

Bibliography

The presence of two asterisks indicates that the book or article was a prime motivator of my book. The presence of a single asterisk means that the book or article has some special feature or quirk which I want to single out.

I have not given many direct pointers into technical literature; instead I have chosen to give "meta-pointers": pointers to books which have pointers to technical literature.

- Allen, John. *The Anatomy of LISP*. New York: McGraw-Hill, 1978. The most comprehensive book on LISP, the computer language which has dominated Artificial Intelligence research for two decades. Clear and crisp.
- ** Anderson, Alan Ross, ed. *Minds and Machines*. Englewood Cliffs, N. J.: Prentice-Hall, 1964. Paperback. A collection of provocative articles for and against Artificial Intelligence. Included are Turing's famous article "Computing Machinery and Intelligence" and Lucas' exasperating article "Minds, Machines, and Gödel".
- Babbage, Charles. *Passages from the Life of a Philosopher*. London: Longman, Green, 1864. Reprinted in 1968 by Dawsons of Pall Mall (London). A rambling selection of events and musings in the life of this little-understood genius. There's even a play starring Turnstile, a retired philosopher turned politician, whose favorite musical instrument is the barrel-organ. I find it quite jolly reading.
- Baker, Adolph. *Modern Physics and Anti-physics*. Reading, Mass.: Addison-Wesley, 1970. Paperback. A book on modern physics—especially quantum mechanics and relativity—whose unusual feature is a set of dialogues between a "Poet" (an antiscience "freak") and a "Physicist". These dialogues illustrate the strange problems which arise when one person uses logical thinking in defense of itself while another turns logic against itself.
- Ball, W. W. Rouse. "Calculating Prodigies", in James R. Newman, ed. *The World of Mathematics*, Vol. 1. New York: Simon and Schuster, 1956. Intriguing descriptions of several different people with amazing abilities that rival computing machines.
- Barker, Stephen F. *Philosophy of Mathematics*. Englewood Cliffs, N. J.: Prentice-Hall, 1969. A short paperback which discusses Euclidean and non-Euclidean geometry, and then Gödel's Theorem and related results without any mathematical formalism.
- * Beckmann, Petr. *A History of Pi*. New York: St. Martin's Press, 1976. Paperback. Actually, a history of the world, with pi as its focus. Most entertaining, as well as a useful reference on the history of mathematics.
- * Bell, Eric Temple. *Men of Mathematics*. New York: Simon & Schuster, 1965. Paperback. Perhaps the most romantic writer of all time on the history of mathematics. He makes every life story read like a short novel. Nonmathematicians can come away with a true sense of the power, beauty, and meaning of mathematics.
- Benacerraf, Paul. "God, the Devil, and Gödel". *Monist* 51 (1967): 9. One of the most important of the many attempts at refutation of Lucas. All about mechanism and metaphysics, in the light of Gödel's work.
- Benacerraf, Paul, and Hilary Putnam. *Philosophy of Mathematics—Selected Readings*. Englewood Cliffs, N. J.: Prentice-Hall, 1964. Articles by Gödel, Russell, Nagel, von Neumann, Brouwer, Frege, Hilbert, Poincaré, Wittgenstein, Carnap, Quine, and others on the reality of numbers and sets, the nature of mathematical truth, and so on.
- * Bergerson, Howard. *Palindromes and Anagrams*. New York: Dover Publications, 1973. Paperback. An incredible collection of some of the most bizarre and unbelievable wordplay in English. Palindromic poems, plays, stories, and so on.
- Bobrow, D. G., and Allan Collins, eds. *Representation and Understanding: Studies in Cognitive Science*. New York: Academic Press, 1975. Various experts on Artificial Intelligence thrash about, debating the nature of the elusive "frames", the question of procedural vs. declarative representation of knowledge, and so on. In a way, this book marks the start of a new era of AI: the era of representation.

- * Boden, Margaret. *Artificial Intelligence and Natural Man*. New York: Basic Books, 1977. The best book I have ever seen on nearly all aspects of Artificial Intelligence, including technical questions, philosophical questions, etc. It is a rich book, and in my opinion, a classic. Continues the British tradition of clear thinking and expression on matters of mind, free will, etc. Also contains an extensive technical bibliography.
- . *Purposive Explanation in Psychology*. Cambridge, Mass.: Harvard University Press, 1972. The book to which her AI book is merely “an extended footnote”, says Boden.
- * Boeke, Kees. *Cosmic View: The Universe in 40 Jumps*. New York: John Day, 1957. The ultimate book on levels of description. Everyone should see this book at some point in their life. Suitable for children.
- ** Bongard, M. *Pattern Recognition*. Rochelle Park, N. J.: Hayden Book Co., Spartan Books, 1970. The author is concerned with problems of determining categories in an ill-defined space. In his book, he sets forth a magnificent collection of 100 “Bongard problems” (as I call them)—puzzles for a pattern recognizer (human or machine) to test its wits on. They are invaluable stimulating for anyone who is interested in the nature of intelligence.
- Boolos, George S., and Richard Jeffrey. *Computability and Logic*. New York: Cambridge University Press, 1974. A sequel to Jeffrey’s *Formal Logic*. It contains a wide number of results not easily obtainable elsewhere. Quite rigorous, but this does not impair its readability.
- Carroll, John B., Peter Davies, and Barry Rickman. *The American Heritage Word Frequency Book*. Boston: Houghton Mifflin, and New York: American Heritage Publishing Co., 1971. A table of words in order of frequency in modern written American English. Perusing it reveals fascinating things about our thought processes.
