to the separate evidence of the features of synthetic life experiment products.

Isomorphic analogy provided by synthetic life experiment products supplies support for either an inductive or a likelihood argument undergirding the design hypothesis (again, at least for bacteria). It seems then that Sober's standards for justifying intelligent design as a scientific hypothesis have been met. Even if one admits intelligent design as a rival hypothesis regarding biological origins, which of the rivals is a "better explanation" or "more likely"? That question cannot be decisively determined yet, but the trends in empirical science seem not to be favoring neo-Darwinism's chances. What should be apparent for now (since that day when humans create organisms has not yet arrived) is that intelligent design at least has a reasonable probability claim. This is because there has been remarkable progress since Hume and Paley's day up through the artifact/organism continuum, toward the ultimate successful replication of organisms by humans. Science can do so much more technologically to mimic life than it could two hundred years ago. While Darwinian evolution in some form is still the most widely-accepted overall explanation for biological organisms in the scientific community, the analogical evidence undergirding an inductive argument or likelihood assessment regarding intelligent design is getting stronger by the year. On analogical grounds, the ongoing progress of science and technology bode poorly for neo-Darwinism permanently remaining "best explanation" or "most likely hypothesis."

Summary: Synthetic Life is Filling the Continuum from Artifacts to Organisms

On the final page of chapter 2 of *Evidence*, Sober makes an interesting prediction: "I expect that human beings will eventually build organisms from nonliving materials." Sober then states his opinion that when that happens, "it will be abundantly clear that the fact of organismic adaptation has nothing to do with whether God exists."[105]

Passing over the frequently-repeated fact that intelligent design proponents do not officially make any claims about the identity of the purported designer, if humans do succeed in building organisms, it seems one could, and indeed should, reach a conclusion exactly opposite to the one Sober draws. In fact, successful synthesis of life in the laboratory would provide stark, empirical evidence that organismic adaptation has *everything* to do with whether a biological designer exists. Fazale Rana explains why:

> While some scientists and others suggest the (anticipated) creation of artificial life makes the need for a Creator obsolete, I take the opposite view. As evidenced in both the top-down and bottom-up approaches, only by deliberate effort, inordinate ingenuity, and astonishing skill can synthetic biologists even begin the process of making artificial life. Their work empirically demonstrates that even the simplest life-form cannot arise without the involvement of an intelligent agent.[106]

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[105]Sober, *Evidence*, 188.

[106]Rana, *Life in the Lab*, 80-81.

In one sense, Sober is correct. If intelligent researchers successfully produce life in the laboratory from nonliving components, those particular synthesized life-forms certainly only need intelligent human design as their explanation. However, all the previous life-forms which have (purportedly) existed for billions of years prior to such synthetic life experiments–including bacteria, the Cambrian fauna, dinosaurs, the fish of the sea and the birds of the air, "the beasts of the earth . . ., the cattle . . ., and everything that creeps on the ground," and even the synthetic biology researchers themselves–justifiably infer the analogous need for intelligent design as *their* explanation. Obviously, humanly-devised synthetic biology experiments were not available for producing all these other life-forms, but the experiments reveal the critical need for intelligent planning, guidance and extensive involvement to produce isomorphically analogous products.

Rana's statement above contains an important additional point: synthetic biology experiments "empirically demonstrate" the crucial role of intelligence in producing the manifestation of specified complexity which humans call life. The involvement of intelligence which permeates these experiments can be (and often is) rigorously documented and verified. The evidence is as scientifically empirical as one could ask for, and therefore the independent support it provides to a likelihood assessment of the design hypothesis justifies qualifying that hypothesis as scientific.

Sober's conclusion that humans creating living organisms from nonliving materials would make it abundantly clear that the existence of God–more correctly, an intelligent designer–had nothing to do with "the fact of organismic adaptation," seems to be a paradoxical turn of logic. Two passages in chapter 2 of *Evidence* previous to this one highlight this paradox. First, recall that in the midst of boldly asserting that no sampling progress along the continuum between artifacts and organisms had been made in over two hundred years, Sober also said.

