The Maintenance of Scientific Proficiency in Nonacademic Research Laboratories

Leonard B. Loeb
University of California, Berkeley

DURING AND IN CONSEQUENCE OF THE UPHEAVALS incident to World War II the technical research laboratories of this country, both civil service and industrial, have been restaffed and reorganized on distinctly high levels of proficiency. It is essential for the national welfare that they be maintained at the present level or improved. On the other hand, past experience indicates that, unless something is done, this efficiency will gradually decline. In fact, closer scrutiny indicates that the relaxation characteristic of such reversion is already setting in and that after 4:30 P.M. the professional aspects of life are giving way to recreational interests.

The questions before us are: Why does this happen? What can be done about it? Basically, the problem is a human one. Man is naturally lazy and will exert himself to an effort compatible with his personal limitations only in so far as his (a) need for self-expression in creative effort (including in this true scientific curiosity), (b) desire for prestige and/or power, (c) desire for economic advancement, or (d) fear of losing his livelihood requires. In that section of the academic world offering research facilities, circumstances foster the three more positive (a, b, and c) of these four incentives. This stems from the fact that salaries are paid primarily for teaching. Thus, the academic man is left very free in his choice of research subjects (a), making his creative effort entirely his own and hence giving the creative instinct its full fruition. Again, promotion (b and c) in the academic research field is definitely more strongly based on scholarship and research achievement than is the case in civil service and industry, where administrative capacity plays an important role. In addition, there is in the academic research career the stimulus and the broadening influence of teaching. Such a broadening element is completely lacking in the present organization of research laboratories. Finally, there is the sabbatical year in which the academic man is expected to go elsewhere for study to broaden his experience and extend his knowledge.

In the civil service and industrial research laboratories the situation is somewhat different. The character of the tasks assigned limits the latitude for autonomy in choice of subject or approach. In a considerable measure, and certainly in the lower brackets, the type of problems requires team work and cooperative effort. These factors, together with the occasional restrictions on publication and the frequent joint publication, do much to nullify the individual creative-effort motive. While advancement in industry could be largely on the basis of achievement, the larger organizations make much discrimination inadvisable, and cooperative effort makes the recognition of an individual contribution difficult. Doubtless glaring exceptions to these generalizations occur, but in the main they apply. In the civil service field the restrictions on promotion, particularly with regard to administrative responsibility, place very severe limitations on the proper utilization of the advancement motive in creative or research achievement. Again, in both types of organization the larger staffs and problems of efficiency in employment tend to narrow down the scope of a worker's activities, and there are neither courses nor students to broaden or advance his knowledge. Furthermore, in both these services the needs for a considerable number of high-grade technicians as the "hewers of wood and drawers of water," together with civil service regulations, make the elimination of the unambitious but limitedly useful employee nearly impossible. Thus, even the fear motive of losing one's livelihood is lacking in some measure. In consequence, the more enterprising, ambitious, and capable receive enticing offers and leave, and the less ambitious remain, growing yearly narrower in their professional interests, duller and more inflexible in their work.

In my various assignments and experience as well as in many conversations with my colleagues who now direct such enterprises I have given much thought to this question and have arrived at some conclusions leading to *positive* recommendations for improvement. I am certain that many of the remedies suggested cannot be applied at once—perhaps not for years—but that some of these remedies, perhaps in modified form, can be initiated *now*. I also believe that something along these lines must be done in the near future; otherwise, industry and civil service will again find themselves cluttered up with dead lumber, with

no room for the very capable young workers to be turned out by the universities in the next 10 years. It is therefore at the risk of stirring up controversy and adverse criticism that the following is written toward, it is hoped, a worthy objective.

It is my opinion, based on years of close observation, that, irrespective of popular belief, the one *large government agency* which at the beginning of the war had shown itself to have been at an exceptionally high degree of *professional* efficiency in its specialized field of activity was the United States Navy. In making this statement I want it clearly understood that I am not referring to the Navy's proficiency in research, but in its professed objective—that of being a competent, offensive, sea-going Navy. Few people realize how easy it could have been for the Navy to have failed badly in the prewar years through even the slightest inertia with the existing lack of proper support and interest. The not inconsiderable success in maintaining efficiency was achieved by a number of largely self-imposed measures devised for that purpose and, in considerable measure, unique to the Navy. These may be listed as follows:

(1) Careful initial selection of officer personnel based on competitive examinations.

(2) Intensive and selective training.

(3) Relatively frequent fitness reports by varied senior officers, which over the years form a most comprehensive record.

(4) Appropriate commendations and citations for meritorious performance even in peacetime.

