COURTESY OF THE ARTIST; PHOTO: S. HOWARD

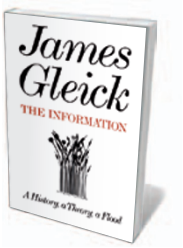
TECHNOLOGY

# The medium is the message

**Thomas J. Misa** enjoys a history of communication tools, from talking drums to Twitter.

Information is the paradigm of our time. Economies that once manufactured goods now create value by processing information. Global flows of money, ideas and news determine which countries engage with global society and which are left silently on the sidelines. A skein of pervasive mobile computing keeps us connected — instantly, continuously, incessantly. James Gleick's latest book, *The Information*, examines the genesis of the information society and the roots and consequences of information theory.

Gleick is no stranger to demanding scientific topics. His blockbuster *Chaos* (Penguin, 1987) popularized Edward Lorenz's mathematics of complexity. He is also the biographer of physicists Richard Feynman and Isaac Newton. In *The Information*, he highlights the great surge of classifying and calculating often labelled as the industrial and scientific revolutions, and he profiles leading theorists, notably US mathematician Claude Shannon. Gleick acknowledges that the concept of information and its impacts are difficult to grasp, yet explains our fascination with seeing information as the driver of just about everything.

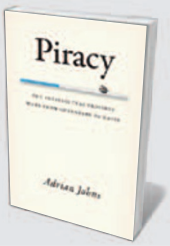



**The Information: A History, A Theory, A Flood**
JAMES GLEICK
*Pantheon/Fourth Estate: 2011. 544 pp. $29.95/£25*

Rather than telegraphs or telephones, Gleick begins with 'talking' African drums. Because African languages had hundreds of sounds, it seemed impossible to European observers that complex messages could be conveyed using drums that made only two sounds, pitched high and low. Yet for centuries, almost all African people could understand the messages that were broadcast by skilled drummers.

After decades of European puzzlement, John Carrington's 1949 book *The Talking Drums of Africa* revealed all. There was no telegraph-like Morse code within drumming. African languages relied only partly on unitary sounds or 'phonemes' and more fundamentally on their intonation. Simply altering their tones could transform the phonemes for 'he watched the riverbank' into 'he boiled his mother-in-law'. With drum tones expressing the rising and falling pitches of African speech, drummers could accurately convey a complex message. And anyone whose ear was attuned could understand it. Using this accessible analogy, Gleick deftly introduces the concepts of information channels, intentional redundancy of messages and the importance of error correction.

Gleick's more technical treatment of Shannon and information theory is a recurring thread of the crucial middle chapters. He serves up enlightening side views




**Piracy: The Intellectual Property Wars from Gutenberg to Gates**
*Adrian Johns (Univ. Chicago Press, 2011; $22.50)*
Intellectual piracy, as historian Adrian Johns explains, is nothing new. From the invention of the printing press to modern file-sharing, Johns explores the wars that have arisen over intellectual property rights. (See Steven Shapin's review: *Nature* **466,** 563; 2010.)


**Power Struggles: Scientific Authority and the Creation of Practical Electricity Before Edison**
*Michael Brian Schiffer (MIT Press, 2011; $19)*
Behavioural archaeologist Michael Schiffer investigates electricity technologies before Thomas Edison's success. He shows why some made an impact while others failed, and the role of scientific authority in determining their fate.

***Size Matters*: *Alphabet* (2005) by Dalton Ghetti.**

to Babylonian mathematics, the *Oxford English Dictionary*, Charles Babbage's mechanical computers, telegraph codes, the 'completeness' of formal mathematics, wartime cryptography and especially the telephone system, which provided a focus for Shannon's work. He also gives apt summaries of Walter Ong, Marshall McLuhan and other commentators on the information age.

The narrative of Shannon's place in information theory is well known to historians. Shannon, a distant relative of Thomas Edison, grew up in rural northern Michigan, studied electrical engineering and mathematics at the University of Michigan, then went to the Massachusetts Institute of Technology (MIT) in Cambridge. Here, after operating Vannevar Bush's massive mechanical differential analyser and working at Bell Telephone Laboratories during the summer break, he started work on his master's thesis: 'A Symbolic Analysis of Relay and Switching Circuits'. It was accepted by MIT in 1937 and published a year later. Psychologist Howard Gardner called it "possibly the most important, and also the most famous, master's thesis of the century". Telephone switching systems at the time were composed of thousands of electromechanical relays; within two decades or so, they had evolved into electronic computers.

