by episodes of creation following geological upheavals (i and iii), that creation had ceased with the appearance of man (ii), and, most vitally, that each successive creation had been characterized by increasing excellence in its products, leading finally to man (iv).

How difficult, then, was it for Lyell to accept evolution? He was loath, at first, to abandon the fixity of species. He argued (p. 84), by the little-bit-pregnant logic, that most "species" might only be varieties, and that fewer true species required far fewer creative acts. He stated repeatedly that the birth of a genius to normal parents was as wondrous and abrupt as the creation of a new species. But when he overcame his reluctance to accept unlimited variability, evolution fit very well with the first three types of uniformity: it was natural, gradual, and operating at present. In fact, it overcame the one real anomaly that had inhered in Lyell's system: the continuing creation, however rare, however evenly spaced, of species through time. For, in many places, Lyell emphasized his discomfort with creation, "a perpetual intervention of the First Cause" (p. 106) "[Evolution is] the only [theory] which even pretends to bring the successive changes under a law or within the dominion of science" (p. 246). "It would be more natural to suppose an ass to give rise to a striped offspring with the other characters of a zebra than that a zebra should come into being out of nothing" (p. 173).

Yet Lyell's greatest reluctance to embrace evolution arose from his view (not shared by Darwin) that it implied the progressive development of life through time, that is, that it controverted the fourth sense of uniformity. In the *Principles* he had attacked Lamarck more for the progressive development that his perfecting tendency entailed than for his evolutionism. The journals pursue this theme: "We seem to be drifting towards the Lamarckian theory by . . . arguments in favor of a successive chronological elevation in the scale of being, the advocates of which protest against the transmutation of species" (p. 185). It is in the context of progressionism that evolution is discussed throughout the journals; what they really record is Lyell's abandonment of his most cherished fourth uniformity, not, primarily, his acceptance of evolution. This is why he discusses the Darwinian mechanism so little and the status of man so much.

By 1860, Lyell was ready to accept evolution, but not for the reason we might suppose—not because Darwin had convinced him of natural selection; it is not that simple. Lyell, to be sure, preferred Darwin's mechanism to the crude, inexorable progression of life that the theories of Lamarck and Chambers entailed. Yet he never accepted natural selection as a sufficient explanation for evolution. His objection, in fact, was a common one that echoed up to the 1930's: he saw how selection could eliminate the unfit, but not how it could create the fit. He compared selection to only two members of the "Hindoo Triad"—to Vishnu the preserver and Siva the destroyer, but not to Brahma the creator (p. 369). He decried Darwin's "deification" of selection and wrote to him: "My only objection is . . . to your assigning to [natural selection] more work than it can do and not guarding against confounding it with the Creative power to which . . . the capacity of ascending in the scale of being must belong" (p. 498). Rather, Lyell embraced evolution in 1860 because he had come to accept as probable the *fact* of *progression* in the history of life. To explain this fact, however, he wanted no part of the *progressionism* that refuted his first three uniformities. He could abandon his fourth uniformity, cite evolution as the cause of progress, and thereby affirm all other aspects of uniformitarianism. Lyell accepted evolution because it allowed him to preserve as much as possible of his older world view after he had, with commendable candor, admitted the collapse of one of its central tenets.

Thus, in *The Antiquity of Man* (1862), Lyell accepted the fact of progress in the history of life. He had maintained throughout the journals that the coexistence of man with extinct mammals would force him to consider *Homo sapiens* as a late and natural product of a system in progressive development; for he could no longer view man as a very recent and special addition to a world in steady state. Of man's antiquity he was now convinced by the discovery of artifacts in many areas of Europe. Other bastions of his nonprogressionism were falling. He had long argued that the discovery of a few Mesozoic mammals implied the possibility of their existence throughout fossil history. But no Paleozoic mammals were found, and all Mesozoic forms were primitive preplacentals. Moreover, he could not argue that the Mesozoic "marsupials" had lived on an isolated, ancient "Australia," for they came from many times and places and had to be representative of their era. One could, of course, reverse the argument and say that Lyell came to accept progression because he had been convinced of evolution. This I doubt. Lyell saw an inevitable link between evolution and the fact of progression. He would not have embraced evolution had he not come to doubt the fourth uniformity that had shaped so much of his thinking.