(5) Change of duties, and transfer of station every two to three years.

(6) Selection for promotion by a critical board of reviewers in competition with a considerable number of their contemporaries. (This selection was very careful and thorough. Those failing selection were retired at the end of some few years for "age in grade" at an appropriate pension.)

(7) An extensive system of written examinations for promotions appropriate to each grade.

(8) Encouragement to growth by utilizing spare time in additional fields of study by means of specialized correspondence courses.

(9) At the end of 7-year periods the selection of officers scheduled for advancement to at least a year of sabbatical study at the Naval Post Graduate School, the War College, or at the various universities.

(10) Relatively early retirement at a living wage.

(11) Maintenance of a balanced dynamic organization of pyramidal structure by means of items 6 and 10 above.

It must be noted that the tasks imposed in some of the items above had to be done out of hours on the standard 8-hour day, 5½-day week of normal operating duties. It is possible that such pressure may have acted adversely on the health and longevity of the personnel involved and perhaps should not have been pushed too far. Nevertheless, whether one approves of the product or not, one must admit that with such a system adequately carried out there is ample pressure to keep the officers alive mentally, to broaden the scope of their knowledge by changing duties and adequate schooling, carefully to select the abler officer for promotion on the basis of adequate and varied data, and finally, to stimulate additional scholastic achievement in correspondence courses with appropriate citations on their records.

Since professional scientific personnel are economically and educationally in the same level of the social structure as naval officers, it is therefore logical to inquire whether some of these apparently successful measures can perhaps be carried over in modified form to the nonacademic research laboratories. As will be seen below, I am certain that, despite probable determined opposition by the inferior and doctrinaire elements in such laboratories, the principles can in considerable measure be adopted to serve a useful purpose. These various measures will be considered in order.

(1) and (2): Unlike Navy personnel, scientists hired by industry and civil service should have completed their training before being hired. I am convinced that "in-service" training for *degrees* requiring academic credit, is educationally generally unsatisfactory and unsound. This statement will arouse a strenuous protest in certain quarters and on this account needs elucidation in order that the thesis of this article may be maintained. In consequence of the short-sighted draft policy with respect to scientific education during the late war, together with the urgent wartime personnel requirements, a most unhealthy and unusual situation has arisen. Large numbers of half-trained young scientists were employed in laboratories and became useful technical operators. Many of them married and have children. These men are of course not eligible for the educational opportunities provided by Congress under legislation for veterans of the armed forces. Many of them are very able. Their future is hampered by virtue of their incomplete or inadequate education. They have in large measure remained in the research laboratories, in which they are valuable. In order to improve their personnel and retain the services of these men, some of the larger and fortunately situated research laboratories, in collaboration with neighboring collegiate and university-grade institutions, have evolved a most amazing system of "in-service" education. In order to give residence and certify degree credit, these academic institutions have placed on their faculty some capable and some less capable full-time members

of the staffs of the research laboratories in question. In this fashion the research laboratory becomes a part of the campus of the academic institution. Credit courses leading to the bachelor's and doctor's degree are then given for the most part out of hours at the research laboratory, largely by its own staff and partly by regular academic faculty. The doctoral dissertation is done at the research laboratory under partial supervision by the university faculty but associated with the man's paid research activity. It appears that under this very convenient scheme students have achieved the baccalaureate and doctoral degrees in not many more years than are required in full-time study in academic institutions. Doubtless some of these men have advanced and matured through their wartime research activities. Nonetheless, in the face of such rapid achievement of the degree, one may properly ask whether the normal academic procedures of the past are too exacting for these degrees or whether the degrees so quickly achieved have much significance. Presently, however, there is an acute shortage of trained men on the higher educational level, and we owe the men caught by the war some chance to advance. Thus, I can only admire the aggressiveness and ingenuity of the educational program personnel of those laboratories for their success in achieving what *must* only be the *temporary emergency solution* of a difficult problem.

For the future of American science and the national safety the education of our scientific personnel must be on a high and sound level. This cannot properly be achieved on a long-drawn-out, part-time, night school type of program. The National Science Foundation when it is established must provide means for full-time, concentrated, coordinated study periods for our ablest young men in institutions designed for that purpose and where work is conducted by men sufficiently engaged in the practice of instruction and study to carry it out properly. In the research institutions, aside from the piecemeal character of the instruction on a temporal basis, neither the occupational environment, the necessity of effectively earning one's living, nor the character of the casual lecturer whose full time in theory is given to research can contribute to sound scholarship. Thus, it must be asserted that academic credit and degree training is *not* the proper or normal function of a research laboratory and, further, that such laboratories must, unlike the Navy with its specialized vocational education, accept only the best available of the adequately trained personnel at the levels required. If some of their exceptionally able men, taken in at a lower educational level, wish to receive further academic training after the present emergency is over, they should be sent on sabbatical leave with pay or on a Science Foundation scholarship to an appropriate academic institution to complete their training.[1]

