CHAOS IN SCIENCE

What space and defense are doing

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Until recently, appropriations for scientific and technological projects were granted by Congress with surprisingly little scrutiny. But when the federal bill for research-and-development hit an all-time high of $14.7 billion in fiscal 1963—a climb of 445 percent in ten years—Congress appointed a committee to "research the researchers."

At first, there was some apprehension in the scientific community about the way the committee, headed by Carl Elliott (Dem. Ala.), might interpret its assignment. Fifteen billion dollars of federal money can hardly be passed out, even to scientists, without the occurrence of some irregularities; the committee, it was feared, might see its task as exposing these irregularities in its search for ways and means to curb them. However, the committee—and with it, Congress—is discovering that the problem is of a larger magnitude than a few irregularities in the counting of test-tubes or a wasteful use of paper clips.

The American science-and-engineering enterprise, two-thirds of which is financed by the federal government, is in a state of disarray, of the kind that often follows periods of rapid growth. What is needed is not just a little trimming and cleaning, but a basic design to guide future growth and bring to the present unruly enterprise some semblance of order.

Looking at this problem, Congress is discovering some facts more startling than that one federally supported researcher is investigating the shape of the atoms on the left bank of the Seine. The Elliott committee might wonder who decided that 87 percent of the federal research-and-development budget should go into defense, space, and atomic energy, leaving only 13 percent for *all* other fields of research; who decided that the number of doctors engaged in research should increase by 233 percent (between 1949 and 1962) while the number of practicing physicians grew only 28 percent; who decided that the medical schools should be forced to admit more girls and inferior students while space-related sciences get better students, and all the males they want; who decided that a score of federal agencies would engage in international education and training and so many federal agencies, exploring the ocean, that any day now two American oceanography ships will collide, trying to take the same sounding; or who decided that the White House staff for the guidance and coordination of all our scientific and technological efforts (which, in 1963, consisted of 29 men, only 12 of whom were professionals) would be sixty-five times smaller than the staff that one agency, NASA, uses to guide and coordinate its scientific and technological efforts?

The fact is that most of these decisions were never really made; the development of our research enterprise is not following any over-all policy. Each agency pursues its own program with little regard for any other agency or for any sort of comprehensive national

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program. The magnitude of this disarray and of its implications deserves telling; we are all affected.

A New Age

Few people realize that in the early fifties we entered into a new phase in the utilization of rational, organized knowledge. We entered the age of "mass-science," where scientific resources are widely used and are critical in determining our security, economic vigor, and health.

If the arms race continues, for example, most experts agree that research and development (R&D) will be the crucial area of activity. Already so few weapons of each model are produced before the model is out-moded and replaced (we are talking about building two, maybe three, RS-70 bombers), that the major cost of new weapons is for R&D: over 60 percent of the cost of intercontinental missiles and close to 90 percent of the cost of military-satellites.

If the arms race is phased out, it will then be up to our scientists and engineers to invent new usages for the idled assembly lines (perhaps flying cars? cigarettes without tar and nicotine? martinis chilled in plastic bags?). The vigor of our economy in general, as well as its rate of growth, depends less and less on the rate of re-investment of capital and more and more on the flow of new ideas into its machinery.

Finally, science is a prime concern to the forty million Americans now alive who will die from cancer; to the mental patients who occupy one bed out of every four in our hospitals; to the ten million Americans who suffer from some form of heart disease. The very lives of all these men, women and children, their families and friends, as well as those afflicted by other diseases, are vitally affected by the progress made by the legions of American researchers; the pills, vaccines, and new surgical tools they come up with.

Factories will soon have more men working in laboratories than on assembly lines; and cities will make their names as the seats of research centers and major universities. The prospects of a country will soon be measured more by the number and quality of Ph.D.'s it turns out than by the tons of steel it casts. Hence, no modern society in charge of its fate, can allow its scientific assets to be maldistributed or debased.

Even if there were no new demands on our scientific capacity, we would have a hard time stretching our supply of professional manpower to cover all these vital current needs. According to the Bane report, prepared for the U.S. Surgeon General, we will be short 18,000 physicians by 1975 if the present rate of graduation is not increased. (This does not mean that every American town will be short one doctor, which seems tolerable, but that less attractive towns will have a hard time keeping any physicians who are not alcoholics, or have no heart condition, or otherwise have no choice but to stay.) College teaching, the Office of Education calculated, will lack 90,000 Ph.D.'s by 1970, by present rates of graduation, which means further shortages on all other fronts, as the training of new professionals will lag behind the need. The number of engineers will fall short of that needed at the end of the decade, according to some calculations, by about fifty percent, if no more are turned out each year than were in the last years.

