CHAPTER

Three Successful Modes of Research Governance: Lessons from the Past, Issues of the Present, Implications for the Future

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INTRODUCTION

In a rapidly changing intellectual environment in which research is growing increasingly specialized while cross-disciplinary collaboration is opening new pathways to understanding, research institutions grapple with an array of internal and external challenges. Boundaries that once separated traditional academic fields have become less distinct, and multi-disciplinary research now spans the continuum from basic science to applied research. These changes, along with dramatic acceleration in the pace of research, have prompted us to examine the internal governance structures of three outstanding research organizations and ask: How will the decision-making procedures that have contributed to the success of these organizations evolve to respond to future challenges?

Leaders of research institutions, relying on input from their scientific associates, are charged with making decisions about issues as diverse as resource allocation and fundraising, hiring and promotion, apportionment of physical space, and, in the case of academic organizations, recruitment and education of students. The processes by which these decisions are made, as well as the decisions themselves, can influence fiscal prosperity, scientific productivity within the institution, and morale of the faculty and research staff.

We begin with a look at the internal structure and management of two top-ranked organizations at the University of California San Diego (UCSD): Scripps Institution of Oceanography (SIO) and the Graduate Program in

Neurosciences (GPN). As a counterpoint to the academic environment, we consider the configuration and leadership of the Physical Sciences Research Laboratory (PSRL) of Bell Laboratories Lucent Technologies in Murray Hill, New Jersey. Our goals are to identify internal management practices, both formal and informal, that contribute to research excellence, and to highlight creative approaches that hold promise for responding to future reconfigurations in the research environment.

The three organizations share a number of fundamental characteristics: size, scientific focus, and reputation for excellence. Each is larger than a traditional academic department, the size of which typically reflects teaching requirements. Each comprises a number of divisions or programs that function semi-independently and present governance challenges. Each relies on a balance of formal and informal decision-making procedures. All are scientific enterprises in which individual productivity is a prerequisite for institutional success. The two university entities, SIO and GPN, have as a second primary mission the education of graduate students. Both were rated number one in their fields by the National Academy of Sciences' National Research Council (Goldberger *et al.*, 1995). Bell Labs' PSRL, a model of private sector research, was selected for this discussion on the basis of its recognized success and familiarity to one of us (RCD).

It is not surprising that these highly regarded organizations have in common certain structural and management features that support their prosperity. More intriguing, however, is the noteworthy differences among the organizations. The complexity of the internal structure and governance system ranges from relatively straightforward in the case of PSRL, to moderately multifarious within GPN, to comparatively enigmatic at SIO. The degree of direct influence exerted by the leader(s) is strongest within PSRL and comparatively circumspect within SIO and GPN. Strategies for recruiting new personnel vary significantly among the three groups. A well-developed system of active recruiting at PSRL and an innovative advertising strategy used by the principal department of GPN contrast with SIO's reliance on its reputation of excellence to attract outstanding candidates. Specific examples will illustrate how aspects of each organization's structure and management contribute to, or in some cases detract from, the goal of promoting continued success in the research arena.

Interviews with faculty, researchers, and administrative leaders at the three organizations shed light on internal structure and policies that contribute to the success of these groups. Those interviewed were forthcoming with constructive criticism as well as praise for their particular organization's structure and decision-making practices. Their insights, opinions, and concerns reveal key elements of successful internal management.

BACKGROUND

Each of the three organizations has a peculiar internal structure and governance that reflect its size, composition, purpose, and, in two of the three cases, position within the university infrastructure.

Scripps Institution of Oceanography (SIO)

Scripps Institution of Oceanography has been a multidisciplinary academic organization since its inception nearly a century ago. With its amalgamation of strengths and weaknesses, SIO may serve as an interesting model for other growing organizations that are becoming increasingly interdisciplinary. The institution now employs some 1,700 people, including 90 faculty, 100 researchers, and 170 graduate students, who work in more than two dozen buildings on the roughly one-half square mile seaside La Jolla campus. Research in the ocean, earth and atmospheric sciences, as well as graduate education are primary missions of the Institution.

