This book contains numerous examples of information, mathematics, and logic puzzles that are instructive and entertaining. However, anyone seeking insight into biological or chemical evolution is advised to look elsewhere.

Notes

¹William F. Basener, "Limits of Chaos and Progress in Evolutionary Dynamics," in *Biological Information: New Perspectives*, ed. Robert J. Marks II et al. (Hackensack, NJ: World Scientific Publishing, 2013), 87–104.

²Stephen C. Meyer, *Signature in the Cell: DNA and the Evidence for Intelligent Design* (New York: HarperCollins, 2010), 85–111.

³For a more detailed discussion of how physical information in DNA can be transformed into new meaningful information, see Loren Haarsma and Terry M. Gray, "Complexity, Self-Organization, and Design," in *Perspectives on an Evolving Creation*, ed. Keith B. Miller (Grand Rapids, MI: Eerdmans, 2003), 288–312.

Meeting Chaitin's Challenge

A Response to Randy Isaac's review of *Introduction to Evolutionary Informatics* (above)

by Robert J. Marks II, Distinguished Professor of Engineering, Department of Engineering at Baylor University, Waco, Texas.

et my response to Randy Isaac's respectful review begin with thanks to James Peterson, the editor-in-chief of *Perspectives on Science and Christian Faith*, who, in concert with Isaac, solicited this response to Isaac's review. Such a practice is not common for book reviews. But we note that, in the venue of this journal, we are followers of Christ where we celebrate iron sharpening iron. One day, in front of our Creator, we will learn the degree to which of us is right. When this happens, I suspect the answer will matter little. Until then, let's continue to reason together.

Chaitin's Challenge

Gregory Chaitin, arguably the greatest and most creative mathematician of my generation, says: "The honor of mathematics requires us to come up with a mathematical theory of evolution and either prove that Darwin was wrong or right!" This question is answered in *Introduction to Evolutionary Informatics*: there exists no computer or mathematical model of Darwinian evolution not requiring the use of a guiding source of knowledge or oracle. Nor will there ever be an evolutionary algorithm that creates complex specified information without guidance supplied within the algorithm by one or more sources of knowledge such as oracles.

Regarding our book, Isaac concludes that those "seeking insight into biological or chemical evolution are advised to look elsewhere." We agree. But if you are looking for insights into the models and mathematics thus far proposed by supporters of Darwinian evolution that purport to describe the theory, our book is spot on.

Evolution Models:

We Didn't Start the Fire

An honest attempt at computer modeling of evolution was Thomas Ray's fascinating program Tierra that, although displaying interesting properties, fell well short of Ray's goal of simulating something akin to the Cambrian explosion. Although Tierra had no explicit goal, Ray attempted to design an environment in which his digital organisms could evolve. He was not successful. After numerous failures and tweaks, Ray abandoned Tierra.¹

More recent evolution simulations include the computer programs Avida and EV. Avida and EV pose evolution as a search algorithm with a specified goal. Engineering design has a long history of using evolutionary search with a design goal.² But Isaac protests that "such a goal [in evolution] is not derived from any study of nature." If true, Isaac has disqualified Avida, EV, and all other evolution models of which we are aware. For different reasons, we therefore find ourselves in agreement with Isaac: there yet exists no mathematical model that describes Darwinian evolution.

Avida is of particular importance because Robert Pennock, a co-author of the first paper describing Avida,³ offered testimony at the Darwin-confirming *Kitzmiller et al. v. Dover Area School District* bench trial which ruled that work such as mine is religious. He testified, "In the [Avida computer program] system, we're not simulating evolution. Evolution is actually happening." If true, Avida and thus evolution is teleological, guided, and overflowing with active information supplied by the programmers.⁴

On the other hand, microbiologist James Shapiro says, "Most debates about evolution sound like the last fifty years of research in molecular biology had never occurred"⁵ and maintains that organisms teleologcally generate novelties which other organisms later adopt. Palaeontologist Simon Conway Morris's book *Life's Solution: Inevitable Humans in a Lonely Universe* makes clear from the title that evolution has a goal as witnessed by observation of evolutionary convergence. So, maybe evolution does have a goal. If so, evolutionary models and the critique of them in our book apply. If not, there exists no mathematical model of Darwinian evolution.

From Whence Design?

