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The Academic Scientist, 1940–1960

Much has changed, from the federal support scientists receive to the political responsibilities they accept.

Bentley Glass

Among academic subjects, the natural sciences and mathematics have come, since World War II, to occupy a favored position in the United States, in respect to the support received from the federal government and from industry. The trend began long before the sputnik era and was an outgrowth of the part played by scientific developments in winning the war. It gained added strength from the rivalry of the chief powers in the Cold War. This was the period that saw the establishment of the National Science Foundation in 1950, and growing attention to the utilization and training of American scientists. The past two years have seen a flurry of added excitement and anxiety as the American public came to perceive that in at least some scientific and technological respects the Russians have exceeded us, and that in advanced education they are far outstripping us in quantity of trained personnel if not in the quality. General concern has led to another unprecedented increase in the effort to hold our own by subsidizing scientific research and development and by improving the educative process that permits further growth. The National Defense Education Act, vast increases in appropriations to existing agencies for science education and scientific research, and new roles of science in the political sphere alike show what enormous concern about these problems now prevails in the executive and legislative branches of our government and in the political life of our people.

In late 1958, the President's Science Advisory Committee issued a highly significant report entitled *Strengthening American Science*, and last year followed it with recommendations for *Education for the Age of Science*. Curriculum studies in physics, mathematics, biology, and shortly in other sciences are revising secondary school courses and preparing textbooks and laboratory programs of novel kinds. Soon these efforts will lap over into the teach-

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ing of mathematics and science in the elementary grades; the college courses are in for remodeling, too. Television finds a place for early morning classes in physics, chemistry, and biology, dramatized and taught by lecture and demonstration. Complete courses are being put on color film—for example, 60 in high school physics, 120 in biology, 48 in college genetics. Summer science institutes multiply (there were 348 of them in 1959); academic year institutes for science teachers are rapidly taking hold (there were 32 of them in the past academic year); programs of visiting scientists, traveling science libraries, demonstration science teachers, and science clubs vitalize the local scene; summer fellowships, graduate fellowships, postdoctoral fellowships, senior postdoctoral fellowships, and science faculty fellowships inject vitamins and hormones into the teachers and their crops of future scientists. James Bryant Conant investigates the status of the comprehensive high school, and Admiral Rickover damns the frills and demands more solid education. The ferment is pervasive. It has clearly not left the academic world of higher education unaffected.

Numbers and Status

It is surely time to take stock of the altering status in education of the academic scientist (that is, the scientist holding an academic post)—time to appraise the influence upon university and college education, as a whole, of the new emphasis on science and technology. What reorientation of existing relations is required? What developing imbalances necessitate compensatory emphasis elsewhere? Is there truly a danger that other, essential aspects of education will be so neglected that our social structure will resemble a giant on puny legs?

Census figures for the decade from 1941 to 1950 show that workers in science and technology were rapidly overhauling teachers as the largest of professional groups (*1*). In that decade the scientists and engineers almost doubled in numbers, while the teachers increased by only 10 percent. (It is worth noting that the census put persons who were both scientists and teachers into the category of teachers.) If there has been anywhere near a proportionate increase in the decade 1951–60, professional workers in science and technology now greatly outnumber both teachers and professional workers in health and constitute about 30 percent of the entire professional element of our population (6 to 7 million persons). The task of the academic scientists is to continue to train this rapidly growing body of professional people, even though their own numbers are increasing much more slowly.

