trol, breathing, and blood pressure probably serves better for illustrating basic interactions.

For the reader to whom the title suggests a more general treatise on biological control systems, including such phenomena as learning and decision-making, and with a greater emphasis on the regulation of behavior, a word of clarification may be helpful. The term "control system," as lifted from its engineering heritage, implies a very different subject matter from that of a "decision function" or "information processing system." The mathematics of control systems has developed entirely around the regulation and stabilization of one or several "output variables" emanating from a system ubiquitously named the "plant." The plant may be anything from an airplane to an oil pipeline. This field of mathematics is now highly developed and systematized, and has been most influential in such presentations as Norbert Wiener's *Cybernetics* or Ross Ashby's *Design for a Brain.* It is only recently, through such hybrid concepts as discrete control systems, that decision theory, which comes from a totally different mathematical heritage concerned with choices among alternatives, has begun to interact with control theory, Bayliss' book adheres rather strictly to the former tradition. A comparable volume dealing with the theory of decisions and choices in biological systems still remains to be written.

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Mankind by Design

Genetics and the Future of Man. A discussion at the first Nobel Conference, St. Peter, Minnesota, January 1965. JOHN D. ROSLANSKY, Ed. Appleton-Century-Crofts, New York, 1966. 216 pp., illus. $5.

The first Nobel Conference, held at Gustavus Adolphus College, covered much the same ground as that of earlier meetings on the genetic prospects of man, notably the Ciba Foundation conference in London (*Man and His Future*, Gordon Wolstenholme, Ed. Churchill, London, 1963) and a conference in Indiana (*The Control of Human Heredity and Evolution*, T. M. Sonneborn, Ed. Macmillan, New York, 1965). The six essays are all excellent, but only two are remarkable enough to deserve extended comment at this time.

Writing on "Sociological aspects of genetic control," Kingsley Davis, professor of sociology at the University of California (Berkeley), gives a penetrating analysis of difficulties in the way of instituting eugenic programs. It is often asserted that effective eugenics must await a complete knowledge of human genetics, presumably down to the last nucleotide. This, says Davis, is a patent rationalization for inactivity embraced for other reasons. Immense progress was made in animal and plant breeding long before anything was known of genes—in prehistoric times, in fact. To change the genetic structure of any species one merely needs to understand selection and believe in heredity.

The allegation that we must have complete agreement on the end desired is also dismissed as a rationalization: we do not agree on anything, says Davis, but that does not prevent our acting in other matters. We pass laws governing birth control, tax exemption for religious institutions, restrictions on the sale of alcohol, and rules governing the adoption of children, though we are far from being in complete agreement in these matters:

> My view is that the main reason why human genetic control has never been seriously tried lies in the stability factors of the socio-cultural system. It does not lie in the slowness of genetic change, in the paucity of genetic knowledge, or in the lack of consensus. It lies rather in the stubborn resistance to change inherent in human societies. In other words, eugenics is itself a social movement. Before it can be effective genetically, it has to be effective socially. It has a double barrier to cross, because it combines in a peculiar way the two systems of transmission in the human species. The changes in society that would be required to succeed in a program of human genetic control would be so fundamental that they would tend to dwarf all previous social revolutions. The socially transmitted sentiments and behavior patterns that would have to be disturbed are so deep in the minds of all of us that any imagined escape from them seems either horrible, paradoxical, or ridiculous, because they turn into pure means the things that we conceive to be ultimates.

Following the path of other speculators, Davis envisages various possible worlds in which transsemination and transplantation of ova are utilized, and in which "parents would . . . regard [such a] child as their own—much as a purchased house or car becomes a source of pride to its new owners, regardless of the fact that they themselves did not manufacture it." The nuclear family might also virtually disappear and the raising of children be taken over by professional child-raisers. But, he adds, "the more one pursues such speculations the clearer it is that they are of little value. They do not, for example, enable us to predict the kind of social system required for genetic control."

Classical eugenics failed to order its problems in the proper sequence for action; hence the nearly total eclipse of eugenics in the 1930's. Today, eugenics survives (but just barely) as a topic for academic discussion perhaps largely because Frederick Osborn in 1940 conferred "denatured respectability" on the subject in his book *Preface to Eugenics.* This he did by paradoxically emphasizing the importance of improving the environment. Why this approach? Davis points out:

> In an era when the Nazis in Germany had made genetic control synonymous with racism in the eyes of most intellectuals, Osborn was apparently trying to deflect hostility by borrowing the ideology of "environmentalism" and conferring it illogically on eugenics. He reached the comforting conclusion that democracy, individualism, and freedom will automatically provide beneficial genetic control. He thus evaded the problem of authority and discipline altogether, but aligned eugenics on the side of liberal dogma, denaturing the movement in the process.

There the movement contentedly rests at present. Davis, keenly aware of the homeostatic powers of society available for the negation of all attempted change, does not assert that we will

ever adopt a political program that is consciously genetic (though it should be repeatedly emphasized that all political programs are unconsciously genetic). He does, however, point to a possibility:

> It seems more likely, however, that the change will be precipitated more suddenly by something new in human history, a genetic crisis. The survivors of a nuclear holocaust might prove willing to adopt a thorough system of genetic control in order to minimize the horrifying effects of radiation on the next generations. Once the barriers inherent in the existing social organization of human life were thus broken, genetic control would probably persist because of the competitive power it would give to the societies that maintained it.

