enzyme. Not only was this regulatory circuit capable of explaining much of the bewildering mass of observations that had accumulated by then on the control of bacterial enzyme synthesis but it could account also for prophage induction, a process that had remained rather mysterious in the decade since its discovery by Lwoff. For, as an experiment by Wollman and Jacob, which was really the heuristic ancestor of the Pa-Ja-Mo experiment, had shown in 1957, the prophage elaborates a specific repressor-like *immunity substance* that holds in check expression of the remainder of its genes. Prophage induction could then be readily understood as a neutralization of the immunity repressor by effector substances, resulting in "opening" of the operators of hitherto quiescent viral operons.

The influence of the work for which Lwoff, Monod, and Jacob are being honored by this prize now far transcends the bounds of molecular biology. Probably its most important impact has been on developmental biology, a field that, in the last analysis, concerns the understanding of regulation of gene activity in ontogeny. Though it still remains quite unclear to what extent the regulatory processes discovered in bacteria actually operate in the cells of higher forms, the messenger RNA-regulator gene concept has by now altered the face of embryology. In addition to their discoveries and dialectic constructs, the three laureates made one further, enormous scientific contribution: in their laboratories they trained a phalanx of young workers (mainly American, some European, and a few French) whose work was to transform the landscape of modern biology. It is hard to imagine anyone more deserving of this prize than André Lwoff, Jacques Monod, and François Jacob.

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R&D Boom: House Report Sees Harm to Higher Education

Until about 5 or 6 years ago, perhaps the most outstanding characteristic of relations between science and government was that the federal politicians were willing to take the scientific politicians on faith. The post-Sputnik boom in research-and-development funds accelerated what has been referred to as the "nationalization" of American science, but despite the scientific community's growing—and in many instances nearly exclusive—reliance on federal funds, science was accorded a remarkable degree of sovereignty and self-government.

In a formal sense, the system of support was tied into the traditional political process of agency proposals, executive reviews, and congressional approval; but, at least as far as basic research was concerned, the working truth of the system was that the federal government turned tax funds over to the scientific community, and the community, through an elaborate apparatus for appraising and bargaining, allocated the funds among competing applicants. The system, the federal politicians were told, could not successfully operate in any other fashion, because science, to be fruitful, must be governed by scientists.

The first major assault on this proposition came in the later 1950's, when Representative L. H. Fountain (D–N.C.) attacked the National Institutes of Health for what he considered to be inadequate supervision of the use of its funds by outside researchers and an alleged decline in the quality of the work approved for support. Meanwhile, in a less conspicuous fashion, the National Science Foundation was being pressured by Congress to spread its funds to the less scientifically developed regions of the country. And then, with the research and development budget rapidly becoming a highly visible portion of overall federal expenditures, Congress in effect concluded that science was too important, or at least too rich, to be left to the scientists. As a consequence, Congress revoked the sovereignty of science on a matter that had once been left virtually entirely to the men of science—the selection of locations for major research facilities. The major culmination of this move has been, of course, the nationwide fight now raging over the location of the proposed 200-bev accelerator.

The trend toward a greater congressional presence on what was once the almost exclusive preserve of the leadership of science has now manifested itself again, this time in the form of a devastating study issued last week by the Research and Technical Programs Subcommittee of the House Committee on Government Operations. Entitled "Conflicts between the Federal Research Programs and the Nation's Goals for Higher Education,"* it forcefully assails a fundamental argument of much of the leadership of the scientific community—that federal expenditures for basic research have had a net effect of improving American science education.

In attacking this argument, the report charges that universities with large federal incomes are thriving partly at the expense of the weak; that the federal government is committing itself to major technical programs whose manpower requirements will reduce the incentives for young persons to engage in teaching of undergraduates; and that the concentration of research funds in a relatively few major institutions is not producing a proportionate increase in scientific training. Finally, in a blow at the scientific leaders who contend that NSF's science development program will help produce an increase in new centers of scientific quality, the report charges that the program will help the "rich get richer" and will not substantially improve or extend scientific education.

* 74 pages, available without charge from the Research and Technical Programs Subcommittee of the House Committee on Government Operations. Other related documents, also available from the subcommittee, are the June 1965 report, "Conflicts between the Federal Research Programs and the Nation's Goals for Higher Education, Responses from the Academic and Other Interested Communities to an Inquiry by the Research and Technical Programs Subcommittee," and Part 2 of that report, issued in August.