Full-time teachers in universities, colleges, and junior colleges are estimated (by the National Education Association) to number at present about 250,000 persons, of whom 78,000 are teachers of science and mathematics (31.2 percent) (*2*). To these should be added some 3000 teachers of dentistry and 10,350 full-time teachers in medical schools, to make a total of approximately 91,000 (*3*). The annual output of persons with doctor's degrees in the sciences and mathematics (exclusive of dentistry and medicine) was 4611 in 1956–57 and amounted to 52.6 percent of doctor's degrees in all academic subjects (exclusive of law, dentistry, and medicine) (*4*). These figures seem to indicate that there is an especially critical shortage of college and university teachers in the sciences and mathematics, since less than one-third of the teachers are producing half of the output of college graduates and Ph.D.'s. This is as would be expected in a rapidly expanding professional field. Although the temporary strain is severe and the inducements extended to new Ph.D.'s in the sciences to enter industry or government work are great, we may nevertheless expect to see in a decade or so a relative increase in the numbers of academic scientists until they make up fully half of the entire college and university teaching force—if we include dental and medical teaching, perhaps two-thirds. This prediction follows from the simple assumption that a rough proportionality will be maintained between the teaching force in any field and the number of undergraduate majors and graduate students enrolled in it. The National Education Association forecasts do not agree with this prediction, for the reason that they assume that growth in number of teachers in each academic field will simply be proportional to the present number. No account is taken of the disproportionate increase in the growth of different professions. It is estimated that by 1970 there will be over 6 million students enrolled in our colleges and universities, who will require approximately 400,000 college and university teachers. But to train an additional 2 million professional scientific and technological workers in that decade, over and above the present 2 million, will require 125,000 additional academic scientists; this, plus the present number, will total more than 200,000. In so far as the majority determines policy, it follows that the views of the academic scientist are of critical importance to all of us in college and university teaching, in respect to the nature of the curriculum, the maintenance of academic freedom and tenure, and the unity of our profession in all other policies and objectives. Narrow, illiberal views, lack of educational perspective, or simply a tendency to overspecialize on the part of this prospectively dominant group may jeopardize our cherished principles.

New Economic Status

In economic status the academic scientist is faring considerably better than his colleague in the humanities or social studies. There are three principal reasons for this. First, the demand on the part of industry, and to a smaller extent of government, for trained personnel in the sciences, engineering, and mathematics has made it not uncommon for a young man just receiving his Ph.D. degree to step into a position carrying a considerably higher income than that of the associate professor, or even the full professor, who has trained him. The academic engineer, geologist, or physicist may smile somewhat wryly at this and console himself with thoughts of the nonmonetary compensations of a university or college post; and in the end his position, too, is bettered financially because of the law of supply and demand. Administrators have long since recognized that in order to have any engineers, geologists, mathematicians, physicists, or chemists of standing on their faculties whatsoever, they must remunerate them on a different scale from that applicable to teachers of history, languages, or literature. Psychologists have recently come to profit more and more from the same pressures. Only biologists, among the scientific groups, seem less favored, because industry has had less demand for them (except in the pharmaceutical industry), and because the applied branches of biology—medicine and agriculture—are recognized as distinct professions or occupations.

The second economic factor that enhances the status of the academic scientist is the availability to him of outside work as a consultant. Individuals who are in considerable demand can more than double their university salaries in this way, although they pay the price for it by overworking on weekends and at night until health and sanity may suffer.

The third and final factor is one that has developed since World War II, in connection with federal research grants or contracts. This is the factor of the "research salary," originally allowed to academic scientists on 9 or 10 months' university duty, who were free to spend 1 or 2 months of their summer time uninterruptedly upon their government-supported research program. Research salary was therefore figured at the equivalent of the monthly college or university salary. Later, because this obviously worked to the disadvantage of scientists on 12-month annual appointments, who might actually be devoting just as much time to the research program as those nominally on 9-month appointments, the system of payment was made more flexible by considering it as compensation for a definite fraction of the scientist's total 12-months' working time. Thus, an academic scientist may now receive, as additional salary connected with a government grant or contract, as much as one-third of his academic salary. (There are still inequities among scientists and institutions in the application of the rules, and some scientists feel strongly that the whole system is a pernicious one. It seems, nonetheless, to have become deeply entrenched. Although not properly regarded as institutional compensation, research salary is all too readily regarded as such, both by recipients and by administrative officers.)

For all of these reasons, members of the science faculties possess a considerable economic advantage over their colleagues, except for the occasional writer of a book that becomes a best-seller or is widely adopted for use as a textbook, or the economist, for example, who obtains numerous fees as a consultant. The resulting situation is one that has long had a parallel in our medical schools, where very often the professors of clinical subjects have outside practices and may enjoy large incomes while the professors of the preclinical subjects are forced to the level of an ordinary professor's income. In a few medical schools, such as the Johns Hopkins Medical School, strenuous efforts have been made to correct the inequity. On the one hand, the salaries of professors of the preclinical sciences in the medical school have been raised until they are considerably higher than those in the Faculty of Philosophy, even in the natural sciences. On the other hand, full-time clinical professors are required to serve the university full time at regular professional salaries and to limit their private practice to their outside time, much as other professors do consultant's work. We may expect, I think, that similar policies and procedures will be required more nearly to equalize the economic status of the scientists and nonscientists on our faculties. The general principle which might well serve is that, regardless of supply and demand, equal service should be rewarded with equal compensation throughout the several professorial ranks.