> If there were a continuum between 'not being alive' and 'being alive,' and we had sampled along this continuum, it would be no great leap to conclude that what we found in our sample also applies to unsampled objects that are a little more down the line.[107]

The occurrence of intelligent human researchers (such as some of the synthetic biology teams mentioned above) creating living organisms from nonliving materials arguably would supply just the sampling along the continuum between 'not being alive' and 'being alive' that Sober suggests. Far from making the issue of God's existence (at least in the sense of such a being hypothetically being willing and capable of intelligently designing biological organisms) irrelevant to organismic adaptation, the two would be much more tightly linked.

One can see a second example of this paradoxical logic when considering Sober's generalization of Hume's objection to inductive design arguments: Recall that Sober admitted that Hume's objection produced a problematic "sting" for proponents of a design argument, due to "the fact that none of us has seen an intelligent designer create an organism from nonliving materials".[108] If, as Sober predicts, intelligent human designers do create organisms from nonliving materials, and there presumably will be an abundance of witnesses to repeatedly observe those events happen, the inductive sample size will not be zero as Sober warned, but arguably will have as full and complete a sample size as Sober's standards here demand. Again, rather than indicating that an

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[107]Sober, *Evidence*, 175.

[108]Ibid., 140.

intelligent biological designer and organismic adaptation are unrelated, humans creating life from non-life in the lab will inextricably link the two, and make an analogical inference to an original biological designer even more compelling and likely than it already has become.

A highly relevant question to ask is on what basis Sober believes that humans will someday create living organisms from nonliving materials? It is hard to imagine how Sober could justify such an expectation unless he has noticed that human designers have already begun bridging that continuum. In fact, in a footnote to this passage, Sober admits:

> Human beings have been modifying the characteristics of animals and plants by artificial selection for thousands of years. This means that some traits of some of the organisms around us now are due to intelligent design while others are not (Dennett, 1987a: 284-5). Even so, the organisms that human planners have deliberately modified were not created by designers working just with nonliving raw materials.[109]

Sober's comment about artificial selection here emphasizes and supports another point raised in the previous chapter: The intelligently-manipulated changes inherent in domestically bred animals and plants could be used to provide one sample along of the continuum Sober demands. More fundamentally, however, if Sober expects that humans will someday create living organisms out of nonliving materials, he must have some inductive evidence that human designers have already started down the road toward such an outcome. If he sees evidence that they have started down that road toward that outcome–and the examples given above show that they have–then contrary to his claim that no evidence for a continuum between organisms and artifacts has been shown in the

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[109]Sober, *Evidence*, 188n45.

two hundred years since Hume's day, there indeed must in fact be some evidence available to him for that continuum after all.

Sober's own claims from earlier in the chapter, therefore, are additional reasons which, given his prediction about humans someday creating life from nonlife (which may be growing toward realization) ought to compel a conclusion exactly opposite to the one Sober himself draws. Philosophers of biology should return all the way back to Hume and contrast the evidence from DNA and computer code, and from molecular machines and synthetic biology, with analogy of the universe and machines which Hume presented to undermine design arguments. The analogical gap has shrunk dramatically in the intervening two hundred years, and if Sober's prediction is realized, that gap, by his own standards, arguably ought to vanish entirely.

While synthetically designed life is not the same as taking a time machine back to eyewitness a designer producing, say, the Cambrian explosion, it certainly will prove empirically that intelligent design can produce the equivalent of what scientists have come to recognize as biological organisms. In such a case there should be no question of intelligent design having a likelihood of producing such organisms. Moreover, unless by then neo-Darwinism advocates have produced empirical evidence that their hypothesized mechanisms, or any other strictly materialistic hypothesized mechanisms, can and do produce life from non-life,[110] intelligent design will not only will be a rival hypothesis, but should be regarded as the most likely hypothesis, at least for the emergence of life from non-life. Of course, if intelligent design is seen as the most likely explanation for

[110] Of course, strictly speaking, neo-Darwinian processes are not theorized to begin until living, reproducing organisms already exist.

bridging the non-life/life gap, then it is likely that an extremely advanced, intelligent and capable designer did exist, lending even more likelihood to the hypothesis that such a designer (or designers) could and would have also caused the later, macro-level developments in the history of life (for example the Cambrian Explosion), which as was discussed above, neo-Darwinian causes also have a very hard time explaining.

