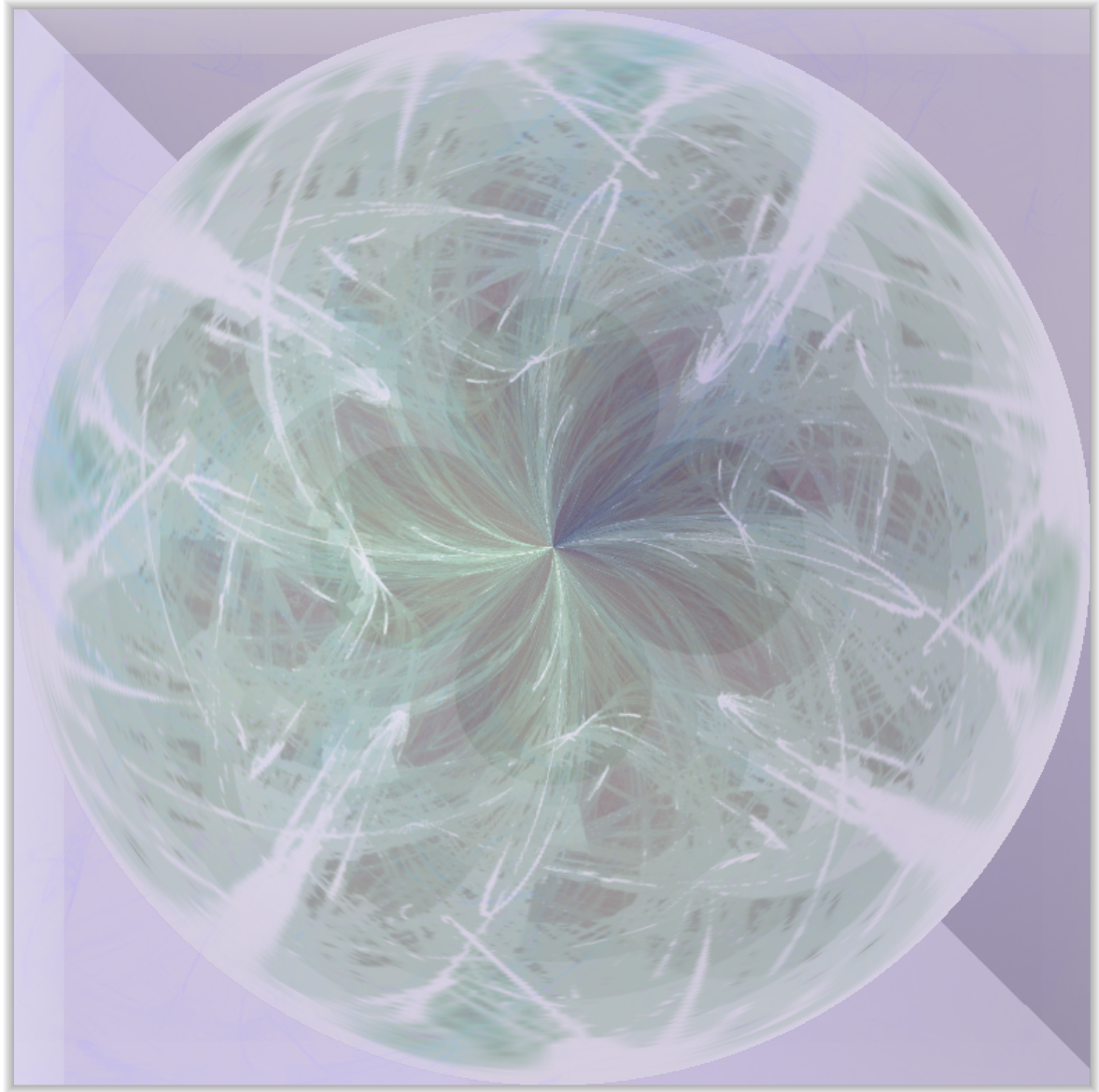


the finest machine
the science and the joy of computing

nick black



DEDICATED to my professors, my students, and my friends at the Georgia Institute of Technology, who give rise to that spirit living *in his machinis ex deis*. Hack on, lads, hack on!

TO ALL THOSE who took a wary chance on a risky bet, especially Coach Jeanette Martin: thanks for everything. You made possible this work of tightly-controlled audacity. *Per ardua ad astra*.

—Atlanta, 2012

This document was prepared on Debian Linux using L^AT_EX, the GIMP, ImageMagick, GNU Make, and Vim.

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I made a discovery today. I found a computer. . . And then it happened. . . a door opened to a world. . . rushing through the phone line like heroin through an addict's veins, an electronic pulse is sent out, a refuge from the day-to-day. . . This is it, this is where I belong.

—The Mentor, “The Hacker Manifesto”
Phrack Vol. One, Issue Seven, Phile 3 (1986-09-25)

Something else gets under your skin, keeps you working days and nights at the sacrifice of your sleeping and eating and attention to your family and friends, something beyond the love of puzzle solving. And that other force is the anticipation of understanding something about the world that no one has ever understood before you. . . I have experienced that pleasure of discovering something new. It is an exquisite sensation, a feeling of power, a rush of the blood, a sense of living forever. To be the first vessel to hold this new thing.

All of the scientists I've known have at least one more quality in common: they do what they do because they love it, and because they cannot imagine doing anything else. In a sense, this is the real reason a scientist does science. Because the scientist must. Such a compulsion is both blessing and burden. A blessing because the creative life, in any endeavor, is a gift filled with beauty and not given to everyone, a burden because the call is unrelenting and can drown out the rest of life.

