quantity itself in order to prevent the experimenter's disturbing a higher-order controlled quantity. Hence the well-known perversity of experimental subjects!

It is this hierarchical character of control systems that makes it seem that organisms value self-determinism. And that is not only appearance: organisms are self-determined in terms of inner control of what they sense, at every level of organization except the highest level.

Only overwhelming force or insuperable obstacles can cause an organism to give up control of what it senses, and that is true at every level. In order to achieve ultimate control over behavior, one must obtain the power to deprive the organism of something its genes tell it it must have, and make restoration contingent on the organism's setting particular goals in the hierarchy of learned systems, or even on acquiring new control systems. But one attempts that at risk. Human beings are more prone to learn how to circumvent arbitrary deprivation than they are to knuckle under and do what someone else demands in order to correct intrinsic error. In the sequence deprive, reward, deprive, reward . . ., one person may see the reward as terminating deprivation, but that is only a matter of perceptual grouping. Another person may learn that reward leads to deprivation, and take appropriate action against the cause of deprivation. Pigeons in Skinner boxes, of course, do not have that option.

Summary

Consistent behavior patterns are created by variable acts, and generally repeat only because detailed acts change. The accepted explanation of this paradox, that "cues" cause the changes, is irrelevant; it is unsupported by evidence, and incapable of dealing with novel situations.

The apparent purposefulness of variations of behavioral acts can be accepted as fact in the framework of a control-system model of behavior. A control system, properly organized for its environment, will produce whatever output is required in order to achieve a constant sensed result, even in the presence of unpredictable disturbances. A control-system model of the brain provides a physical explanation for the existence of goals or purposes, and shows that behavior is the control of input, not output.

A systematic investigation of controlled quantities can reveal an organism's structure of control systems. The structure is hierarchical, in that some quantities are controlled as the means for controlling higher-order quantities. The output of a higher-order system is not a muscle force, but a reference level (variable) for a lower-order controlled quantity. The highest-order reference levels are inherited and are associated with the meta-behavior termed reorganization.

When controlled quantities are discovered, the related stimulus-response laws become trivially predictable. Variability of behavior all but disappears once controlled quantities are known. Behavior itself is seen in terms of this model to be self-determined in a specific and highly significant sense that calls into serious doubt the ultimate feasibility of operant conditioning of human beings by other human beings.

References and Notes

1. L. von Bertalanffy, in *Toward Unification in Psychology*, J. R. Royce, Ed. (Univ. of Toronto Press, Toronto, 1970), p. 40.
2. W. T. Powers, *Behavior: The Control of Perception* (Aldine, Chicago, in press).
3. This distinction is akin to the older distinction beween movement and action, the more recent distinctions between molecular and molar, or proximal and distal aspects of behavior. What I term an *act* is a behavior that is arbitrarily left unanalyzed, while a *result* is defined as an understandable physical consequence of an act. Act and result are relative terms, whereas those they replace are absolute. In some circumstances it may be appropriate to consider a movement as a result, in which case the *acts* would be the tensing of muscles. What is proximal or molecular at one level of analysis may be distal or molar at another level. "Distal achievement," in this feedback theory, becomes *perceptual* achievement, and is multiordinate.
4. W. W. Rozeboom, in *Toward Unification in Psychology*, J. R. Royce, Ed. (Univ. of Toronto Press, Toronto, 1970), p. 141.
5. E. Brunswik, *The Conceptual Framework of Psychology* (Univ. of Chicago Press, Chicago, 1952).
6. N. Wiener, *Cybernetics: Control and Communication in the Animal and the Machine* (Wiley, New York, 1948).
7. W. R. Ashby, *Design for a Brain* (Wiley, New York, 1952).
8. W. Powers, R. K. Clark, R. L. MacFarland, "A General Feedback Theory of Human Behavior," in *General Systems—Yearbook of the Society for General Systems Research 1960*, L. von Bertalanffy, Ed. (Society for General Systems Research, Ann Arbor, Mich., 1960), pp. 63–83.
9. W. T. Powers, *Behav. Sci.* **16**, 588 (1971).
10. This article is adapted from a series of lectures given at a faculty seminar on "Foundations of Science," held at Northwestern University, 1971.

