BOOK REVIEWS

Cosmological Quest

Wrinkles in Time. GEORGE SMOOT and KEAY DAVIDSON. Morrow, New York, 1994. x, 331 pp., illus., + plates. $25.

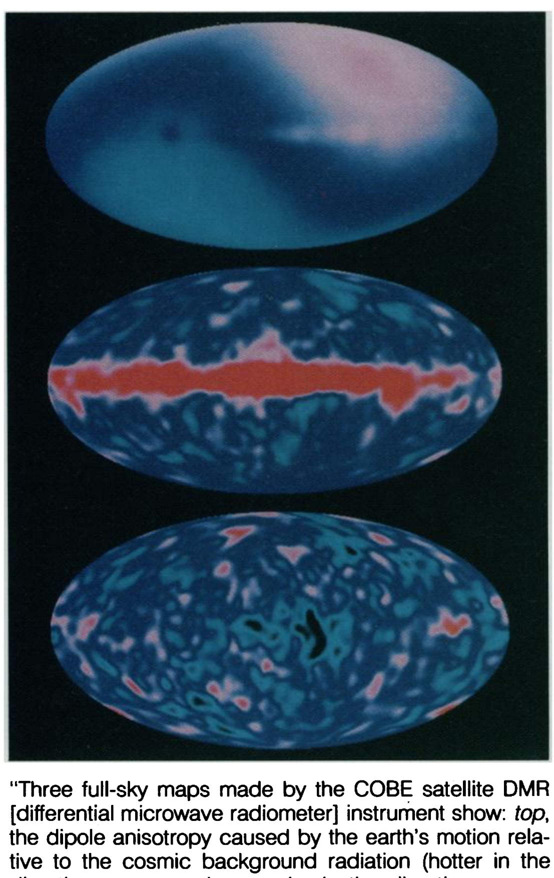
Ripples in the Cosmos. A View Behind the Scenes of the New Cosmology. MICHAEL ROWAN-ROBINSON. Freeman/Spektrum, New York, 1993. viii, 224 pp., illus. $22.95.

About 300,000 years after the Big Bang, the density of free electrons in the universe became low enough for photons to stream freely without further impediment. The universe thereby became filled with a uniform distribution of hot photons of a virtually perfect Planckian, blackbody spectrum. A unique property of such a spectrum is that it is preserved under the wavelength-stretching cosmological redshift: the expansion of the universe produces a continuously decreasing temperature, but preserves a perfect blackbody photon distribution. By about 10 to 15 billion years later, in the year 1965 (when this cosmic background radiation was first observed by Penzias and Wilson, who thereby earned a Nobel Prize), its temperature had decreased to a chilly 3 K, and its constituent wavelengths had stretched into the microwave radio region.

Although a single photon has no unique rest frame, the isotropic distribution of the photons in the microwave background does define one: it is the fossilized rest frame of material in the very early universe. Motion of the Earth through the sea of microwave photons is in principle detectable as a very slight, Doppler-induced, apparent increase in the temperature of radiation coming from the direction of the Earth's motion, and a corresponding slight temperature decrease in the antipodal direction. This so-called dipole anisotropy, amounting to only about one part in 1000, was in fact detected in 1977, most notably by a team led by Smoot, whose instrumentation was flown in a U-2 former spy plane inherited by NASA. Surprisingly, our own Milky Way galaxy was found to be hurtling at something like 600 kilometers per second in an otherwise unremarkable direction in space.

There is general agreement among theorists that this "peculiar velocity" must be due to the gravitational attraction of an excess mass density in the direction of our motion. Observers, however, are divided: One camp finds evidence for a dense knot of matter, a "Great Attractor," some 200 million light-years away in the direction of the constellation Centaurus. Another camp, which includes Rowan-Robinson, relying on systematic maps of galaxy positions derived from the infrared observations of the Infrared Astronomical Satellite (IRAS), finds that the peculiar velocity can be explained by the vector aggregation of the smaller velocities due to the attraction of known galaxy clusters out to large distances.