In chapter 2 of *Evidence,* Sober says that his fundamental criticism of the design hypothesis is that it is untestable.[111] Yet, since evidence that life crucially depends upon intelligent involvement is supplied analogically and hence inductively from empirically observable and verifiable synthetic biology experiments, those experiments themselves provide a mode of testing the design hypothesis. While synthetic biologists probably are not intending their experiments to be used for testing the hypothesis of design, the presence and essential role intelligence has played is clearly evident nonetheless. A similar argument for testability could be made emerging from empirical, scientific discoveries about isomorphic analogies between molecular machines and humanly-devised machines as well as between DNA and humanly-devised information systems.

An objection could be raised that such evidence, while empirical, testable and thus scientific, is still merely analogical. Yet precisely such an objection should then also be lodged against all empirical, testable, scientific and analogical evidence for purely materialistic hypotheses, including neo-Darwinian macroevolution. As pointed out in earlier chapters, since the causes for the emergence and major changes of life on earth lie in the unobservable past, one must reach inferences about those causes analogically,

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[111]Sober, *Evidence*, 148.

regardless of whether one operates from a design paradigm or a neo-Darwinian paradigm. One could argue that all experimental scientific research is fundamentally analogical, but especially so in the case of research concerning events in the distant past.

Neo-Darwinists may use empirically-observed microevolutionary changes of today to extrapolate macroevolutionary changes in the past. They may use the observed changes wrought by domestic breeding to infer larger scale changes wrought by natural selection in the unobserved past. They may attempt to experimentally recapitulate life in the laboratory by observable top-down or bottom-up approaches, and may infer from such experiments ingredients and processes which may have caused the first life to appear in the distant past. In any case, they must analogically link the observed products and their causes to the observed products and their unobserved causes. The analogical approach is inherent in Charles Lyell's fundamental inferential perspective (discussed in chapter 3) that the present is the key to the past.[112] In fact, Lyell himself touts the superiority of his method because, as he clearly implies, it has "reference to existing analogies."[113]   Given the observed products of the past, having sufficient "resemblance or identity"[114] to the observed products of the present, whose causes are also presently observed, both neo-Darwinists and design advocates are justified, depending upon the extent of isomorphism at high-order relations, in inferring unobserved causes with resemblance or identity to the presently observed causes.

Therefore, if one rejects the design hypothesis as scientific because it's support

[112]Charles Lyell, *Principles of Geology*, 11th ed. (New York: Appleton, 1889), 1:318-20.

[113]Ibid., 1:318.

[114]Ibid., 1:319.

is “merely analogical,” one must likewise reject the neo-Darwinian hypothesis as scientific for the same reason. Sober would probably be unwilling to reject the neo-Darwinian hypothesis as scientific. Therefore, since both depend upon analogical inference and since both are equally testable, intelligent design deserves a fair hearing along with neo-Darwinism, as a competing scientific hypothesis.

CHAPTER 8

CONCLUSION

Almost thirty years ago, in his groundbreaking book, which profoundly influenced some of the pioneers of the intelligent design movement,[1] Australian M.D. and Ph.D. in biochemistry Michael Denton summarized the impact of a realm of newly-emerging scientific evidence, evidence which he saw as a challenge to both Humean skepticism and blind evolution, a hypothesis which he labeled "a theory in crisis":

> It has only been over the past twenty years, with the molecular biological revolution, and with the advances in cybernetic and computer technology that Hume's criticism has been finally invalidated, and the analogy between organisms and machines has at last become convincing. . . . In every direction the biochemist gazes, as he journeys through this weird molecular labyrinth, he sees devices and appliances reminiscent of our own twentieth-century world of advanced technology. In the atomic fabric of life we have found a reflection of our own technology. We have seen a world as artificial as our own and as familiar as if we had held up a mirror to our own machines. . . .
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> The almost irresistible force of the analogy has completely undermined the complacent assumption, prevalent in biological circles over most of the past century, that the design hypothesis can be excluded on the grounds that the notion is fundamentally a metaphysical a priori concept and therefore scientifically unsound. On the contrary, the inference to design is a purely a posteriori induction based upon a ruthlessly consistent application of the logic of analogy.[2]

Given the additional evidence which has emerged since Denton's book was published, some of which appears in this paper, his words are proving prescient. This paper's

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[1] "Michael Denton, Senior Fellow, CSC," Discovery Institute, http://www.discovery.org/ p/521 (accessed January 17, 2014).