Modest Empires

The picture of the academic scientist of 1960 is not complete without some further description of the modest empires over which many of them now preside. Let us consider an example. In 1940, an assistant professor of biology, a fairly typical scientist, had no special funds for his research. An amount not exceeding $100 annually came from the departmental budget and was used for consumable supplies. He had for his use one moderately good compound microscope and one good binocular dissecting microscope. He made all his own media, did his own sterilizing in a Sears Roebuck pressure cooker, kept his own stocks without assistance, and was grateful for some help in washing up the glassware. Without even a chest to run at a controlled temperature, he worked during the hot summer weeks in a dusty, normally unused, but cool basement room. Still the research went on, in spite of the fact that perhaps 80 percent of the scientist's time was spent in routine chores. In 1960 the professor has charge of two research laboratories, both supported by funds from the federal government. A senior research associate operates one of these laboratories semi-independently, with a research assistant to aid him. Two research assistants work in the other laboratory. In addition, there are two part-time laboratory assistants to wash bottles, keep animals, and prepare media. The annual research budget of the group is close to $50,000, not including the scientist's university salary, and none of this sum comes from the regular department budget. There is no lack of equipment. There are compound microscopes of the best quality; binocular dissecting microscopes for each worker; phase microscopes; photomicrographic equipment; an x-ray machine; a cold room; constant-temperature incubators, refrigerators, and deep-freeze; air-conditioning for the laboratories; special supplies of chemicals; special rooms and equipment for preparing and sterilizing media and washing glassware; animal quarters—in short, everything that is really needed for an experimental program of some size.

One might be moved to say, "But this is exceptional. It reflects seniority as well as the change of the times." On the contrary, junior members in the same department are about equally well established. The changed situation is perhaps best reflected in the departmental budget, which at the end of World War II was about $70,000 per annum and today is close to $1 million, while the size of the staff has perhaps doubled. This is not atypical of science departments in our larger universities, although colleges where research is quite secondary to teaching have not altered greatly. True, government grants or contracts for research are open to every applicant on the basis of merit, but heavy teaching loads often prevent faculty scientists from capitalizing on the opportunity. The cleavage is thus deepening between colleges which are primarily teaching institutions and universities where teaching is secondary to research, whether the criterion is expenditure or staff time.

Federal Support of Research

The involvement of the universities and the academic scientist in government-subsidized research has been sketched elsewhere. Perhaps few persons, outside of the government agencies which grant funds and the science departments which are the recipients, actually realize the extent to which matters have gone. According to statements of the National Science Foundation, last year over 10 billions of dollars were spent in the United States for research and development. Of that vast amount, less than 8 percent was for basic scientific research, most of which is done in the universities and colleges. Yet even 8 percent means an annual sum that is over $800 million, and in addition there are large sums for science education in the form of fellowship programs, summer and academic-year institutes, and the like. The President's Committee on Education beyond the High School estimated that as a nation we are currently spending $3 billion annually for higher education. It seems reasonable to suppose, therefore, that approximately one-fourth of the entire budget for higher education is now coming from the federal government in the form of funds for scientific research and science education. Since many institutions are still but little involved in these programs, others must be so largely supported by them that *in fact*, public or private, they would collapse if federal aid were to be withdrawn.

