Materials Research Laboratories: Reviewing the First Twenty-Five Years

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Creativity is a singular effort. It is often said that no original idea has ever come from a committee. And yet, increasingly, group efforts are devoted to the solution of technical problems. Industrial research laboratories first, and then universities, turned to collaborative research teams that cross rigid departmental boundaries and use systems approaches to attack complex problems. The efforts leading to establishment of Materials Research Laboratories have been in the vanguard of this transition.

In 1960 the Advanced Research Projects Agency (ARPA) of the U.S. Department of Defense established the Interdisciplinary Laboratories (IDLs), later known as Materials Research Laboratories (MRLs). Their impact on materials research, on the universities in which they are housed, and on the very manner in which university research is organized has been profound and is still growing. The purpose of this chapter is to survey the brief but significant history of these laboratories, looking back to the time of their origin, tracing their evolution, and then summarizing some of their accomplishments.[1]

INTERDISCIPLINARY LABORATORIES

In the atmosphere of international competition symptomatic of the cold war and dramatized by the Soviet launching of *Sputnik I* in October 1957, an interagency Coordinating Committee on Materials Research and Development (CCMRD) was convened in 1958 at the urging of the U.S. Department of Defense (DOD). It was clear then as it is now that the national economy and security would depend increasingly on new technology, which in many cases would require new, more reliable materials. It was not as clear then as it is today that a broad interdisciplinary education was necessary to make progress in materials research, but the farsighted members of the CCMRD did recognize that need. In 1959 they recommended the establishment of interdisciplinary laboratories for materials research to be built on university campuses to carry on research and to train graduate students. Their intention was to foster research in which the pertinent scientific and engineering disciplines would be brought to bear in a collective and cooperative manner on common problem areas in materials science.

TABLE 1 Year of Establishment and Termination of Interdisciplinary Laboratories (IDLs)/Materials Research Laboratories (MRLs)

IDL/MRL University	Year Initiated	Year Terminated
Cornell	1960	
Pennsylvania	1960	
Northwestern	1960	
Brown	1961	
Chicago	1961	
Harvard	1961	
Maryland	1961	1977
MIT	1961	
North Carolina	1961	1978
Purdue	1961	*
Stanford	1961	
Illinois (Urbana)	1962 (with AEC)	
Carnegie Mellon	1973	*
Massachusetts (Amherst)	1973	
Pennsylvania State	1974	1980
Case Western Reserve	1974	*
Ohio State	1982	*

*Materials Research Laboratories at these institutions are being phased out. Materials Research Groups have recently been established at Carnegie Mellon University, Case Western Reserve University, Purdue University, the University of Michigan, Michigan State University, and the University of Texas at Austin.

The CCMRD recommendation was adopted by the Federal Council for Science and Technology and was assigned to ARPA in June 1959 for execution. During the next three years, 12 IDLs were established, as shown in Table 1. Coincidentally, the Atomic Energy Commission (now the Department of Energy [DOE]) supported analogous laboratories in three universities (University of California, Berkeley; University of Iowa; and University of Illinois), and the National Aeronautics and Space Administration followed with a smaller program. (Details of the events leading to the establishment of these various laboratories are presented in a 1960 address by William O. Baker.[2]) This presentation is limited to a discussion of the ARPA IDLs, which were renamed Materials Research Laboratories when the National Science Foundation (NSF) took over the program in 1972.

It is instructive to quote directly from the work statement in ARPA IDL contracts from 1960:

The Contractor shall establish an *interdisciplinary materials research* program and shall furnish the necessary *personnel* and *facilities* for the conduct of research in the science of materials with the objective of furthering the *understanding of the factors which influence the properties of materials* and the *fundamental relationships which exist between composition and structure and the behavior of materials* [emphasis added].

In looking back, it should be recalled that in 1960 few academic departments at universities had sufficient breadth of coverage to justify the title "Materials Science," and none would even have considered the title "Materials Science and Engineering." Instead, there were many departments in which mining, process metallurgy, physical and mechanical metallurgy, and the physics of metals were the principal, and largely separate, areas of materials research. An occasional individual effort in ceramic engineering could be found, and polymer science, if available at all, was a topical course in advanced chemistry. Yet, 12 years later when the IDLs were transferred to NSF, materials science was a recognized discipline at many major research universities, and the change in emphasis in academia could be clearly demonstrated by the names selected by materials departments (see Table 2). The trend toward more general "materials" departments is continuing, as shown in the table.