- Cerf, Vinton. “Parry Encounters the Doctor”. *Datamation*, July 1973, pp. 62-64. The first meeting of artificial “minds”—what a shock!
- Chadwick, John. *The Decipherment of Linear B*. New York: Cambridge University Press, 1958. Paperback. A book about a classic decipherment—that of a script from the island of Crete—done by a single man: Michael Ventris.
- Chaitin, Gregory J. “Randomness and Mathematical Proof”. *Scientific American*, May 1975. An article about an algorithmic definition of randomness, and its intimate relation to simplicity. These two concepts are tied in with Gödel’s Theorem, which assumes a new meaning. An important article.
- Cohen, Paul C. *Set Theory and the Continuum Hypothesis*. Menlo Park, Calif.: W. A. Benjamin, 1966. Paperback. A great contribution to modern mathematics—the demonstration that various statements are undecidable within the usual formalisms for set theory—is here explained to nonspecialists by its discoverer. The necessary prerequisites in mathematical logic are quickly, concisely, and quite clearly presented.
- Cooke, Deryck. *The Language of Music*. New York: Oxford University Press, 1959. Paperback. The only book that I know which tries to draw an explicit connection between elements of music and elements of human emotion. A valuable start down what is sure to be a long hard road to understanding music and the human mind.
- * David, Hans Theodore. *J. S. Bach’s Musical Offering*. New York: Dover Publications, 1972. Paperback. Subtitled “History, Interpretation, and Analysis”. A wealth of information about this *tour de force* by Bach. Attractively written.
- ** David, Hans Theodore, and Arthur Mendel. *The Bach Reader*. New York: W. W. Norton, 1966. Paperback. An excellent annotated collection of original source material on Bach’s life, containing pictures, reproductions of manuscript pages, many short quotes from contemporaries, anecdotes, etc., etc.
- Davis, Martin. *The Undecidable*. Hewlett, N. Y.: Raven Press, 1965. An anthology of some of the most important papers in metamathematics from 1931 onwards (thus quite complementary to van Heijenoort’s anthology). Included are a translation of Gödel’s 1931 paper, lecture notes from a course which Gödel once gave on his results, and then papers by Church, Kleene, Rosser, Post, and Turing.
- Davis, Martin, and Reuben Hersh. “Hilbert’s Tenth Problem”. *Scientific American*, November 1973, p. 84. How a famous problem in number theory was finally shown to be unsolvable, by a twenty-two-year old Russian.
- ** DeLong, Howard. *A Profile of Mathematical Logic*. Reading, Mass.: Addison-Wesley, 1970. An extremely carefully written book about mathematical logic, with an exposition of Gödel’s Theorem and discussions of many philosophical questions. One of its strong features is its outstanding, fully annotated bibliography. A book which influenced me greatly.

- Doblhofer, Ernst. *Voices in Stone*. New York: Macmillan, Collier Books, 1961. Paperback. A good book on the decipherment of ancient scripts.
- * Dreyfus, Hubert. *What Computers Can't Do: A Critique of Artificial Reason*. New York: Harper & Row, 1972. A collection of many arguments against Artificial Intelligence from someone outside of the field. Interesting to try to refute. The AI community and Dreyfus enjoy a relation of strong mutual antagonism. It is important to have people like Dreyfus around, even if you find them very irritating.
- Edwards, Harold M. "Fermat's Last Theorem". *Scientific American*, October 1978, pp. 104-122. A complete discussion of this hardest of all mathematical nuts to crack, from its origins to the most modern results. Excellently illustrated.
- * Ernst, Bruno. *The Magic Mirror of M. C. Escher*. New York: Random House, 1976. Paperback. Escher as a human being, and the origins of his drawings, are discussed with devotion by a friend of many years. A "must" for any lover of Escher.
- ** Escher, Maurits C., et al. *The World of M. C. Escher*. New York: Harry N. Abrams, 1972. Paperback. The most extensive collection of reproductions of Escher's works. Escher comes about as close as one can to recursion in art, and captures the spirit of Gödel's Theorem in some of his drawings amazingly well.
- Feigenbaum, Edward, and Julian Feldman, eds. *Computers and Thought*. New York: McGraw-Hill, 1963. Although it is a little old now, this book is still an important collection of ideas about Artificial Intelligence. Included are articles on Gelernter's geometry program, Samuel's checkers program, and others on pattern recognition, language understanding, philosophy, and so on.
- Finsler, Paul. "Formal Proofs and Undecidability". Reprinted in van Heijenoort's anthology *From Frege to Gödel* (see below). A forerunner of Gödel's paper, in which the existence of undecidable mathematical statements is suggested, though not rigorously demonstrated.
- Fitzpatrick, P. J. "To Gödel via Babel". *Mind* 75 (1966): 332-350. An innovative exposition of Gödel's proof which distinguishes between the relevant levels by using three different languages: English, French, and Latin!
- von Foerster, Heinz and James W. Beauchamp, eds. *Music by Computers*. New York: John Wiley, 1969. This book contains not only a set of articles about various types of computer-produced music, but also a set of four small phonograph records so you can actually hear (and judge) the pieces described. Among the pieces is Max Mathews' mixture of "Johnny Comes Marching Home" and "The British Grenadiers".
- Fraenkel, Abraham, Yehoshua Bar-Hillel, and Azriel Levy. *Foundations of Set Theory*, 2nd ed. Atlantic Highlands, N. J.: Humanities Press, 1973. A fairly nontechnical discussion of set theory, logic, limitative Theorems and undecidable statements. Included is a long treatment of intuitionism.