The other remarkable essay is by Paul Ramsey, Harrington Spear Paine Professor of Religion at Princeton University. "Moral and religious implications of genetic control," which takes up a third of the volume, views eugenic ideas from a standpoint that is novel to most scientists. The many essays of H. J. Muller are sympathetically and critically examined through the eyes of a man to whom the Bible is a living presence. The five billion nucleotides of a human cell are continuously being degraded by mutation, spontaneous or other. In a state of nature, natural selection just as continuously acts as a proofreader, keeping the genetic message reasonably close to its proper meaning. Tenderhearted man, in the role of the physician, tries his utmost to pinion the proofreader to the rack of benevolent desires. Somatic medicine steadily degrades our genetic ability to deal with the challenges of a simpler, more "natural" life.

Is this a legitimate cause for worry? Dobzhansky, in *Mankind Evolving*, has said no, pointing to comparable changes that have taken place in the domestication of laboratory rats: "Norway rats . . . have been kept in laboratories since some time before 1840 and 1850. . . . But it does not follow that laboratory rats are decadent and unfit; nor does it follow that the 'welfare state' is making man decadent and unfit—to live in a welfare state!" Ramsey, however, thinks there is more truth in Muller's view, which he identifies as a genetic Apocalypse. The accumulation of genetic defects now going on is inexorably fashioning a man of the future who will be kept going only by a burgeoning armamentarium of prosthetic devices: eyeglasses, hearing aids, allergy shots, tranquilizers, heart-pacers, insulin, and who knows what else. Tenderheartedly we refuse to press for the evolution of Superman, in favor of an evolution of Prostheticman. Dobzhansky, presumably, would say that in the Prosthetic State Prostheticman *is* Superman.

At this point Ramsey interjects a *Quis custodiet?* by suggesting that in such a world the genetic deterioriation of the medical men themselves might ultimately result in their being unable to deal with the genetic chaos they had created. The probable consequence, in a world that is not completely stable (will there ever be another?), would ultimately be a complete collapse. This, says Ramsey, is the eschatology that Muller offers us, the vision of a time when *there will be none like us to come after us.* "No philosophy since Bertrand Russell's youthful essay," says Ramsey, "has been so self-consciously built upon the firm foundations of an unyielding despair." Ramsey is comparing Muller's writings to Russell's classic essay, "A Free Man's Worship." He points out, however, an interesting contrast between the two men: "There is less posturing in Muller's despair, more in the optimism that floats over this despair, than in Russell."

Muller's optimism is connected with his schemes for improving the race by "germinal selection," that is, by parents' choosing other, and better, germplasm for the production of "their" children:

> [Muller's] language soars, the author aspires higher, he challenges his contemporaries to nobler acts of genetic self-formation and improvement, all the more because of the abyss below. The abyss sets up such powerful wind currents that mankind seems destined to be drawn into it no matter how high we fly. These are some of the consequences of the fact [that] when all hope is gone Muller hopes on *in despair.* An Abraham of genetic science, if one should arise, would be one who when all hope is gone hopes on *in faith,* and who therefore need neither fear the problem nor trust the solution of it too much.

Ramsey makes a thorough ethical examination of the proposals of Muller, as well as various counterproposals and criticisms by Crick, Lederberg, Dobzhansky, and Medawar. The discussions are too intricate for easy summary, especially since they are couched in a religious idiom that is unfamiliar to scientists. Some may doubt the relevancy of this idiom, but the intelligence and earnestness of the discussion are such that any scientist who finds himself periodically engaged in dialogues with laymen interested in the possibility of eugenic action can hardly afford not to read Ramsey's excellent essay.

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Explaining Consciousness

Of Molecules and Men. FRANCIS CRICK. University of Washington Press, Seattle, 1966. 115 pp. $3.95. John Danz Lecture Series.

The main purpose of this book is, apparently, to refute what the author calls "vitalism." However, in the course of this refutation, an interesting and at times brilliant exposition is presented of some recent results of biology in the development of which the author had a major share. This applies particularly to the second chapter of the book, where DNA replication is described with skill and clarity and the action, production, and function of enzymes, proteins, and RNA are also sketched—though with somewhat less clarity. The second section is, in the opinion of this reviewer, the heart of the book, and it alone makes it well worth reading.

The first section is largely polemic, and polemic often in sharp language: "Elsasser's book is a beautiful example of the confusion that can be brought about by ignorance." The author, magnanimously, attributes the *Gestaltslehre* to Polanyi but compensates for this by declaring that it is ridiculous. On the other hand, this reviewer considers the criticism leveled against one of his own articles to be entirely fair, even though he disagrees with it.

There are very few complexes of phenomena which have been adequately described in terms of concepts developed in the earlier study of a much more restricted set of phenomena. Light turned out not to be a stream of particles which move according to the laws of mechanics; the study of electromagnetism did necessitate the introduction of the concept of fields—revolutionary and entirely new at the time. Modern cosmology is based on the theory of general relativity, and the study of microscopic phenomena led to the concepts of quantum mechanics and its profound modification of our earlier concepts. All these ex-