

than S. Chandrasekhar: *The Man Behind the Legend*, newly compiled by Wali, to read the recollections of some 35 of Chandra's former students, colleagues, friends and close relatives. Chandrasekhar was a private person and thinker; he very much shunned the limelight. As Wali reminds us, his was never a household name, nor was he a media persona, unlike some other influential scientists of his time. Yet this volume attests to the fact that he was deeply revered, especially by the young scientists with whom he was delighted to interact. The stories and anecdotes that fill this touching volume reveal that Chandra's extraordinary devotion to science, his breadth, modesty and wit, made as much an impression on those who knew him as did his scientific insight.

From more than one account, including another from Lalitha Chandrasekhar, we are reminded that the acclaim Chandra ultimately received was preceded by a few bitter experiences. He was publicly ridiculed at the Royal Astronomical Society in 1935 by Arthur Eddington, his mentor, who would not accept the inevitability of catastrophic collapse; he was refused the right to lecture in the physics department at Chicago by a dean who was blunt in objecting to having a "black" scientist from India lecture in his department. (University president

Robert Hutchins intervened to overrule this outrage.) Chandra was able somehow to draw on the same inner fortitude that he used to subdue the most intractable of mathematical equations to overcome these early injustices.

By the end of S. Chandrasekhar: *The Man Behind the Legend*, the reader recognizes that Chandra's friends and colleagues, like his life and work, spanned many decades, several generations and many different intellectual passions. He lived for 85 years, but he never really got old. He died in 1995, but this inspiring volume proves that his memory and influence will be with us forever.

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The Cambridge Quintet: A Work of Scientific Speculation

John L. Casti
Helix Books (Addison Wesley Longman), Reading, Mass., 1998.
181 pp. \$23.00 hc
ISBN 0-201-32828-3

Many of us would enjoy an excellent dinner, accompanied by sparkling conversation on a matter of profound in-

terest, with truly luminary companions. We rarely, if ever, enjoy such a meal. John Casti's *Cambridge Quintet* conjures such a dinner, transporting us during the summer of 1949 to Charles Darwin's old suite at Christ Church College of the University of Cambridge to hear an illustrious quintet of diners challenged by the notion of machine intelligence: Can it exist?

Casti is a well-known lay and professional expositor of nonlinear applied mathematics and its manifestations in complexity and chaos theory. The meal he offers (the concept and the subject matter) is tasty and nutritious and should appeal to the appetite of any philosophically inclined scientist. I know of no other short work providing such an engaging review of or introduction to artificial intelligence. But, as with many a real meal, the service is flawed.

The imagined participants are C. P. Snow, novelist, British civil servant and physicist and, in this case, the host; Alan Turing, whose universal computing engine foreshadowed the logical structure of modern digital computers; J. B. S. Haldane, geneticist, population statistician and Marxist writer; physicist Erwin Schrödinger, whose interests included molecular biology, the foundations of physics, philosophy and Eastern religious thought; and Ludwig Wittgenstein, the "influential philosopher of this century." Their task is to advise an anxious British government as to whether or not the new computers coming on the scene after World War II can "think." To answer this question, they first introduce the concept of a universal computer and describe the ways in which its functions compare to those of a human brain. They discuss what it means to think, the relationship of thought to communication and the ability to sense the environment, and how thinking might be a distinguishing human characteristic.

After describing the participants, the book's prologue introduces the central theme: Can computers think? Chapter 1, "The Sherry: An Evening at Christ's," sets the scene and introduces the five diners. Chapter 2, "The Soup: Brains and Machines," summarizes universal computing machines, Gödel incompleteness, solvability and computability. Chapter 3, "The Fish: Minds and Machines," introduces Turing's answer to the question, How do we know another being is thinking? Chapter 4, "The Meat: Meaning and Machines," questions whether syntax implies semantics. Chapter 5, "The Salad: Language and Thought," explores the questions, What is language? and Is it necessary for thought? Chapter 6, "The Dessert: Life and Personhood," asks, What is a person? Then

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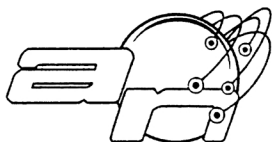
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there is chapter 7, "The Cigars and Brandy: Social Behavior, Culture and Thought," which raises the issue: Would machines behave like humans, individually and collectively? Finally, there is an "Afterwards," with a summary and bibliography on the development of artificial intelligence since the imagined Cambridge dinner.