The peculiarities of SIO's flexible academic personnel structure, which distinguish it as a non-traditional constituent of the university, can be simplified by a two-component model: 1) faculty (professors) of the SIO Department who teach, conduct research, and vote in the University's strong Academic Senate; and 2) researchers who are members of SIO and employees of UCSD but who do not engage in the organizations' governance via the Academic Senate. Since many faculty members also hold research appointments, and some researchers are actively involved in the guidance of graduate students, the distinction between faculty and researcher is not as sharp as the simple model might lead one to believe. But the reality of the separation bears conspicuously on decision-making practices within SIO, and consequently affects perceptions of hierarchy among individuals and groups. On the other hand, the administration has steadfastly held to the principle (and practice) of maintaining equity between faculty and researchers by maintaining equivalent salary scales. This required substantial effort on the part of the administration.

This brings us to the sub-divisional structure at SIO, which, layered upon the complexity of the faculty/researcher dichotomy, makes for an institutional structure that frequently bewilders insiders as well as outside observers. Academicians (faculty and researchers) are grouped into twelve research divisions and their equivalents (Organized Research Units). The number of academics in each research division ranges from a half-dozen to more than three dozen, and some individuals are affiliated with more than one research division. The SIO director appoints research division directors who typically serve in this capacity for five years. Independent of the system of research divisions are the eight curricular groups into which SIO faculty partition themselves. Curricu-

lar groups concern themselves with graduate student recruiting, admitting, teaching, and supervision, among other issues relevant to the faculty, and are the rough equivalents of academic departments within UCSD. According to their status as faculty or researcher, and via their participation in research divisions, curricular groups, and institutional and *ad hoc* committees, scientists can participate extensively in decision-making about hiring, promotion, graduate education, design of new physical space, and more recently, fundraising.

The research and teaching functions at SIO maintain an uneasy distance from each other. They are not combined in departments as in most research universities, nor are they separated as at many institutions in continental Europe. This partial decoupling of research and curricular decision-making processes has both benefits and drawbacks. It allows interdisciplinary research to flourish, but weakens formal graduate teaching and curriculum design.

Historically, SIO has relied on strong directors; the Director also serves as a UCSD Dean and Vice Chancellor. As a university division, SIO thrives on a blend of faculty self-governance and directorial initiative. For an academic unit, the Director/Dean/Vice Chancellor holds an extraordinary concentration of formal power. This concentration of power can enable unconventional, often multi-disciplinary innovation. At the same time, the Director ignores faculty views at his extreme risk.

There is a strong tradition of "shared governance" in the University of California, in which the administration and the faculty govern together. Throughout the entire University of California system, the Academic Senate is strong, and SIO and UCSD follow well-defined administrative procedures that govern how decisions are made. The faculty arm of the governance, the academic assembly, holds primary responsibility for curriculum and student admissions, while the remainder is under the purview of the administration. In practice, the faculty and the academic assembly are an integral part of the advice to the administration. SIO strongly follows these principles of shared governance.

Graduate Program in Neurosciences (GPN)

In contrast to SIO, the GPN is not an academic division or department of UCSD; rather, it is a highly regarded, cross-departmental, multi-institution, integrated program focused on graduate student training in the field of brain research. The relatively youthful field of neuroscience comprises specialties as diverse as physiology, anatomy, pharmacology, chemistry, biology, psychiatry, and cognitive sciences. The GPN brings together more than 120 faculty members supervising some 70 graduate students. Faculty hold appointments in a dozen academic departments and the School of Medicine at UCSD, and a number of affiliated, neighboring institutes, including The Salk Institute, the Scripps Research Institute, SIO, the UCSD Medical Center, and the Veterans

Administration Medical Center.

Under the leadership of a program chairman, GPN faculty make decisions about the content and structure of the graduate program. It is important to note that the only real power of the GPN chairman is controlling access to bright graduate students. Matters such as hiring, promoting, and resource allocation are handled not within the GPN, but within the university departments and affiliated organizations in which faculty are appointed. Unencumbered by the requirement to deal with such issues, the GPN is more comparable to a curricular group within SIO than to the Institution as a whole.

Faculty members affiliated with the GPN describe its leadership as a collective effort and characterize the program as relatively flexible and unstructured. One individual suggested that part of the GPN's success may be rooted in its youth and the absence of long-standing traditions and traditionalists. As within SIO, a lack of rigidity and blend of self-organization and effective leadership provide fertile ground for GPN scholars and entrepreneurs to take initiative. On the other hand, the lack of structure presents few clear pathways to success.