[2] Michael Denton, *Evolution: A Theory in Crisis*, paperback ed. (Chevy Chase, MD: Adler and Adler Publishers, 1996), 340-41.

arguments, while admittedly focused on the views of one philosopher of biology, still seem to fill out and concretely illustrate the essence of Denton's key claims. A brief review of those arguments may serve to strengthen the persuasive force of those claims.

Argument Summary Review

This paper has consistently been responding to two central criticisms by Elliott Sober of intelligent design as science, one claiming intelligent design has no discernible likelihood, and one claiming intelligent design has no empirical samples from which to make a reasonable inductive argument. As discussed in chapter 2 of this paper, both of these criticisms ultimately lead Sober to conclude that intelligent design is not testable as a scientific hypothesis should be (at least not at the present level of knowledge and evidence) because from the standpoints of both likelihood and induction, it lacks any independent, empirical support.

In response to Sober's objections, this paper has first raised points in defense of intelligent design as science. Chapter 3 pointed out that general scientific practice (both in fields concerned with intelligent causation, such as forensics, and within the historical sciences at large) does not necessarily require providing independent support for designer goals and abilities, as Sober demands, nor, more broadly, for dismissing hypotheses when necessary preconditions are as yet unknown. Chapter 3 also suggested alternative auxiliary propositions, supplied via analogy between biological and humanly designed phenomena, which would circumvent Sober's demand for knowledge of designer goals and abilities and yet still supply independent support for design hypotheses. Chapter 3 also noted, however, that such analogy with human designers could also reasonably supply at least some non-zero likelihood for the requisite designer goals and abilities which Sober seeks, but claims are unknown.

As a second method of response to Sober's objections, this paper next pointed out shortcomings in Sober's argumentation in *Evidence*. Chapter 4 described how unlike his approach to intelligent design, Sober did not rigorously examine auxiliary propositions regarding the necessary preconditions for the neo-Darwinian hypothesis in terms of macroevolutionary events. Referencing recent work by Stephen Meyer, chapter 4 did examine those preconditions regarding a classic macroevolutionary event: the Cambrian explosion. The chapter revealed what seem to be inconsistent standards on Sober's part, showing that by holding neo-Darwinism to demands parallel to what Sober demands of intelligent design, macroevolutionary neo-Darwinism would not be left with a discernible likelihood either. Interestingly, chapter 4 also showed how Sober crucially mischaracterizes the designer of intelligent design theory, and is therefore attacking somewhat of a straw man. Sober's effective conflation of the designer with the God of theism, and his subsequent assumption that God is categorically different from human beings and thus utterly inscrutable, misrepresent intelligent design theory on the one hand, and the Bible and traditional Christian theology on the other. Chapter 4 also showed how Sober's strategy for reframing design arguments so as to avoid Hume's criticisms actually makes independent support impossible, whether for a likelihood assessment or for an argument from induction. On the contrary, chapter 4 advised that intelligent design advocates face Hume's criticism's squarely through the growing power of analogy.

The next step of this paper was to show why analogy is a legitimate tool in scientific explanations in general, and (contrary to Hume's and Sober's apparently similar perspectives) in discussions of design arguments in particular. Sober's critique of intelligent design as science seems to address inadequately analogy's scientific legitimacy as it relates to design arguments. Chapter 5 referenced scholars who affirm that analogies, when framed according to "higher order relations"[3] or to an "isomorphic determining structure,"[4] serve as powerful tools in support of explanatory theories.[5]

The chapter then pointed out that both Sober's account of analogy, as well as David Hume's account which Sober draws upon, are shallow, oversimplified descriptions which misrepresent the more powerful versions of analogy which the best design arguments utilize. The chapter also explained how Sober's objection to *probabilistic modus tollens* (which he uses as a step in defending neo-Darwinism's likelihood) also entails that design arguments, even if (as Hume warned) they are founded upon very weak analogies, will still retain some non-zero likelihood. This is another reason design theorists should not take Sober's advice by reformulating design arguments so as to avoid appeals to analogy and induction.