In return for the abundant financial aid now available from governmental agencies and private foundations, the scientist must give ever more freely of his time to serve on innumerable advisory committees and panels for judging the relative merits of applications for research grants and for fellowships —undergraduate, graduate, postdoctoral, and even more senior. There is today a sort of scientific Washington Merry-Go-Round where the scientists who form these boards, committees, and panels meet their friends and, from time to time, exchange places. To be sure, it is gratifying that the government agencies consult the scientists themselves in making awards. No scientist would choose to be judged other than by his own peers. The very multiplicity of the granting agencies and their panels, moreover, provides a guarantee that everyone will have a good opportunity to win a prize, since if one agency fails to award the guerdon, another is very likely to be more generous. It is in fact a common practice for suppliant scientists to present the same application for support to two or even three different agencies simultaneously; or one may divide up his program into several parts, for each of which support is sought from a separate source. No sense in putting all one's eggs in one basket! The government agencies, of course, exchange information about these applications and note the divergence or agreement in the opinions of their panels—which is all to the good. (Nongovernment agencies are less in the know in this respect, since they tend to operate more independently.) The drawback of this fair, but elaborate, system lies in its demand upon the academic scientist for an ever-increasing proportion of his one priceless and most strictly limited commodity, his time. The time spent in preparation and travel to and from panel and committee meetings adds to the time of the sessions themselves; these are scarcely over when it is time to make an annual report and reapply for the renewal of some grant. Between these activities the best part of a month is consumed, to be followed by a second and even a third round on the part of many hard-pressed participants. To withdraw from the game, once fully in course, is almost impossible. There are both tangible and intangible rewards for committee and panel service; and a thriving research program not only involves the livelihood of research assistants and the support of graduate students but is, after all, the very life of the academic scientist, perhaps more than his classroom teaching.

Aid to Education

Another development growing out of the current recognition by government of the importance of science is the budding and burgeoning of programs for the improvement of science education. These have commonly begun by focusing on the high school curriculum, but they soon spread to comprehend all the years from the earliest elementary grades to the college and graduate years. It quickly becomes evident that a solid improvement in the high school course must needs be based on good teaching and improved content in the earlier years; and the problem of educating and preparing teachers to use new methods and deal with modern scientific concepts in the high school, and earlier, takes the planners immediately into the area of the college and the problems of accreditation of schools and certification of teachers.

The first of these large-scale programs was that of the Physical Science Study Committee, begun in 1956 and now at the final stage of producing a physics course for the high school —a course that has already been tried and tested with success in many schools. A series of textbooks embodying a radically new approach to the elementary study of physics has been completed and is already in widespread use. The Physical Science Study Committee has also prepared laboratory programs, guides to demonstration, films, and separate paperback monographs for supplementary topics. Shortly after the Physical Science Study Committee had begun work, the School Mathematics Study Group was organized to rehabilitate and revitalize the teaching of secondary school mathematics. It has already prepared novel and interesting courses for the junior as well as the senior high school years, six courses in all.

Last year the Biological Sciences Curriculum Study was initiated, again with funds from the National Science Foundation, and it has begun to formulate new biology courses, especially for the tenth grade, although attention is already being directed toward the eighth grade, as well. A very original "block" program in which experiments in the laboratory will lead directly to real scientific inquiry on the part of students organized into pairs and squads is proposed to replace a number of weeks of routine classroom and laboratory surveys of the subject matter.

Several smaller curriculum committees are working in various subjects. Probably an effort similar to the three major curriculum studies will soon be directed at the improvement of chemistry teaching. For our present purpose the important thing to note is that these organized studies are of unprecedented magnitude, both in terms of money spent on them, amounting to a total of perhaps $5 million per annum, and, even more significantly, in terms of the large numbers of academic scientists involved in them.

The day of the college or university scientist who held himself professionally aloof from the problems of elementary and secondary school teaching has ended. The realization has been sharply forced upon us that the foundation of good college and graduate training in the sciences, as well as our supply of scientific manpower, depends on the excellence of science education throughout the elementary and secondary school systems. The outcry against the practice of training teachers how to teach but giving little attention to teaching them what to teach has roused the conscience of many a college or university science teacher who has until now been satisfied to teach his classes with only future physicists, mathematicians, or biologists in mind. This is demonstrated by the willingness and enthusiasm with which the college scientists have responded to the opportunity to participate in these curriculum studies. To use the Biological Sciences Curriculum Study, which I know best, as an example, its full-time staff consists of several university scientists on leave of absence; its steering committee of 27 persons includes 17 academic scientists; its working committees include many more; the writing conference it held this summer in order to prepare materials for classroom trials in 1960–61 comprised 30 college and university scientists as well as 30 high school biology teachers. This represents, I think, a fair indication of the growing numbers of academic scientists who are involved in such programs. The zest with which they are meeting this challenging opportunity must be seen to be believed.