For their subject matter alone, these journals will interest all geologists and evolutionary biologists. But this is not their main fascination, for they allow us to watch a first-rate mind at work as he reassesses and abandons, rather late in life, a bulwark of his former system. To those of us who can comprehend genius only through its display in another man, this is a rare privilege indeed. For Charles Lyell was an exemplar of excellent science: discerning; profound; perhaps, though I hope not, even prophetic: "In no modern community would a teacher go on like Socrates for 50 years inculcating truths distasteful to the higher power. It might be impossible now even at Boston in New England" (p. 365).

STEPHEN JAY GOULD
Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts

Almost There

The Coming of the Golden Age. A View of the End of Progress. GUNTHER S. STENT. Published for the American Museum of Natural History by Natural History Press, Garden City, N.Y., 1969. xiv, 146 pp., illus. $4.95.

It is often pointed out that the experimenter is a part of his experiment, and that the task of science is to remove any bias contributed by him to the observations or conclusions. When on the other hand we do concern ourselves with the preconceptions and involvement of the experimenter or his audience, we are dealing with the history of science. The ranking scholar-historian of bacteriophage genetics dwells in this book upon his heartfelt conviction that man is reaching his limits of understanding in genetic biology and argues the existence of analogous limits to man's reach for scientific, social, and artistic advance generally. Stent believes that a widening sense of

these limits, beginning as always among the avant-garde, is portending an increasing frustration among the achievers in society. Alienation from older values, currently exemplified in beat philosophy, is seen as heralding the end of the predominant striving for mastery characteristic of Faustian man and the beginning of an approach to a Golden Age. The latter, in some contradistinction to the classic Greek conception, is seen as a terminal age of dissemination and restrained Polynesian-like enjoyment of the fruits of earlier struggles.

All of this can be deeply provocative, for we cannot dispute Stent's thesis until we have dispensed with first subjective reactions and felt his challenge to our motives and our concept of progress. The book can serve this provocative role for all who have lived through, or hope to survive, the great exploitative development of genetics and molecular biology, and I therefore recommend it to young biologists and biochemists—and trust that some of them will argue with its thesis.

Both the arts and the sciences are taken by the author to be involved in discovering and communicating truths about the world. He sets forth with suitable modesty a stimulating scholarly exposition and brief analysis of the views of other humanists on the subjects of modern arts, music, and literature. The reader inevitably asks himself whether the so-called "two cultures" can after all be as far apart as Snow considered them to be. The parallel fates of the arts and sciences are here questioned not so much in the familiar plaint "Where does all this lead?" as in the more conscientious and difficult "Given the innate limitations of man and society, where *can* all this lead?"

The first half of this book—portions of which have appeared previously in *Science* ("That was the molecular biology that was," **160**, 390–95 [1968]) and elsewhere—portrays the molecular-biological revolution from the classical (before 1935) to the present period. Three stages subsequent to the classical are pictured: the Romantic (groping for unimaginable "other laws" or paradoxes), the Dogmatic (confirmation of imagined postulates for the transcription and replication of genetic information), and the Academic (proof and fulfillment of the hypothesis, its codes, regulation, and mechanics). The last stage is still at hand—technological exploitation has only begun—but the earlier periods of heroic strife are past. This sequence is seen as a pattern reproduced in other creative developments.

In artistic as well as scholarly pursuits man is viewed as expressing his urge for control or mastery—a sublimation of a more primitive will to power that once was serviceable as a "fitness" for survival. Progress—a concept of the last two centuries only—as commonly measured in terms of mastery over nature, is necessarily self-limiting, and therefore is increasingly inhibitory to personal achievement. Although some ancients and moderns turn toward mastery of man's inner nature, Stent does not appear to see this as a future trend. Man is largely engaged in control or imitation of external nature and communication of knowledge about it.