The fifth chapter also described how scientists from Darwin himself to neo-Darwinians, regularly and successfully use analogies. Even Sober himself uses analogies, both explicitly when defending neo-Darwinism, and implicitly when building his case against intelligent design as science.

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[3]Keith J. Holyoak and Paul Thagard, *Mental Leaps: Analogy in Creative Thought* (Cambridge, MA: MIT Press, 1995), 29; Dedre Gentner and Arthur B. Markman, "Structure Mapping in Analogy and Similarity," *American Psychologist* 52, no. 1 (January 1997): 47.

[4]Julian S. Weitzenfeld, "Valid Reasoning by Analogy," *Philosophy of Science* 51, no. 1 (Mar 1984): 148-49.

[5]Holyoak and Thagard, *Mental Leaps*, 177; C. Kenneth Waters, "Taking Analogical Inference Seriously: Darwin's Argument from Artificial Selection," in *Contributed Papers*, vol. 1 of *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* (Chicago: University of Chicago Press, 1986), 503, 507, 510.

Chapter 5 also pointed out that when Sober rejects intelligent design on inductive grounds, his requirement of a “bridge principle” is tantamount to analogy. Therefore, strong analogy (as explained earlier in the chapter), if undergirded by empirical evidence from science and technology, can work to bridge the continuum between humanly-designed artifacts and organisms. In the end it yields a reasonable and scientific inductive argument, just as such analogical evidence supplies the independent auxiliary propositions needed for a scientifically legitimate likelihood argument.

In chapters 6 and 7, the paper focused on providing numerous examples of the empirical evidence just mentioned, which undergirds a strong analogical inductive case, as well as a likelihood case for intelligent design as science. Such evidence should falsify Sober’s claim that there has been no empirical evidence of progress across the continuum between artifacts and organisms from Hume’s day to the present.

Chapter 6 presented evidence of scientific progress along that continuum from organisms to artifacts, specifically highlighting striking similarities between biological information and computer software and human language in general. The chapter also highlighted the similarities, and the growing awareness of them, between molecular machines and humanly-designed machines or systems.

For its part, chapter 7 presented evidence of scientific and technological progress along the continuum from artifacts to organisms, specifically emphasizing strides made in the field of synthetic life research. The products described in chapter 7, whether entire functional genomes, or steps toward protocells, as well as the scientific discoveries described in chapter 6 both seem to be filling in the continuum between artifacts and organisms (from both directions), gradually and steadily fulfilling the requirement which Sober claimed would undergird a reasonable inductive design argument.

Chapter 7 also notes Sober's prediction that human designers will one day create organisms from nonliving materials. Sober claims that such a development will show that "the fact of organismic adaptation has nothing to do with whether God exists."[6] Yet, humans designing life from non-life would at least seem immensely to strengthen the implication that intelligent planning, guidance and extensive involvement are indispensible to have produced all the isomorphically analogous products, namely, the life forms as biologists already know them which have existed since life first began on this planet. Additionally, although intelligent design theory formally doesn't demand theological implications, this development would also seem to be a great help in undergirding a further inference that "God" is the source of that intelligent planning, guidance and involvement. It would be very easy to come to a conclusion exactly opposite to Sober's.

Analogy's Pivotal Role

Contrary to Sober's conclusions, one should not reject intelligent design as science either on likelihood grounds; neither should one reject it on inductive grounds. One key reason Sober's conclusions are mistaken is that they crucially depend on a generalized objection taken from David Hume, but which seems increasingly inapplicable. That objection says that people know from empirical experience that humanly designed devices and the natural world are simply too different in kind to infer a

[6]Elliott Sober, *Evidence and Evolution* (New York: Cambridge University Press, 2008), 188.

common cause of intelligence. Tacitly accepting that Hume's objections are more devastating than they really are (especially in today's scientifically and technologically developed context), Sober has too hastily dismisses analogical support for the design hypothesis. It turns out that using analogy between artifacts and organisms greatly helps intelligent design as science both in terms of likelihood and in terms of induction.