A similar development is a biology film course (120 films of 27 minutes each) initiated by the American Institute of Biological Sciences and intended to aid in meeting the growing critical shortage of trained science teachers. In the preparation of these films well over a hundred academic scientists have been called upon to contribute material for scripts, to act as consultants, and to serve as critics in the reediting of the preliminary films. Still another program is that of "visiting lecturers," a selected group of college and university scientists whose travel expenses and honoraria are paid by the American Institute of Biological Sciences or some similar agency, with funds granted by the National Science Foundation, and who visit the smaller, more isolated colleges for several days at a time to lecture, take part in seminars, advise students, and in general carry the breath of the advancing front of science to those who otherwise might think that the natural sciences are simply static bodies of knowledge, crystallized into unalterable laws. More and more frequently these visitors are including the local high schools in their tours.

All of these developments in science education are obviously of great benefit, on the one hand to the nation, on the other to the participating scientists themselves. They do, nevertheless, require time, time, and more time. They take the scientist out of his own classroom and out of his laboratory. The very function to be served demands the academic scientist and no substitute; yet the increasing number of calls made on him make it less and less possible for him to remain an academic scientist.

In Politics To Stay

In the past two decades the academic scientist has become increasingly involved in politics. That was inevitable, from the day the Manhattan Project was initiated. It became quite apparent with the exploding of atomic bombs over Hiroshima and Nagasaki. The atomic scientists were for the most part academic people on leave from their posts, from Robert Oppenheimer down to the youngest Ph.D.'s. The formation of the Federation of American Scientists and the foundation of the *Bulletin of the Atomic Scientists* were symptoms of the awakened political conscience of men appalled at what they had let loose in the world. The secret preparations for chemical and biological warfare embroiled chemists and biologists in the same schizophrenia that the conscience-stricken physicists were in. The era of nuclear testing brought more and more scientists into the prolonged argument over the relative weight to be given the need for military security and the harm done by radioactive fallout. Linus Pauling and Edward Teller became familiar figures to Americans. Meanwhile the disloyalty and defection of a few scientists engaged in secret work made it all the easier for the late Senator McCarthy to hale academic scientists before his committee and to pry into their political opinions. A rash of "loyalty oaths" and disclaimer affidavits spread round the land, unfortunately to remain with us long after the hysteria of the McCarthy era had died down.

Scientists have become increasingly concerned about the effect of security regulations on the rate of scientific advance. In 1958 the House Special Subcommittee on Government Information concluded that "the Federal Government has mired the American scientist in a swamp of secrecy" and that classification of scientific information played a real part in "the nation's loss of the first lap in the race into space." A year later the Constitutional Rights Subcommittee of the Senate Judiciary Committee made public letters from 17 American Nobel prize-winning scientists, who agreed almost unanimously that undue secrecy is gravely impeding scientific progress and development in the United States. It is obviously much easier to classify a paper as top-secret than it is to declassify even the most innocuous or ancient document. I have myself had the experience of preparing for the State Department, after a tour of scientific visits in West Germany in 1950–51, a report which was so rigorously classified that after it was once handed in I was never able to see it again, since I was not sufficiently cleared to be allowed to examine such top-secret information. Although that report is antiquated beyond any conceivable remaining value after the passage of 10 years, no efforts to get it and similar reports declassified for general scientific reference have ever succeeded.

The disease of secrecy is probably even more serious in other agencies, such as the Atomic Energy Commission and the Department of Defense, and many similar anecdotes could be told. Orders to declassify and refrain from classifying have made only a little dent in the monolithic system of secrecy. Last summer, when an international scientific conference was held at Pugwash in Nova Scotia on the dangers of chemical and biological warfare, no chemists or biologists who had been at all recently associated with such activities could be found to participate. The most personally informed scientist in attendance had been dissociated from such work for no less than 12 years. It is no wonder that, as a consequence, the academic scientists discussing such a problem are very academic and theoretical indeed. The experts who are really informed about actual developments are unable to speak. The consequence, as in the nuclear area, is that representatives of the military services can make almost any claims they wish without fear of contradiction. Let us honor, therefore, such scientists as Linus Pauling, Ralph Lapp, Eugene Rabinowitch, and others who have run the risk of being sometimes egregiously in error in order to dispel the miasma of secrecy that is choking scientific advance.

