the superiority of the American system in marshaling resources for great accomplishments. This was not just for pride and prestige, but to sway nonaligned nations which were choosing which nation-system to follow. As Kennedy said in his speech to Congress announcing the lunar-landing goal:

> Finally, if we are to win the battle that is now going on around the world between freedom and tyranny, the dramatic achievements in space which occurred in recent weeks should have made clear to us all, as did the Sputnik in 1957, the impact of this adventure on the minds of men everywhere, who are attempting to make a determination of which road they should take.

The goal is geopolitical persuasion, not science or exploration or heroism. That much is clear and undisputed. However, what is lacking is an objective assessment of the international impact on the "minds of men everywhere." Some anecdotes are provided as to the outpouring of international goodwill for the US after Apollo 11, but nowhere—in this book or otherwise—have I seen a popular account of the impact on unaligned nations.

By using human spaceflight as a tool for political ends, enormous resources were made available, but the public came to see space exploration as a series of spectacles. Anything less spectacular than Apollo was perceived to be an unfortunate loss of direction and lack of leadership by NASA—a sentiment that prevails even today. But Apollo is a hard act to follow. As the author points out, Apollo was a product of the times, and NASA did not seem to understand that; this left a "divided legacy as to the true meaning of the accomplishment and what it meant for the future of space exploration." It was astoundingly successful in the context of the time, and then the context changed.

Enthusiasm for space peaked when it was novel and heroic and geopolitically crucial. It is a mistake to think that there ever was a time that the American public overwhelmingly supported huge strides in human spaceflight in and of themselves. That is a sobering conclusion. It says much about us as a nation and makes one question just how bold and adventurous we are, as opposed to willing to take risks for pragmatic ends.

Apollo was a clear demonstration of technological prowess, which fed America's self-image as a great nation and contributed to a long sense of technological progress as inherent to American greatness and uniqueness. The technical virtuosity of Apollo was truly impressive, which also gave the impression that large government technology programs could solve any problem no matter how challenging. NASA reaped the rewards of this, and continues to benefit from this image, but NASA is also trapped by it since its resources do not match these expectations. Apollo was successful because it was constrained and bounded, the basic technology was understood and defined from the start, and no great conceptual leaps were needed for its fulfillment. The problems of world hunger and poverty are not so easily formulated.

That the Apollo moon landings still hold a fascination for us tells us something about ourselves, but what? To some extent, there is something for everyone, since the program was so wide ranging. Begun with purely political motivations, it touches on something much more fundamental, as explored in the final chapter. It has often been noted that seeing Earth in its wholeness from deep space was the start of the environmental movement. As T. S. Eliot stated, "We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know the place for the first time."

On a more regrettable note, some of the fascination with Apollo, in some quarters, is nostalgia for a time when America seemed to have a clear manifest destiny that was largely promulgated by white males. Also mentioned is the desire of many people to frame Apollo as a form of religious experience—humans touching the cosmos, reaching beyond physical limitations, and the like. This journal has previously published two of my reviews of books that attempted to make this religious connection, with little success. Apollo remains a major technical accomplishment, one of the most significant of the twentieth century, which was conceived under geopolitical necessity but continues to inspire and beg for more noble interpretations.

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THE CREATIVITY CODE: Art and Innovation in the Age of AI by Marcus du Sautoy. Cambridge, MA: Harvard University Press, 2019. 295 pages plus preface and acknowledgments. Hardcover; $30.00. ISBN: 9780674988132.

Following his international bestseller *The Music of the Primes*, mathematician and science popularizer Marcus du Sautoy, Simonyi Professor for the Public Understanding of Science at Oxford University, takes lay readers on a vibrant tour of the world of creativity and the history of attempts at automating the creative process. In so doing, he touches on deep questions of what it means to be human.

In his first chapter, du Sautoy poses what he terms "The Lovelace Test" of computer creativity, an analogy to the well-known "Turing Test" for determining machine intelligence, and in homage to computing pioneer Ada Lovelace. Lovelace's musings on the future applications of computers to creative pursuits form a recurring theme throughout the book.