As it is applied in a likelihood approach, analogy helps an intelligent design hypothesis because Sober's incorporation into likelihood assessments of the Duhemian requirement for independently supported auxiliary propositions allows a place for analogical induction to be used in the role of independent auxiliary propositions. Analogies between artifacts and organisms emerging from scientific discovery and technological development like those considered in chapters 6 and 7 can be used effectively as those independently supported auxiliary propositions, thus producing assurance for design hypotheses of at least a non-zero likelihood. Moreover, as such analogies grow in isomorphism through further scientific discovery and technological progress, the corresponding likelihood also seems destined to grow.

Likewise, as it is applied in an inductive approach, analogy also helps an intelligent design hypothesis because as the body of evidence and developments in molecular biology, biochemistry and synthetic biology continue to grow, analogies between artifacts and organisms become more manifest. This fills the continuum between them, and produces an ever-broader sample size. All of this is the equivalent of an ever-stronger "bridge principle," which progressively improves intelligent design as an inductive argument.

Further, chapter 4 claimed that the notion of a likelihood comparison, as promoted by Sober, at least when dealing with events in the unobservable past, effectively boils down to the same conceptual process as an inference to the best explanation, the conception which Stephen Meyer prefers when evaluating scientific hypotheses in the historical sciences. Consequently, these same analogies can be usefully employed to support the causal adequacy of an explanation of design, and again, as such analogies grow in isomorphism through further scientific discovery and technological progress, inferences to design explanations also seem destined to grow better and better in comparison with rival, non-design explanations.

Analogy Overcomes Sober's Reasons for Rejecting Intelligent Design as Untestable

Analogy helps show how design hypotheses are testable, and through that, how they qualify as science. Recall that from Sober's viewpoint, his likelihood and induction objections to intelligent design ultimately boil down to a problem of testability: "My criticism of the design argument might be summarized by saying that the design hypothesis is [presently] untestable."[7] Sober views it as untestable "because we don't at present have the independently attested auxiliary propositions that are needed to bring it into contact with observations."[8]

Sober has thus chosen testability, measured by the capability of providing independently supported auxiliary propositions, as his line of demarcation for what counts as science and what does not. In *Darwin's Doubt*, Stephen Meyer asserts that proponents of methodological naturalism sometimes have used a variety of demarcation

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[7]Sober, *Evidence*, 148.

[8]Ibid.

criteria as a means of eliminating intelligent design from consideration as science, for instance, that intelligent design

> (a) is not testable, (b) is not falsifiable, (c) does not make predictions, (d) does not describe repeatable phenomena, (e) does not explain by reference to natural law, (f) does not cite a mechanism, (g) does not make tentative claims, and (h) has no problem-solving capability. They have also claimed that is not science because it (i) refers to an unobservable entity. These critics also assume, imply, or assert that materialistic evolutionary theories do meet such criteria of proper scientific method.[9]

Meyer gives two broad responses to these criticisms, both of which parallel two general categories of responses which this paper has provided to Sober's objections. First, Meyer responds, "many of these claims are simply false (e.g., contrary to the claims of its critics of intelligent design is testable; it does make predictions; it does formulate its claims tentatively; and it does have scientific problem-solving capability). . . ."[10] This paper has shown that through the employment of analogy from artifact to organism, or from organism to artifact, design hypotheses attain both a likelihood and inductive support.

How are design hypotheses testable, however? Chapter 6 listed three "machine-like" manifestations, which, if appearing simultaneously, indicate specified complexity: integrated functionality, specified structural dependence and information flux. One might therefore empirically test biological design hypotheses according to the following question: "As scientists continue to examine biological organisms (or their systems, structures, hierarchies, etc.), do they, or do they not find integrated functionality,

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[9]Stephen C. Meyer, *Darwin's Doubt The Explosive Origin of Animal Life and the Case for Intelligent Design* (New York: Harper Collins, 2013), 389.

[10]Ibid., 390.

specified structural dependence and information flux all simultaneously present in ways highly analogous to those same three qualities found in humanly designed artifacts?"[11] Thus, given the analogical evidence presented in this paper undergirding either a likelihood or inductive argument to support a design hypothesis, I claim, along with Meyer, that contrary to Sober's conclusion, in regard to unobservable, so-called "macroevolutionary" events, intelligent design is, in fact scientifically testable.