The extent of scarcity reflected by these figures is in some dispute. But granted some case can be made for less alarmist calculations, the danger remains of an over-optimistic approach which expects a "natural" adjustment of demand and supply, helped along by some limited government financing and guidance. But this conclusion, that a few stop-gap measures will suffice, is not borne out by the facts. Let us take a look at the monumental disorder and bottlenecks which already exist.

Scientific Resources

An observer fresh upon the facts of the American science and engineering enterprise would conclude not only that we value our security above all else, but that reaching the moon is twice as valuable to us as the additional contributions research-and-development could make to our health, to our social problems (from under-developed America to juvenile delinquency), to our international relations, and to all earth-sciences combined—from growing food in the ocean to boundless, inexpensive energy released through new chemical processes. He would reach this conclusion by noting that, while in 1963 we spent an estimated $11.4 billion on military and space R&D, we spent only seven percent of this amount ($0.8 billion) on R&D under the Health, Education and Welfare Department.

Despite all the complaints about the inadequacy of our foreign aid program, we appropriated only $7.7 million in 1963 on efforts to study its limitations and to search systematically for ways to improve it. Likewise our Arms Control and Disarmament Agency, one of the major research centers for ways to move toward "a world which is free from the scourge of war and the danger and burdens of armaments," received—even in the years when we were seeking to expand and exploit a major thaw in the cold war—a total budget

of a mere $6.5 million, only part of which could be applied to research; this piddling sum would not pay NASA's electric bill.

The counter-argument is: we have enough resources to satisfy all our needs; no field need be deprived. But in fact as space and defense absorb an increasing segment of our science budget, drawing 25,000 out of the 27,000 R&D scientists and engineers graduated in 1963, not many funds or men were left for other needs.

If some national authority had consciously decided that our scientific resources should be distributed the way they are, we could argue that it had made a bad decision, but at least there would be an authority to argue with, and one that could reverse the decision. But this is not the case.

American science is not guided by any over-all policy or authority. The White House staff (organized into the Office of Science and Technology) is too small and politically too weak for this purpose. Assisted by the Federal Council for Science and Technology, it is primarily engaged in giving advice to the President, and in some coordination work among the agencies.

Congress has no committee in charge of federal research-and-development; the responsibility is dispersed among numerous committees, each looking after the particular program carried out by one or a few agencies. (When the President sent to the Senate for approval the name of his scientific advisor, the Senate had a hard time deciding which committee had jurisdiction.) Hence, Congress tends to deal with each program on its own merits—do we need more work in the area of mental health? more in space?—and it grants funds accordingly. Later, when the budget is found too big, something else is cut (e.g., a basic research project, Mohole, attempting to dig a hole through the earth's crust, was cut back late in 1963). But the critical question is not faced: what sector is deprived if mental health gets more? Who loses when the moon race gains?

Professional Manpower

The manpower problem is particularly important. Levels of taxation and the national debt can be raised by legislation and thus more funds be made available. But the same does not hold true for professional manpower; one cannot use today a Ph.D. that will graduate in the seventies, the way the government spends now tax-revenues that will be paid in the next decade.

Deciding how many Ph.D.'s will be reserved to train new Ph.D.'s and how many will be "consumed" by being recruited for research here and now, is not unlike a problem faced by the most primitive farmer: how many of his seeds should he reserve for next year's crop and how many will be eaten up this year? In the absence of a solid policy on this question, as the federal research empires have multiplied, they use up the manpower needed to train the next generation of researchers and engineers; thus the balance is upset and our scientific enterprise is put on borrowed time.