From Statements to the Reuss Subcommittee

. . . [C]onsider a distinguished scientist in a particular field who may command research support for his program of several hundred thousands of dollars per year. As an individual, he may command more support than the rest of his department, taken altogether—more than the chairman of his department and, in some cases, even more than the dean of his college. He is in a position to exercise immense leverage because of the funds at his disposal. In many cases he provides funds for most of his own salary. All of his equipment comes from Federal funds, as does the support for six or seven graduate students in the department. He gets his own way and teaches very little. If complaints are made about his activities, he threatens to "pick up his marbles" and go elsewhere.—HOWARD A. SCHNEIDERMAN, *chairman, Department of Biology, Western Reserve University*

If two institutions A and B vie for the same federally supported research project, and if institution A had higher competence than institution B in this research field, it is proper enough that institution A receive the project. But let us suppose that institution B is a developing institution, one which the Nation urgently needs to have take its place up among quality universities of the land. One must now face the fact that the award of the initial grant to institution A places institution B in an even worse competitive position the next time it seeks a project in this field. It is clear that the overall development of a strong university system for the United States is an important consideration, and the promise for future development of a strong scientific program may sometimes be a valid reason for awarding Federal research support to one institution when another may actually at that moment have somewhat higher competence in the same field.—GEORGE E. PAKE, *provost of Washington University*

. . . It is not so much that the "hard science" departments are being supported, but that the "hard" outlooks are being supported within every field, including the humanities. The academic judgments as to what is "research" and the judgments as to what are the appropriate methods for discovery, tend to become stereotyped as the result of the anxieties of young researchers lest they not be pursuing the approved formulas—approved, that is, within their academic subguilds. Throughout American life, and not only in the academic and research world, there is a research for easily grasped standards of performance which avoid the making of difficult qualitative judgments.—DAVID RIESMAN, *Department of Social Relations, Harvard University*

The growth of surrogate instruction stems not only from the reductions in the teaching load of the established faculty, but from the reluctance of the established faculty to add new members to bear that load. Research-centered institutions have high aspirations and august self-images. They cannot and will not make wholesale permanent appointments to match the rapid growth of student bodies. Rather than attenuate the quality of their staff, they would rather attenuate the quality of their instruction. The fact that this strategy is economical makes it even more attractive. . . .—WALTER P. METZGER, *professor of history, Columbia University*

In recent years, especially in hearings before the various congressional committees that have been studying federal support of science, most of these arguments have been suggested or even shouted. The significance of their latest appearance is that they are concisely and powerfully presented in the subcommittee report, rather than strewn among a great deal of other material; also, the subcommittee, which is the House's latest addition to the proliferating science study field, is headed by Representative Henry S. Reuss (D–Wis.), a Harvard-trained lawyer, widely regarded as possessing one of the leading intellects in the House, and respected by his colleagues as a sound and careful student of whatever engages his interest; and, finally, the Reuss report dovetails in time and substance with the recent White House edict for federal agencies to broaden the distribution of research funds (*Science*, 24 September 1965).

Based on public hearings and statements solicited from more than 200 persons associated with universities throughout the country, including a few students, the report acknowledges that the boom in federal support for research has, in fact, produced many benefits. But once having paid its respects to the widely praised credit side of the picture, it goes on to recite some highly illuminating details of what has been happening within the academic world as a presumable consequence of federal largesse, and it accompanies these with some potent complaints about the consequences:

1) Between 1953 and 1964, the number of full-time-equivalent science and nonscience teachers at American universities increased from 177,000 to 324,000. During this period, overall enrollments more than doubled, to 4.7 million. At the same time, the number of full-time-equivalent research staff rose from 23,000 to 71,000—and it is a reasonable assumption that most of these were in the sciences.

2) In 1962, 49 to 82 percent of new Ph.D.'s in field, outside the natural sciences went into teaching as a primary occupation but only 23 to 25 percent did so in psychology and the natural sciences. Of the new Ph.D's in the physical and biological sciences, two-thirds "chose to do paid research or received fellowships which enable them to do research."

3) According to testimony by Fay Ajzenberg-Selove, professor of physics at Haverford College and executive secretary of the Committee on Physics Faculties in Colleges, "600-odd colleges awarding 55 percent of all bachelor's degrees in physics received only 12

physics grants in fiscal 1964. The 12 grants totaled less than $300,000 or about 2 to 3 percent of all federal research funds for physics available in that year."

4) Despite a widespread belief to the contrary, there appears to be no direct relationship between the federal research funds received by a university and its output of Ph.D's, the subcommittee concluded. "California produced 2.3 times as many doctorates as Wisconsin but received more than 3 times as much money; it produced twice as many doctorates as Purdue but received more than 10 times the money; and it produced 2.8 times as many doctorates as Iowa State but got nearly a hundred times the amount of money."