Within evolutionary models, the evolutionary process is not the source of design. The design is, rather, due to the imbedded source of knowledge in the model or simulation. For Avida and EV, our group was able to use the same resident sources of knowledge and generate results much more efficiently using simple stochastic hill climbing. Gold miners can dig using a spoon or a shovel. Evolution can be an inefficient tool for mining results from an oracle. For those interested, we have interactive GUI's (graphical user interfaces) on our website that demonstrate this.⁶

Hitting a limit called Basener's ceiling, evolutionary models such as Tierra and Avida will evolve only to the resident oracle's level of expertise. An evolutionary program written to play chess will not evolve an ability to play GO unless programmed to do so. Doing so makes the problem even more complex, necessitating even more guidance from a source of knowledge.

Some Information about Information

Measuring the algorithmic specified complexity (ASC) of a design involves defining applicable information measures. ASC does not deal directly with evolution, but is useful in assessing the meaning of end design information.

An entire chapter in *Introduction to Evolutionary Informatics* is dedicated to various definitions of information. We like Claude Shannon's take on defining information:

It seems to me that we all define "information" as we choose; and, depending upon what field we are working in, we will choose different definitions. My own model of information theory ... was framed precisely to work with the problem of communication. 7

Isaac's claim that "information is physical" is narrow. It is like saying "squirrels are mass and energy." In the strictest sense, Shannon's definition of information is based on probability – events in the future which have not yet happened and therefore have nothing directly to do with anything yet physical. Nevertheless, we today universally assign Shannon's binary digit as the measure of physical information storage.

And then there's the Kolmogorov-Chaitin-Solomonov (KCS) information model that differs from Shannon's. Although more difficult to measure, KCS information deals with existing structures and is as much a part of the universe as energy, mass, and time. KCS information can be used as the foundation for determining the ASC-or meaning-of an object.

Here's an illustration. Consider a computer program that instructs a 3D printer to construct a bust of Abraham Lincoln in sufficient detail to see the wrinkles on his forehead and the mole on his right cheek. Contrast this with a program for printing a new bowling ball. For both the bowling ball and Lincoln bust, there exists a shortest program to accomplish the print. These shortest programs are called "elegant." The length of the elegant program is an object's KCS information content. The elegant program for the bowling ball, in bit count, will be shorter than that of Lincoln's bust. Lincoln's bust, measured by the bit count of its elegant program, contains more KCS information than the bowling ball.

However, the elegant program for detailed construction of a bumpy rock might be similar in length to the program needed for Lincoln's bust. So, assuming the details of the rock are not as meaningful as those on Lincoln's face, KCS information is seen to not measure meaning. Lincoln's bust is more meaningful because it is specified via context. Consider short 3D-printer-assisting subprograms called MOLE, BEARD, and HUMAN HEAD to which the programmer has access. When computing the length of the Lincoln elegant program, the subprograms used by the master program are not included in the bit tally. The conditional elegant program will be shorter. The ASC measure of the meaning of an object is obtained by subtracting this context-conditional elegant program length from the information measure of the

object based on chance construction by the best available theory, for example, the laws of physics. ASC appropriately bears a resemblance to Shannon's measure of mutual information.

Here are two examples from our book. A snowflake is very complex, but complex things like snowflakes happen all the time. Two arbitrary complex snowflakes have a low ASC whereas two identical snowflakes have a large ASC. In the context of poker, a two-of-a-kind poker hand has negligible ASC whereas a royal flush has an enormous ASC content.

"So You're Telling Me There's a Chance!"

... is *Dumb and Dumber*'s Lloyd Christmas's response to pretty Mary "Samsonite" Swanson who told Lloyd his odds with her were one in a million. The line is funny because Lloyd's response is clearly dumb. As I type, the odds of my right thumb quantum tunneling into my keyboard's space bar is finite but so small that saying "so you're telling me there's a chance" is also dumb.

How small must a probability be before we announce impossibility? The answer is fuzzy in the sense of Zadeh. So, to remove doubt, we must set chances beyond all argument.

Based on Landauer's contention that "information is physical," Seth Lloyd estimates the computing capacity of the universe throughout history to be 10¹²⁰ operations on 10⁹⁰ bits. Without guidance, 10¹²⁰ bits is not able on average to generate unguided random creation of *any* sequence exceeding 165 Webster's dictionary words.⁸ The low number of words is astonishing. For a specified phrase, the chances are smaller.⁹

Let's dwarf Lloyd's information bound. One Planck length stretched to an inch scales the diameter of a proton to several light years. A Planck time unit is the time it takes light to travel one Planck length. Consider a bit count equal to the number of Planck cubes in the universe integrated in Planck time units over 14 billion years. This number interpreted as bits is insufficient for generating any string of dictionary words as long as the Gettysburg Address. If you are astonished by this low figure, you are not alone. Even if multiplied by 10¹⁰⁰⁰ universes in a multiverse, the resulting number, in bits, is insufficient for generating any sequence of words as long as the Declaration of Independence.