TABLE 2 Trends in Titles of Materials Departments at U.S. Universities, 1964–1985

	Number of Departments, by Year		
Department Title	1964[a]	1970[b]	1985[b]
Minerals and Mining	9	7	5
Metallurgy	31	21	17
Materials	11	29	51
Other	18	21	17
Total	69	78	90

[a]Compiled from 1964–1970 *ASM Metallurgy Materials Education Yearbook,* ed., J.P.Nielsen (American Society for Metals, Metals Park, Ohio).
[b]Compiled from 1985 *ASM Metallurgy/Materials Education Yearbook,* ed., K.Mukherjee (American Society for Metals, Metals Park, Ohio, 1985).

The establishment of the ARPA IDLs was the first attempt on U.S. university campuses to create a new style of research organization and to accelerate the processes of academic curricular change resulting from federal recognition of a specific national need. It was clear to the organizers of this experiment that this new mode for funding university research would require changes in the way universities do business—in particular, the traditional departmental organization would be threatened.

During the dramatic first years (see Sproull, in this volume), many of the IDL program goals were realized. Buildings were built, paid for by ARPA through a building use fee incorporated into the contract; interdisciplinary research facilities were established in these buildings, with sophisticated equipment operated by trained technicians and available to the entire materials community at the IDL. Graduate students were trained in large numbers and went on to populate the universities and federal and industrial laboratories, which were growing rapidly during this period. Research was carried out in myriad materials fields using federal funds assigned as block grants to the universities and administered locally.

A brief statistical view of the IDLs at their height is informative. In Fiscal Year 1969, for example, the funding for the IDL program reached its maximum —$18.97 million,[3] including $1.8 million in building use charges. In that same year a total of nearly 600 faculty members and 2,385 graduate students participated in the program, 360 doctoral degrees were awarded, and more than 2,000 papers by program participants were published. The research efforts of these students and faculty members were grouped into 134 "work units," or identifiable research project areas, and each participating university engaged in 6 to 20 such units. Significantly missing from the program at that time was the strong interactive team approach, which we now identify as a dominant feature of the Materials Research Laboratories and which would be left to the National Science Foundation to foster.

In the report *Materials and Man's Needs,* the National Academy of Sciences Committee on the Survey of Materials Science and Engineering (COSMAT) devoted extensive study to the materials centers (including all ARPA, AEC, and NASA block-funded institutions). The committee's list of successes for the materials center concept included the following:

- Drawing "attention to the emergence of coupled materials science and engineering as a new interdisciplinary focus of activity in a way which could not have been achieved otherwise."
- Demonstration "that block funding is perfectly feasible on a campus."
- Development of "excellent research groupings of faculty members, the building-up of a reputation and attraction for good students, and the training of first-rate materials scientists, physicists, chemists, and other professionals."
- Administrative efficiency achieved "through faculty saving their time

in writing proposals and seeking support, and the agency officials likewise saving a great deal of administrative time."

- "A large number of students were trained in an excellent environment for advanced degrees."[4]

Not surprisingly, the COSMAT report found some deficiencies in the program, the most important of which was the limited evidence of interdisciplinary effort as measured principally by the limited number of joint publications. (Of course, the number of joint publications should not be the only criterion in such an evaluation.) One could say of this period that the seeds for interdisciplinary cooperation had been sown but that the young plant needed cultivation. At its best, interdisciplinary activity at the IDLs consisted of the development of a community of scholars brought together by a block grant, which they administered jointly; of research facilities developed by expert disciplinarians but designed and operated in a manner conducive to shared use by students from other disciplines; of additions to faculties in related departments with expertise intended to complement existing strengths throughout the fields of materials research; and of seminar series and internal meetings organized expressly for educating colleagues in other departments. Without these beginnings, the next critical steps toward fully collaborative cross-disciplinarity could not have been achieved in the NSF program.