- * Frey, Peter W. *Chess Skill in Man and Machine*. New York: Springer Verlag, 1977. An excellent survey of contemporary ideas in computer chess: why programs work, why they don't work, retrospects and prospects.
- Friedman, Daniel P. *The Little Lisper*. Palo Alto, Calif.: Science Research Associates, 1974. Paperback. An easily digested introduction to recursive thinking in LISP. You'll eat it up!
- * Gablik, Suzi. *Magritte*. Boston, Mass.: New York Graphic Society, 1976. Paperback. An excellent book on Magritte and his works by someone who really understands their setting in a wide sense; has a good selection of reproductions.
- * Gardner, Martin. *Fads and Fallacies*. New York: Dover Publications, 1952. Paperback. Still probably the best of all the anti-occult books. Although probably not intended as a book on the philosophy of science, this book contains many lessons therein. Over and over, one faces the question, "What is evidence?" Gardner demonstrates how unearthing "the truth" requires art as much as science.
- Gebstadter, Egbert B. *Copper, Silver, Gold: an Indestructible Metallic Alloy*. Perth: Acidic Books, 1979. A formidable hodge-podge, turgid and confused—yet remarkably similar to the present work. Professor Gebstadter's Shandean digressions include some excellent examples of indirect self-reference. Of particular interest is a reference in its well-annotated bibliography to an isomorphic, but imaginary, book.
- ** Gödel, Kurt. *On Formally Undecidable Propositions*. New York: Basic Books, 1962. A translation of Gödel's 1931 paper, together with some discussion.
- . "Über Formal Unentscheidbare Sätze der *Principia Mathematica* und Ver-

- wandter Systeme, I." *Monatshefte für Mathematik und Physik*, 38 (1931), 173-198. Gödel's 1931 paper.
- * Goffman, Erving. *Frame Analysis*. New York: Harper & Row, Colophon Books, 1974. Paperback. A long documentation of the definition of "systems" in human communication, and how in art and advertising and reporting and the theatre, the borderline between "the system" and "the world" is perceived and exploited and violated.
- Goldstein, Ira, and Seymour Papert. "Artificial Intelligence, Language, and the Study of Knowledge". *Cognitive Science* 1 (January 1977): 84-123. A survey article concerned with the past and future of AI. The authors see three periods so far: "Classic", "Romantic", and "Modern".
- Good, I. J. "Human and Machine Logic". *British Journal for the Philosophy of Science* 18 (1967): 144. One of the most interesting attempts to refute Lucas, having to do with whether the repeated application of the diagonal method is itself a mechanizable operation.
- . "Gödel's Theorem is a Red Herring". *British Journal for the Philosophy of Science* 19 (1969): 357. In which Good maintains that Lucas' argument has nothing to do with Gödel's Theorem, and that Lucas should in fact have entitled his article "Minds, Machines, and Transfinite Counting". The Good-Lucas repartee is fascinating.
- Goodman, Nelson. *Fact, Fiction, and Forecast*. 3rd ed. Indianapolis: Bobbs-Merrill, 1973. Paperback. A discussion of contrary-to-fact conditionals and inductive logic, including Goodman's famous problem-words "bleen" and "grue". Bears very much on the question of how humans perceive the world, and therefore interesting especially from the AI perspective.
- * Goodstein, R. L. *Development of Mathematical Logic*. New York: Springer Verlag, 1971. A concise survey of mathematical logic, including much material not easily found elsewhere. An enjoyable book, and useful as a reference.
- Gordon, Cyrus. *Forgotten Scripts*. New York: Basic Books, 1968. A short and nicely written account of the decipherment of ancient hieroglyphics, cuneiform, and other scripts.
- Griffin, Donald. *The Question of Animal Awareness*. New York: Rockefeller University Press, 1976. A short book about bees, apes, and other animals, and whether or not they are "conscious"—and particularly whether or not it is legitimate to use the word "consciousness" in scientific explanations of animal behavior.
- deGroot, Adriaan. *Thought and Choice in Chess*. The Hague: Mouton, 1965. A thorough study in cognitive psychology, reporting on experiments that have a classical simplicity and elegance.
- Gunderson, Keith. *Mentality and Machines*. New York: Doubleday, Anchor Books, 1971. Paperback. A very anti-AI person tells why. Sometimes hilarious.
- ** Hanawalt, Philip C., and Robert H. Haynes, eds. *The Chemical Basis of Life*. San Francisco: W. H. Freeman, 1973. Paperback. An excellent collection of reprints from the *Scientific American*. One of the best ways to get a feeling for what molecular biology is about.
- * Hardy, G. H. and E. M. Wright. *An Introduction to the Theory of Numbers*, 4th ed. New York: Oxford University Press, 1960. The classic book on number theory. Chock-full of information about those mysterious entities, the whole numbers.
- Harmon, Leon. "The Recognition of Faces". *Scientific American*, November 1973, p. 70. Explorations concerning how we represent faces in our memories, and how much information is needed in what form for us to be able to recognize a face. One of the most fascinating of pattern recognition problems.
- van Heijenoort, Jean. *From Frege to Gödel: A Source Book in Mathematical Logic*. Cambridge, Mass.: Harvard University Press, 1977. Paperback. A collection of epoch-making articles on mathematical logic, all leading up to Gödel's climactic revelation, which is the final paper in the book.
- Henri, Adrian. *Total Art: Environments, Happenings, and Performances*. New York: Praeger, 1974. Paperback. In which it is shown how meaning has degenerated so far in modern art that the absence of meaning becomes profoundly meaningful (whatever that means).