Statements of insights about the world, in order to be meaningful, must be special—unique statements out of a somehow recognizable array of possible expressions. But, Stent goes on to say, as an art form such as music matures, the canons of permissible expressions have from time to time to be widened into ever more liberal styles. This greater and greater permissiveness tends to make the artist ever more arbitrary in his statement, and the jaded beholder ever less likely to perceive in what mode the statement is special and has meaning.

Debate is most likely to revolve around Stent's assumption of the intrinsic limitations imposed by man's innate biological makeup, and the manner in which these will work themselves out in society. One may argue that we have for ages, long before computers arrived, known cumulatively far more than any individual, and yet have learned how to benefit from new individual inputs. One may suspect and hope that even now altruistic-social rewards are in the awkward process of being substituted for the old individualistic goals. If man's physical energy and enterprise are more fundamental than his rationalist-abstract search for value systems, we need not believe that he will reach an end to striving. His Golden Age could involve a different kind of heroics, foreshadowed, to be sure, but not denied in present reevaluations of our common goals, and perhaps painfully to be attained.

My principal criticism of Stent's development of his case is that some of his projections are too intellectual, too literal. At the time when he is making the case for ever-accelerating exponential growth (of progress or, for that matter, population) he leaves entirely out of account that in manifold insights elsewhere he has indicated that opposed, negative-exponential, processes have already set in. Stent is aware of the pitfalls of qualitative prophecy, but in the quantitative aspect merely suggests lamely that the social adjustment processes are too slow. If such leveling-out processes occur at all, then all projections are unreliable—unless one presumes to know the restoring forces in detail. It remains highly debatable whether the acceleration will reverse, level out, or merely diminish, and at what time or rate can hardly be estimated, or for which components of progress.

It would be most unfortunate if a shallow reading of this book led ordinary citizens, politicians, or educators to think that biological and other scientific development were at an end, no longer needing support, and ready to be entombed in ultimate lexicons. The author actually claims only that the grand principles are mainly discovered, for such areas as genetics, development, differentiation, and immunology. Further working out and application to man still remain ahead, as does neurophysiology of the brain and higher centers. If the reader wishes in addition to leave room for some surprises and unexpected relationships, biology is for most intents and purposes still a developing field.

In the interesting and profound summary of modern genetics that makes up the technical part of the volume, the historical perspective is that of the physicist-turned-virologist, and the emotional angle that of romanticist-*malgré-lui* still looking for the heroic steps, the bold statements enunciated before support was completely assembled. Perhaps it is true that the carefully documented but modestly generalized findings of Avery and coworkers in 1944 of a series of heritable properties of pneumococci carried by DNA did not have great impact upon the "phage group." Perhaps they had more impact than Stent recalls, not an emotional release, but rather an anxiety—I well recall serious discussions on the subject with Delbrück, Cohen, and especially Hershey in the period 1949–51. Certainly microbiologists and biochemists in much more than a narrow circle were deeply concerned and interested. It is perhaps also ironic that the fundamental implication of the Avery work—chemical differentiation of DNA struc-

ture—was revolutionary according to textbook knowledge of the time, whereas the demonstration persuasive to the phage group depended upon the conventional generalization that proteins contain sulfur and never phosphorus, which was not expected to hold, either as a generalization or experimentally, below the 10 percent level. I find it also somewhat unexpected that the x-ray analysis of long spacings in macromolecules that led up to the structural studies of DNA are also considered to be unrevolutionary. Probably this is because each step was preceded by another one, and the giant step to helical structures and fibers could be technically supported in a most unromantic way. Nevertheless, if this reviewer put all of his favorite giant steps into Stent's competent framework, he would merely have slightly reduced the impact of a thought-provoking work that may send many of us scurrying to reexamine our motives and aims in the months ahead.

ROLLIN D. HOTCHKISS
Rockefeller University, New York City

Regulating Man

Physical Control of the Mind. Toward a Psychocivilized Society. JOSÉ M. R. DELGADO. Harper and Row, New York, 1969. xxii, 282 pp., illus. $7.95. World Perspectives, vol. 41.

