in ways that would best "protect or enhance their school's reputation." This, she concludes, rendered academic freedom "an essentially corporate protection" (pp. 11, 23). The real dilemma McCarthyism created for the academy and the real conflict it provoked in individuals need more serious consideration. As the institutional home of the higher learning, the university provides and protects the conditions necessary for scholar-teachers to work. For that reason institutional autonomy is as essential to academic freedom as individual rights. The American university always has had an uncertain and uneasy relationship with society. The McCarthyite attack on the academy presented a real Catch 22: it appeared necessary to sacrifice individuals to protect institutions that were necessary to protect individuals. In the 1960's when the university no longer was perceived as the protector of humane values, for several of its constituencies institutional loyalty collapsed.

Schrecker is particularly concerned about the failure of faculty to stand up for their colleagues. Among her explanations for that failure are agreement with the verdict of the firings; persistent "gentlemanliness," which made professors reluctant to attack presidents; belief that it was more effective to work behind the scenes; fear of getting fired; and the AAUP's abysmal failure "to perform its expected function," which, she says, "contributed as much, if not more, to the inability of the nation's college teachers to protect their colleagues as the shortcomings of individual professors and faculties" (p. 315). Schrecker's description of "bureaucratic torpor" at the AAUP, particularly under the last years of Ralph Himstead's general secretaryship, makes a real contribution to knowledge. But her observation that AAUP censure, when it finally did come, proved to be little more than an "irksome annoyance," undercuts her charge that the organization bears a central responsibility for what happened.

At bottom, "most of the men and women who participated in or condoned the firing of their controversial colleagues did so because they sincerely believed that what they were doing was in the nation's interest" (p. 340). If it is so that the academic community really believed that national security was at stake in the search for subversives, we need look no further for explanations of why it collaborated with McCarthyism. The episode is as much a reflection of credulity and provincialism in the American academy as it is of faint-hearted commitment to principle.

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Physics of the Early Universe

Inner Space/Outer Space. The Interface between Cosmology and Particle Physics. EDWARD W. KOLB *et al.*, Eds. University of Chicago Press, Chicago, 1986. xii, 638 pp., illus. $55; paper, $25. Theoretical Astrophysics. From a conference, Batavia, IL, May 1984.

In 1958–60, when I was a graduate student, the big news in cosmology was the measurement by William Baum and Rudolph Minkowski of record high galaxy redshifts, $z = 0.3$ to 0.46. ($1 + z$ is the ratio of observed to emitted wavelength of a feature in the spectrum of the light from a distant object. At $z << 1$, z is proportional to the distance of the object. In conventional cosmological models, $1 + z$ is also the factor by which the universe has expanded since the time of emission, so z can be used to label an epoch in the early universe.) Now measurements of galaxy redshifts at $z \simeq 0.5$ are, if not routine, at least commonly done, and there is a rich web of data to $z \simeq 4$ from observations of absorption by material along the lines of sight to quasars. We have learned that we are in a smooth bath of radiation with a blackbody (statistical equilibrium) spectrum at a temperature of 2.76 ± 0.02 K. Since no one has been able to think of a way radiation with this spectrum could have been produced in the universe as it is now, this is generally thought to be tangible evidence that the universe expanded from a hot, dense state where radiation could have relaxed to statistical equilibrium. If we trace the expansion of the universe further back in time to a redshift $z \simeq 10^{10}$, when the temperature of the heat bath would have been $T \simeq 10^{10}$ K $\simeq 10^6$ eV, we find neutrons and protons reacting to form light elements up to lithium in amounts that agree with the observed abundances in the oldest stars. This is evidence that we understand the outlines of the behavior of the universe when it was just 1 second old, a remarkable accomplishment indeed.