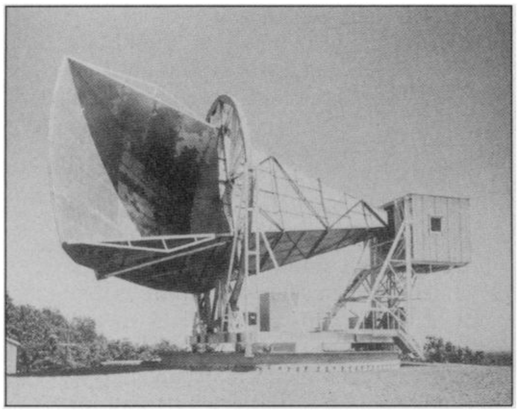
If the universe is lumpy enough today to cause our peculiar velocity, it must likewise (and in a calculable fashion) have been at least slightly lumpy in the distant past when the microwave photons were released. That lumpiness should, according to theory, be detectable in the microwave background today. The microwave photons should be not quite isotropic but rather should show temperature ripples or wrinkles when mapped onto the sky. These ripples or wrinkles are not observer-dependent effects but represent actual maps of features in the universe when it was only 300,000 years old. They are literally the oldest artifacts in the universe that are subject to direct observation. Because of the enormous subsequent cosmological expansion, they are also (today) the largest structures that can possibly be observed.



"Three full-sky maps made by the COBE satellite DMR [differential microwave radiometer] instrument show: *top*, the dipole anisotropy caused by the earth's motion relative to the cosmic background radiation (hotter in the direction we are going, cooler in the direction we are leaving); *center*, the dipole-removed sky showing the emission from the plane of the galaxy—the horizontal red strip and the large-scale ripples in space-time; *bottom*, a map of the wrinkles in time." [From *Wrinkles in Time*]

In the decade culminating with the 1992 announcement of positive detections by the Cosmic Background Explorer (COBE) satellite team, led by Smoot, the predicted ripples were a cosmological Holy Grail. Unlike its medieval antecedent, this quest was practically guaranteed to produce some kind of success: either the ripples would be found, or else (if upper limits on their existence were convincingly pushed down) a glaring inconsistency in the theory of the Big Bang and the formation of galaxies would be adduced. But while the quest itself was thus a sure thing, the success of any individual experimental effort was by no means guaranteed. The COBE project, although blessed by funding levels that only NASA could provide, was very nearly a casualty of the Challenger shuttle disaster. By heroic engineering efforts COBE was completely redesigned, its weight shaved by 50 percent, for launch on one of very few Delta rockets that were literally rusting in a warehouse. Meanwhile, ground- and balloon-based efforts, at much smaller budgets, competed to be first. Counterbalancing the danger of not being first was the danger of announcing incorrect results (either wrong positive detections or inaccurate upper limits). Indeed, some groups did fall into the second trap. The ripples amount to only one part in 100,000 of the microwave background, requiring a terrifying degree of control of systematic sources of error.

Smoot (with science journalist Keay Davidson) and Rowan-Robinson have now written personal accounts of these very exciting years in the field of observational cosmology. Like authors of all such personal histories, both have had to find a balance between background and explanatory material, the purpose of which is to bring the reader up to speed in the discipline, and first-person accounts of events in



"The Bell Laboratories antenna with which the microwave background was discovered in 1965." [From *Ripples in the Cosmos*]

which they were themselves central, the purpose of which should be to provide the reader with a rip-roaring adventure story, a vicarious immersion into the thrill of doing real science.

By the latter criterion, Smoot provides the more authentic account. He was really there for two major discoveries in 20th-century cosmology: the dipole anisotropy and the ripples. His book is also the better written of the two (perhaps owing to his collaboration with a professional journalist). His "adventures" are more gripping, including the search for a balloon payload lost in the Amazon jungle and, much later in his story, a hastily organized Antarctic expedition to make microwave measurements from the South Pole. His book deserves a place of honor on a short shelf of good science popularizations.

Rowan-Robinson has also made important contributions to cosmology, but of a more arcane character, less easily explained to the lay audience. In the necessary attempt to dramatize, he commits the sin (allowable in specialized forums but unpardonable in popular accounts) of being just too sure of himself. He unwincingly concludes that the universe must consist of 3 percent ordinary matter, 67 percent cold, dark matter, and 30 percent matter in the form of a species of neutrino with a mass of 7 electron volts, and that the total density must add up to exactly the critical cosmological closure density. While such mixed hot-cold cosmologies indeed have some support from some cosmologists, there is still plenty of evidence in apparent contradiction with such models. It is surely misleading to represent the situation as in any sense settled.

