sentational painting and the virtually limitless visual armory of modern science? Is there not a risk of arbitrariness? One recalls the dialogue between Hamlet and Polonius over the shape of a cloud, in which the latter agreed in turn that it resembled a camel, then a weasel, and then a whale. Without a simple, direct link between the formulations of science and the accomplishments of artists, no specific referent can be singled out for an abstract painting or the motifs within it. This question can only be resolved by an effort to situate science and art in a larger frame of reference within a concept of culture, which Waddington has made a noteworthy effort to do.

What is the view of science that Waddington urges his readers to take? He describes two styles of inquiry or, if you like, subcultures within science. The first is suggested by Eddington's statement that "the nature of the external world is inscrutable" and that science therefore consists only of such relationships as may be discovered in a smaller domain of measurable regularities. The second, exemplified in the treatise on the psychology of invention by the French mathematician Hadamard, maintains that the intelligence subconsciously conforms itself to reality, yielding insights to the scientist. As Waddington puts it, "Are scientists merely soulless men in white coats, good at recording pointer readings? Or are they some peculiar form of poet, whose unconscious mind throws up to them from time to time some unforeseeable but penetrating notion about the nature of existing things?" Waddington cites James Watson's adoption of the double helix as an instance of the latter procedure, adducing Whitehead's term, "perception by causal efficacy." He concludes that the mental elaboration of visual experience is the primary creative activity of science. Analytical diagrams of relationships and complex images to be resolved visually into patterns are characteristic working materials in key fields of contemporary science, which become increasingly concerned with systems of organization.

Waddington suggests that science entered a new era about 20 years ago in coming to address higher orders of complexity. And it was this transformation of the sciences, he contends, that caused paintings to change so drastically after the Second World War. The new painting demolished the coherent motif just as the new science passed by fixed objects of inquiry in favor of complex relationships. DeKooning and Pollock presented works without a single focus, restless vortices of action and energetic expression. He says of Pollock's "Autumn Rhythm" (1950) that

> [It] is not only the winter twigs of a forest against the sky, it is not only the veins of a heap of dead leaves whose substance has vanished; it could be the electrons buzzing around the atomic nuclei of a complex molecule, or the stars slithering along their orbits in the galaxy. You can see in it a macrocosm or a microcosm: the landscape of withered grass stems you would see if you lay flat on a winter meadow and looked through the eyes of an ant, the hair of the Virgin Mary falling over the crib of the infant Jesus, the whips of the Fates scourging man through the universe . . . the interconnection of everything with everything else, the flickering surface of evanescent thoughts just below the threshold of consciousness. You can explore it in a search for whatever you may bring with you to find.

Among numerous excellent discussions of individual artists Waddington's treatments of Pollock, Dubuffet, and Giacometti are the best, and the plates are especially well presented. In my judgment his exposition of their sense of contingency and texture sustains his argument that they are expositors of a new landscape of scientific thought. It is not that they have copied from technical journals. Rather they have reacted sensitively to concepts of reality of which they may have been only partly aware, through cultural linkages that may be highly tenuous and hard to trace. One of the most valuable sections of the book consists of a description of 11 attributes held to be characteristic of modern painting, each of which finds its counterpart in some aspect of modern science. The cumulative effect of Waddington's argument is to lend credence to the belief that artists have responded to scientists' experiences of reality in many important ways.

In an essay on art and science the Russian-born artist Naum Gabo wrote:

> [It is] a fallacy to assume that the aspects of life and nature which contemporary science is unfolding are only communicable through science itself . . . that would be to confine science and scientists to a new species of sorcerers, producing miracles which they alone can do and to which the mortal common man has no access unless he is initiated.

Waddington confirms the hope that the communication skills and empathy of artists may be enlisted in breaking the spell. Unremitting in honesty and beautiful to contemplate, scientific concepts may be given communicable form through the sensitive responses and expressive gifts of artists. A final service which Waddington performs in this distinguished and important book is to remind educators and other erstwhile well-wishers of the public understanding of science that they have too long ignored the arts, a social dimension of science that can reach the minds and touch the hearts of men where the feeble apparatus of publicism has so sadly failed.

PHILIP C. RITTERBUSH
Smithsonian Institution, Washington, D.C.

Report on the State of the Life Sciences

Biology and the Future of Man. PHILIP HANDLER, Ed. Oxford University Press, New York, 1970. xxiv, 936 pp., illus. $12.50.

François Arago (1786–1853), astronomer, mathematician, physicist, member of the French Academy at the age of 23, and later its permanent secretary —a post, *mutatis mutandis*, equivalent to that now occupied by Philip Handler as president of the National Academy of Sciences—once defined the life road of a scientist, which underlies the book under review. To be sure, there are piquant differences between Arago and Handler. The former was not only a scientist but also a political leader; he was head of the French Republican party (not to be confused with the U.S. party of the same name) and became navy and war minister in the provisional government of the second French republic after the 1848 revolution. Be this as it may, Arago's dictum may well form an epigraph to the book under review: "Connaître, découvrir, communiquer, telle est la destinée d'un savant."