Bell Laboratories' Physical Science Research Laboratory (PSRL)

Bell Labs' PSRL includes approximately 150 scientists, including 30 post-doctoral researchers. Supervised by a director who reports to a company vice-president, nine department heads and five technical managers oversee research conducted by the technical staff. In contrast to SIO and GPN, PSRL does not concern itself with graduate training, except in a few isolated cases; however, it must deal with an array of business issues less relevant to the two academic organizations. While self-governance and shared governance figure prominently within academia, PSRL's industrial orientation relies much more heavily on a strong hierarchical system in which it is always clear who makes management decisions. It should not be inferred from this statement that the research environment lacks intellectual freedom, or that scientists' views are unimportant in management decisions—on the contrary, researchers enjoy the support of the company in pursuing their scientific and technological interests. Managers, themselves scientists, recognize and encourage staff members' intellectual pursuits.

While it is more generally the case that management decisions are made within the hierarchy of the administration, staff scientists clearly can strongly influence research directions. An administration of good scientists recognizes good ideas that "bubble up", and it is perceived that a good first line manager is one who can recognize these good ideas and facilitate them, while all the while being aware of the corporate mission.

While less formally empowered than their university counterparts, Bell Labs' staff advisory organizations report to the senior management on issues ranging from science to technology to staff morale. These organizations do not have the power of the academic assembly but do carry influence on decisions. At Bell Labs, an effective administration usually has a strong "kitchen cabinet" of staff.

Overriding this organization is the company mission, for which the Director is responsible. It is his job to justify the research on the basis of the long term mission.

Hiring and Promoting the Best and the Brightest

Attracting and keeping outstanding scientists is the highest priority for both academic and private-sector research organizations. We look at how SIO and PSRL, as well as UCSD's Neuroscience Department, in which nearly a third of GPN faculty hold appointments, have been successful in hiring the best and the brightest scientists. In all three organizations, maintenance of high standards is practically accomplished by hiring, promoting, and releasing. Within the university, Academic Senate procedures uphold high standards. Strong institutional reputation, the presence of a world-class professional community that includes young creative thinkers, commitment to active recruiting, and willingness to let individual talent rather than scientific specialty frequently drive hiring decisions are among the factors that contribute to these organizations' successes.

Success breeds success. Organizations that enjoy reputations of scientific excellence attract outstanding researchers. For several decades the GPN has produced accomplished young researchers, whose achievements continue to reflect well on the UCSD program and its faculty. Likewise, for nearly a century SIO graduates have gone on to become world leaders in the oceanographic community. Bell Labs PSRL though not directly involved in graduate education very actively supports post-doctoral research and has been instrumental in launching the careers of many young scientists. The very presence of bright young scientists at these institutions, as well as the respectability their continued career success conveys on the programs responsible for their training, draws outstanding researchers. Many successful scientists throughout the world have passed through these institutions and their careers have benefited, while in return they have contributed to the intellectual fervor during their stay.

Consider the GPN that does not itself hire or promote faculty. Interestingly, this loose program is a salient enticement to prospective faculty in many traditional university departments. Active, voluntary participation in the GPN entitles faculty to supervise the high-caliber graduate students that the program attracts. Since many of these students are funded by grants from the UCSD Medical School, The Salk Institute, the UCSD Office of Graduate

Studies and Research, and the National Institute of Health, the full burden of support for students does not fall to individual researchers as is the case in conventional departments. This mutually beneficial arrangement in which the interdisciplinary, inter-departmental GPN and the individual university departments are strengthened suggests that development of such cross-departmental graduate training programs is a worthwhile endeavor.

In addition to its valuable role in drawing outstanding faculty and students to UCSD, the GPN may represent a model of scholarly reform. A provocative statement made by a senior professor illustrates an intellectual advantage of the multi-disciplinary program. In explaining that the GPN is not overly subject to the parochialism of any individual department, he asserted that "departments are graveyards where faculty are buried." He went on to describe how peer evaluation, so critical to funding, publication, and promotion decisions, encourages stasis and narrow focus among academicians. There is little incentive in a traditional department to branch out, despite this professor's observation that so much "interesting stuff happens at the fringes or between fields." His answer to this dilemma is formation of institutes, labs and centers created explicitly to pursue research at the margins. A recent example illustrates the point: a chorus of researchers from across the UCSD campus and sister institutions, with the support of the UCSD administration, worked together to raise the funds to build a research grade FMRI (functional magnetic resonance imaging) facility that is now in the planning stages. This leading edge laboratory will surely serve as a recruiting tool.