NEWS AND COMMENT

NIH Training Grants: Going, Going, Gone?

In reality, there is no such entity as the NIH training program. . . .—From a 1972 analysis prepared by the office of the director of the National Institutes of Health.

Every January, close to the end of the month, the President sends his budget for the next fiscal year to Congress. And every January, during the weeks before that happens, Washington is caught up with dark rumors about programs whose death warrant will be issued in the budget message. Around town, bootleg copies of pages of the budget pass surreptitiously from hand to hand, becoming a special currency whose value lasts a fortnight or so. It will be worthless by 29 January, when the budget is revealed.

From such documents and from the people who have had a hand in shaping them, or who have tried to, came word a couple of weeks ago that the training and fellowship programs of the National Institutes of Health (NIH) are about to meet their end (*Science*, 19 January). This rumor—and it must be considered that until the budget is finally cast in type—has aroused considerable unhappiness and brought no small measure of confusion to the nation's medical schools and research institutions. No more training grants? Is it true? How can that be? Will we survive? Deans, department chairmen, and young investigators seem to have been repeating these questions to themselves, to Washington officials, and to national journalists as the rumor spread.

Several inquiries by *Science* indicate

that the answers to the first two questions are, quite simply, yes. It is true that training grants and fellowships in the NIH program will be phased out by 1974. Ironically, the NIH statement quoted above says more than it intended to at the time it was written. What it said in full was that there is no such beast as "the NIH training program," if by that one means a "centrally planned and operated activity." Rather, the NIH report said, each of the institutes and research divisions of the NIH "plans its training program in relation to its unique mission, tailoring it to the specific requirements and opportunities perceived." Whatever was meant, it appears that the abbreviated quotation now sums things up.

The NIH training programs emerged a couple of decades ago as a way of supporting young scientists and have since come to be the backbone of the institutes' support efforts. Funds are distributed as training grants and as fellowships. Training grants include stipends for predoctoral and postdoctoral students in biological and medical sciences, with the greatest concentration of predoctoral individuals working in the basic sciences, such as anatomy, biochemistry, biophysics, and microbiology. Support is "spread lightly" over other related fields, such as engineering, statistics, environmental health, psychology, and the social sciences. Postdoctoral training for medical doctors covers the whole range of clinical disciplines. Training grant money also goes to support the departments in which the students are learning, and a significant portion of it goes for faculty salaries. Stipends under training grant programs are usually awarded through the departments involved. Fellowships, on the other hand, go to the institution, but with the proviso that specific individuals receive support.

According to NIH officials, in all cases support goes to individuals who intend to obtain a doctorate and go on to work in teaching and research. Persons seeking a master's degree, for example, are excluded, as are M.D.'s who specifically intend to enter private practice. Naturally, officials point out, this cannot apply 100 percent of the time, because individuals drop out of programs or change their career plans. Nevertheless, they stress, the training program support is *intended* for persons who will join the academic community. Thus, in fiscal 1971, for example, about 37.5 percent of all persons enrolled full time in graduate programs in basic medical sciences and 21 percent of those in all biosciences together received NIH support under the training grant and fellowship programs.

Within the biomedical community, there are various responses to the training program issue as it is perceived now, responses complicated somewhat by the fact that the full details of the situation are anything but perfectly clear. No one is certain what, if any, mechanism will be proposed as a substitute for supporting pre- and postdoctoral scientists. Nor is it certain when the program cuts will take effect. Reportedly, the budget for fiscal 1974 says there will be no "new starts" in training programs. A critical question that cannot yet be answered is whether this means that funds which have already been committed to individuals for work to begin next 1 July will be honored.

NIH data indicate that stipends for Ph.D. candidates average about $2400 per year. Postdoctoral research trainees get about $5100 a year, and M.D. trainees, most of whom have fulfilled specialty board requirements, receive an average of $7100 a year. In total, training support peaked in fiscal 1969 at $169 million and by fiscal 1972 had dropped to $154 million. Unless appeals to keep the programs are heard, the figure will plummet to zero within 2 years.