Isaac and others are critical of our use of probabilities. Even if "information is physical," these astronomical resources¹⁰ eclipse the universe's current mass-energy parsed into single bit energies measured in von Neumann–Landauer lower energy bounds multiplied by the number of Planck time units in 14 billion years. Given the resulting staggeringly limited creativity of this bit count resource, creation requires enormous guidance to explain the ASC we see in nature, which certainly exceeds the length of the Gettysburg Address.

In a separate but related theory, the chance of generating a design decays at least exponentially as a function of the resulting ASC. The probability of a thousand bits of ASC occurring by chance is less than 2^{-1000} .

Are Meaningful and Meaningless Information Models Meaningful?

In his review, Isaac proposes his own information model to rebuke some of our research conclusions.¹¹ His theory consists of ideas such as meaningful information and meaningless information and the possibility of transforming the latter into the former. Isaac objects that we consider only meaninPPgful information while ignoring meaningless information. This is critical because, according to Isaac, it is possible to derive meaningful information from meaningless information.

If true, a DVD of bits generated by a quantum random number generator can be transformed into a DVD that has meaning—something like the movie *Braveheart*. Even if an enormous codebook translating random sequences into words were written, a source of knowledge in the form of human intelligence is required to establish the context required for meaning. We are simply agreeing on a new alphabet. In this sense, we concur that Isaac is correct in saying meaningless information can be defined as artificial context. In the same sense, hieroglyphics can be redefined into English without knowing hieroglyphics or caring about the meaning originally intended by some long-dead Egyptian writer.

Functional Information's Definition Is Abstract

Isaac points out that the information one might find in abstract symbols such as letters is different from functional information corresponding to a useful function in some physical context. He accepts that abstract information requires an intelligent agent, but argues that functional information does not. This begs a question: Does the instruction manual for my juicer contain functional information? No definition of functional information is given, and therefore the answer is not clear. "Functional information" needs to be defined in a mathematical sense. In molecular biology, functional information is "-log₂ of the probability that a random sequence will encode a molecule with greater than any given degree of function."12 I do not believe that this is what Isaac means. Curiously, functional information's definition according to Isaac looks to be abstract.

Isaac attempts to dismiss the applicability of our conservation of information results by arguing that one can increase meaningful information in a biological system by adding noise. But this is simply increasing the randomness of a system. Introducing randomness into a system is fully part of what is taken into account by the conservation of information. In a paper titled "Meaningful Information," Vitányi also disagrees with respect to KCS information.

One can divide ... [KCS] information into two parts: the information accounting for the useful regularity [meaningful information] present in the object and the information accounting for the remaining accidental [meaningless] information.¹³

Unlike our approach, the Kolmogorov sufficient statistic just described does not take into account context.¹⁴ It is concerned only with the structure of an object. Nevertheless, the conclusion is the same: if you add random bits into a sequence, the pile of random meaningless information will simply be bigger. The meaningful information pile will remain the same size.

A fixed structure, such as Donald Trump's DNA, has fixed KCS information. But its ASC bound can increase as more context is found. Hieroglyphic texts were assigned more meaning when new context was provided by the discovery of the Rosetta stone. But, once successfully translated, a hieroglyphic text has no more meaning than that intended by the original writer. Likewise, the ENCODE project has given DNA more meaning than it had twenty years ago. The term "junk DNA" (Isaac's meaningless information?) is now rarely used because it has found function. DNA did not change but its meaning did. Was formerly meaningless junk DNA now meaningful? No. The meaning was always there but the context remained undiscovered. ASC, like KCS complexity, is expressed via a bound. KCS complexity is upper bounded by the shortest program thus far known. For a fixed theory of random object constrained construction, ASC is likewise lower bounded. Higher ASC can occur as more context is discovered.

Finis

If anyone generates a model demonstrating Darwinian evolution without guidance that ends in an object with significant specified complexity, let us know. No hand-waving or anecdotal proofs allowed.

We believe that Chaitin's challenge has been met in the negative and that no such model exists.

Space limitations prohibit further comment. Thanks for listening.