On extrapolating still further back in time we are led to consider a phase transition prior to which neutrons and protons were decomposed into their parts, an almost free gas of quarks; an earlier transition that may have fixed the baryon number density out of entropy; and a transition that may have produced the entropy of the heat bath out of a high-energy state of the vacuum. This vacuum energy would have driven the universe to inflate through an enormous expansion factor that obliterated all traces of past imperfections, including perhaps a time when space behaved as though it had more dimensions than the three we know or even dissolved into a quantum space-time foam. Other phase transitions may have left topological defects: magnetic monopoles that would be readily detectable if they were present now in sufficient numbers; massive domain walls that would seriously distort space if too abundant; and massive cosmic strings that act like magnetic flux tubes in a superconductor or like vortex lines in the rotation of superfluid helium and that may have been responsible for the formation of galaxies and clusters of galaxies. And all this may have been accomplished by the creation and annihilation of a host of particles that have not been observed, including perhaps some that survived to make up the dark matter needed to account for the observations of dynamics on the scale of galaxies and larger.

All this heady stuff, and not lacking in a substantial dose of public relations puffery, but still it is based on a clear and pressing need and opportunity. We know enough about the physics of the universe now and at modest redshifts to be confident that we can extrapolate its expansion back in time to a state whose physics we know we do not understand. The expansion of the universe carries the 2.76 K heat bath we observe back in time to enormous values of the energy density in the heat bath, and, with what is believed to be the appropriate equation of state, to energies per particle that are vastly larger than anything available in the present universe. For example, the Fermilab TeV I collider produces proton-antiproton collisions at 2×10^{12} eV, and the proposed Superconducting Super Collider accelerator would reach collision energies of 4×10^{13} eV. The most energetic cosmic ray events (thought to be protons) have energy seven orders of magnitude higher than that, at about 10^{20} eV. But the Planck epoch in the early universe would have had characteristic energy another eight orders of magnitude beyond that. Thus it seems that if we are to understand the early universe we will have to borrow the expertise of particle physicists, and if we are to push research in high-energy particle physics beyond the limits of what can be reached on Earth we will have to rely on the "ultimate accelerator" of the universe.

There have been many conferences and workshops on this proposed symbiosis of cosmology and particle physics, and inevitably, many published proceedings. This book is among the best of the lot. The conference brought together a fair sample of the people working on the subject and produced 90 interesting papers covering all the main topics. The editors have helped us by providing thoughtful commentaries. If you follow developments in the physics of the early universe the odds are that you will find yourself consulting this book.

Hard results from all the work described in this book are rare: the big news so far is that particle physicists seem to be able to provide initial conditions for cosmology that meet what astronomers generally think they want without undue forcing of the particle physicists' theory. Indeed I sometimes have the feeling of taking part in a vaudeville skit: "You want a tuck taken in the waist? We'll take a tuck. You want massive weakly interacting particles? We have a rack full. You want an effective potential for inflation with a shallow slope? We have several possibilities." This is a lot of activity to be fed by the thin gruel of theory and negative observational results, with no prediction and experimental verification of the sort that, according to the usual rules of evidence in physics, would lead us to think we are surely on the right track of the physics of the universe at $z > 10^{10}$. There are prospects: magnetic monopoles may yet be found; calorimetric detectors may demonstrate the existence of massive weakly interacting particles; scans of the sky brightness at centimeter wavelengths may reveal the presence of cosmic strings. If any of this happens the work will have paid off in a very big way.

The editors argue that we ought to take this possibility seriously, that theoretical physics led us in the right direction during the first 50 years of modern cosmology and may very well do so again. I think they are right, for when people have been motivated to work hard on a problem we usually see results, albeit not always what was intended. A lot of people are working very hard on the physics of the early universe, as witness the fact that this book fills 600 pages. And it will be fun to see in 20 years' time how the results compare to the ideas in this volume.

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Psychology and Neuroscience

Mind and Brain. Dialogues in Cognitive Neuroscience. Joseph E. LeDoux and William Hirst, Eds. Cambridge University Press, New York, 1986. x, 449 pp., illus. $54.50.

A specter is haunting neuroscience. It is the specter of cognition, of higher-level influences that can no longer be ignored. These influences are generating a revolution in the neurosciences, motivating systematic attempts at interaction between neurobiologists and cognitive psychologists.