A blue-ribbon committee of 175 distinguished American scientists (containing, curiously enough, only two of the U.S. Nobel laureates in biology) was convened in 1966 to work on some 20 panels in order to fulfill the third of Arago's functions of scientists; their task was to provide a "pithy summary" of the status of specific subfields in biology, to visualize trends for tomorrow, to identify promising areas, methods of

attack, major questions and problems. In sum, the charge by the Committee on Science and Public Policy of the National Academy of Sciences was to arrive at a "complete overview of the highlights of current understanding of the life sciences" and the consequences of further developments not only for biology but in practical terms of human existence and the use of nature for the benefit of the human species. Above all the report of the committee was expected to "convey a sense of the excitement and enthusiasm of the practitioners" of the life sciences and their sense of values.

Before describing the contents of the book, I would say that the goal of providing an overview of the state of biology at the time the panels were convened (and in some cases later, owing to the skillful editing) is met. There are earmarks of a committee production, unevenness in the way a subfield is handled, repetitions, and, in areas of my own competence, statements with which I can wholeheartedly disagree or which I would claim are downright erroneous. But these reservations are essentially trivial.

More serious is the fact that the title of the book, which derives from the ultimate chapter of some 40 pages rather than from the book as a whole, is a misnomer. Thus, although the intent of a survey of modern biology is accomplished, the predictive value implied in the title, and this reviewer's hopeful expectation that the merciless deluge of volumes and symposia on mankind's future would be cut off by a definitive book on the subject, which might have been the main virtue of the report, are not realized.

To put this in another way: I am personally grateful to have the skillful distillation of the near-current state of biology (to attempt a list of major advances since the proofs were read, let alone since the panels and review committees convened, would be sheer folly) condensed into less than 1000 pages at a reasonable cost the way books are priced now. I am distressed, however, not only at the book's failure to fulfill completely the promise of the title but also at the lack of an index. My generation of biologists still remembers the Menckenesque book reviews of Raymond Pearl in his *Quarterly Review of Biology*, wherein it was at least a sin against the Holy Ghost to publish a book without an index (a sin I happen to be guilty of myself). For a book of this scope, authority, and potential influence on the readers, this omission is inexcusable.

It is, of course, impossible within the space available to give a detailed analysis of each of the 20 chapters of the book. I shall confine myself to listing the general topics discussed with the relative amount of attention given to each, and to a more specific comment on the final chapter, not only because the book owes its title to it, but because I think that the primary concern of a biologist in 1970 does not lie in the curiosa of discovering homunculi under newfangled microscopes, or similar excitements, but rather in a responsible evaluation of such findings; in communication à la Arago; in the education of the laity; in qualified prediction of consequences; in *individual* political action —all relevant not only to the satisfaction of human curiosity or vanity, but, much more importantly, to human welfare.

It is difficult to judge what priorities guided the panels or the guiding review committee which passed on the panel reports before the editor was assigned the task of a final rewrite, or again those that motivated the editor himself. But for the record, the pages assigned to each area are, in round numbers: molecular biology and biochemistry, 130; cellular biology, 30; origins of life, 40; developmental biology, 40; organismal biology, 80; nervous system and behavior, 110; ecology, 40; heredity, evolution, and systematics, 60; food and nutrition, 40; medicine, 100; resources, technology (including computers), 150; environmental health, 60; the future of man, 40.

I, like everybody else, have prejudices as to priorities in space assignment to this variety of topics. By and large, they are very similar to those of the editor. I have no intent to quarrel with his.

Being literal-minded, I shall assume the last chapter to be the crux of the book; being old-fashioned I believe that the message of a book is epitomized in its title, and hence will devote my remaining space to the subject the title suggests. The preamble of the ultimate chapter states unequivocally that *Homo sapiens* is the only product of evolution capable of controlling its own destiny. I myself have been preaching this myth for years in my own classes, despite J. B. S. Haldane's injunction that in actual fact it is arrant nonsense. The technology of such control is here or nearly here; the social machinery of implementing the technology is light years away. In the Soviet Union scientists are confined to insane asylums for expressed dissent. In the United States, students are shot to death for presumed dissent. In Southeast Asia, in the Middle East, human beings are killed daily. In South America the kidnapping of uninvolved people is used as a means of blackmail. In South Africa racism is rampant. Hijacking of planes is the order of the day. Environmental pollution, no doubt including mutagenic effects, is not under control. How, even forebearing to enter upon the racial problems in our country, can we claim to be in control of the destiny of our species?

For the record, I would, however, like to enumerate the hazards and the opportunities listed in the book related to our galloping biological technology:

Hazards: (i) war; (ii) pollution; (iii) population growth; (iv) deterioration of the genetic quality of human populations.

Opportunities: (i) life-span extension; (ii) control of infectious diseases; (iii) organ transplants; (iv) improvement of terminal medical care; (v) euphenics and its ethics; (vi) improvement of early environment; (vii) sex determination; (viii) selection for fertility.

To be fair to the 175 people who worked on this report, their optimism with respect to the opportunities outweighs their pessimism with respect to the hazards. But in all honesty, I must, in quoting the last two sentences of the book, add one more of my own; these phrases are in reference to the evolution of *H. sapiens*: "At last he is a Man. May he behave so!" I am afraid he does.

I. MICHAEL LERNER
Department of Genetics, University of California, Berkeley

Biological Substances

Pigments in Pathology. MOSHE WOLMAN, Ed. Academic Press, New York, 1969. xviii, 554 pp., illus. $29.50.

Pigments, as defined by the editor of this book, are "substances . . . which absorb visible light." Using this broad definition, the editor has assembled 16 chapters on these various substances by authors from widely scattered geographic locations.

The chapter titles clearly indicate that the term "pigment" does not imply a substance of any common origin or similarity in chemical composition or biologic significance. Pigments can be