As we think about how the presence of bright, capable students enhances the research environment, it is also worth contemplating the merit of hiring junior faculty and staff who infuse an institution with fresh ideas and creative vitality. Since young researchers cost less than their more senior colleagues, it would seem that adding to the entry-level ranks would be fiscally as well as scientifically attractive to a growing research organization. Indeed, the director of Bell Labs' PSRL related that of the three dozen people hired over the last two years, the vast majority are young scientists and engineers. A sizable flow of Bell Labs' research staff into product divisions as well as other institutions and corporations allows continual replenishment of young researchers. Within UCSD's Neuroscience Department, of the five FTE appointments made over the last three years, four were at the assistant professor level. These groups seem to be doing well in fortifying their ranks with young professionals.

Though young scientists are reasonably well represented in SIO's research series, there is a relative dearth of young (under 40 years of age) faculty. While the reasons for this are complex, it appears that a hesitancy to hire young faculty may be rooted in concerns about the Institution's ability to maintain sufficient and consistent quality control at the promotion and tenure stages. Nearly 90 percent of faculty who come up for tenure are awarded it. While the

high tenuring percentage is typical of units at the University of California, the percentages at top-ranking private institutions in the US are typically much lower. With such a high percentage of faculty promoted to tenure this way, there is reluctance to hire young, unproved scientists. Several SIO faculty members suggested that resurrection of an institutional post-doctoral program could provide an effective funnel and filter for new hires.

It is clear that change is on the horizon, for SIO has recently moved to rejuvenate its faculty and research staff by hiring predominantly at the assistant level. The Director and faculty engaged in broad discussions concerning how as many as 9 faculty and 6 research positions should be utilized to foster the long-term intellectual vigor of the institution. While there was consensus on the commitment to hire young scientists, there were tensions concerning the relative merits of directing the search for candidates at individuals with expertise in specified areas, versus conducting broadly defined searches with the goal of attracting the very best scientists, irrespective of specialty. Ultimately, SIO decided to recruit in only four very broad areas. It took a year to consider the hundreds of applications received, but in the end SIO succeeded in landing its first choices for the six junior positions. Two of the successful candidates were geochemists, an area not recognized organizationally at SIO. This suggests that individual excellence was the most important consideration in the institution-wide faculty vote.

UCSD's Neurosciences Department, in which many GPN faculty hold appointments, conducts very broad searches, specifying as many as a half-dozen diverse areas in which they intend to hire. These position announcements have produced an extensive field of qualified applicants, from which outstanding candidates have been hired. Primary criteria in candidate selection have more to do with excellence of an individual's research than with her or his field of specialization. Recognizing that such a flexible approach might be serve SIO well in its goal of attracting the very best earth, ocean and atmospheric scientists, the Director has set in motion a novel process for stimulating faculty-wide discussions and potentially creating consensus on new directions and new hires. With this process underway, the cross-disciplinary discussions have generated a valuable exchange of ideas among colleagues.

Within a system of shared governance in a state-supported university, the university is obliged to adhere to public hiring regulations and procedures that can slow the process to a snail's pace, much to the frustration of prospective employers and employees. In the business world, such constraints are negligible. The PSRL Director, reporting to a Bell Labs' Vice President, can and does respond quickly in offering positions to outstanding job candidates. Offers can be made within a few days if the situation warrants it.

In contrast to the usual university course in which a position announcement is issued to identify candidates, hiring at PSRL relies extensively on

active, personal recruitment by Bell Labs' scientists. Researchers assigned "prime recruiter" responsibilities regularly travel to major universities throughout the US and internationally to identify and follow the careers of outstanding graduate students whom they encourage to apply for post-doctoral and junior positions. Similarly, when appropriate, they encourage more experienced academic colleagues to join the Bell Labs research team. A close relationship between the prime recruiter and the university is maintained. Often the recruiter is a graduate of that institution and is in a good position to identify the best students.