Reactions Vary Widely

One reaction to the end of the NIH training programs has been glibly characterized as the "hysterical dean response," which equates the end of training money with the demise of basic research. Another holds that, although termination of the programs might be acceptable, the suddenness of the Administration's move is not. Finally, there are those who think that the situation is not nearly as critical as many in the biomedical community believe it to be.

Administration dissatisfaction with the NIH training programs is nothing new; nor is it confined to the Nixon Administration, although it has intensified during that time. The Office of Management and Budget (OMB), then the Bureau of the Budget, expressed dissatisfaction as early as the mid-1960's. By 1969, OMB objections to the programs were strong enough to force a reduction of the funding for fiscal 1970 to $18 million below the 1969 appropriation. Last year, training programs were virtually eliminated in the original version of the President's budget but were restored at the last minute. Clearly, the threat to this form of support has been around for a while and should come as no surprise.

Solid evidence that the threat was growing steadily came last May, although at the time only a few persons were privy to it. A memorandum from the staff of the OMB dated 11 May asked the NIH for a special justification of its training programs to accompany its budget requests for fiscal 1974. The NIH's answer, which apparently was not convincing, is 160 pages long.

In pushing the NIH for a justification of the training programs, the economy-minded OMB spelled out precisely what it wanted to know. The OMB asked the purpose of the training funds; the NIH said they were spent to train high-*quality* investigators and teachers. The OMB asked for figures on the numbers of persons in various disciplines, information about their financial status and that of their parents, and whether they were members of minority groups. It wanted to know about the relationship between the number of Ph.D.'s in biomedical sciences in certain key years compared to the output of Ph.D.'s in social sciences and the arts. It wanted to know how one tells whether the country is training too many or too few persons in a given field and, taking a historical look at the field of research manpower, asked this question:

> For trainees in 1965, 1969, and 1973 show separately those supported by NIH and those not supported. Then discuss the how and why of the distribution by specialty: (a) for each year the distribution by specialty, (b) the change in distribution by specialty over the 8-year period, (c) the differences, if any, between supported trainees and nonsupported trainees in (a) and (b). Discussion should help answer whether trends in (a), (b), and (c) were based on national priorities, institute choices, university selection, trainee choices, or were not reflective of any planned priorities.

According to Administration officials, excluding OMB officers, who will not comment, the OMB is not convinced that it gets a good return on its investment in training programs. The NIH argues that it should be viewed as an insurance premium to keep the system going rather than as an investment with guaranteed returns from every single trainee. Reportedly, the OMB also finds the training programs elitist, supporting the rich or individuals who will wind

up making healthy salaries in private practice. (There is little evidence on this one way or the other, but NIH leaders say the "dropout" rate is not very high.) NIH data, admittedly incomplete, show that the scientists it supports generally come from families with average to slightly below average incomes. They maintain that, since scientists in academic work will never make as much as practicing doctors, federal support of their training is a

Earl L. Butz, Counselor for Natural Resources:

For more than 20 years recurrent proposals have been made in Washington for all of the various widely scattered resource agencies to be brought together in a single Department of Natural Resources (DNR). The most recent such proposal was made in early 1971 by President Nixon as part of a sweeping executive reorganization plan. The DNR called for by the President would be made up of the agencies now within the Department of the Interior plus a number from other departments such as Commerce and Agriculture. It was generally assumed that the incumbent Secretary of the Interior, Rogers C. B. Morton, would head the DNR once it was established. The Interior agencies would constitute the core of the new department, and it was Secretary Morton who presented the DNR proposal on Capitol Hill. Yet, with respect to this very question as to whom the President would anoint as the top official in the field of natural resources, events recently have taken a surprising turn.

For various reasons Congress never acted on the President's reorganization plan during 1971 and 1972. This being the situation, an interim arrangement not requiring congressional approval was developed by the White House and announced by the President on 5 January. Simply stated, three new "counselor" posts were being established in the Executive Office of the President and one of these was to be the Counselor for Natural Resources, responsible for advising the President on the numerous resource issues which involve more than one government department. The official selected for this potentially important post turned out not to be Secretary of the Interior Morton but rather Secretary of Agriculture Earl L. Butz, who only a few years ago (shortly before becoming secretary) was making speeches deploring the nation's "environmental binge."