Meyer also responds that

> when the claims of those making demarcation arguments are true–when intelligent design doesn't meet a specific criterion– . . . the materialistic evolutionary theories that intelligent design challenges, theories widely regarded by convention as 'scientific,' *fail to meet the very same demarcation standard*.[12]

Similar to Meyer's response, this paper also gave examples of how applying Sober's standards with parity would eliminate macroevolutionary neo-Darwinism as well as intelligent design as scientific hypotheses. For example, given the problems providing independently supported auxiliary propositions concerning necessary preconditions to support neo-Darwinism as a hypothesis for the Cambrian Explosion, that hypothesis, in that particular context, may not be testable from Sober's likelihood approach at all.[13]

As the argument summary review above shows, this paper's responses to

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[11]Others have suggested alternative testing methods, of course. E.g., Dembski's "Explanatory Filter," William A. Dembski, *The Design Revolution: Answering the Toughest Questions about Intelligent Design* (Downers Grove, IL: InterVarsity Press, 2004), 87-93. Dembski also discusses four other key ways in which intelligent design is testable: refutability, confirmation, predictability and explanatory power, Dembski, *Revolution*, 280-90. Stephen Meyer briefly presents three methods under which intelligent design is testable: explanatory power comparable with other theories; alignment with known cause-and-effect processes; generation of predictions which can be confirmed or disconfirmed, Meyer, *Darwin's Doubt*, 391.

[12]Meyer, *Darwin's Doubt*, 390.

[13]Whether neo-Darwinism would meet Sober's standards for a reasonable inductive argument is another question. Sober does not address this, nor does he address the broader issue of testability's relationship to hypotheses supported by inductive arguments (e.g., how much inductive support is necessary for a hypothesis to be considered testable?).

Sober's objections closely parallel Meyer's two responses to demarcation criticisms of intelligent design. Meyer summarizes what these two responses show: "Depending upon which criteria are used to adjudicate their scientific status, and provided metaphysically neutral criteria are selected to make such assessments, intelligent design and materialistic origins theories invariably prove equally scientific or unscientific."[14] At least in terms of the criteria Sober presents in *Evidence*, and how he links it to testability, this paper's conclusion is very much in line with the spirit of Meyer's conclusion.

Echoing Denton's comments above, this paper presented, on one hand, a portion of the accumulating evidence which strengthens an analogical inductive argument for design far beyond anything Hume would have imagined or could have reasonably refuted. Discoveries have steadily accumulated of "devices and appliances reminiscent of our own twentieth-century world of advanced technology,"[15] and that accumulation today is even more abundant and remarkable than what Denton observed thirty years ago. Given such an accumulation of discoveries, intelligent design ought to qualify as science because it "is a purely a posteriori induction based upon a ruthlessly consistent application of the logic of analogy."[16] In other words, despite Sober's contention to the contrary, intelligent design hypotheses should qualify as science on inductive grounds. Similarly, this paper has also presented the case that that same accumulating evidence causes intelligent design hypotheses to meet Sober's likelihood requirements. In either case then, there are excellent reasons, based upon both unbiased logic and rapidly

[14]Meyer, *Darwin's Doubt*, 390.

[15]Denton, *Crisis* 341.

[16]Ibid.

accumulating and compelling evidence, to conclude, contrary to Sober's objections, that intelligent design qualifies as science.

Topics for Further Research

While I am personally interested in many topics relevant to intelligent design, including the specific issue of intelligent design's claims to be science, here I limit suggested topics for further research to the following six.

First, I strongly urge ongoing research into "Additional Examples of Artifact-Organism Analogies from Biology and Biotechnology to Measure against Hume's Objection to Design Analogies." I feel that unfortunately, far too many philosophers of science are convinced that Hume's objections to both analogical and inductive design arguments are still hopelessly devastating, when in fact, I believe they have far exceeded their philosophical shelf-life.