Shannon was the link between algebra and switches. He saw that the on–off states of telephone relays resembled the algebra originally conceived by George Boole in the 1850s, with its now-familiar notation of ones and zeroes and 'and', 'or' and 'not' operators, and that immense systems of telephone relays could be analysed through Boolean algebra. Shannon also showed that logical problems, such as adding two binary numbers together, could be modelled exactly using telephone relays — and, soon enough, vacuum tubes, transistors and semiconductor chips too. Having grounded modern computing in this way, Shannon created 'An Algebra for Theoretical Genetics', as his doctoral thesis was titled, in 1940.

A full-blown information theory arrived soon after. Following a year at the Institute for Advanced Study in Princeton, New Jersey, Shannon joined Bell Telephone Laboratories full-time in 1941 and worked on wartime cryptography and fire-control projects. Shrouded in secrecy, the wartime work introduced him to British computer scientist Alan Turing (they had tea together for two months but could not discuss their code work), and linked his thinking with mathematician Norbert Wiener's broadly similar theory of the role of randomness or 'entropy' in information. All communication, Shannon decided, resembled coded messages sent through a noisy channel: distortion and noise battled against redundancy and bandwidth. He defined these terms mathematically. Shannon gained international acclaim after publishing two famous technical articles in which he named the bit (short for 'binary digit', first coined in a Bell Labs memo by statistician John Tukey), and after writing a popular book with engineer and mathematician Warren Weaver, *The Mathematical Theory of Communication* (University of Illinois Press, 1949).

Having engagingly assembled information theory, Gleick might have examined its many ramifications in the mathematics of coding theory, data compression and error correction that underpins everything from mobile phones to DVDs. Instead, he treats information more metaphorically, covering the founding of cybernetics, the genetic code of DNA and the birth of quantum information science and the allure of quantum computing. His asides on the editing history of Wikipedia articles, although entertaining, begin to stretch the interpretive framework. A final substantive chapter surveys our predicament of information overload, the flood of the book's subtitle: too many genomes, sky surveys and climate models, let alone e-mails. He confronts social media such as Twitter, describing it as "banality shrink-wrapped, enforcing triviality by limiting all messages to 140 characters".

Gleick admirably raises the question of how information relates to meaning and semantics, which Shannon specifically ruled out of scope in his theory, yet Gleick mostly inclines towards instances of verbal and mathematical thinking. "The written word — the persistent word — was a prerequisite for conscious thought as we understand it," Gleick suggests. An anecdote from Feynman opens up this tidy world: "Thinking is nothing but talking to yourself," he once remarked. "Oh yeah?" countered a friend. "Do you know the crazy shape of the crankshaft in a car? Now tell me: how did you describe it when you were talking to yourself?" Thinking in this spatial way, Feynman set the stage for nanotechnology in his article in *Popular Science* in November 1960, titled 'There's Plenty of Room at the Bottom: How to Build an Automobile Smaller than this Dot.' Semantics and spatial thinking might be considered for a new, generative theory of information to enhance Shannon's. ■

*CHAIN* (1997) BY DALTON GHETTI. COURTESY OF THE ARTIST; PHOTO: S. HOWARD

**Thomas J. Misa** *is director of the Charles Babbage Institute at the University of Minnesota, Minneapolis, Minnesota 55455, USA.*
*e-mail: tmisa@umn.edu*


**Fermilab: Physics, the Frontier, and Megascience**
*Lillian Hoddeson, Adrienne W. Kolb and Catherine Westfall (Univ. Chicago Press, 2011; $30)*
For 40 years, the Fermi National Accelerator Laboratory in Illinois has stood at the frontier of high-energy physics. The book charts the rise of this institution, detailing the difficulties of balancing pioneering science with tightened budgets.


**The Eerie Silence**
*Paul Davies (Mariner Books, 2011; $15.95)*
Astrophysicist Paul Davies describes the 50-year Search for Extra-Terrestrial Intelligence project. He proposes other approaches, from scouring Earth for microscopic aliens to seeking intelligence on planets beyond the Solar System. (See Chris McKay's review: *Nature* **464,** 34; 2010.)