Let me say, parenthetically, that I do not at all wish to imply that I advocate any weakening, during these critical times, of the free world's strength. Obviously, one can negotiate only from a position of strength. But it may be stoutly argued that scientific advance will be far greater and more rapid when there is maximum access to new discoveries than when each scientist and engineer is restricted in the information he may obtain.

Nature discovered this truth long ago. Evolutionary progress depends upon the occurrence of rare, fortuitous, advantageous mutations, and even more upon the lucky combinations of these that happen to work best in a particular environment. In living organisms that reproduce asexually, such combinations arise with extreme infrequency. For example, if the rates of occurrence of each of two mutations that might be advantageous together is one per million individuals—a rather ordinary mutation frequency—then the probability that both will occur together is the product of the two frequencies, which is 10^{-12}, or one in a trillion individuals. Consequently, the mutations really get together only when one occurs first and persists for a long time and when the other then occurs in some descendant of the first mutant individual. But if the first mutation confers no great advantage by itself, or quite possibly is actually harmful in the absence of the other, then the probability that mutation number one will persist over many generations until mutation number two occurs to complete the advantageous type is indeed infinitesimal. To obviate this difficulty nature invented sex, whereby mutations that occur in different lineages can be combined immediately in various ways in the offspring of a mating between male and female individuals. In this way, as I have said elsewhere, "the genes that made us, as they made our forefathers, cast into ever new combinations in the recurrent cycle of sexual reproduction, may live on to produce new hands, new eyes, and new minds, to test out each variety of environment, to continue to mold a world one step nearer the heart's desire." It is even so with the transmission of ideas and the generation of new discoveries. As every scientist knows, the free interplay of thoughts between minds far outstrips in productivity the isolated, clonal generation of ideas, even by a genius.

Science is truly in politics to stay, and the academic scientist is rapidly becoming highly political in outlook. This is evident, on the one hand, in the government itself, evident from the growing significance of the President's Science Advisory Committee under, first, Killian and then Kistiakowsky, and on the other hand, evident in party guidance, through the formation by the Democratic Advisory Council of a Committee on Science and Technology that is actually composed wholly of scientists, most of them in academic life. On the international scene, the open letter which Bertrand Russell and Albert Einstein addressed to all scientists, urging them to bestir themselves before it was too late to arouse the world to a realization of the overwhelming disaster implicit in any nuclear war, and to talk candidly with one another, as scientists should, about the relationship of science to world peace, has resulted in the formation of the Pugwash movement. The five conferences of this group during the past three years have done much to lay a foundation for a real solution of some critical world problems.

Conclusion

In recent months there has been considerable discussion of C. P. Snow's thought-provoking Rede lecture entitled "The Two Cultures and the Scientific Revolution" (*5*). Is it in fact true that scientists and "literary intellectuals" now represent two poles of culture so remote that they have lost all real communication with one another, and live in different worlds? Are the misunderstandings that separate us irreconcilable?

To this extent I must agree: that the major problem of higher education today is the need to cure this growing schizophrenia. The sciences must become the core of a liberal education, as I have argued elsewhere, although "in teaching science we must not forget . . . that it is simultaneously social study and creative art, a history of ideas, a philosophy, and a supreme product of esthetic ingenuity" (*6*). The humanities and social sciences, on their part, must do more than merely recognize that the natural sciences exist. They must become permeated with the knowledge and spirit of science if they are to be more than relics of a departed age.

The academic scientist represents more than a growing proportion of the teaching profession. He will be, whether we like it or not, the dominant figure in higher education in a very few decades. He is a strange, harsh figure to many of us, a figure tormented by a growing world-conscience, aware of dawning power but blind to his own limitations. The scientist passionately defends the freedom of science and fails to perceive that it and academic freedom are one. Academic scientists have been rather ordinary participants in the defense of academic freedom and the elevation of the standards of their profession. They are under-represented in general organizations with these aims, and they do not support their own special organizations and societies with either the vigor or the funds that physicians, lawyers, and members of labor unions expend in support of theirs. This growing and awakening giant, the academic scientist, has indeed much to learn as he moves toward leadership. As Bertrand Russell has so well said, science can enhance among men two great evils, tyranny and war. And which, I wonder, is preferable, to perish in a nuclear holocaust or to live under a scientific tyranny?

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