- * Hoare, C. A. R. and D. C. S. Allison. "Incomputability". *Computing Surveys* 4, no. 3 (September 1972). A smoothly presented exposition of why the halting problem is unsolvable. Proves this fundamental theorem: "Any language containing conditionals and recursive function definitions which is powerful enough to program its own interpreter cannot be used to program its own 'terminates' function."

- Hofstadter, Douglas R. "Energy levels and wave functions of Bloch electrons in rational and irrational magnetic fields". *Physical Review B*, 14, no. 6 (15 September 1976). The author's Ph.D. work, presented as a paper. Details the origin of "Gplot", the recursive graph shown in Figure 34.
- Hook, Sidney, ed. *Dimensions of Mind*. New York: Macmillan, Collier Books, 1961. Paperback. A collection of articles on the mind-body problem and the mind-computer problem. Some rather strong-minded entries here.
- * Horney, Karen. *Self-Analysis*. New York: W. W. Norton, 1942. Paperback. A fascinating description of how the levels of the self must tangle to grapple with problems of self-definition of any individual in this complex world. Humane and insightful.
- Hubbard, John I. *The Biological Basis of Mental Activity*. Reading, Mass.: Addison-Wesley, 1975. Paperback. Just one more book about the brain, with one special virtue, however: it contains many long lists of questions for the reader to ponder, and references to articles which treat those questions.
- * Jackson, Philip C. *Introduction to Artificial Intelligence*. New York, Petrocelli Charter, 1975. A recent book, describing, with some exuberance, the ideas of AI. There are a huge number of vaguely suggested ideas floating around this book, and for that reason it is very stimulating just to page through it. Has a giant bibliography, which is another reason to recommend it.
- Jacobs, Robert L. *Understanding Harmony*. New York: Oxford University Press, 1958. Paperback. A straightforward book on harmony, which can lead one to ask many questions about why it is that conventional Western harmony has such a grip on our brains.
- Jaki, Stanley L. *Brain, Mind, and Computers*. South Bend, Ind.: Gateway Editions, 1969. Paperback. A polemic book whose every page exudes contempt for the computational paradigm for understanding the mind. Nonetheless it is interesting to ponder the points he brings up.
- * Jauch, J. M. *Are Quanta Real?* Bloomington, Ind.: Indiana University Press, 1973. A delightful little book of dialogues, using three characters borrowed from Galileo, put in a modern setting. Not only are questions of quantum mechanics discussed, but also issues of pattern recognition, simplicity, brain processes, and philosophy of science enter. Most enjoyable and provocative.
- * Jeffrey, Richard. *Formal Logic: Its Scope and Limits*. New York: McGraw-Hill, 1967. An easy-to-read elementary textbook whose last chapter is on Gödel's and Church's Theorems. This book has quite a different approach from many logic texts, which makes it stand out.
- * Jensen, Hans. *Sign, Symbol, and Script*. New York: G. P. Putnam's, 1969. A—or perhaps the—top-notch book on symbolic writing systems the world over, both of now and long ago. There is much beauty and mystery in this book—for instance, the undeciphered script of Easter Island.
- Kalmár, László. "An Argument Against the Plausibility of Church's Thesis". In A. Heyting, ed. *Constructivity in Mathematics: Proceedings of the Colloquium held at Amsterdam, 1957*, North-Holland, 1959. An interesting article by perhaps the best-known disbeliever in the Church-Turing Thesis.
- * Kim, Scott E. "The Impossible Skew Quadrilateral: A Four-Dimensional Optical Illusion". In David Brisson, ed. *Proceedings of the 1978 A.A.A.S. Symposium on Hypergraphics: Visualizing Complex Relationships in Art and Science*. Boulder, Colo.: Westview Press, 1978. What seems at first an inconceivably hard idea—an optical illusion for four-dimensional "people"—is gradually made crystal clear, in an amazing virtuoso presentation utilizing a long series of excellently executed diagrams. The form of this article is just as intriguing and unusual as its content: it is tripartite on many levels simultaneously. This article and my book developed in parallel and each stimulated the other.
- Kleene, Stephen C. *Introduction to Mathematical Logic*. New York: John Wiley, 1967. A thorough, thoughtful text by an important figure in the subject. Very worthwhile. Each time I reread a passage, I find something new in it which had escaped me before.
- . *Introduction to Metamathematics*. Princeton: D. Van Nostrand (1952). Classic work on mathematical logic; his textbook (above) is essentially an abridged version. Rigorous and complete, but oldish.
- Kneebone G. J. *Mathematical Logic and the Foundations of Mathematics*. New York: Van Nostrand Reinhold, 1963. A solid book with much philosophical discussion of such topics as intuitionism, and the "reality" of the natural numbers, etc.

- Koestler, Arthur. *The Act of Creation*. New York: Dell, 1966. Paperback. A wide-ranging and generally stimulating theory about how ideas are "bisociated" to yield novelty. Best to open it at random and read, rather than begin at the beginning.
- Koestler, Arthur and J. R. Smythies, eds. *Beyond Reductionism*. Boston: Beacon Press, 1969. Paperback. Proceedings of a conference whose participants all were of the opinion that biological systems cannot be explained reductionistically, and that there is something "emergent" about life. I am intrigued by books which seem wrong to me, yet in a hard-to-pin-down way.
- ** Kubose, Gyomay. *Zen Koans*. Chicago: Regnery, 1973. Paperback. One of the best collections of kōans available. Attractively presented. An essential book for any Zen library.