Why one official is preferred over another in matters of appointments is one of the mysteries of the palace guard, and reliable explanations are not easily come by. Just why Morton—formerly a popular member of Congress and chairman of the Republican National Committee—has lost favor at the White House is not clear. There does not appear to have been any major conflict between Morton and the President or the White House staff. He is said to be a mediocre administrator, but this is commonly said of department heads in Washington. One hears that people such as John D. Ehrlichman, the presidential assistant for domestic affairs, do not find Morton to be coolly analytical enough to suit their tastes. In any case, Morton is now in an awkward situation, and how much longer he will choose to remain in the Nixon Cabinet may be in question. On many matters his only access to the President—or even to Ehrlichman—is likely to be through Butz. And his own under secretary-designate, John C. Whitaker, comes from the White House where he has been Ehrlichman's deputy for resource and environmental matters. Morton has not been rated a great secretary by the environmentalists, but he has been about as sympathetic to their cause as Nixon Administration policies would allow.

Butz will continue to be Secretary of Agriculture, and in this latter role resource and environmental matters are a peripheral part of his functions, which have primarily to do with crop stabilization and marketing problems. Indeed, the greater part of Agriculture is not to be included in the DNR if and when Congress establishes this new department. Only the Forest Service, the Soil Conservation Service, and the program of soil and water conservation research would go to the DNR. Butz appears to have been chosen largely on the basis of his personal qualities, and it is true that he is widely regarded within the government as exceptionally able.

Yet Butz is a controversial figure and may soon become more controversial yet. President Nixon nominated him as Secretary of Agriculture in late 1971. Because of his close connections with agribusiness and the free market philosophy which he had espoused as a ranking assistant to Secretary of Agriculture Ezra Taft Benson during the 1950's, his nomination aroused immediate opposition and Butz won Senate confirmation by the surprisingly close vote of 51 to 44. Last summer, Butz was the target of criticism alleging that large grain trading companies had profited from favoritism and inside information concerning the wheat sale agreement between the United States and Russia.

What is less well known about Butz is the fact that, as recently as the spring of 1971, he was expressing open contempt for the environmental movement. An agricultural economist and former dean at Purdue University, Butz has been used as a speaker by the General Motors speakers bureau. In April 1971, in an appearance before a seminar held by the National Agricultural Advertising and Marketing Association, Butz said that the benefits of scientific agriculture—benefits associated with pesticides and other agricultural chemicals—should be extolled. "This fadism that we follow as a nation—and currently it is ecology and pollution—hits us right in the solar plexus. We are now completely dependent on a scientific agriculture," he said. But Butz noted what he regarded were some hopeful signs. "Now we're at the crest of what I would call the agitation curve in this environmental binge we're on," he said. "I think there is some evidence that we may be headed downward on this agitation curve a little bit. Last week we had Earth Week. I'm informed that attendance at the various meetings and seminars . . . was down substantially from what it was [during Earth Week] a year ago."

Early during his tenure as Secretary of Agriculture Butz had a key role in persuading the President not to

significant factor in enticing people into the field. According to their thinking, if a guaranteed loan program were substituted for straight support, people would be more likely to choose more lucrative fields of work rather than incur enormous debts of $50,000 or more that might take some a lifetime to repay. Surveys of postdoctoral trainees have indicated as much. Nevertheless, it looks as though the OMB is trying to force medical schools to

President's Choice a Surprise for Environmentalists

issue an Executive Order to modify clear-cutting practices on federal timberlands—an order which the President's Council on Environmental Quality (CEQ) had prepared. In general, however, Butz does not seem to have taken much part one way or the other in environmental matters since he has been secretary. Officials at the Environmental Protection Agency (EPA) are grateful that Butz did not try to prevent the recent ban on use of DDT, but here it must be noted that use of DDT had in any case been declining.