The COSMAT report was also critical of the effectiveness of the ARPA IDL effort to increase graduate education in materials research more rapidly than in other disciplines. It found that the number of M.S. and Ph.D. degrees granted in the traditional materials departments (Figure 1) grew at 12 to 13 percent per year through the 1960s, the same rate as that for the engineering field as a whole. It seems clear in retrospect that substantial government funding in many forms led to a general expansion of graduate education in all engineering fields. Instead of focusing on any failure of ARPA to do better in some quantitative sense in materials education than was done in other fields by other DOD agencies, DOE, and NASA, one should focus on the quality of the education received by the students. Both graduate and undergraduate students at the institutions where IDLs had been established benefited from the broad interdisciplinary view of materials research that entered the curriculum as faculties grew in size and diversity. By the early 1970s it was no longer uncommon at these schools to find ceramics (and even polymer science) taught as an integral part of the curriculum. Although the IDLs were not alone in this trend, they certainly led the way. Thus, much of the interdisciplinarity sought in the original CCMRD concept was realized through evolutionary changes in the traditional materials departments rather than by dramatic changes in interaction across university departmental lines. This cross-departmental interaction would come only with the group research concept introduced by NSF.

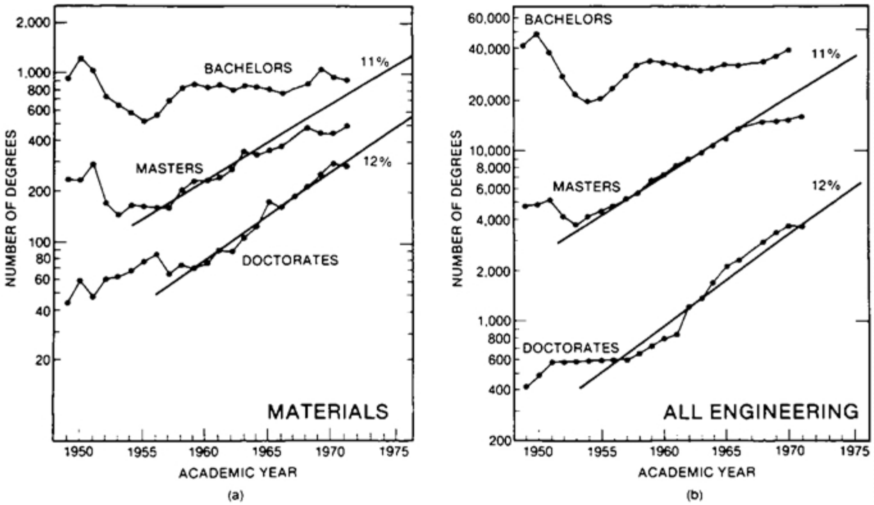

FIGURE 1 Number of degrees awarded by (a) materials-designated departments and (b) engineering departments in all fields (U.S. Engineering Council for Professional Development Schools), 1950–1970. (Percentages indicate average annual rate of growth during the 1960s.)[4]

TRANSFER OF IDLs TO NSF

The political complexities of the late 1960s led to reevaluation of the role of DOD in sponsoring non-mission-oriented research at universities. In 1970 it was decided that the appropriate agency to which responsibility for this program of research centers should be transferred was the National Science Foundation. However, the concepts of block funding, delegation of authority to local management, and shared experimental facilities differed markedly from those characterizing the traditional single-investigator, discipline-oriented mode of operation at NSF. After an extensive review of the program in 1971, NSF assumed responsibility for the IDLs in 1972, accepting the operational modes built into the program but adding a critical new component. As described in NSF's program policy statement, the laboratories—now renamed Materials Research Laboratories—would retain locally administered block (or “core”) funding intended to “facilitate research in materials science and engineering which is either difficult or unfeasible to carry out under traditional funding of individual research.” Most importantly, the new component added by NSF was that “scientific excellence is viewed as a necessary, but no longer sufficient, condition to qualify for MRL core support.” In addition, the MRLs would be judged by their ability to foster “coherent, multidisciplinary and multi-investigator projects in major thrust areas requiring the expertise of two or more materials-related disciplines." These so-called thrust groups are the heart of the current core funding at MRLs; at their best they have achieved a transformation in the way materials research is done at universities and in the way graduate education proceeds.

The transfer of the MRLs to NSF required an organizational change and led to the establishment of the Materials Research Division, grouping the MRLs with programs that had concentrated on traditional materials departments as well as on areas of physics and chemistry clearly dealing with materials research.