- Kuffler, Stephen W. and John G. Nicholls. *From Neuron to Brain*. Sunderland, Mass.: Sinauer Associates, 1976. Paperback. A book which, despite its title, deals mostly with microscopic processes in the brain, and quite little with the way people's thoughts come out of the tangled mess. The work of Hubel and Wiesel on visual systems is covered particularly well.
- Lacey, Hugh, and Geoffrey Joseph. "What the Gödel Formula Says". *Mind* 77 (1968): 77. A useful discussion of the meaning of the Gödel formula, based on a strict separation of three levels: uninterpreted formal system, interpreted formal system, and metamathematics. Worth studying.
- Lakatos, Imre. *Proofs and Refutations*. New York: Cambridge University Press, 1976. Paperback. A most entertaining book in dialogue form, discussing how concepts are formed in mathematics. Valuable not only to mathematicians, but also to people interested in thought processes.
- ** Lehninger, Albert. *Biochemistry*. New York: Worth Publishers, 1976. A wonderfully readable text, considering its technical level. In this book one can find many ways in which proteins and genes are tangled together. Well organized, and exciting.
- ** Lucas, J. R. "Minds, Machines, and Gödel". *Philosophy* 36 (1961): 112. This article is reprinted in Anderson's *Minds and Machines*, and in Sayre and Crosson's *The Modeling of Mind*. A highly controversial and provocative article, it claims to show that the human brain cannot, in principle, be modeled by a computer program. The argument is based entirely on Gödel's Incompleteness Theorem, and is a fascinating one. The prose is (to my mind) incredibly infuriating—yet for that very reason, it makes humorous reading.
- . "Satan Stultified: A Rejoinder to Paul Benacerraf". *Monist* 52 (1968): 145. Anti-Benacerraf argument, written in hilariously learned style: at one point Lucas refers to Benacerraf as "self-stultifyingly eristic" (whatever that means). The Lucas-Benacerraf battle, like the Lucas-Good battle, offers much food for thought.
- . "Human and Machine Logic: A Rejoinder". *British Journal for the Philosophy of Science* 19 (1967): 155. An attempted refutation of Good's attempted refutation of Lucas' original article.
- ** MacGillavry, Caroline H. *Symmetry Aspects of the Periodic Drawings of M. C. Escher*. Utrecht: A. Oosthoek's Uitgevermaatschappij, 1965. A collection of tilings of the plane by Escher, with scientific commentary by a crystallographer. The source for some of my illustrations—e.g., the *Ant Fugue* and the *Crab Canon*. Reissued in 1976 in New York by Harry N. Abrams under the title *Fantasy and Symmetry*.
- MacKay, Donald M. *Information, Mechanism and Meaning*. Cambridge, Mass.: M.I.T. Press, 1970. Paperback. A book about different measures of information, applicable in different situations; theoretical issues related to human perception and understanding; and the way in which conscious activity can arise from a mechanistic underpinning.
- * Mandelbrot, Benoît. *Fractals: Form, Chance, and Dimension*. San Francisco: W. H. Freeman, 1977. A rarity: a picture book of sophisticated contemporary research ideas in mathematics. Here, it concerns recursively defined curves and shapes, whose dimensionality is not a whole number. Amazingly, Mandelbrot shows their relevance to practically every branch of science.
- * McCarthy, John. "Ascribing Mental Qualities to Machines". To appear in Martin Ringle, ed. *Philosophical Perspectives in Artificial Intelligence*. New York: Humanities Press, 1979. A penetrating article about the circumstances under which it would make sense to say that a machine had beliefs, desires, intentions, consciousness, or free will. It is interesting to compare this article with the book by Griffin.
- Meschkowski, Herbert. *Non-Euclidean Geometry*. New York: Academic Press, 1964. Paperback. A short book with good historical commentary.

- Meyer, Jean. "Essai d'application de certains modèles cybernétiques à la coordination chez les insectes sociaux". *Insectes Sociaux* XIII, no. 2 (1966): 127. An article which draws some parallels between the neural organization in the brain, and the organization of an ant colony.
- Meyer, Leonard B. *Emotion and Meaning in Music*. Chicago: University of Chicago Press, 1956. Paperback. A book which attempts to use ideas of Gestalt psychology and the theory of perception to explain why musical structure is as it is. One of the more unusual books on music and mind.
- . *Music, The Arts, and Ideas*. Chicago: University of Chicago Press, 1967. Paperback. A thoughtful analysis of mental processes involved in listening to music, and of hierarchical structures in music. The author compares modern trends in music with Zen Buddhism.
- Miller, G. A. and P. N. Johnson-Laird. *Language and Perception*. Cambridge, Mass.: Harvard University Press, Belknap Press, 1976. A fascinating compendium of linguistic facts and theories, bearing on Whorf's hypothesis that language is the same as world-view. A typical example is the discussion of the weird "mother-in-law" language of the Dyirbal people of Northern Queensland: a separate language used only for speaking to one's mother-in-law.
- ** Minsky, Marvin L. "Matter, Mind, and Models". In Marvin L. Minsky, ed. *Semantic Information Processing*. Cambridge, Mass.: M.I.T. Press, 1968. Though merely a few pages long, this article implies a whole philosophy of consciousness and machine intelligence. It is a memorable piece of writing by one of the deepest thinkers in the field.
- Minsky, Marvin L., and Seymour Papert. *Artificial Intelligence Progress Report*. Cambridge, Mass.: M.I.T. Artificial Intelligence Laboratory, AI Memo 252, 1972. A survey of all the work in Artificial Intelligence done at M.I.T. up to 1972, relating it to psychology and epistemology. Could serve excellently as an introduction to AI.