Until recent times, our knowledge of the human brain and its specialized functional regions came largely from the study of disease. Thus, the lesions of epilepsy with their propensity for localized activation of brain circuits provided a "Pandora's box" of information that could be interpreted in physiologic terms and thereby provide functional maps of the human brain. With the advent of electronic technology, nature's relatively crude experiments have been supplemented by accurate methods of electrode access and stimulus control so that now the clinician or neurophysiologist can activate virtually any selected neuronal population within the human brain. In *Physical Control of the Mind* Delgado gives us a timely review of what this technic can effect in the animal and in the human patient that has bearing on the control of the mind. If the book had appeared ten years ago, its impact would have been greater, since today it is very apparent that effective physical control of the mind is more likely to be achieved through some of the powerful chemical agents that are being used by the youthful populace to "expand the mind" than through the technically difficult methods involved in applying an electrical stimulus to appropriate regions within the cranium.

Delgado has also attempted a more ambitious task, namely to define the philosophic and sociologic implications of these advances in scientific knowledge in line with the intent of the monograph series World Perspectives as stated on the dust jacket: "to reveal basic new trends in modern civilization, to interpret the creative forces at work today, in the East as well as in the West, and to point to the new consciousness which can contribute a deeper understanding of the interrelation of man and the universe, the individual and society, and the values shared by all society." With these goals in mind, Delgado sets in the first nine chapters an evolutionary background for the development of mind-brain concepts. The next seven chapters review the progress that has been made in the control of primate behavior in social groups by intracerebral stimulation. The remaining ten chapters discuss work on brain stimulation in patients and attempt a synthesis of human and animal studies. In the final chapter Delgado considers the social implications of work in this field and properly emphasizes the urgent need for further multidisciplinary research before social problems pass out of rational control.

By many readers the treatment of the mind-brain problem so intimately involved in stimulation experiments in man will be judged as simplistic and cavalier. One might illustrate Delgado's approach by quoting the definition of mind which he adopts, namely, "the intracerebral processing of extracerebral information." This appears to beg the question and is out of step with contemporary efforts to reach a more meaningful approach to this complex subject. An example of such an approach can be found in the monograph *Free Action* by A. I. Melden, which treats in great depth the philosophic-physiologic interface involved in such apparently simple voluntary acts as flexing the finger. Questions of equal complexity appear in relation to such effects as memory change, hallucination, and illusion produced by depth stimulation, and one would have welcomed a more penetrating analysis than is offered in this book.

The most informative chapters are those in which Delgado describes his own work concerning the effects of electrical stimulation of the brain on the behavior of primates in a social environment. This is unique research bridging a gap between brain mechanisms and their expression as sociosexual forces in the group. Here we see Delgado's talent for technical inventiveness combined with his experience with the social structure of a primate colony to produce a unique addition to our knowledge of how brain mechanisms contribute to our understanding of social and group activities. Furthermore, this kind of research seems particularly relevant as providing basic data for use in the interpretation of the breakdown now becoming apparent in social groups and institutions at a human level. In this respect the book fulfills some of the wide-ranging objectives of the World Perspectives series.

In his closing chapters, Delgado ranges over a variety of topics including the ethical problems encountered in human experimentation and in the assessment of brain death. His final plea for a "psychocivilized" society is not very convincing, for it gives the impression of a demand for action on the basis of rather fragmentary data.

The general reader will find in this book much well-documented and useful information about aspects of brain function that is not readily available elsewhere.

REGINALD G. BICKFORD
Department of Neurosciences, University of California School of Medicine, La Jolla

Nociperception and Analgesia

Pain. Proceedings of an international symposium, Paris, April 1967. A. SOULAIRAC, J. CAHN, and J. CHARPENTIER, Eds. Academic Press, New York, 1968. xii, 562 pp., illus. $19.50.

The 54 contributors to this symposium sought in their 41 papers to cover the neural and psychic bases of pain; experimental methods for producing pain in animals and man and for evaluating analgesic agents; the biochemical and psychopharmacologic basis of action of such agents; the psychopharmacology of analgesics; the modification of neuroelectric activity by analgesics and local anesthetics; and finally some clinical applications of studies of those subjects. The editors have generously published in English all but three pages.