Second, and third, other topics very closely related to this paper's theme may deserve additional attention: Beyond Sober's criteria, "Is Macroevolutionary Neo-Darwinism any more Testable than Intelligent Design?"; and "How Persuasive is Macroevolutionary Neo-Darwinism as an Inductive Argument?" Addressing these topics might bring further clarity (beyond the issues Sober has raised) to the issue of whether intelligent design qualifies as a hypothesis to rival other scientific theories of biological origins and development.

Fourth, for an audience with theological interests, I suggest research into The Biblical Roots of Complex Specified Biological Information. The topic of biological information is presently the most prominent one driving the intelligent design theory community. This probably is because biological information, including its complexity, its multiple levels, its apparent teleological functioning, its similarity to manifestations of humanly-produced information, its lack of material dependence and perhaps especially the lack of naturalistic explanations of its origins seem to most starkly imply its need for intelligent causation and/or management. Does the Bible mention or even imply the existence or importance of biological information, or even an inchoate version of it? What do the various passages in the Bible which allude to creation or the Creator leave any hints as to biological information, its functions or its origins?

Fifth, another important, related topic is "The History of Darwinist Use of the Argument from Conceivability." Evolutionists of many stripes have in common a practice of defending the general Darwinian hypothesis by elaborating scenarios by which Darwinian processes conceivably could have produced the observations in question, and then claiming that such conceivability scenarios are sufficient evidence to refute Darwin-doubters. Besides being ad hoc responses, such scenarios often suffer a paucity of independent empirical evidence to support them. What is the history of such strategies in Darwinian apologetics? Why has the scientific and education community, the media and the public at large been so accepting of this method of persuasion? Have intelligent design advocates adopted such methods in any ways in order to defend their own hypothesis?

A sixth and final topic is another one which in the coming years will may gain significant attention, at least among the thinkers and scientists in the intelligent design community. That topic examines analogies between hierarchies in biological systems (e.g., proteins, cells, tissues, organs, body systems, body plans, families, communities, ecosystems and the worldwide biosphere) and hierarchies in humanly-designed systems (e.g., components, machines, assembly lines, factories, industries, entire economies). Can scientists find integrated functionality, specified structural dependency and information flux at all these various levels of the hierarchies found in both analogues? If so, does the crucial role of intelligence throughout the hierarchy on the human side have implications about intelligence throughout the hierarchy on the biological side?

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ABSTRACT

A CRITIQUE OF THE REJECTION OF INTELLIGENT DESIGN AS A SCIENTIFIC HYPOTHESIS BY ELLIOTT SOBER FROM HIS BOOK *EVIDENCE AND EVOLUTION*

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This dissertation critiques and rejects Elliott Sober's dismissal of intelligent design as a scientific hypothesis. Sober builds the case for this dismissal in chapter 2 of his 2008 book *Evidence and Evolution*. Sober's case against intelligent design as science is a philosophical one, emerging from a Bayesian likelihood approach. Sober claims that unlike neo-Darwinian processes, intelligent design cannot supply independent evidence to support the claim that it is a measurably likely cause responsible for the emergence of biological organisms and the structures or processes of which they are composed. Without an assessable likelihood, Sober asserts that intelligent design (again, unlike neo-Darwinian mechanisms) is not testable, and since it is not testable, it does not qualify as a scientific hypothesis.

This dissertation argues however, that according to Sober's own standards in *Evidence*, because intelligent design and the neo-Darwinian hypothesis both address unrepeated, major biological changes in the unobservable past, and because they both depend upon crucial analogies in order to support either inductive arguments or likelihood assessments, the two hypotheses stand on equivalent evidential and logical

grounds. Either Sober must reject both neo-Darwinism and intelligent design, or he must allow them both as equivalent, rival hypotheses based upon a fair application of his argumentation requirements. In addition, after explaining important basics of analogy theory, and its crucial, even unavoidable role in the historical (or "origins") sciences, the dissertation goes on to show how intelligent design's empirical support, based upon analogy with humanly designed artifacts, machines and increasingly cell-like creations in the laboratory, is continuing to grow stronger by the year in both likelihood and in explanatory power. The dissertation thus concludes that intelligent design should be treated as a viable scientific explanation for the dramatic examples of specified complexity being discovered in biology, and indeed should be regarded as an increasingly vigorous rival to the neo-Darwinian explanation of such complexity.

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