- ** Monod, Jacques. *Chance and Necessity*. New York: Random House, Vintage Books, 1971. Paperback. An extremely fertile mind writing in an idiosyncratic way about fascinating questions, such as how life is constructed out of non-life; how evolution, seeming to violate the second law of thermodynamics, is actually dependent on it. The book excited me deeply.
- * Morrison, Philip and Emily, eds. *Charles Babbage and his Calculating Engines*. New York: Dover Publications, 1961. Paperback. A valuable source of information about the life of Babbage. A large fraction of Babbage's autobiography is reprinted here, along with several articles about Babbage's machines and his "Mechanical Notation".
- Myhill, John. "Some Philosophical Implications of Mathematical Logic". *Review of Metaphysics* 6 (1952): 165. An unusual discussion of ways in which Gödel's Theorem and Church's Theorem are connected to psychology and epistemology. Ends up in a discussion of beauty and creativity.
- Nagel, Ernest. *The Structure of Science*. New York: Harcourt, Brace, and World, 1961. A classic in the philosophy of science, featuring clear discussions of reductionism vs. holism, teleological vs. nonteleological explanations, etc.
- ** Nagel, Ernest and James R. Newman. *Gödel's Proof*. New York: New York University Press, 1958. Paperback. An enjoyable and exciting presentation, which was, in many ways, the inspiration for my own book.
- * Nievergelt, Jurg, J. C. Farrar, and E. M. Reingold. *Computer Approaches to Mathematical Problems*. Englewood Cliffs, N. J.: Prentice-Hall, 1974. An unusual collection of different types of problems which can be and have been attacked on computers—for instance, the " $3n + 1$ problem" (mentioned in my *Aria with Diverse Variations*) and other problems of number theory.
- Pattee, Howard H., ed. *Hierarchy Theory*. New York: George Braziller, 1973. Paperback. Subtitled "The Challenge of Complex Systems". Contains a good article by Herbert Simon covering some of the same ideas as does my Chapter on "Levels of Description".
- Péter, Rózsa. *Recursive Functions*. New York: Academic Press, 1967. A thorough discussion of primitive recursive functions, general recursive functions, partial recursive functions, the diagonal method, and many other fairly technical topics.
- Quine, Willard Van Orman. *The Ways of Paradox, and Other Essays*. New York: Random House, 1966. A collection of Quine's thoughts on many topics. The first essay deals with various sorts of paradoxes, and their resolutions. In it, he introduces the operation I call "quining" in my book.

- Ranganathan, S. R. *Ramanujan, The Man and the Mathematician*. London: Asia Publishing House, 1967. An occult-oriented biography of the Indian genius by an admirer. An odd but charming book.
- Reichardt, Jasia. *Cybernetics, Arts, and Ideas*. Boston: New York Graphic Society, 1971. A weird collection of ideas about computers and art, music, literature. Some of it is definitely off the deep end—but some of it is not. Examples of the latter are the articles “A Chance for Art” by J. R. Pierce, and “Computerized Haiku” by Margaret Masterman.
- Rényi, Alfréd. *Dialogues on Mathematics*. San Francisco: Holden-Day, 1967. Paperback. Three simple but stimulating dialogues involving classic characters in history, trying to get at the nature of mathematics. For the general public.
- ** Reps, Paul. *Zen Flesh, Zen Bones*. New York: Doubleday, Anchor Books. Paperback. This book imparts very well the flavor of Zen—its antirational, antilanguage, antireductionistic, basically holistic orientation.
- Rogers, Hartley. *Theory of Recursive Functions and Effective Computability*. New York: McGraw-Hill, 1967. A highly technical treatise, but a good one to learn from. Contains discussions of many intriguing problems in set theory and recursive function theory.
- Rokeach, Milton. *The Three Christs of Ypsilanti*. New York: Vintage Books, 1964. Paperback. A study of schizophrenia and the strange breeds of “consistency” which arise in the afflicted. A fascinating conflict between three men in a mental institution, all of whom imagined they were God, and how they dealt with being brought face to face for many months.
- ** Rose, Steven. *The Conscious Brain*, updated ed. New York: Vintage Books, 1976. Paperback. An excellent book—probably the best introduction to the study of the brain. Contains full discussions of the physical nature of the brain, as well as philosophical discussions on the nature of mind, reductionism vs. holism, free will vs. determinism, etc. from a broad, intelligent, and humanistic viewpoint. Only his ideas on AI are way off.
- Rosenblueth, Arturo. *Mind and Brain: A Philosophy of Science*. Cambridge, Mass.: M.I.T. Press, 1970. Paperback. A well written book by a brain researcher who deals with most of the deep problems concerning mind and brain.
- * Sagan, Carl, ed. *Communication with Extraterrestrial Intelligence*. Cambridge, Mass.: M.I.T. Press, 1973. Paperback. Transcripts of a truly far-out conference, where a stellar group of scientists and others battle it out on this speculative issue.
- Salmon, Wesley, ed. *Zeno's Paradoxes*. New York: Bobbs-Merrill, 1970. Paperback. A collection of articles on Zeno's ancient paradoxes, scrutinized under the light of modern set theory, quantum mechanics, and so on. Curious and thought-provoking, occasionally humorous.
- Sanger, F., et al. “Nucleotide sequence of bacteriophage ϕ X174 DNA”, *Nature* 265 (Feb. 24, 1977). An exciting presentation of the first laying-bare ever of the full hereditary material of any organism. The surprise is the double-entendre: two proteins coded for in an overlapping way: almost too much to believe.