This mixed blessing and burden must be why the astrophysicist Chandrasekhar continued working until his mid-80's, why a visitor to Einstein's apartment in Bern found the young physicist rocking his infant with one hand while doing mathematical calculations with the other. This mixed blessing and burden must have been the “sweet hell” that Walt Whitman referred to when he realized at a young age that he was destined to be a poet. “Never more,” he wrote, “shall I escape.”

—Alan Lightman, “Spellbound by the Eternal Riddle, Scientists Revel in Their Captivity”,
New York Times (2003-11-11)

Part of the inhumanity of the computer is that, once it is competently programmed and working smoothly, it is completely honest. I do not fear computers. I fear the lack of them.

—Isaac Asimov, source unknown

Nature does not know extinction; all it knows is transformation. Everything science has taught me, and continues to teach me, strengthens my belief in the continuity of our spiritual existence.

—Wernher Von Braun, “Why I Believe in Immortality”,
from *The Third Book of Words to Live By*, W. Nichols (ed.) (1962)

In the particular is contained the universal.

—Anton Chekhov, as quoted by James Joyce in
Arthur Power's *From the Old Waterford House* (1949)

There may indeed be other applications of the system than its use as a logic.

—Alonzo Church,
The Calculi of Lambda-Conversion (1932)

III THE ESSENCE AND LIMITS OF COMPUTATION.

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“All physical systems can be thought of as registering and processing information, and how one wishes to define computation will determine your view of what computation consists of.”

—Seth Lloyd,
“Ultimate Physical Limits to Computation”, *Nature* 406 (2000-08-31)

- 10 Hierarchy theory of Chomsky. Deterministic and nondeterministic machines. Turing’s Machine, Curry’s combinatory logic, and Church’s λ -calculus. The Church-Turing Thesis. Information-theoretic limitations of formal systems. ■ 31
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IV THE INELUCTABLE MODALITY OF STATE.

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“μεταβάλλον ἀναπαύεται.”

(“Even while it changes, it stands still.”)

—Ἡράκλειτος (Heraclitus the Ephesian), as quoted in Abelson and Sussman’s
The Structure and Interpretation of Computer Programs (Second Edition, 1996)

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“Die Welt ist alles, was der Fall ist. . . Wovon man nicht sprechen kann, darüber muß man schweigen.”
 (“The world is all that is the case. Whereof one cannot speak, one must remain silent.”)

—Ludwig Wittgenstein, *Tractatus Logico-Philosophicus* (1918)

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28 A machine dreams it is Turing.

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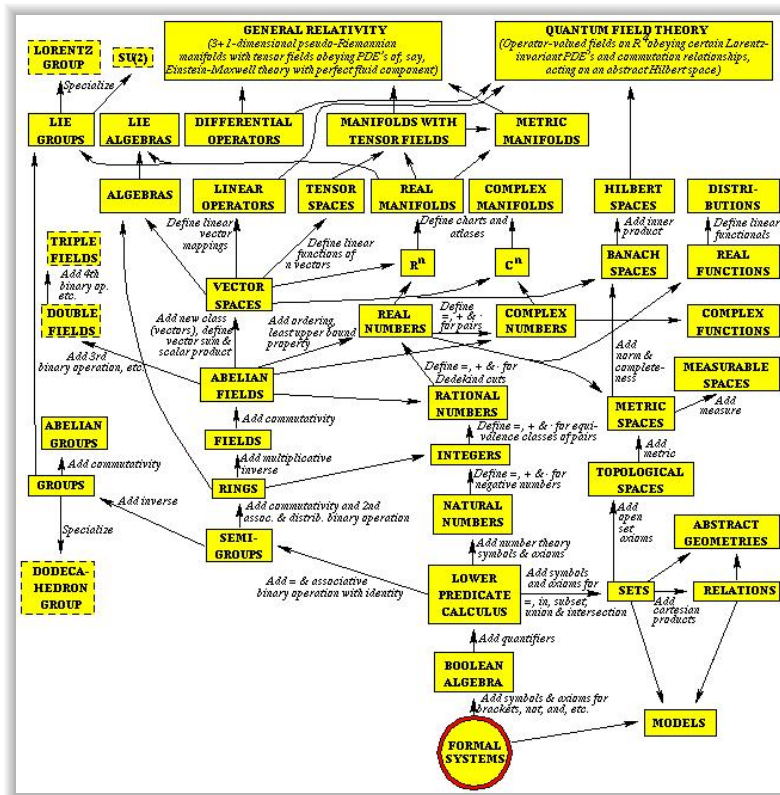


Figure 0.1: “What Goes on at the Top?” Max Tegmark, 2001. Used with permission.

Part I

BEYOND THE ZERO.

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Diagonalization. Gödel numbering and
semiotics. Formally undecidable propositions
and Gödel's Theorem.

Chapter 2

Wittgenstein and correspondence theories of truth. Stochastic processes. Richard's Paradox and the Paradox of Rosser and Kleene.

Chapter 3

Digital representation of seemingly analog existence. Advantages of digital systems. Digital life.

Chapter 4

Computable recursive functions. Von Neumann and Harvard architectures. Circuit complexity. Instruction set architecture. Processor frontends. Real computation.

Part II

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Entropy and negentropy. Periodic and
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Chapter 6

Signals. Sampling theory of Nyquist. The Fourier transform.

Chapter 7

Time's Arrow and the Second Law of Thermodynamics. Heisenberg's uncertainty principle. Landauer's principle. The wrath of Maxwell's Demon.

Chapter 8

The employ of direct currents. Voltage, frequency, resistance, and capacitance. Semiconductors.

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