At the time of its move from ARPA to NSF, the program included 600 faculty members at 12 universities. Of these faculty members, some 35 percent were physicists, 25 percent were chemists, 19 percent were metallurgists or members of materials science and engineering departments, 16 percent were from other engineering departments (mainly electrical), and the remaining 5 percent were from other fields. The transition from ARPA to NSF was rather complex, taking place over a two-year period; not all projects (or funds) were finally transferred. The total MRL budget for FY 1974 was $12.1 million, reduced from the $17.2 million for operations of the FY 1971 IDL budget. When the program was examined in 1975 by the MITRE Corporation on contract from the NSF,[5] the number of faculty members had been reduced to 532 and the distribution had shifted slightly from physics toward materials and engineering (Table 3). Inflation and limited NSF budgets in subsequent years led to further reduction in effort as measured in constant dollars (Figure 2) and a consequent further reduction in faculty to the 1985 level of 400. Furthermore, additions of new schools to the MRL program and phaseout of others led to the 1985 faculty distribution shown in Table 3. It is significant, and disturbing, that these trends seem counter to the increased emphasis on materials processing and chemistry in materials research. Balance in NSF funding is being achieved by other funding modes.

TABLE 3 Faculty Distribution in IDLs/MRLs, 1970, 1975, and 1985

Faculty	1970[a]	1975[b]	1985[c]
Materials science and engineering (includes metallurgy, geosciences, etc.)	19%	27%	35%
Physicists	35%	31%	35%
Chemists	25%	19%	17%
Other engineering	16%	23%	12%
Other	5%	2%	
Total number	600	532	400

[a]Note 1 of this chapter.

[b]Note 4.

[c]Note 6.

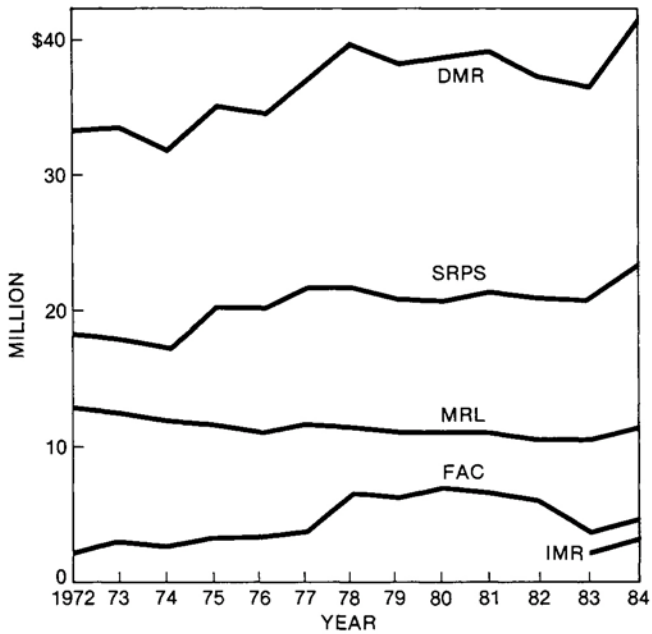

FIGURE 2 NSF-DMR budget, FY 1972-FY 1984, in constant 1982 dollars. DMR, Division of Materials Research; SRPS, single-investigator research project support; MRL, Materials Research Laboratories; FAC, national user facilities; IMR, instrumentation for materials research.

THRUST GROUPS

The formation of the interdisciplinary thrust groups referred to above varies among institutions. It often begins when several faculty members with common interests, challenged by the opportunity to attack complex problems and encouraged by the availability of a funding mode for group effort, come together for brainstorming. This exercise may be stimulated by an MRL director or may result from the efforts and ideas of a single faculty member, but it leads to the definition of a program area in which the university has substantial current or developing capability. As the research program concept is refined, other faculty members with complementary talents may be attracted to the group. In the formative years of the NSF MRL program, most projects proposed by well-conceived thrust groups were accepted, replacing single-investigator activity in the MRL.

By the mid-1970s, this new form of endeavor would compete with existing programs for limited core funding. New thrust groups are commonly given minimal (seed) funding to encourage continued effort and program refinement before full funding. The decision to fund is made by the MRL director in consultation with his advisory committee (and often with the further advice of an external visiting committee). Until 1985 the start-up of a major new thrust group activity began with a three-year grant from NSF after a site visit and further program evaluation. A recent change in NSF management procedure has opened the way for substantial redistribution of funds among MRLs, allowing for rapid response to new opportunities for research by thrust groups.

