nounced on a 30-foot screen before an audience of hundreds. . . . Even in solitary encounters with nature . . . our pleasure . . . has been anticipated by a thousand L.L. Bean catalogues, Ansel Adams calendars, and advertisements."

Despite a few weak spots—he too hastily dismisses sincere conservative forms of civic activism, and his treatment of religion is superficial—*For Common Things* is the work of an unusually perceptive social observer. If one wishes to see the world through the eyes of a very intelligent 24-year-old, this is an excellent place to begin.

—*Patrick Glynn*

Science & Technology

THE UNIVERSAL HISTORY OF NUMBERS:
From Prehistory to the Invention of the Computer.
By Georges Ifrah. Translated by David Bellos, E. F. Harding, Sophie Wood, and Ian Monk. Wiley. 633 pp. $39.95

In 1937, archeologists in Czechoslovakia unearthed a 30,000-year-old wolf bone with 55 notches carved into it. A caveman had used the bone to count something (nobody knows what), but he would have been at a loss to say how many notches he had made. Other than perhaps 1 and 2, numbers hadn't been invented. There was no word for 55; like the numbers 6, 78, and 203, it was too large to have an individual name. It was "many."

Humans got by with "1, 2, many" for millennia. Even in the 20th century, the Siriona Indians of Bolivia used the word *pruka* to describe any number greater than 3. Luckily, though, humans have a built-in calculator, which gave rise to number systems based on 5, 10, and 20. In the Ali language of Africa, the word for 5 means "hand" and the one for 10 means "two hands." When each value was associated with an individual word, numbers were born.

In *The Universal History of Numbers*, Ifrah, a former math teacher, traces the tortured past of our Arabic system, which denotes each number by a combination of 10 symbols. It started in Babylon, was carried to India by Alexander, was captured by the conquering Arabs a millennium later, and reached Europe during the 13th century, where it was promptly banned. Westerners were so suspicious of Arabic numerals that Pope Sylvester II, an early advocate of the system, was accused of selling his soul in order to borrow Muslim magic. In 1648, papal authorities cracked open Sylvester's tomb to ensure that Satan wasn't in residence.

Ifrah also describes the evolution of number systems that failed. Early in the first millennium A.D., the Mayans developed a system that was much more advanced than medieval Europe's—it had a zero, which was unknown in the West until after the Spanish conquest in the 16th century. But Mayan civilization mysteriously collapsed in the 10th century, leaving others to discover zero for themselves.

The Universal History of Numbers is less narrative history than reference work. In the middle, Ifrah interrupts the text with a 70-page alphabetical list of Hindu number concepts. The book also bears little anecdotal filigree. For instance, the author explains that the British Court of Exchequer kept records on wooden tally sticks, but he doesn't tell what happened when the government ended the practice and tried to get rid of the sticks in 1834: the tally stick bonfire got out of control and burned down Parliament.

Despite its lack of flourish, this is a highly satisfying volume, none the worse for having been translated from the French. It will give the same pleasure to math and history buffs that a fine dictionary gives to philologists.

—*Charles Seife*

MEANING IN TECHNOLOGY.
By Arnold Pacey. MIT Press. 264 pp. $27.50

Pacey, who teaches at Britain's Open University, has long been one of the most learned and humane scholars of technology. He made his reputation with a series of wide-ranging works, including *The Maze of Ingenuity* (1976), *The Culture of Technology* (1983), and *Technology in World Civilization* (1991). In popular usage, the word *technology* has become synonymous with computerized devices and software; for Pacey, technology

and its related sciences are human endeavors spanning centuries and continents.

In the remarkable *Meaning in Technology*, he argues that technology expresses the aesthetic drives of its creators and users. Machines, for example, have characteristic tempos and sounds, and many automobiles and motorcycles are tuned acoustically for a pleasing effect. And, just as musicians develop tactile relationships with their instruments, scientists, engineers, and artisans often can understand and diagnose conditions by touch. Some aircraft radio repair technicians during World War II developed a kind of empathy toward the electronics equipment the worked on that enabled them to find problems without full testing. Technology, Pacey argues, unites ears, eyes, and hands.

Machines and structures also unite people. *Things* bear meanings for society. The design of bicycles and aircraft incorporates ideas about who is going to operate them, and how. Will the devices be unforgiving but powerful, rewarding strength and precision but treating weakness and misjudgment harshly? Will they require authoritarian, top-down control for safe operation, or will they promote cooperation among smaller communities? Do they draw on our innate playfulness? Are they available equally to girls and boys, women and men?

If music is Pacey's central metaphor for scientific and technological creation, the garden exemplifies human works in the natural world. The human transformation of the landscape, he shows, goes beyond anything required by the body's simple need for nourishment and shelter. This change is not always harmful to nature, either. Preserves and other artificial microhabitats (he could also have mentioned England's remaining hedgerows) support higher densities of species, including some rare ones, than their "natural" surroundings. To many engineers, bridges and roads can enhance the beauty of landscapes.

The strength of this book, its catholic approach to technology, is also a limitation. Too little space is devoted to the central scientific and engineering trend of the new century, the rise of electronic networks—and to the fortunes being made from them. Many great inventors of a hundred years ago, notably Thomas Edison, lived for innovation rather than for profits. Even the engineers and scientists of the old military-industrial complex, which Pacey sees as a source of Faustian temptation, were generally interested less in wealth or military power than in opportunities to pursue elegant work with ample resources. Salaries, in those days before stock options, were merely comfortable.

Do today's technological entrepreneurs pursue new meaning in the products they create? Or does the prospect of rapid wealth make values—not to mention basic business ethics—a luxury? More broadly, does the present Internet embody the "people-centered" technology that Pacey advocates and many of its pioneers had in mind, or does the driving competition of electronic commerce substitute staring eyeballs and clicking fingers for engaged minds? Pacey does not ask these questions directly, but he gives us the right tools for answering them.

—Edward Tenner

THE UNDISCOVERED MIND: How the Human Brain Defies Replication, Medication, and Explanation.

By John Horgan. Free Press. 336 pp. $25

Horgan's last book whipped up a small storm. *The End of Science* (1996) argued that various sciences, their big problems either solved or insoluble, have hit the wall. Scientists protested, conferences convened, pundits pondered, and the storm passed. Nevertheless, one protest registered on the author, who was then a writer at *Scientific American*. Neuroscientists denied that their science was stymied by the brain's "sheer complexity." The mind sciences were not ending, they insisted, but just beginning. Chastened, Horgan set out to write *The Undiscovered Mind*.

Along with neuroscience, the book focuses on the fuzzier sciences that study the mind by trying to control its problems, recount its evolution, or reproduce it in a machine. The mind sciences, Horgan says, haven't ended. They just don't get anywhere, and in one chapter after another, he knocks them down. The genetics of behavior can't explain the mind's motivations. Psychoanalytic, psychological, and pharmacological therapies can't cure the mind's malfunctions. Neuroscience can't put systems of neurons together and explain the mind's capabilities. Evolutionary psychology can't account for the mind's predilections.