Unfortunately, Casti puts into his participants' mouths arguments they would never have made themselves. There is sloppy physics for Schrödinger—for example; "Axiom 1: Electricity and Magnetism are forces." Tautological self-contradictory progressions and non sequiturs are attributed to Wittgenstein, who offers apparently formal "proofs" in which one of the axioms asserted is self-evidently the contention to be proved—for instance, that rule-driven processes can never lead to "understanding": "Axiom 1: Programs are purely syntactic objects. Axiom 2: Human minds have semantic content. Axiom 3: No amount of syntax can generate semantics. Conclusion: Programs are neither necessary nor sufficient for minds." (I am confident in my assessment of the Schrödinger section, less so for Wittgenstein.)

What's more, fundamental points that were well known at the time, and that these luminary intellects would certainly have made, are missed. For example, none of Casti's diners mentions that a computer's program is expressed in the same manner as its data. This makes it possible to transform the programs as well as the data, certainly an important aspect in discussing computer learning. Nor do the discussants point out, in spite of its obvious relevance to the discussion of rule-based versus social-based languages, that people do learn each other's languages without verbal explanation of the rules; effective working rules are inferred from observation of behavior.

Of the five dinner celebrants, only Turing seems coherent and consistent. Wittgenstein is continually flipping back and forth between, for example, the assertion that thought requires words (language) and the counter-assertion that thought is independent of words. The others often seem to follow his sudden, unexplained reversals. It is hard not to conclude that the dinner party is a setup to display Casti's favorite diner—Turing.

Among the points upon which the five conversationalists seem to reach consensus are: 1) A machine must have a complete set of sensory organs to be said to think; 2) for machines to be said to think they must belong to a population of similar machines so

as to have the "culture" required for language and, hence, thought; and 3) somehow, a "thinking machine," implies a "living machine," which then requires the consideration of its "personhood."

To me, these are non sequiturs. There are many like them in the book, as well as numerous missed opportunities to make pungent, clarifying arguments on either side of the issue: Turing makes some pragmatic, testable arguments that machines can think; Wittgenstein simply asserts the contrary! And yet, the book is informative and fun to read. Savor or taste it; participate deeply in the conversation to find your own set of flaws and weaknesses of arguments, or skim it lightly just to enjoy the conceit. Perhaps Casti is hinting that the five dining companions, in spite of their luminous intellectual reputations, are mere mortals, prone to error and shortcomings and in need of replacement by thinking machines. But would the machines enjoy the meal?

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Introduction to Geomagnetic Fields

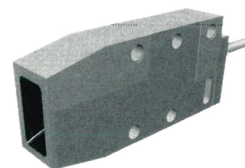
Wallace H. Campbell
Cambridge U. P., New York, 1997.
290 pp. \$69.95 hc
ISBN 0-521-57193-6

The plural "fields" in the title of Wallace Campbell's *Introduction to Geomagnetic Fields* drew my attention, and I was not disappointed when I later delved into this compact introductory text. Campbell has attempted to cover three major types of Earth's magnetic fields: the internal or main field that originates in the fluid core; the "quiet time" or regular daily perturbations in Earth's magnetic field, originating in the upper atmospheric currents; and the geomagnetic storms, solar flares and other occasional sharp changes in the field whose causes lie in an active Sun.

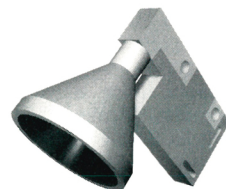
The magnitudes of geomagnetic fields have a dynamic range of 16:1. While the main field can have a magnitude of around 60 000 nanotesla (Campbell uses "gamma" instead of nanotesla), the solar quiet (Sq) diurnal variations can be as low as 20 nT, while geomagnetic storms can reach 1000 nT. Given this wide range in magnitudes, sources and variability, it would be difficult to write a text, not to speak of an introductory text, that would cover the origin and behavior of all the components of geomagnetic fields with

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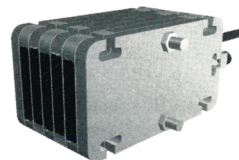
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