It should furthermore be made clear to the employee on hiring that, with the particular education which he has, he can normally expect no promotion beyond a certain grade. Rare exceptions in promotion of remarkable but inadequately trained men could be made but then primarily in an administrative capacity with certain exceptions to be noted. The men who by education are not eligible for promotion beyond a certain grade should if they wish, be retained in their proper and useful function or encouraged to seek other employment. If they choose to stay on, they should not by measures indicated below be permitted to narrow down. Such narrowing down will naturally vary greatly with the nature of the unit to which they are assigned.

(3) and (4): Some attempt is made in civil service to get at a continuous performance record by means of the very stultified efficiency rating system. It has many weaknesses aside from that of being set in terms of a form which is incapable of applications to the wide variations of human character and the diversity of qualifications required for any given scientific task. The form suffers also from the general permanence of an employee's departmental assignment, so that the variation in reporting seniors is not great. Furthermore, the most valuable evaluation of an individual is through the immediate supervisor's estimate of the man's characteristics and achievement as expressed in a carefully worded description, provision for which is usually not mandatory in such ratings but is mandatory in the fitness report of the Navy. It is further desirable to have data on a man's intellectual growth in the form of objective grading on the basis of performance as manifested by written examinations. An additional positive set of data on the man is possible in terms of annual commendation awards, as is the current naval practice. Thus, where a project has been expeditiously done, a clever design is proposed and executed, or a notable advance in knowledge is made, the department head, through his chain of command, can ascertain with a fair degree of accuracy the contributions of each of the men. With this information at hand it is then possible to award an appropriately worded distinguished, meritorious, or commendatory citation to be placed in the man's record. This was done near the end of the war in two civilian naval units with which I was connected with definitely beneficial results with respect

[1] In occasional cases it is permissible, and perhaps useful, for the student to complete his doctoral *research dissertation* at his own research laboratory on a subject acceptable to his university, under joint supervision, once he has *otherwise qualified* for the degree.

to both record and morale. Unfortunately, this practice was later considered to be too much of a bother and was discontinued. However, the achievement of good morale and efficiency is always a bother. At any rate, this would add a separate factor which would cumulatively give valuable support where meritorious selection for promotion is considered. These measures could be utilized for increasing the scope and value of the fitness report data.

(5): Probably the most effective item in keeping laboratory personnel broadened and alive is change of work assignments requiring the acquisition of new knowledge and techniques in greater or less degree. For example, I believe that a good physicist, if properly trained, is an all-around physicist, not just a nuclear, an electronic, or an optical specialist. He should without too much effort be capable of useful employment in, for example, electronics, optics, or acoustics, irrespective of the subject on which he did his Ph.D. thesis. If he cannot do this, he is not a physicist. The same should apply to engineers. It is therefore imperative in a man's first 10–15 years of service that he change fields of activity at least three times. Through exigencies of teaching, the average academic man has in a like period covered numerous and diversified fields of study. Considerably more specializations should perhaps be allowed the more senior research personnel, but here at least they should, by virtue of their positions and by earlier training, be broader than the younger men. With curtailed staffs as at present, it may not be convenient or even most efficient to rotate the personnel on the P-1 to P-3 civil service levels in their fields of activity. Nevertheless, it *must* be done in the interest of their and the laboratories' future, for with inadequate background education plus intensive specializations without the stimulus of learning a new job, laziness, narrowness, and inertia will conquer. The result is that the organizations will have many useless narrow specialists on their hands whom they cannot use when the interest focuses on other fields and whom no one else will hire. Rotation will also insure a wider diversity of fitness reports. Rotation in duty in the Navy is a requisite for higher command as well as for maintenance of efficiency. In research laboratories it is imperative for the latter purpose only.

(6): Selection for promotion in some universities and probably in some measure in industry and less in civil service is done on the basis of impartial selection boards or promotion committees. It is believed that, because of the lack of uniformity in the duties and backgrounds of individuals even in a given grade in research laboratories, it is impossible to promote on the wholesale comparative basis as in the Navy. It is, however, desirable for the sake of uniformity that while promotion is recommended by a given divisional group for its personnel, the selection boards have on them representatives of other divisions. This will mediate against injustices and favoritism. I was shocked to discover how little this practice is now used in certain otherwise excellent research laboratories. The disposal of those failing selection must be diverse. They should be encouraged to seek employment more suited to their talents elsewhere and helped to obtain such employment. Otherwise, they may be retained in the status quo as high-grade technicians, but their duties should continue to be varied at least in three yearly intervals until they find their stride. They also should be made to continue study. This problem is a serious one which will later be discussed in another connection.