Within the business community there is more latitude than within the university to offer fiscal and other incentives to top-notch prospective employees. Among the most alluring enticement an industrial lab can offer is freedom from the continual exigency of generating funding proposals, an often fruitless, energy-consuming activity that can be the bane of university researchers.

Turning briefly from the issue of hiring personnel to evaluating and rewarding employees' contributions, once again we note substantial differences between the academic and industrial approaches. The procedure by which academicians are promoted in the University of California is formal, involves numerous time-consuming steps, and requires considerable input from colleagues both within and outside of the institution. In contrast, PSRL conducts annual performance reviews for every member of its technical staff during an intensive one-week session. Department heads and technical managers together consider each individual's accomplishments during the previous year and over the preceding several years. Employees whose productivity is questionable are given assistance in resolving difficulties and ample opportunity to improve their performance. On average, fewer than one percent of employees leave the company as a result of their unsatisfactory performance. Following PSRL's performance review week, lab leaders conduct a strategy meeting during which they take a good hard look at what changes should be made to enhance individual and collective productivity. Compared to the academic system for faculty evaluation, the industrial model is more efficient, better streamlined, offers more constructive feedback to both employees and management, and allows more flexibility in performance-based rewards.

What can research university leaders learn by studying the hiring and promotion processes within an industrial research lab? The success of PSRL's recruiting suggests that using professional connections to stimulate interest in joining a research group can be an effective tool in attracting highly talented personnel. The model also suggests that it might behoove academic research institutions to streamline their hiring and promotion procedures to keep pace with their private sector counterparts. Finally, more extensive private or public endowment of academic research could significantly improve recruitment and scientific performance of top-notch university researchers.

While much of this discussion implies an advantage that a scientist at Bell Labs has over his or her academic colleagues, the independence of researchers at SIO and GPN counterbalances the advantages of Bell Labs discussed above. Scientists in the academic environment, while more heavily burdened with raising their own support, are much more independent in their choice of research direction. A faculty researcher doesn't have a "boss" in the same sense as a researcher at PSRL has. This independence results in a more individualistic and entrepreneurial style inside the organization.

FACILITATING INTERNAL COMMUNICATION

Assembling a team of brilliant scientists is a requirement in building an outstanding research institution; creating an environment in which these great minds can interact is the subsequent fundamental challenge. By no means is research excellence predicated on collaboration; many outstanding scientists do their best work independently. However, the ease with which members of a research organization can recognize colleagues with common interests and coordinate research initiatives is perhaps a measure of internal institutional synergy. Beyond building a sense of community, collaboration is increasingly essential in addressing multi-disciplinary scientific issues. With the current ease of global electronic communication, a scientist in California might find it as easy to exchange data (but not necessarily work) with a colleague in Tokyo as with a colleague in the lab down the hall. What can or should be done to facilitate communication and encourage collaboration among scientists within an institution?

When we posed this question to a dozen university professors and researchers, their initial responses amounted to a collective shrug of the shoulders. At SIO, most agreed that there is room for improvement in internal communication. They expressed concern, however, that the task is daunting at so large an institution where curricular and research groups are de-coupled and individuals are affiliated to varying degrees in multiple subdivisions that tend to view each other as competitors for resources rather than members of the same team. One associate professor bemoaned the weakness of internal communications within her research division of 40 people, and sighed that the climate at SIO can best be described as "every man for himself". Some roots of this divisiveness are no doubt historical in origin, and those gnarled fibers are resistant to extrication.

While the road to improved communications may be rough, members of the SIO community and outside institutional reviewers agree that the time has come to begin to pave the way. Whether or not the process will entail major structural changes remains to be seen. The goal will be to strike a bal-

ance between preserving the flexible, individualistic organization that fosters exciting science and an entrepreneurial spirit and promoting collaborations that foster interdisciplinary projects. Some tempering of overly assertive personalities that may threaten institutional cohesiveness may be required.

The Bell Labs organization is masterful at internal communications. One of the most important responsibilities of the first and second level administration is to bring together scientists with overlapping interests and complementary skills. Indeed, managers are measured and rewarded for these accomplishments. As a result of the annual performance review, each manager acquires a good sense of the interests, skills and accomplishments of every staff member. Much of the discussion of the performance evaluation is aimed at bringing scientists together on problems of interest.