> To pass the Lovelace Test, an algorithm has to produce something that is truly creative. The process has to be repeatable … and the programmer has to be unable to explain how the algorithm produced its output. (p. 6)

As for what counts as "creative," du Sautoy specifies that it must be *new, surprising*, and *of value*. Furthermore, "[f]or a machine to be deemed truly creative, its contribution has to be more than an expression of the creativity of its coder or the person who built its dataset" (p. 6).

So begins a discussion of *human* creativity, drawing on the work of cognitive scientist Margaret Boden, who identified three main types of creativity: exploratory (pushing the boundaries while keeping to the rules), combinational (achieving a synthesis by combining different constructs), and transformational (complete game-changers). Du Sautoy describes examples of these from the worlds of art, music, and mathematics, and notes that while computers may do well at exploratory and combinational creativity, transformational creativity is not yet well enough understood to be taught to humans, let alone machines. However, Boden believes that 97 percent of human creativity is of the exploration type, and thus machines present a potential "threat" that might overturn the human dominance in creative accomplishment.

Some might wonder what a mathematician knows of creativity, as du Sautoy concedes that "mathematicians are a bit of a misunderstood breed" (p. 145). In chapter 9, "The Art of Mathematics," he relates his quandary as a young man upon encountering the work of the great G. H. Hardy, who wrote in *A Mathematician's Apology* (Cambridge University Press, 2004),

> A mathematician, like a painter or a poet, is a maker of patterns … The mathematician's patterns, like the painter's or the poet's, must be beautiful; the ideas like the colors or the words must fit together in a harmonious way. (p. 141)

Du Sautoy confesses that, up to that point, "I'd never imagined mathematics to be a creative subject, but as I read Hardy's little book it seemed that aesthetic sensibilities were as important as the logical correctness of the ideas" (p. 141). Echoes of this appear in Douglas Hofstadter's famous *Gödel, Escher, Bach*

(Basic Books, 1979) and William Dunham's lovely *Journey through Genius* (Penguin Books, 1991), in which the great theorems of mathematics are presented as enduring masterpieces of art. To these discussions, du Sautoy adds the metaphor of mathematics as story: "I believe a good proof has many things in common with a great story or a great composition in that it takes its listeners on a journey of transformation and change" (p. 229). He ties this in with AI efforts toward story generation and essay writing. He even concedes at the end that a portion of the book's text was generated by an AI authorship tool.

It is an apt analogy, for narrative is a skill that du Sautoy shares with other successful science communicators, telling stories from history as well as from personal encounters with a host of leading computer scientists, artists, and musicians—names like art curator Hans-Ulrich Obrist and musician Brian Eno. Du Sautoy's lofty academic position provides him with the privilege of access to such luminaries, allowing for off-hand remarks such as the beginning to chapter 3 about the development of the *AlphaGo* program which soundly defeated the world's top-ranked player in the game of Go: "I was sitting next to [DeepMind co-founder] Demis Hassabis at one of the Royal Society's meetings …" (p. 218). Du Sautoy's personal story is woven throughout the book, from his own experiences in contributing to the mathematical study of symmetry to his appreciation for art and music. *The Creativity Code* contains narratives about the development of, if not *every* attempt at machine-based creativity, a vast panoply of major and minor systems throughout history: for example, from the dice-based compositional games of Mozart to the neural nets of *DeepBach*, from Gerhard Richter's *4900 Farben* to *The Next Rambrandt* of Microsoft and TU Delft, and from early choose-your-own-adventure stories to the interactive narratives of Mark Riedl's *Scheherazade-IF*.

Toward the end, the intensity and depth of feeling in the book escalate. After surveying developments in the fields of music, art, poetry, and more, he shares his own musings on mathematics via AI, in which one can feel his personal stake; for example, in concerns of computers taking over his livelihood. Remarks made earlier by artists and musicians about whether a computer-generated piece is not merely new, but also surprising and valuable, take on a new poignancy, as in his lament about the mathematical proof-generating program Mizar: "I left the DeepMind offices rather downcast … what I had seen was like a mindless machine cranking out mathematical Muzak" (p. 223). He then shares a quote from mathematician Henri Poincaré who might as

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well have been speaking of songwriting: "To create consists precisely in not making useless combinations. Creation is discernment, choice …" (p. 228).