Likewise, the inroads that federal research has made on the campus and the distorting effects it has had on our major universities have often been cited, but few realize the full extent of the impact. By the end of the fifties 24% of the budgets of universities such as Harvard and Stanford was already covered by federal contracts, most of which go to research and not to education. For other universities it was higher, running as high as 66% for M.I.T., and an astounding 88% for the California Institute of Technology. Even more revealing is a recent study, conducted by Harold Orlans at the Brookings Institution, which showed that the majority of the senior scientists at twelve major universities could not provide the name of any of the undergraduate seniors majoring in their departments, and quite a few were unable to recall the names of more than a few graduate students. Teaching of future scientists cannot be effectively carried out on a part-time, afterthought, no-personal-contact basis.

All in all, the federal space-drive, whose budget has doubled every second year since 1958, coming on top of a giant military research and development empire, has greatly accelerated the current "consumption" of Ph.D.'s, at the cost of training new Ph.D.'s to replenish the supply tomorrow. The limited aid the government did give to education, far from alleviating the situation, had some distorting effects of its own.

Aid is given in the form of agency-bound fellowships (by the A.E.C., the National Institutes of Health, and NASA), and recently, for construction of buildings (but not for teacher's salaries). This particular mode of granting aid has several consequences: first, while the agencies are rather lenient in interpreting the tie between the fellowship and the particular area they promote, they do manage to plug their special concern. Some students accept fellowships to study "health related sciences" (or "space related") and end up studying whatever they initially desired; others, though, are swayed to follow the course the particular agency has in mind.

As a consequence, the same skewed distribution of resources that appears in the distribution of scientific resources in the federal government is gradually ex-

tended to the campus. Today many more students are writing Ph.D. dissertations on mental hospitals and space-related subjects than was the case a few years ago, while other social science subjects and earth-sciences are neglected. This is one of the reasons for the increasing paucity of well-founded social criticism in this country. The David Riesmans, not to mention the C. Wright Millses, of tomorrow will be the only graduate students paying for their own education and research; federal money is not to be used for studies that have manifest political implications.

Moreover, there is, at a given time, a limited pool of high IQ talent on the campus. Even if every chair in every classroom is covered by a body, this does not mean that no re-distribution of talent has taken place. Because of factors such as the higher fellowships given by some agencies than by others, and the great publicity given to the exploits of NASA over, for instance, N.I.H., it is an open secret on the campus that medical schools get poorer students, and have to lower their admissions standards, while the space sciences attract better students.

By failing to take such redistributions of talent into account, a policy for science omits a most crucial factor. A loss of ten percent of its best talents by one discipline cannot be made up by increasing its federal budget fifty times and its student body by a hundred percent. The difference between a good and a bad student is much greater than between a good and a bad area of farm land, bushel of wheat, or tank—the kind of commodities federal authorities are more accustomed to dealing with.

The final—and in the long run, the most important—distorting factor is that almost all the federal aid to education so far has gone to graduate education. This eases the shortages somewhat, but its net effect is to shift the bottleneck in American scientific manpower one level lower. According to one poll, most graduates who have good and fair science ability already go into these disciplines. Obviously the solution to the scarcity of professional trainees lies elsewhere.

More and better junior colleges and high schools, better trained and more highly paid teachers, are essential if the supply of undergraduates is to increase and its level of quality is to be maintained. But even deeper reforms are needed.

Natural talents are distributed throughout all social and economic groups. So far we have utilized mainly those of the more privileged groups, but this pool is now close to exhaustion. The most profound problem of American society—that of fully introducing into the modern age and more fully sharing our affluence with millions of Negroes, unemployed families and the many Americans who must do on less than $2,000 a year—lies only two steps removed from our professional-manpower problems.

These are matters of long-term policy, our avoidance of which has many roots. Historically we have been affluent enough to do without formulating a national policy; psychologically, we are optimistic, expecting that things will work themselves out somehow; politically, Congress is more a blocking force than a force for action; and it is more responsive to the needs of specific agencies and services who have pull on the Hill, come over well on television, and claim to help us keep ahead of the Russians. The White House has neither the facilities to formulate a national policy on these matters, nor has it in the past revealed the political courage to fight these issues all the way, on the Hill and in the country.

All this must now change. We need additional Ph.D.'s, test tubes, classrooms, and cyclotrons. Even more, however, we need a rationally arrived at, long-run policy. We must begin now to build up the additional scientific assets we will need in the seventies, and we must begin also to use the assets we have in a way more in keeping with our national objectives and values. Waste of our scientific assets and failure to plan for the future are dubious luxuries the nation simply cannot afford.