The editors of this book have structured such an interaction around four areas: perception, attention, memory, and emotion. In each area a psychology chapter is followed by a neurobiology chapter. Each author then comments on the other's contribution. Finally they reply to one another's comments, completing a formalized conversation in print. In this format the contributors talk to each other, rather than past each other. The result combines the breadth of many authors with the structure of a monograph.

With its innovative format and ambitious goal the book is an experiment, as the editors point out. Their conclusion that psychology and neurobiology have something to offer one another is clear at the outset, for they admit that they have stacked the deck by their choice of topics and contributors. The book provides more than just reviews from each discipline: both sets of contributors write with an eye toward interpreting their field in terms of what is relevant to the other. The results magnify both strengths and problems of the interactions.

The emotion section illustrates several characteristics of the dialogue. The book shows that each field has a slightly outdated and distorted view of the other. Ross Buck, in his otherwise excellent psychological chapter, swallows whole exaggerated overgeneralizations about left-right hemispheric differences, discussing the hemispheres as if they had independent little half-personalities. Joseph LeDoux, the insightful neurobiologist of this section, is more circumspect about hemispheric differences but accepts at face value Neal Miller's early report of instrumental conditioning in the autonomic system. The result has proven impossible to replicate, and even Miller now doubts that such effects exist. LeDoux also accepts Wilder Penfield's reports of "reexperienced memories" elicited by brain stimulation. Subsequent work has shown that the phenomenon occurs only in epileptics and even there has proven difficult to validate.

The memory section directly attacks conflicts between cognitive psychology and neuroscience, with Daniel Schacter emphasizing psychological problems that neuroscience generally ignores. According to cognitive psychologists, we remember only a filtered version of experience. Neuroscience until now has assumed a trivial encoding rule, that a signal passing through a synapse should pass through more easily the next time. Gabriel *et al.* in their chapter on the neurobiology of memory recognize that assuming such an encoding rule is a "leap of faith." Psychologists are insisting that a simple encoding rule is not enough: remembered information is highly preprocessed and linked both with the context and with other information before it is stored.

In general one can distinguish between a mechanism, a physical substrate for memory, and the code that gives the substrate meaning. Ink on paper is a mechanism, for example, while the English language is a code. Is the mechanism of memory the growth of dendritic spines, or strengthened synapses, or something else? Is the code a simple increase in nerve-spike frequency, a recruitment of new channels, or something else? The dilemma is that without the code we won't recognize the mechanism, and without the mechanism we cannot study the physical instantiation of the code.

Schacter also differentiates three kinds of interdisciplinary relationships: collateral, complementary, and convergent. Collateral relations cannot be mapped onto one another; for instance, presynaptic versus postsynaptic actions have no parallel in psychology. Collateral relations also appear in Richard Marrocco's review of peripheral anatomy. Like other anatomical reviews by neurobiologist contributors, it is a reductionist's promissory note for eventual relevance to cognition. The psychologist reads patiently, hoping that the anatomy will someday contribute to the construction of psychological theories. Complementary relations occur when one level supplements the other, and convergent relations exist when the two disciplines coordinate their agendas in attacking a common problem, such as the issue of the number of distinct forms of memory.

Some conflicts arise because psychology and neurobiology have different agendas for the same data. James Hoffman's psychology of perception chapter reviews a neuron that seems to detect a monkey's hand, the neuron with perhaps the best public relations of all time (neurobiologists would hesitate to accept any result based on just one neuron). This cell became famous in psychology because it filled a theoretical need for detectors of psychologically meaningful states, though a single cell's output is always ambiguous. In the real world, as opposed to the laboratory, a neuron almost never fires at its maximal rate. Did it fire less because the stimulus was slightly wrong in orientation, or contrast, or motion? Only comparison with the firing of other neurons can resolve the question, so that the idea of a single cell as a detector is obsolete. The psychologist takes the neuroscientist's records of what a neuron is looking at and tries to infer what the neuron is looking for.

Though the editors conceived their book as a contact between separate disciplines, the fields can also be interpreted as specializations along a continuum. The phrase "cog-