The question now is how Butz will use the influence of his new position when resource issues must be decided. Morton is not the only top official in the field of resources and environmental quality for whom the route to the White House will often be through Counselor Butz when the issue at hand involves more than one department. In such cases the chairman of the CEQ, Russell E. Train, and the administrator of EPA, William Ruckelshaus, will be going through either Butz or one of the other two new presidential counselors, these being the Counselor for Human Development (Caspar Weinberger, secretary-designate for Health, Education, and Welfare) and the Counselor for Community Development (James Lynn, secretary-designate for Housing and Urban Development). If Russell Train were to intervene in an issue arising from, say, a highway project, the counselor he would consult would not be Butz but rather Lynn. Butz would, however, be the man-to-see in a variety of interagency issues pertaining to federal lands, energy policy, exploitation of oil and minerals, pesticides, oceanic and water resource development, and (if pending legislation is passed) national land use policy. Without question, Butz could become an immensely powerful figure.

Of course, Butz will come under substantial pressure to take the environmentalist viewpoint into greater account than he has ever had to do in the past. Leaders of the national conservation organizations and officials such as Morton, Train, and Ruckelshaus will be pressing their views upon him. Furthermore, as counselor, Butz will be expected to be an honest broker, advising the President of alternative courses of action and of the arguments for each—this, at any rate, is how the White House staff has described the job. John Ehrlichman has even suggested to newsmen that Secretary Morton believes that, by sitting with Butz as a member of the White House Domestic Council's committee on natural resources, his "direct input" to the President will increase. Yet, in the past, Morton reported to an Ehrlichman deputy (Whitaker), who was a personal friend of the President's and enjoyed good access to the Oval Office, usually through Ehrlichman but sometimes directly. Ehrlichman was not the only official to put a fine gloss on the new counselor arrangement. Russell Train, after a wide-ranging talk with the President on 11 January, said that CEQ had not been downgraded in the least by the appointment of the new counselor. CEQ would, Train indicated, function pretty much as it has in the past—and, here, it is well to note that CEQ's influence has generally been modest—except that now a useful new mechanism would be available for resolving interagency problems.

Executive organizational arrangements in Washington tend to have all the permanence of the morning dew, and no one can safely predict how long the new system of presidential counselors will last or how it will work while it does last. But, quite aside from the qualities and attitudes of the officials named to these positions, there are important questions to be raised as to the wisdom of having a "superdepartment" for natural resources, the format toward which the naming of Butz as counselor apparently is a first step. For instance, would the establishment of such a department—and will the appointment of a natural resources counselor—have the effect of "internalizing" and thus hiding from public view (and perhaps the President's view as well) some important policy conflicts between agencies? And will Butz and the other counselors be as accessible to Congress and citizens' groups as the head of a department would be? Senator Henry M. Jackson, chairman of the Senate Interior Committee, already has indicated that he does not like the counselor system, in part because he feels that executive accountability will be further obscured, with Congress and citizens' groups finding it harder to know who is responsible for many decisions made below the presidential level.

There is now a perceptible tendency for the Nixon Administration to turn away from the thou-shalt-not attitude which has been necessary for coping with environmental polluters. After his recent talk with President Nixon, Russell Train said that the President had indicated a desire to see a "more positive and creative emphasis" in the environmental movement. Taken at face value, that statement is one with which environmentalists could not quarrel. But they will find it hard to accept the way the President's natural resources counselor, Earl Butz, seems to interpret his new mandate. Giving a press conference on 12 January in Indiana, Butz said his first priority as counselor would be to look at ways of meeting energy shortages. "We should have been thinking about the energy shortage when construction of the Alaskan pipeline was blocked 5 years ago," Butz said. "When we run short of power, the first people to have their power shut off should be those who blocked the Alaskan pipeline."—LUTHER J. CARTER

Carter, on leave from Science *for the past 2 years to write a book on land use policy in Florida, returned to the staff of News and Comment on 1 January.*

look for other ways to support both their trainees and their teaching faculty.

Among alternatives that have come up, but that appear to be less acceptable to the medical community than the present system, are these three:

► A guaranteed loan program.

► A work-study program in which the government would support training through research grants. Under this system, students would be employed to work on specific research projects. An argument against this approach is that it would limit the scope of an individual's training.