Unlike his Simonyi Professor predecessor Richard Dawkins, du Sautoy demonstrates no antipathy toward religion, yet his musings on human identity and religious motivations for art ring, at times, strangely superficial in comparison to the other topics he covers so deftly. At one point, without any hint of irony, he tells a story about how religion arose from humans' need to tell stories to explain the world around them. Almost the entirety of the book is concerned with the *how* of creativity (i.e., in the processes), as well as concerns about the implications for the future employment of artists, writers, musicians, and, indeed, mathematicians in the face of AI advances. These lead naturally to the capstone final chapter, "Why We Create," in which he quotes from psychologist Carl Rogers and author Paul Coelho on the roots of creativity as a human need to communicate and to bind communities together. While du Sautoy doesn't go on to provide it, these reasons form a subset of a Christian response to the *why* of human creativity, for example, as seen in *Creator Spirit: The Holy Spirit and the Art of Becoming Human* (Baker Academic, 2011) by theologian/musician Steven Guthrie, who likens creativity to gift-giving: "God invites us into the ecology of gift that is at the center of God's own life … God's intention is that we would, like God, be agents capable of giving to others" (p. 158).

The Creativity Code is current with respect to AI developments up until the time it went to press. However, this was prior to the debut of the "transformer" language models in early 2019, which far surpassed many people's conceptions of the capabilities of generative language models, even inspiring widespread concerns regarding their potential misuse (for example, see J. Vincent, "OpenAI's New Multitalented AI Writes, Translates, and Slanders," *The Verge*, Feb. 14, 2019). Thus, in reading the later chapters on AI, language, and text-creation, one wonders how differently an updated edition of this book would read in light of these developments. With AI changing so quickly, it may be impossible to produce a book that will stand the test of time in every respect, and it remains to be seen what other "updates" the coming years will bring as far as AI's capabilities. Yet, as both a comprehensive historical survey and as an authoritative statement of values about creativity, du Sautoy's book will remain a significant contribution and should be read by anyone interested in the intersection of AI and creativity.

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MEDICINE AND HEALTH

CARE AND CURE: An Introduction to Philosophy of Medicine by Jacob Stegenga. Chicago, IL: University of Chicago Press, 2018. 248 + xiii pages, including bibliography and index. Paperback; $25.00. ISBN: 9780226595030.

As I began writing this review, our Minneapolis newspaper reported on the controversy that Blue Cross Blue Shield Minnesota raised when it decided to work with a for-profit contractor in South Carolina to use evidence based medicine (EBM) for prior approval of procedures that it will cover. Many physicians, hospitals, and patients are complaining that the newly aggressive denials are tantamount to fraud. This is the intersection of medicine, economics, and public policy and, according to Jacob Stegenga, philosophy of medicine can help us clarify the issues. He sees it as a branch of philosophy of science (he is a philosopher teaching in the Department of History and Philosophy of Science at the University of Cambridge) and defines philosophy of medicine as "the study of epistemological, metaphysical, and logical aspects of medicine, with occasional forays into historical, sociological, and political aspects of medicine" (p. 1). As defined, it covers a lot of territory, so an introduction that provides a map of the main issues and the controversies involved in them is very useful, and that is what Stegenga provides. He does not provide a detailed discussion, much less a resolution of all or any of the debates, but he gives an informed overview and a clear outline of the dueling positions and even of the intramural debates within them.

Part I, "Concepts," begins with chapters on health and disease: is the former simply the absence of disease or, more positively, the sort of flourishing that includes mental and social well-being? The reader will find problems (or, as Stegenga is fond of saying "puzzles") with either of these answers. And defining disease raises similar issues: both "naturalism" (disease is simply dysfunctioning physiological systems) and "normativism" (disease is a disvalued state), as well as the hybrid effort to mediate them, elicit enough puzzles that "eliminativism" tries unfruitfully to get along without a theory of disease. The role of phenomenology is to describe what it is like to be diseased, something even naturalists try to recognize with the category of "illness." Chapter 3, "Death," asks whether it is a biological event (such as the whole brain death of an organism) or a metaphysical one (higher brain death of a person). Some might like more detail here, especially when he dis-