As the thrust group's activity develops, several forms of interaction may be found. For example, graduate students and postdoctoral associates who have the same faculty adviser usually work on common problems, some characterizing the structure of a given material, some studying its properties, others studying problems of theory. Group meetings permit interchange of information about progress as well as plans for the future. Major equipment facilities commonly are used for collaborative projects, and in other instances new, specialized laboratories are designed to support the research needs of the thrust group. At their best, thrust groups create an educational environment that differs radically from that of 25 years ago when each student associated almost exclusively with his adviser and peers. Thrust groups produce materials research unlike that carried out at universities even a decade ago when collaborative efforts by more than two investigators were difficult to stimulate and, once stimulated, difficult to fund.

SUMMARY OF MRL ACCOMPLISHMENTS

The current status of the MRL program may be summarized as follows. The NSF budget for the MRL program in FY 1985 was $27 million. MRL awards range from about $0.75 million to nearly $4 million, with the average award at about $2 million. About 60 percent of the budget is spent on thrust group research, 30 percent on facilities, and 10 percent on seed projects. The average number of faculty members participating in an MRL is about 30, with about 6 postdoctoral scholars, 25 graduate students, and 6 technicians. Since their inception in 1960, the MRLs have produced an estimated 3,000 Ph.D.s in materials research, funded primarily by block grants. Since 1972, when NSF took over the program, five new MRLs have been started and seven have been phased out (see Table 1).

In evaluating the research programs of the MRLs, issues of quality and character must be addressed. In its study of the MRL program, the MITRE Corporation evaluated quality using a complex peer review process. Reviewers compared publications of the faculty and students at the MRLs with those from peer non-MRL universities. Significant achievements identified and submitted to MITRE by MRLs were compared with those submitted from non-MRL "control" schools. The results of this analysis led the MITRE study group to conclude that the quality of research at the MRLs "is high with a greater number of major achievements at MRL's than at non-MRL institutions."[5]

The character of the research at MRLs is more difficult to describe. In the mid-1970s when data were being gathered for the MITRE study, only one graduate-student cycle (4 years) had passed since the introduction of the thrust group concept, and most thrust group efforts were only at their initiation stage. Now, 10 years later, the accomplishments of those thrust groups are the measure of the MRLs' character and effectiveness. The following list of research accomplishments of the MRLs was compiled in 1984 by Roman J. Wasilewski, head of NSF's MRL program for 10 years. His intention was to identify those developments that would be difficult or infeasible to achieve under traditional disciplinary project support.[1] The list omits numerous accomplishments of comparable caliber in which project support might just as readily have led to their success.

Organic Metals The research field of organic metals opened as the result of the University of Pennsylvania group's early findings on tetrathiofulvalene-tetracyanoquinodimethane (TTF-TCNQ), which led to an unprecedented degree of collaboration between organic chemists and physicists. Most of the materials initially investigated were not new. Rather, it was the collaboration between researchers in synthesis chemistry and solid-state physics that led to exciting findings. The development of new, related materials followed quickly at the MRL at Northwestern University and elsewhere.

Ultralow Temperatures Cornell University has pioneered in research in the millidegree range for over a decade. Support for this research had originally been requested from—and was declined by—a traditional disciplinary NSF program. The first disciplinary project support was in fact provided only several years after establishment of the MRL at Cornell—after the facilities and the technique had been developed and the first experimental observations of unexpected phase transitions were observed. Since then most of the low-temperature physics aspects of the program have been project-supported, while the parts of the research primarily concerned with phase transitions, which expanded rapidly to metallurgical transitions, remain core-supported.

Lower-Dimensionality Materials The field of lower-dimensionality materials shows how rapidly progress can be achieved by cross-disciplinary involvement. Although materials like liquid crystals and intercalation compounds had long been known, they were of limited scientific interest for decades, viewed as curiosities with little scientific or technological potential. A collaborative MRL program combining research in synthesis and physics developed early at Harvard University and provided a major stimulus to the field. Similarly, MRL programs on intercalated compounds at MIT and the University of Pennsylvania and on molecularly stacked organic crystals at Northwestern University developed rapidly.

Surfaces and Interfaces With the current availability of sophisticated equipment and techniques, the area of surfaces and interfaces may be viewed as largely disciplinary and no longer requiring cross-disciplinary collaboration. Nevertheless, many of the original techniques, kinds of instrumentation, and approaches were adopted by groups at several of the MRLs. Areas in which major—and at times definitive—contributions came from the MRL surface science programs include the development of ultraviolet spectroscopy at the University of Pennsylvania and Cornell University (the Wisconsin Synchrotron Radiation Center was used); the application of synchrotron radiation to surface studies at Stanford University, where the MRL provided a significant input at the early stages; and the technique for spectroscopic analysis of adsorbed species at Purdue University. These contributions were primarily due to the close though seldom formalized collaboration between chemists and physicists and—equally significantly—between theorists and experimentalists.