Furthermore, seminars, journal clubs and focus groups are institutionalized. It is part of the culture to attend internal seminars in which debate, discussion and ideas abound. Scientists and managers routinely attend these regularly scheduled seminars. Everyone is expected to contribute periodically to these seminars; they are used in performance evaluations and rewards.

In thinking about how to facilitate internal communication at SIO, it may be worthwhile to analyze when and how scientists interact, and identify barriers to dialog. The most successful scientific collaborations are self-initiated. Commonly built on a history of mutual professional respect, these joint efforts arise almost spontaneously among scientists in the same or related fields. Opportunities to learn about the work of colleagues in other disciplines, however, may arise infrequently, limiting cross-disciplinary communication. Exacerbating this paucity of opportunity is a natural tendency to stick with the familiar rather than endeavor to understand, much less participate in fields in which we are less knowledgeable. On top of all this, spatially immaterial, but psychologically immense, geographical barriers to interaction inhibit communication.

In this era when ubiquitous access to electronic communication seems to shrink space and compress time, it might seem as if physical separation no longer presents a barrier to scientific communication and collaboration. Yet, somehow, the physical size and structure of a research organization do affect, either beneficially or deleteriously, the level and effectiveness of internal communication among individuals and groups. It is interesting to note that the perception of physical distance may be more important than true distance in shaping attitudes about the cohesiveness or fragmentation of the institution. It has been observed that, at Bell Labs, collaborations thrive over a range of about 100 meters on the same floor of a building and on adjacent floors. Farther away, interactions amongst colleagues decline dramatically. This could be regarded as a surprising result in this era of electronic communications, but it illustrates clearly how important personal interactions are.

Prior to exploring strategies aimed at forging ideational connections that transcend geographical impediments, we contrast perceptions of distance within two university organizations. At SIO, scientists work in more than two dozen buildings spread out over a seaside campus of less than one-half square mile. In some cases, the structures house scientists with similar research interests; others accommodate specialists in diverse fields. While the actual distances among buildings, offices, and people are not great, and the mild climate is conducive to walks and lunches outdoors, it is surprising how infrequently many scientists make the effort to visit their colleagues in nearby buildings. A perception among many at SIO, that the institution is a loose confederacy of individuals, is reinforced by the inscrutable internal structure described earlier.

Oddly enough, GPN faculty, who are spread out over a much larger physical area (on the order of 5 square miles) than SIO scientists, expressed a stronger sense of community and seemed less influenced by physical separation. Since it's unlikely that these individuals are far more physically fit than their SIO counterparts, we must look elsewhere to account for this observation. One tenable explanation is that the GPN faculty network is united by a more clearly defined sense of joint purpose. Graduate student training is the cardinal mandate of the GPN, whereas SIO scientists must interact with colleagues to contend with a dizzying array of issues. Dealing with more tractable tasks may create a situation where collegiality thrives and spatial separation does not seem to hinder cooperation.

Additional factors that come into play in fostering cohesiveness within the GPN involve the nature of neuroscience research and the structure of the student program. Many scientific problems involving brain structure and function require multiple techniques and instrumentation available only in particular laboratories. In the course of formulating and carrying out experiments, students are often the catalysts for the exchange of ideas among their faculty advisors. Students rotate among several laboratories during their first year and later are commonly co-advised by faculty from two or more different departments. Cross-pollination facilitated by student "bees" continues as students carry out their research. The role of students in catalyzing scientific exchanges among professors may be paralleled by Bell Labs managers who instigate and support collaboration among members of their staff.

One overriding contribution to communication and interaction is the interdisciplinary nature of all three institutions. No one investigator can have all the skills, equipment and expertise in his or her lab to remain at the edge of their discipline. Interactions then becomes the necessity in order to compete. If the quality of the investigators is such that being "second" is not good enough, the scientists will seek out knowledgeable collaborators and complementary techniques.

Let us turn now from observations about collegial interactions – or lack thereof – to viable suggestions for counteracting perceived geographical obstacles to communication, in effect, "extending the virtual corridor" as one SIO professor eloquently put it.

