

While mostly enthusiastic about sled dogs, they raise serious questions about service dogs, such as seeing-eye dogs and dogs that pull wheelchairs. They question whether the animals can possibly enjoy work that, unlike the work of sled dogs, is not in their genetic history. They also demonstrate that the physical work of pulling a wheelchair is very hard on the dog. But, again, they say nothing about the bond that develops between dogs and their guardians (I won't call them owners). And they apply their master-slave critique selectively; the exploitation of sled dogs and herding dogs doesn't trouble them.

The Coppingers' interest in the emotional lives of dogs seems limited to aggression, but they do a fantastic job of exploring that topic. I always wondered how a dog that guards sheep could possibly fend off a wolf much stronger than itself. According to the Coppingers, a predator rarely engages a dog in a fight, because victory is bound to be costly in terms of energy and potential injuries. Even bears, consequently, are cautious around dogs.

There is lots more here that is first rate—scientific explanations and conjectures that are intelligent, well observed, even brilliant. But sometimes you wish the Coppingers were not quite so scientific, that they were willing to indulge readers, if not themselves, with a bit more sentiment, a few more telling anecdotes, and a great deal more imaginative empathy.

—JEFFREY MOUSSAIEFF MASSON

BOLTZMANN'S ATOM:
The Great Debate That Launched a Revolution in Physics.

By David Lindley. Free Press. 272 pp. \$24

Though they may grasp little of its meaning, most reasonably educated people who encounter the equation $E = mc^2$ immediately think of Albert Einstein. But only true physics aficionados know that the equally illustrious expression $S = k \log W$ is inscribed on the grave of Ludwig Boltzmann (1844–1906).

The Viennese theorist's work marked the transition between two great ages of scientific thought: the classical and the quantum. His formula describes entropy, a measure of disorder. Implicit in the arrangement of the symbols is an explanation of why, as the Second Law of Thermodynamics holds, entropy tends to increase in the universe. Lindley, the author of

The End of Physics (1993), provides a lucid account of Boltzmann's discovery and its implications. By the time readers reach the end, they will have a good idea of what his epiphany means.

In the late 19th century, when Boltzmann was making his mark, physicists knew how to describe a gas using such measures as temperature and pressure. Inject a gas into a container, heat it with a flame or squeeze it with a plunger, and the outcome could be foretold by a collection of seemingly ironclad laws. For

many physicists, that was enough. Temperature and pressure were treated as irreducible components of the physical world.

Boltzmann was among those determined to look deeper, to show that temperature, pressure, viscosity, heat conduction, and other qualities were epiphenomena arising from



Ludwig Boltzmann

the jostling of invisible specks of matter: molecules and atoms. The motion of each of these tiny objects could, like that of marbles or billiard balls, be described by simple laws of mechanics. But because there were far too many individual trajectories to track, their mass behavior had to be treated statistically using the mathematics of probability. First, though, one had to believe in atoms—and the only evidence for them seemed to be that positing their existence made the theories work. Skeptics, led by the physicist/philosopher Ernst Mach, denounced the “atomists” and the statistical magicians for straying into metaphysics.

Boltzmann ultimately prevailed by showing that his approach could explain the Second Law. Given a collection of atoms or molecules, there are vastly more disorderly arrangements than orderly ones. So it was most likely that, without outside intervention, order would give way to entropy. Before long, almost everyone believed in atoms, and statistical methods became an important tool in the development of quantum mechanics. More significantly, Lindley shows, the constricting Machian philosophy—rejecting any phenomenon that could not be directly perceived by human

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senses—gave way to the rigorous creativity of modern physics.

Boltzmann wasn't content with his accomplishment. Plagued by depression and still surrounded by doubters, he hanged himself at age 62. Though his fate may sound romantically tragic, his dyspeptic, neurotic manner keeps him from being a very sympathetic character. But the unfolding of his ideas, rendered so well by Lindley, makes for a very absorbing story.

—GEORGE JOHNSON

THE BOTANY OF DESIRE: A Plant's Eye View of the World.

By Michael Pollan. Random House.
304 pp. \$24.95

In a common schoolbook image of evolution, all forms of life are represented by the forking branches of a vast tree. This scheme positions man and his fellow mammals far from their green cousins, the elms, algae, and artichokes. Pollan, a contributor to the *New York Times Magazine* and the author of *Second Nature* (1991), shows how the evolutionary branches of man and plant have come to be intertwined, with complicated consequences for each. In a meditation by turns poetic, historical, and scientific, he traces the reciprocal strategies of the cultivator and the cultivated. If man has moved nature by domesticating certain plants, so nature has moved man, first by stimulating his desires, and then by evolving to gratify them.

Pollan takes four plants that he himself has grown—the apple, the tulip, marijuana, and the potato—and relates their social histories to the human desire each has been bred to satisfy: sweetness, beauty, intoxication, and, through manipulation of the potato's genetic code, control. He travels to central Ohio on a search for

traces of John Chapman, known to schoolchildren as Johnny Appleseed; to Amsterdam, the center of the 17th-century Dutch tulip craze and, more recently, the city where pothead botanists have developed highly fortified marijuana; and to the St. Louis headquarters of Monsanto, where the potato's genes have been redesigned and licensed as intellectual property.

In *Second Nature*, Pollan used Thoreau to illuminate the tension between wildness and cultivation. Here he summons Nietzsche, particularly the philosopher's idea of the dual tendencies of the Greek spirit: the apollonian will toward form, restraint, and balance, and the dionysian will toward dissolution and ecstasy. Pollan describes both gardening and hybridization as contests between these forces.

Although their cultivation may be apollonian, the recombinant potato, supercannabis, applejack, and the rare tulip are intended to satisfy the dionysian appetite for pleasure. The suggestion of sensual excess naturally galvanizes an opposition. Against these hybrids has stood a mixed group of moralists, Calvinists, organic farmers, temperance groups, antidrug forces, the cautious, and the just plain frightened. The author treats this response with a light touch, as a form of evolution in its own right.

Pollan writes crystalline prose. He brings a generous curiosity to the scientists and plantmen he interviews, some of them odd specimens themselves. In the end, though, the main character in his meditation may be the human imagination, which is capable of regarding the apple (to choose but one example) as cash crop, childhood memory, Eve's undoing, national emblem, gene bank, and consummate companion to cheddar.

—CHRISTOPHER HEWAT

RELIGION & PHILOSOPHY

JOHN UPDIKE AND RELIGION: The Sense of the Sacred and the Motions of Grace.

Edited by James Yerkes. Eerdmans.
290 pp. \$24

Preachers tend to read narrative (if at all) as fable or allegory. The intricate tissue of experiential detail vital to fiction is apt to be set

aside as extrinsic to meaning and treated as an attractive but disposable container for the hard nugget of moral instruction within. Happily, no such tendency mars this collection of 15 essays by religious and literary scholars. The contributors all take fiction seriously enough to engage it on its own terms. They are able to confront irresolvable tensions without forcing res-