- Sayre, Kenneth M., and Frederick J. Crosson. *The Modeling of Mind: Computers and Intelligence*. New York: Simon and Schuster, Clarion Books, 1963. A collection of philosophical comments on the idea of Artificial Intelligence by people from a wide range of disciplines. Contributors include Anatol Rapoport, Ludwig Wittgenstein, Donald Mackay, Michael Scriven, Gilbert Ryle, and others.
- * Schank, Roger, and Kenneth Colby. *Computer Models of Thought and Language*. San Francisco: W. H. Freeman, 1973. A collection of articles on various approaches to the simulation of mental processes such as language-understanding, belief-systems, translation, and so forth. An important AI book, and many of the articles are not hard to read, even for the layman.
- Schrödinger, Erwin. *What is Life? & Mind and Matter*. New York: Cambridge University Press, 1967. Paperback. A famous book by a famous physicist (one of the main founders of quantum mechanics). Explores the physical basis of life and brain; then goes on to discuss consciousness in quite metaphysical terms. The first half, *What is Life?*, had considerable influence in the 1940's on the search for the carrier of genetic information.
- Shepard, Roger N. “Circularity in Judgments of Relative Pitch”. *Journal of the Acoustical Society of America* 36, no. 12 (December 1964), pp. 2346-2353. The source of the amazing auditory illusion of “Shepard tones”.
- Simon, Herbert A. *The Sciences of the Artificial*. Cambridge, Mass.: M.I.T. Press, 1969. Paperback. An interesting book on understanding complex systems. The last chapter,

- entitled "The Architecture of Complexity", discusses problems of reductionism versus holism somewhat.
- Smart, J. J. C. "Gödel's Theorem, Church's Theorem, and Mechanism". *Synthese* 13 (1961): 105. A well written article predating Lucas' 1961 article, but essentially arguing against it. One might conclude that you have to be Good and Smart, to argue against Lucas. . .
- ** Smullyan, Raymond. *Theory of Formal Systems*. Princeton, N. J.: Princeton University Press, 1961. Paperback. An advanced treatise, but one which begins with a beautiful discussion of formal systems, and proves a simple version of Gödel's Theorem in an elegant way. Worthwhile for Chapter 1 alone.
- * ———. *What Is the Name of This Book?* Englewood Cliffs, N. J.: Prentice-Hall, 1978. A book of puzzles and fantasies on paradoxes, self-reference, and Gödel's Theorem. Sounds like it will appeal to many of the same readers as my book. It appeared after mine was all written (with the exception of a certain entry in my bibliography).
- Sommerhoff, Gerd. *The Logic of the Living Brain*. New York: John Wiley, 1974. A book which attempts to use knowledge of small-scale structures in the brain, in creating a theory of how the brain as a whole works.
- Sperry, Roger. "Mind, Brain, and Humanist Values". In John R. Platt, ed. *New Views on the Nature of Man*. Chicago: University of Chicago Press, 1965. A pioneering neurophysiologist here explains most vividly how he reconciles brain activity and consciousness.
- * Steiner, George. *After Babel: Aspects of Language and Translation*. New York: Oxford University Press, 1975. Paperback. A book by a scholar in linguistics about the deep problems of translation and understanding of language by humans. Although AI is hardly discussed, the tone is that to program a computer to understand a novel or a poem is out of the question. A well written, thought-provoking—sometimes infuriating—book.
- Stenesh, J. *Dictionary of Biochemistry*. New York: John Wiley, Wiley-Interscience, 1975. For me, a useful companion to technical books on molecular biology.
- ** Stent, Gunther. "Explicit and Implicit Semantic Content of the Genetic Information". In *The Centrality of Science and Absolute Values*, Vol. I. Proceedings of the 4th International Conference on the Unity of the Sciences, New York, 1975. Amazingly enough, this article is in the proceedings of a conference organized by the now-infamous Rev. Sun Myung Moon. Despite this, the article is excellent. It is about whether a genotype can be said, in any operational sense, to contain "all" the information about its phenotype. In other words, it is about the location of meaning in the genotype.
- . *Molecular Genetics: A Historical Narrative*. San Francisco: W. H. Freeman, 1971. Stent has a broad, humanistic viewpoint, and conveys ideas in their historical perspective. An unusual text on molecular biology.
- Suppes, Patrick. *Introduction to Logic*. New York: Van Nostrand Reinhold, 1957. A standard text, with clear presentations of both the Propositional Calculus and the Predicate Calculus. My Propositional Calculus stems mainly from here.
- Sussman, Gerald Jay. *A Computer Model of Skill Acquisition*. New York: American Elsevier, 1975. Paperback. A theory of programs which understand the task of programming a computer. The questions of how to break the task into parts, and of how the different parts of such a program should interact, are discussed in detail.
- ** Tanenbaum, Andrew S. *Structured Computer Organization*. Englewood Cliffs, N. J.: Prentice-Hall, 1976. Excellent: a straightforward, extremely well written account of the many levels which are present in modern computer systems. It covers microprogramming languages, machine languages, assembly languages, operating systems, and many other topics. Has a good, partially annotated, bibliography.
- Tarski, Alfred. *Logic, Semantics, Metamathematics. Papers from 1923 to 1938*. Translated by J. H. Woodger. New York: Oxford University Press, 1956. Sets forth Tarski's ideas about truth, and the relationship between language and the world it represents. These ideas are still having repercussions in the problem of knowledge representation in Artificial Intelligence.