(7): The promotion examination which was eliminated in the Navy during the war is now being reinstituted. While it has its merits, it is probably not possible or desirable to enforce such a system in research laboratories. It is, of course, entirely feasible to institute a set of advanced written examinations for those very able men who by virtue of past education do not qualify for a higher grade but whose abilities mark them as desirable for promotion. Preparation for such examinations can be had by the educational systems suggested below. Thus, on the basis of passing certain advanced examinations of broader scope, the selected few could achieve promotion without a higher degree. At least consideration could be given to such a scheme.

(8): It is now essential to consider the question of "in-service" training as epitomized by the naval correspondence courses. Such training is *not,* however, *to be confused with collegiate credit courses at any level,* as elsewhere stated. "Lifelong learning" is an absolute imperative in nonacademic research laboratories if efficiency is to be maintained and stagnation avoided. Toward this end the following scheme is proposed: (a) The year is to be divided into four quarters. (b) All members of the staff must engage in some sort of controlled and coordinated study programs or their equivalent for three out of the four quarters. (c) Of the three quarters of study, two of them are to be devoted to the study of some subject or field not immediately connected with the main field of research interest of that individual. One quarter may be devoted to a study appropriate to that field. (d) The courses of instruction should be divided into at least two and perhaps more levels—graduate study levels for those with the bachelor's degree, no collegiate credit; seminar level for those with the doctor's degree. (e) The first category should consist of courses such as mathematics and mathematical physics, atomic structure,

nuclear physics, advanced heat and kinetic theory, electrical theory, electronics, gaseous electronics, hydrodynamics, advanced mechanics, acoustics, optics, etc., just to mention a few as examples. (f) Instructors for these courses could be drawn from the senior staff members with adequate qualifications or from outside and hired on a contract basis. (g) All such courses should meet *no more* than 3 hours a week and require at least 6–9 hours of outside homework weekly, with problems and a final written examination. (h) Men with a doctor's degree would have group seminars of no more than 15–20 members meeting twice a week for 2 hours each. These should be assigned fields of study requiring the reading of current advanced monographs and articles in scientific periodicals. Each member should be required to work up an original paper to be presented over a 2-hour session and submit it in writing with adequate references. The choice of assignments should be based on some new advanced field of study, e.g. the solid state, electron theory of metals, nuclear physics, atomic physics, microwave analysis, radar techniques, etc. Each participant would be graded by the three senior members of the group. (i) Those more senior staff members presenting courses for the lower groups should be allowed to substitute such instruction in lieu of a seminar, provided that they teach a sufficient spread of courses to broaden their outlook. (j) All grades should be filed in the confidential file of the person involved and would be seen only by the grading authority and those with access to the files. To prevent gossip and ill feeling, the grade would not be divulged to the students at any time. Such grades should assist in evaluating the individual's intellectual growth. It should be noted in passing that, while no collegiate degree credit is given, such a study system will greatly facilitate the advancement to candidacy for higher degrees for those taking leave to obtain a doctoral degree. It is also to be noted that this type of training should be applied to *all* scientific or research personnel on a professional level. It requires some evenings of home study instead of indulging in hobbies when 4:30 comes around and is aimed at broadening *all* individuals and keeping them up to date. It forces those who would otherwise relax and encourages and directs those who wish to grow.

(9): The sabbatical leave year of refresher and advanced study for qualified research personnel after some 7 years of duty is possible of achievement. Under civil service it probably cannot as yet be achieved, although bills toward this end are being placed before Congress. It *must* be striven for. The naval precedent for such study could be used with telling effect. Agreements for continued service in the laboratory after such study could be provided as with the Navy. Some help could *now* be achieved by exchange of suitable personnel with universities and industry. This would have an all-around beneficial effect for the future national welfare. It is believed that while no serious attempt at such exchanges have been made in the past, they can be essayed on a person-for-person basis in a number of appropriate cases. It is to be concluded that the equivalent of a sabbatical year for appropriate study by able personnel should be striven for either on an exchange or on a direct basis.

(10): The question of retirement at an earlier age on a living wage is important in order to make possible a more dynamic flow in the top positions. It should be subject to considerable flexibility in individual cases. It would not preclude useful activity for retired personnel, as witness the diversity of useful employment for able retired naval officers.