Phase Transitions Although phase-transition phenomena have been of major interest to physicists over the last decade, the extension of the classical approaches to other than model materials was initiated at MRLs. The statistical mechanics approach to structural transitions in polyvinyl fluoride, successfully developed at Case Western Reserve University and already largely experimentally verified, has opened a new way of treating "real"—and quite complex—phase-transformation phenomena in polymeric materials. Theoretical calculations of the highly complex process of solidification in welding are now partly verified by research at Carnegie Mellon University and have similarly provided both a new approach and a potential for better control of this technologically important process. Studies of sol-gel (solution-to-gellation) transition across the transition temperature at Brown University and MIT, as well as the studies of spin glasses at the University of Chicago, all benefited markedly from the participation of cross-disciplinary expertise from the earliest stages of the programs.

New Materials According to the MITRE report, MRLs were unique in academia in 1975 in developing significant new materials, and they continue to dominate this field today. To mention only a few of these materials, nonlinear optical crystals of lithium niobate have been developed at Stanford University, and urea crystals at Cornell. Organic metals have been developed at the University of Pennsylvania and Northwestern University, block copolymers have been synthesized and studied at the University of Massachusetts, and highly reproducible fiber-polymer composites have been developed at Case Western Reserve University. Uniquely characterized transition metal oxides have been developed at Purdue University. All of these new materials represent sophistication in preparation and characterization of relatively common materials. Modulated materials with layer thicknesses varying from 5 to 50 angstroms are now almost routinely prepared at Northwestern University, Stanford University, and the University of Illinois. Quaternary and semimagnetic semiconductors are prepared at the University of Illinois and Purdue University, respectively. Submicron composite materials prepared at Cornell University for possible solar energy applications are some of the more novel, unorthodox materials originating at the MRLs. In each case of the preparation of a new material, the ultimate success demands a sustained collaboration of individuals with expertise in materials synthesis and characterization techniques at a level of sophistication seldom available in traditional disciplinary research.

To this list of accomplishments compiled by Wasilewski, I wish to add the following MRL programs:

- Mechanical behavior of metals fracture and high-strain-rate behavior (Brown University); fatigue and high-temperature behavior (Northwestern University and University of Pennsylvania); intergranular fracture (University of Pennsylvania)
- Fabrication of single-crystal optical fibers (Stanford University)
- Preparation, characterization, and understanding of amorphous materials (MIT, Harvard University, University of Pennsylvania, Stanford University, and the University of Chicago)
- Rapid solidification (MIT)
- Polymer science—dependence of crystallization properties on molecular weight (Northwestern University); high-modulus polyethylene (University of Massachusetts)
- New techniques for nondestructive testing (Stanford University)

The investment by ARPA and NSF in the IDL/MRL program has been substantial; ARPA contributed $158 million to the IDL program between 1960 and 1972, and NSF contributed $261 million to the MRL program between 1972 and 1985. The continued health of the program, the accomplishments in research and education, and the development of the MRL universities as major national resources have justified the continuation of the program in its evolved form.

To look only at the importance of the MRLs to the fields of materials research, however, is to miss some of their most profound effects. The IDLs were among the first examples of an interdisciplinary research center at their respective institutions. Their success and the perceived value of cross-disciplinary research set an example for other faculties and, perhaps even more importantly, for university administrations. Today's university register is incomplete without its list of study centers—in areas as diverse as information and technology, design, urban studies, robotics, environment, teaching, art, and history. There may be no cause and effect operating here, but it is certain that the IDL/MRL concept helped pave the way toward reorganization of the university research environment.

Significant in another area, the success of the MRL concept has encouraged new funding patterns by federal agencies. One can point to the significant research opportunity grants that have been made by the Office of Naval Research and those that have gone to the Centers for Super-Computers, the University/ Industry Centers, the new Engineering Research Centers, and the new program for Materials Research Groups (MRGs) at NSF. The Engineering Research Centers share some of the same interdisciplinary goals for attacking complex problems that are the central theme of the MRLs. Of the first six Engineering Research Centers, two deal with materials—the Center for Composites Manufacturing Science and Engineering at the University of Delaware and Rutgers University, and the Center for Robotics Systems in Microelectronics at the University of California, Santa Barbara.