► A departmentally related research allowance. Research departments would receive awards for training in proportion to the amount of research grant money they have. The NIH would "only endorse this proposal as a retreat position," according to its position paper for the OMB.

In spite of the fact that the end of traditional training programs has been in sight for some time, reports that there will be no "new starts" have taken the biomedical community by surprise. Some medical school leaders fear that a few schools may go under if they lose support as early as next year. Others, including Merlin K. DuVal, vice-president of medical affairs at the University of Arizona at Tucson and former assistant secretary for health in the Department of Health, Education, and Welfare, thinks such fears are greatly exaggerated. However, DuVal believes, there is no question that medical schools will be hurt if the training support is pulled out too quickly.

The amounts of money involved are significant, and even the strongest of medical schools will have to do some serious thinking about how to handle their resources and make choices if the training funds dry up. Albert Einstein College of Medicine in the Bronx is reported to receive approximately $1.6 million a year for stipends and another $2.7 million in institutional support, including faculty salaries. That money all comes through training grants. Paul Marks, vice president of medical affairs at Columbia University, reports that his institution gets about $1.2 million a year through training grants for faculty salaries as well as a large sum for stipends. The situation is similar at other schools.

Unless some other mechanism of student and faculty support comes into play soon, medical leaders are saying, things are going to be "fantastically difficult," as Louis G. Welt of Yale University puts it. Welt, president of the Association of Professors of Medicine, says that training program cuts knock the whole financial substrate for training teachers and researchers out just at a time when the nation is demanding more output, both in clinical and research areas. And that seems to be what the academic physicians and investigators are really worried about.

If there is any hope in their minds that training support will be rescued, it seems to center on the Congress. Already, a variety of scientific groups have been in touch with Congressmen. Paul G. Rogers (D–Fla.), whose interest in health matters is well known, has heard from what a spokesman called a "considerable number" of scientists and will inevitably hear from more. According to one of Rogers' aides, cutting training programs is "evidence of false economy" within the Administration, reflecting a desire "to cut dollars today to make the tally book look good" without regard to the long-term effect of such maneuvers. "Remember," he said, "the budget is only a recommendation from the President. I doubt the Congress will go for it."

The question is whether it will really make any difference in the end if Congress does try to put back money the President has taken away. Even if it does, the funds might get lost in the OMB anyway.—BARBARA J. CULLITON

Nuclear Safety: AEC Report Makes the Best of It

With a little prodding from Congress, the Atomic Energy Commission has prepared a major report on the safety of nuclear power. The report is expected to be the centerpiece of congressional hearings on nuclear safety planned by the Joint Committee on Atomic Energy (JCAE) later this winter. Once the hearings are over, the AEC intends to publish its report as part of a stepped-up public relations effort to counter growing opposition to the construction of nuclear power plants.

Fourteen months in the making, the safety report—at least in its final draft version—runs 600 pages and weighs 3 pounds. Much of it is taken up with a bland and reassuring discussion of the AEC's regulatory process, the design of nuclear power plants, and the elaborate precautions taken to ensure their safety. Nevertheless, the report contains one revelation that a number of the AEC's outside critics consider startling at the least. In a discussion of the highly controversial matter of accident probabilities, the report estimates that the chances of a nuclear power plant suffering a serious accident and a consequent release of radioactivity may—for a given reactor in a given year—be as great as one in a thousand. Coupling this estimate with the AEC's projection that about 100 power reactors will be operating in the United States by 1980 and 1000 by the end of the century, the report indicates that one such accident each year may become a virtual certainty.

Hitherto, the AEC has maintained that the chances of a serious "loss of cooling" accident of this sort were so hard to calculate and were undoubtedly so small in the first place as to defy meaningful estimation. The phrase commonly used to describe such an accident is "extremely unlikely."

Moreover, the safety report presents an estimate by non-AEC researchers that the chances of a reactor's massive steel pressure vessel rupturing catastrophically may be on the order of one in a million in any given year. Both the AEC and the nuclear industry have traditionally regarded the explosive rupture of a pressure vessel—the "pot" containing a reactor's core of nuclear fuel—as "not credible," which is to say, all but impossible; indeed, the thick concrete containment shells that surround power reactors are not de-