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Anatomy of Addiction

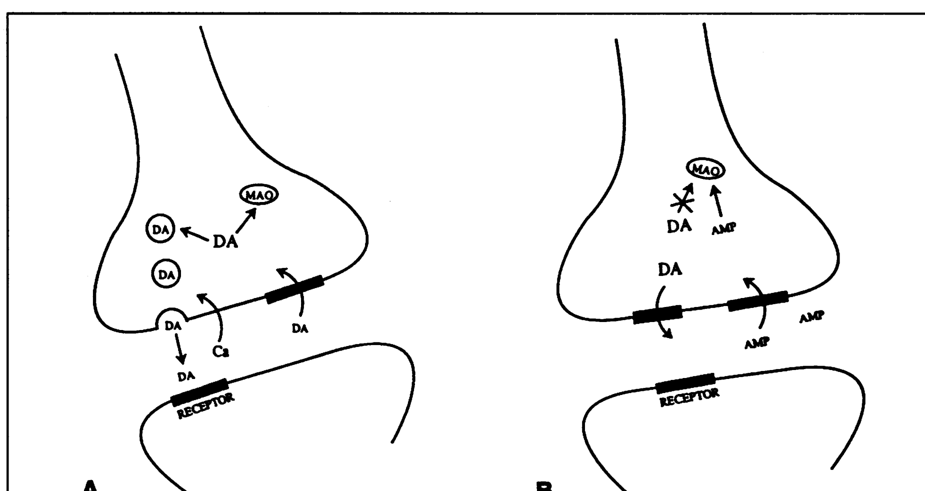
Biological Basis of Substance Abuse. STANLEY G. KORENMAN and JACK D. BARCHAS, Eds. Oxford University Press, New York, 1993. xviii, 516 pp., illus. $75 or £65.

Few issues, as the editors of this book point out, cross so many disciplines as substance abuse. Long thought of in terms of criminology or as a social phenomenon, drug addiction is now recognized as a category of chronic, biologically based illnesses. Recently, powerful new tools of neurobiology have allowed researchers to begin to unravel the mysteries of the brain mechanisms involved in substance abuse and addiction.

Biological Basis of Substance Abuse conveys the current excitement in drug abuse research. The book reflects the diversity of disciplines encompassed by the field, the changing views and latest theories of addiction, and a wealth of new information from molecular and cellular studies. The observation that different drugs of abuse often have many similar biological effects has led the editors to organize this volume by biological system rather than by pharmacological class of agents: the 30 contributions are arranged under the headings of cell biology, neural systems, neuropharmacology, behavioral mechanisms, and human genetics and pharmacological treatment. Compelling topics addressed include the brain mechanisms responsible for initial drug-induced euphoria, the neuroadaptive changes that occur with repeated drug exposure, and the possibility of a genetic vulnerability to drug addiction.

Central to the theory that substance abuse has a neurological basis is the idea that there exists an endogenous reward center in the brain that mediates all types of reinforcement, including natural reinforcers such as food as well as artificial reinforcers such as drugs. Hence the inherent abuse potential of a given substance is likely to reflect its ability to activate this reward pathway. Some controversy exists as to the precise neuroanatomical site of this reward center. However, the mesolimbic dopamine system together with opioid-releasing neurons is most often implicated; in the book evidence is presented for the ventral tegmental area, the nucleus accumbens, the prefrontal cortex, the lateral hypothalamus, the olfactory tubercle, the hippocampus, and the ventral pallidum as critical areas. Although neurochemical studies have shown that different classes of abused substances produce their initial effects on different neurotransmitter systems (opiates activate opioid receptors, central stimulants potentiate catecholamine neurotransmission), all of these agents interact at some level with the brain's endogenous reward center and thereby become reinforcers. Several excellent chapters discuss the neural circuitry of drug reward and dependence.

The evidence supporting the role of the mesolimbic system in drug reinforcement offers an explanation for the initial euphorigenic nature of many drugs. With repeated exposure to a given drug neuroadaptive changes occur that help maintain normal physiological processes in the pres-



"**A**, Depolarization-induced release of dopamine. The neurotransmitter is stored in vesicles that fuse with the plasma membrane and release their contents by a calcium-dependent process. The cytoplasmic concentration of dopamine (DA) is normally controlled by the uptake into vesicles and by degradation by monoamine oxidase (MAO). **B**, Amphetamine-induced release. Amphetamine (AMP) is taken up into the terminal by the carrier where it inhibits monoamine oxidase and increases cytoplasmic dopamine. The cytoplasmic dopamine is transported out into the synapse by the transporter." [From A. Cho's chapter in *Biological Basis of Substance Abuse*]