The Materials Research Groups, a new program in the Materials Research Division at NSF, create opportunities for multi-investigator efforts by individual thrust groups. In most cases, the universities awarded an MRG do not have an MRL, although MRGs have been established at Purdue, Carnegie Mellon, Pennsylvania State, and Case Western Reserve universities, where the MRLs have been or are being phased out (Table 1). MRGs should expand the variety of cross-disciplinary collaboration and further stimulate the trend toward interdisciplinary organization of the traditional materials departments. The following list of proposed areas of study in the first five MRGs shows the kinds of exciting new programs made possible by the MRG concept:

- Rensselaer Polytechnic Institute will investigate the various aspects of glass stability—chemical, mechanical, and microstructural—in order to understand the causes of glass degradation and provide a basis for developing more stable glasses.
- The Polytechnic Institute of New York will launch a program to gain a better understanding of chemical, physical, and processing effects on the aging of polymer blends, an important emerging class of materials.
- Pennsylvania State University will focus on the molecular engineering of new, chemically bonded ceramics. The materials will be consolidated without resorting to thermal diffusion, relying instead on chemical reactions at relatively low temperatures to cause the bonding.
- The University of Texas at Austin will seek answers to questions associated with the synthesis of new materials for photoelectrochemical devices and the underlying mechanisms of photochemical processes at interfaces.
- The California Institute of Technology will develop a program dealing with the motions of atoms and molecules at interfaces and their relationship to the synthesis and characterization of new materials.

The MRGs should be viewed as a logical intermediate stage between the traditional single-investigator research programs and the MRLs. Taken together, the MRLs and MRGs represent an increasing fraction of the budget of the NSF Materials Research Division and demonstrate a recognition of the trend toward greater cross-departmental interaction in materials research. Furthermore, as the project titles indicate, these Materials Research Groups, along with the new Engineering Research Centers, will bring more chemistry and engineering into the NSF group research program in materials.

The concept of block funding was originally viewed as an experiment. The experiment led to radical measures intended to eliminate barriers to the solution of complex problems in the study of materials. It is fair to conclude, 25 years later, that the experiment was successful and that materials science has fared much better than it might have otherwise.

NOTES

1. My own personal experiences strongly color my remarks, as I have grown up professionally at Northwestern University (which housed one of the first three IDLs, along with Cornell University and the University of Pennsylvania), and was privileged to serve as the director of the Materials Research Center at Northwestern before assuming my present position as director of the Institute for Materials Science and Engineering at the National Bureau of Standards.

I am particularly indebted to the late Roman J.Wasilewski for the detailed historical perspective provided in his final report to the National Science Foundation (NSF) [R.J. Wasilewski, Outline of MRL Program. Internal NSF Memorandum to Division Director, Materials Research Division, National Science Foundation, Dec. 22, 1981] and in a 1984 unpublished manuscript dealing with the development of the Materials Research Laboratory program. Ro Wasilewski, who died on 3 February 1985, headed the Materials Research Laboratory Section at NSF for 10 years from the time of the transfer of the IDLs to NSF in 1972. Much of what is good about the MRLs can be attributed to his farsighted management of the program.

2. W.O.Baker, “The National Role of Materials Research and Development,” in *Properties of Crystalline Solids,* Special Technical Publication No. 283, American Society for Testing and Materials, 1960, pp. 1–7.

3. R.A.Huggins, Overview of Advanced Research Projects Agency Interdisciplinary Research Laboratories as of June 30, 1970. Advanced Research Projects Agency, U.S. Department of Defense.

4. National Academy of Sciences, Committee on the Survey of Materials Science and Engineering (COSMAT), *Materials and Man's Needs: Materials Science and Engineering,* Vol. III (National Academy of Sciences, Washington, D.C., 1975), pp. 7–209–7–210.

5. J.G.Ling and M.A.Hand, “Federal Funding in Materials Research,” (summary of the findings of the MITRE report). Science **209,** 1203 (1980); Technical Report 7764 (MITRE Corp., Bedford, Mass., Sept. 1978).

6. K.Mukherjee, ed., *ASM Metallurgy/Materials Education Yearbook,* American Society for Metals, Metals Park, Ohio, 1985.