- Taube, Mortimer. *Computers and Common Sense*. New York: McGraw-Hill, 1961. Paperback. Perhaps the first tirade against the modern concept of Artificial Intelligence. Annoying.
- Tietze, Heinrich. *Famous Problems of Mathematics*. Baltimore: Graylock Press, 1965. A book on famous problems, written in a very personal and erudite style. Good illustrations and historical material.

- Trakhtenbrot, V. *Algorithms and Computing Machines*. Heath. Paperback. A discussion of theoretical issues involving computers, particularly unsolvable problems such as the halting problem, and the word-equivalence problem. Short, which is nice.
- Turing, Sara. *Alan M. Turing*. Cambridge, U. K.: W. Heffer & Sons, 1959. A biography of the great computer pioneer. A mother's work of love.
- * Ulam, Stanislaw. *Adventures of a Mathematician*. New York: Charles Scribner's, 1976. An autobiography written by a sixty-five-year old man who writes as if he were still twenty and drunk in love with mathematics. Chock-full of gossip about who thought who was the best, and who envied whom, etc. Not only fun, but serious.
- Watson, J. D. *The Molecular Biology of the Gene*, 3rd edition. Menlo Park, Calif.: W. A. Benjamin, 1976. A good book but not nearly as well organized as Lehninger's, in my opinion. Still almost every page has something interesting on it.
- Webb, Judson. "Metamathematics and the Philosophy of Mind". *Philosophy of Science* 35 (1968): 156. A detailed and rigorous argument against Lucas, which contains this conclusion: "My overall position in the present paper may be stated by saying that the mind-machine-Gödel problem cannot be coherently treated until the constructivity problem in the foundations of mathematics is clarified."
- Weiss, Paul. "One Plus One Does Not Equal Two". In G. C. Quarton, T. Melnechuk, and F. O. Schmitt, eds. *The Neurosciences: A Study Program*. New York: Rockefeller University Press, 1967. An article trying to reconcile holism and reductionism, but a good bit too holism-oriented for my taste.
- * Weizenbaum, Joseph. *Computer Power and Human Reason*. San Francisco: W. H. Freeman, 1976. Paperback. A provocative book by an early AI worker who has come to the conclusion that much work in computer science, particularly in AI, is dangerous. Although I can agree with him on some of his criticisms, I think he goes too far. His sanctimonious reference to AI people as "artificial intelligentsia" is funny the first time, but becomes tiring after the dozenth time. Anyone interested in computers should read it.
- Wheeler, William Morton. "The Ant-Colony as an Organism". *Journal of Morphology* 22, 2 (1911): 307-325. One of the foremost authorities of his time on insects gives a famous statement about why an ant colony deserves the label "organism" as much as its parts do.
- Whitely, C. H. "Minds, Machines, and Gödel: A Reply to Mr Lucas". *Philosophy* 37 (1962): 61. A simple but potent reply to Lucas' argument.
- Wilder, Raymond. *An Introduction to the Foundations of Mathematics*. New York: John Wiley, 1952. A good general overview, putting into perspective the important ideas of the past century.
- * Wilson, Edward O. *The Insect Societies*. Cambridge, Mass.: Harvard University Press, Belknap Press, 1971. Paperback. The authoritative book on collective behavior of insects. Although it is detailed, it is still readable, and discusses many fascinating ideas. It has excellent illustrations, and a giant (although regrettably not annotated) bibliography.
- Winograd, Terry. *Five Lectures on Artificial Intelligence*. AI Memo 246. Stanford, Calif.: Stanford University Artificial Intelligence Laboratory, 1974. Paperback. A description of fundamental problems in AI and new ideas for attacking them, by one of the important contemporary workers in the field.
- * ———. *Language as a Cognitive Process*. Reading, Mass.: Addison-Wesley (forthcoming). From what I have seen of the manuscript, this will be a most exciting book, dealing with language in its full complexity as no other book ever has.
- * ———. *Understanding Natural Language*. New York: Academic Press, 1972. A detailed discussion of one particular program which is remarkably "smart", in a limited world. The book shows how language cannot be separated from a general understanding of the world, and suggests directions to go in, in writing programs which can use language in the way that people do. An important contribution; many ideas can be stimulated by a reading of this book.
- . "On some contested suppositions of generative linguistics about the scientific study of language", *Cognition* 4:6. A droll rebuttal to a head-on attack on Artificial Intelligence by some doctrinaire linguists.
- * Winston, Patrick. *Artificial Intelligence*. Reading, Mass.: Addison-Wesley, 1977. A strong, general presentation of many facets of AI by a dedicated and influential young proponent. The first half is independent of programs; the second half is LISP-dependent and includes a good brief exposition of the language LISP. The book contains many pointers to present-day AI literature.

- * ———, ed. *The Psychology of Computer Vision*. New York: McGraw-Hill, 1975. Silly title, but fine book. It contains articles on how to program computers to do visual recognition of objects, scenes, and so forth. The articles deal with all levels of the problem, from the detection of line segments to the general organization of knowledge. In particular, there is an article by Winston himself on a program he wrote which develops abstract concepts from concrete examples, and an article by Minsky on the nascent notion of "frames".
- * Wooldridge, Dean. *Mechanical Man—The Physical Basis of Intelligent Life*. New York: McGraw-Hill, 1968. Paperback. A thorough-going discussion of the relationship of mental phenomena to brain phenomena, written in clear language. Explores difficult philosophical concepts in novel ways, shedding light on them by means of concrete examples.