Seminars and Retreats

Institution-wide seminars can be effective in providing a non-intimidating forum in which to learn about colleagues' research. Incentive to attend and interact can be bolstered by concluding each seminar with light refreshments in an atmosphere conducive to conversation. SIO has recently begun to experiment once again with periodic institution-wide seminars presented by highly engaging faculty. Attendance by faculty at GPN weekly seminars is strong, and faculty attend mini-retreats – three times a year for three hours each – to promote internal communication. At Bell Labs, too, staff members present internal seminars that are highly stimulating, interactive, and well-attended.

Informal Social Events

Casual, social encounters present outstanding opportunities for researchers to exchange ideas and sow the seeds for more formal collaboration. Bringing together scientists to chat over coffee, lunch, or cocktails can stimulate exchanges that seldom occur in the course of more formal meetings and seminars where the pressure to impress one's peers is more intense. Introductions of unfamiliar or newly hired members of the organization are another important benefit of social gatherings. This is particularly important in larger institutions with many subdivisions where the natural encounter rates among individuals tends to be low. At SIO the Director hosts monthly coffee & bagel get-togethers in various locations on the SIO campus, and the Institution finds occasions for collective celebrations.

To encourage participation in informal social events and reinforce an institution's atmosphere of collegiality, directors might consider extending personal invitations to some of these events and perhaps limit the size of the groups to promote more personal interactions and draw out colleagues with a tendency toward shyness. To have one's presence personally requested is an honor and conveys an impression that the leader(s) of the institution value the invitee's contributions to the organization.

Encounters in the Course of Daily Activities

Where and when possible, shared facilities such as mailboxes, copy machines, fax machines, and even attractive break areas can be arranged to draw people out of their offices and labs, increasing the likelihood of casual encounters.

Many faculty members voiced their conviction that the most effective strategies for enhancing interactions among scientists involve uncontrived meetings in the course of everyday activities. Several enthusiastically echoed a desire that SIO establish an attractive centralized cafe or pub where scientists could gather informally. Already burdened with too many formal meetings, university researchers favor low-energy opportunities for dialog.

Introductions via Newsletters

Weekly newsletters announcing seminars and meetings might include a feature on a "colleague of the week". A brief summary of the individual's professional and personal interests could be accompanied by a photograph. Each year this practice would offer 52 opportunities to meet or learn more about colleagues in the organization. Such unceremonious introductions would make it easier for people to initiate conversations.

Benefits of the approaches described here may extend beyond sowing seeds for potentially fruitful scientific exchanges; improved communication can lead to better-informed decisions on matters of institutional importance as well as engender a stronger sense of community. It would not be at all surprising to find more formal institutional meetings infused with a new sense of civility and respect developed in a context of personal and professional familiarity. Heightened communication among individuals in different divisions could also be useful in resolving real or perceived differences in the way these groups function. Recognition of shared or overlapping interests among individuals and groups could facilitate the identification of joint funding opportunities and even potential new job candidates. Considering their low-cost and potential rewards, the approaches outlined here seem to be logical starting points in efforts to improve internal communication.

SUMMARIZING KEYS OF SUCCESS

Our examination of two academic organizations and one private industry research division reveals management practices that foster research excellence:

1. Whether management is strongly hierarchical or more loosely structured, ensuring that individual scientists participate in decision-making processes promotes effective leadership and contributes to the overall health of an organization.
2. Recruitment and promotion of bright, young scientists and/or students, who lead into new directions, challenge the establishment, and create headaches for administration, fosters research excellence. In turn, a reputation for research excellence is a factor in attracting and retaining the best scientists.

3. Hire the best people, placing less emphasis on specialty and more on individual talent. Employ active recruiting strategies, and strive to streamline hiring and promotion procedures.
4. Create an environment of collaboration and competition. Some internal competition is healthy, but it must be managed so that it is not destructive.
5. Mitigate geographic barriers to internal communication by facilitating informal as well as formal encounters among individuals. Students can be particularly effective in catalyzing scientific exchanges.

CONCLUSIONS

Perhaps the most striking observation is that, despite their differences, these organizations are all highly successful. None of the three is structured as a traditional academic department; all are larger than a typical university department, and seem more able to cope with the diverse demands of interdisciplinary research. Each has evolved its own approach to its internal structure and governance, which presumably responds to the particular challenges presented by its research goals and by its mission. One has to be very careful not to be overly prescriptive as to what constitutes success. Nonetheless, the clear thread that runs through all three institutions is that the quality and motivation of the scientists is the *sine qua non* of success.

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