5) Figures supplied by the National Education Association dispute the contention that the increase in federal research funds has raised the general level of training in university faculties. The subcommitte noted that "between 1954 and 1965, the proportion of new teachers holding the Ph.D. (in universities, colleges, and junior colleges) fell from 60.1 percent to 50.2 percent in the heavily supported field of biological sciences. Mathematics, which also received substantial assistance throughout the period covered by the NEA figure, shows a decline in the proportion of new teachers with the Ph.D. from 34.2 percent in 1954 to 19.7 percent in 1960, and then a partial recovery to 28.2 percent in 1965. Business administration, which has received no assistance from Federal science funds, increased its percentage of new teachers with doctorates from 8.8 percent in 1957 to 20.1 percent in 1965."

6) "No close relationship is discernable" between the volume of federal research funds and objective tests of undergraduate achievement, the subcommittee concluded. Referring to a study that the American Council of Education made of 12,500 winners of competitive fellowships (NSF, NDEA, and Woodrow Wilson) between 1960 and 1963, the subcommittee noted that a poor showing was made by undergraduates from many of the universities that are major recipients of federal research funds. Caltech led the list, with 20.1 percent of its 1960–1963 baccalaureates winning fellowships, but next came Reed, Haverford, Swarthmore, and Carelton colleges, whose total federal research receipts probably wouldn't pay 1 week's electric bill for a medium-sized accelerator. The committee added that "The University of California, at Berkeley, Columbia University, and a number of the great State universities are among those absent" from the list, which included 50 institutions. And it quoted Framker J. Rohfleisch, professor of history at San Diego State College, who said that "if Berkeley had produced fellowship winners at the rate achieved by Oberlin, Berkeley would have had 1728 winners instead of the 132 which it actually achieved. At the Swarthmore rate, Berkeley would have had 2790, and the University of Michigan, 2325. At the enormous rate achieved by Reed College of 72 awards among 600 students, Berkeley would have had 3240 fellowships."

7) The federal agencies, the subcommittee continued, have followed policies that tend to concentrate funds in relatively few institutions, despite a massive increase in the total funds available. In the decade since 1955, the report stated, NIH's funds have increased 14-fold, but the number of awards has increased by only a factor of 4. Since 1957, funds distributed by NSF have increased seven times, but the number of recipient institutions has risen only 17 percent. The net result of these developments, the committee concluded, is that federal agencies, with their attention focused on research, have helped undermine the economy and status of teaching, particularly at major institutions.

The remedies proposed by the Reuss committee in some ways coincide with the proposals that have come recently from studies produced by the committees of the National Academy of Sciences and other scientific groups—more federal money for university activities across the board, fewer strings held in Washington, and more discretionary power for campus administrators. But one proposal is sure to grate on the leaders of the scientific community, for it intrudes upon one of the most sacred governing concepts of post-war science, namely, that scientific research must proceed as rapidly as its practitioners can make it. In contrast to this belief, the Reuss committee poses an interesting question: "What is to be gained if a basic research project is completed in 1 year by a scientist with a minimal teaching load at a large university rather than in 2 years by a scientist with a heavier teaching load at a college or small university? In basic research devoid of immediate mission and far removed from the time pressures of high priority development programs, time is not of the essence. Some educated guess, moreover, can be made of the risk that the proposed project will be scooped or made obsolete if the research period is an 'extended' one. The subcommittee believes that 'the amount of time and effort the investigator will devote to the work' [one of NSF's stated criteria for awarding research grants] should be given weight only in extraordinary cases in which there is doubt as to the seriousness of the intent of the investigator, his workload is excessive by any reasonable standard, or there is a substantial risk that the project will be of little value upon the proposed date of completion."

Further, NSF's Science Development Program, which is the reply of the rich to the cries of the have-nots, provided no balm for the Reuss Committee's irritation with the distribution of federal research funds. The report noted that Henry Riecken, NSF Associate Director, had testified that "We think of a center of excellence as an institution that is as much as possible uniformly excellent. A major part of our effort in the science development program is to raise the level of excellence everywhere in the institution.

To this the report commented: "With these objectives, it is clear that the rich will continue to get richer despite the development program. The subcommittee believes that, given the necessarily limited funds available to the program, the net ought to be cast more widely, and emphasis should be placed on improving developing institutions rather than lagging departments within already important research institutions." And it was observed that the first four recipients of development grants, approximately $4 million each —Washington University, Western Reserve, Case Institute of Technology, and the University of Oregon at Eugene —cannot be considered "research deprived; three of the four, in fact, rank in the top 40 institutions in terms of Federal research money received."

All of which is enough to make a statesman of science gaze into his Cosmos Club martini and reminisce about the good old days when Congress left the business alone, and you weren't damned (in the manner of Fountain) for buying less than top quality research, and equally damned (now in the manner of Reuss) for failing to let the third team into the game.

—D. S. GREENBERG