(11): Of necessity, the Navy must maintain an organization in which the number of officers in the different ranks decreases with rank, giving the organization a pyramidal structure of population in rank. In academic institutions such a structure is not as imperative if the senior professorial ranks are willing to share alike in the burden of lower-grade instruction. Faculty groups are small, and administrative function is limited. Sound academic institutions will, however, fill their ranks from below with proper junior personnel and promote in the measure of a man's research and creative achievement. In the larger research laboratories the size, the cooperative nature of most projects, the character of much of the work, and the considerable administrative function required, especially by civil service, introduce situations akin to those met with in the Navy although to a lesser degree. Still a large number of lower-grade, technically competent professional operatives are employed. This, together with the directive and supervisory functions needed in large organizations, makes a pyramidal type of organization imperative. On the other hand, it is urgent that personnel be attracted to and retained in such laboratories. This implies a sense of security and opportunity for advancement. The Navy maintains its pyramidal structure by feeding in at the lowest rank of its officer personnel and through its accentuated system of fitness reports, promotion examinations, and selection boards, retiring personnel as this becomes necessary while promoting the able ones. It maintains its morale by retiring those officers who fail to make the grade and by a sensible and fair retirement and pension system. Thus, officers retired on failure to achieve promotion are assured of retirement after a certain number of years in service under such conditions that, with their

pension, they can be certain of a livelihood while readjusting to rehabilitation in civil life.[2]

The situation in research laboratories, especially under civil service, in contrast to the Navy, is at the present writing alarming in a high degree. Manpower in such organizations, even with urgent needs and extensive programs, is limited by what are known as ceilings. These are limitations imposed by Congressional action on the total number of personnel aboard including the very necessary nonprofessional service personnel, irrespective of rank or function. They limit hiring on sound functional and program bases. During the war hiring was extensive, and in general such hiring yielded a healthy pyramidal structure, though with a shortage of senior personnel. Thus, during the war rapid promotion was urgent and was effected. With the advent of peace and the placing of relatively low manpower ceilings a peculiar structural change took place. Junior ratings were dropped, and the abler and more experienced employees were retained at higher ratings. In addition, with the urgent need for retaining the services of competent personnel, in a labor market depleted in lower ratings by the draft, promotion was utilized as an incentive for holding valuable personnel. This was aggravated by competition with academic institutions and industrial laboratories offering better financial inducements. In consequence, in the civil service research laboratories the following trend is universal. In 1945 the peak of the employment curve lay between the P-1 and P-2 levels with a proper decline in the higher ratings. In 1948 the peak lies between the P-3 and P-4 ratings with ceilings filled and relatively few P-1 ratings present. The significance of this situation is, first, that work normally done by those with P-1 ratings is now being done by men with a P-3 rating. Secondly, it signifies that in the next years promotion of only a very few of these men will be possible. This will cause serious discontent among the present personnel with the abler personnel leaving and the less able remaining. Thirdly, it signifies that when the production of capable technical personnel from the intensive academic mass-training programs now in force reaches the labor market, there will be no places available for a healthy filling of quotas from below. As far as I can see, the *only* proper solution lies in the speedy enactment of legislation permitting a retirement on pension or subsidy, based on length of service, which will make it possible to retire overcomplement higher ratings without loss of morale and permit replenishment from below. Pensions on such a system need not be payable for life as with the Navy. They should be of such character that for three to four years the personnel have a salary sufficient to permit them to go to universities or otherwise prepare for employment that will insure their future. They, like the GIs, are also in a measure war casualties. Such a scheme is not without precedent in the academic world for nontenure appointees (below the rank of associate professor). If after 5–7 years of service, with an education on the higher level complete, a faculty member cannot expect to receive promotion, he is given a year on full pay to seek other employment. The writer therefore urges that aggressive action at once be taken toward establishing some sort of a retirement for "age in grade" plan and, with it, proceeding by means of the proper selection boards to re-establish the balance of a healthy organizational structure.

It is believed that if this general plan as outlined above, and with modifications appropriate to the particular laboratory, can be put into operation, there is a hope that stagnation and deterioration of scientific proficiency can in a large measure be avoided.

[2] It appears that with the consolidation of the armed forces under the Secretary of Defense a new system of contributory retiring annuities is being proposed to replace the excellent pension system now in force in the Navy. Judging from the lamentable conditions faced by academic staffs under such a system in these inflationary years, the Secretariat of Defense is ruining an otherwise very effective and human system. This will seriously impair the efficiency of the present Navy and will discourage enrollment and retirement of the present high grade of personnel. It is hoped that serious consideration will be given to this change before it is too late.