Notes

- ¹Citations for any material not explicitly referenced herein are in our book: Robert J. Marks II, William A. Dembski, and Winston Ewert, *Introduction to Evolutionary Informatics* (Hackensack, NJ: World Scientific, 2017).
- ²For example, check out the engineering journal, *IEEE Transactions on Evolutionary Computation.*
- ³Richard E. Lenski, Charles Ofria, Robert T. Pennock, and Christoph Adami, "The Evolutionary Origin of Complex Features," *Nature* 423, no. 6936 (2003): 139–44.
- ⁴One should not infer that knowledge sources were placed in Avida with any thought of deception on the part of the authors, who are all highly credentialed and respected researchers. Nevertheless, they are there.
- ⁵James Alan Shapiro, *Evolution: A View from the 21st Century* (Upper Saddle River, NJ: Pearson Education, 2011).
- ⁶http://evoinfo.org. See EV Ware, Minivida, and Weasel Ware.
- ⁷Quoted in P. Mirowski, *Machine Dreams: Economics Becomes a Cyborg Science* (New York: Cambridge University Press, 2002), 170.
- ⁸Eric Holloway and Robert J. Marks II, "Informational Cost of Generating Meaningful Text and Its Implications on Creativity" (in review).

¹⁰Pun intended.

¹¹We could be wrong here, but Isaac provides no references concerning his model – nor are we aware of any.

⁹Marks, Dembski, and Ewert, Introduction to Evolutionary Informatics, 120–25.

- ¹²Jack W. Szostak, "Functional Information: Molecular Messages," *Nature* 423, no. 6941 (2003): 689.
- ¹³Paul Vitányi, "Meaningful Information," in International Symposium on Algorithms and Computation: 13th International Symposium, ISAAC 2002 Vancouver, BC, Canada, November 21–23, 2002: Proceedings (Berlin, Germany: Springer, 2002), 588–99.

¹⁴See Thomas M. Cover and Joy A. Thomas, *Elements of Information Theory*, 2nd ed. (Hoboken, NJ: Wiley-Interscience, 2006) or Ming Li and Paul Vitányi, *An Introduction to Kolmogorov Complexity and Its Applications* (New York: Springer Science + Business Media, 2008).

Rejoinder

by Randy Isaac

appreciate Robert Marks's kind remarks and his taking the time to clarify his perspectives. I would like to underscore several points.

- Any input from an intelligent source required by a mathematical model or an algorithm such as Chaitin's is due to the fact that these models and algorithms are human simulations of a natural process. It cannot be inferred that the natural process itself requires an intelligent source of information. Whatever merit the law of conservation of information – which asserts that new information can be generated only by an intelligent agent – may have in computer models, it does not apply to information in general and is not relevant to DNA information.
- 2. A key assumption of the information argument for intelligent design is that functional meaning of information such as DNA is identical in every way to abstract meaning of information. Hence it is claimed that since abstract meaning can be generated only by an intelligent source, it is also true for functional meaning. However, the reason that abstract meaning requires an intelligent source is the abstract nature of the meaning and not the characteristic of information itself. Functional meaning does not necessarily have an abstract component.¹ Biochemical processes transform DNA information into functional biological activity without a single step of abstract relationships. Evolutionary processes associate useful biological activity with specific DNA information without the need for an a priori abstract blueprint.
- 3. The way in which Marks considers probabilities implies that complex biomolecules are assembled anew by starting from a random collection of com-

ponents. No such process is proposed in biological evolutionary theory. Rather, each reproductive event starts with a proven successful set of DNA information. Descent with modification has a high probability of succeeding in generating a new living organism. Biological evolution works.

- 4. Biology abounds with examples of DNA altered through descent with modification which changes the DNA information set and generates new biochemical functions.² Such creation of new information is theoretically possible without an intelligent source, and it is experimentally observed.
- The assumption of teleology is the primary reason why some mathematical models of evolution lead to impossibly low probabilities. The existence and nature of teleology in evolution is an open question of great interest.³ I look forward to studying it further.

Notes

¹Randy Isaac, "Information, Intelligence, and the Origins of Life," *Perspectives on Science and Christian Faith* 63, no. 4 (2011): 219–30.

²Dennis Venema, *Letters to the Duchess: ID and Information* (blog series), http://biologos.org/blogs/dennis-venema -letters-to-the-duchess/series/id-and-information.

³Sy Garte, "Teleology and the Origin of Evolution," *Perspectives on Science and Christian Faith* 69, no. 1 (2017): 42–50.

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