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Confronting the social context of science.

Summary

Much of biological science both in academia and in the for- profit sector is done in complex group and organizational settings. The Human Genome Project highlights one prominent example of collaborative biology. However, in addition to successful collaborative efforts, there are many that do not succeed or are hampered by issues that transcend the scientific. Chief among these issues are those that fall into the social dimension of science, encompassing interpersonal conflict, poor team dynamics, and dysfunctional organizations. Science-based organizations and the higher educational system need to recognize that the practice of science requires more than technical skills. Our educational system must develop and provide scientists with the tools to function in and manage the social context of complex scientific endeavors. By ignoring the impact of the social environment in which science is practiced, graduate and professional programs are shortchanging their students and the organizations in which they will work.

Is there a problem?

American universities do a superb job of teaching scientific and technical skills to those who choose science as a profession. While there will continue to be debates as to whether we are producing too many or too few scientifically trained professionals, those that we do train are generally thought to be reasonably well prepared to pursue their careers. Are they?

Having spent over 20 years in academic research and nearly 7 in the biotechnology sector I have come to the conclusion that they are not. Scientists are typically well trained in the technologies and academic subjects of their discipline. However, they are missing a set of skills, which handicaps them both in academic and for-profit environments. These are the interpersonal, social and organizational skills needed to practice science in a social context. These skills include conflict management and negotiation skills, working in and managing teams, understanding and working within complex scientific organizations, and communication skills.

Every first year graduate student can relate stories of projects stymied or collaborations hampered by principal investigators who fail to communicate clear objectives; simmering conflicts gone un-addressed and of team members who function more as antagonists than supporters. The private sector is afflicted by all of the problems encountered in academe (interpersonal conflicts, poor team dynamics, turf issues etc) and a few of its own. Although as the barrier between academe and the private sector, especially biotechnology, becomes more porous, the problems will become indistinguishable. (As my experience is in Biotechnology I will use this industry in my examples, but parallels will be found in many other applied sciences).

Scientists who enter the biotechnology industry spend their first 3 or more years adapting with difficulty to new reward structures and new work paradigms. In academia rewards come largely on the basis of individual achievement (although much of the work is done in teams). In the private sector well-meaning attempts are made to reward on the basis of team performance. Under such conditions, young scientists may hoard information or ideas and use them as currency to enhance their individual status. In biotechnology especially, projects begin and end for reasons that are often opaque to bench scientists. Because scientists become intellectually bonded to projects, they often react to this experience with feelings of frustration and of being manipulated. In some cases they may avoid fully committing themselves to projects to minimize disappointment. These behaviors hamper productivity and are typically attributed to individual personality issues. In fact they are a direct result of the poor preparation that scientists receive for functioning as a member of a team, and of the failure of scientific leaders to anticipate and deal with the human consequences of scientific and business decisions. In short, both the members and leaders of science efforts are deficient in skills that extend beyond the technical discipline of their specialty.

There is evidence of increasing awareness of the need to address this deficit. A recent NIH conference on "Catalyzing Team Science" (1) focused on issues of teamwork in the life sciences, albeit from a rather limited and mechanistic perspective. Also, some graduate programs attempt to address communication and other "meta" scientific skills. However, those programs that offer training in management related skills typically do so as part of specialized certificate programs poorly integrated with mainstream degree programs. In many cases these efforts are perfunctory in part because scientists have a strongly held belief that if you get the science right everything else is irrelevant.

While this belief view may be harmless in a scientist working by his or her self, it is detrimental when adopted in a social or organizational scientific context and constitutes a fatal conceptual error when adopted by scientists in the private sector.

Scholarly studies in other disciplines reveal that biological scientists are no more likely to fall into the trap of focusing only on the technical aspects of their discipline than others. Analysis of catastrophic failures in the chemical industry (2), in the space program (3) and in military contexts (4) is instructive. As noted by Cohen and Gooch (4) the principle cause of failure to learn from military disasters lies in the tendency of analysts to focus exclusively on technical and logistical explanations. This narrow focus betrays a naive indifference to the roles of leadership style, command structure, and of the organization as a whole. By the same token, because the business of biotechnology is one which is deeply rooted in science, what post hoc analyses of success and failures there are tend to focus on the science, technology and economics, and fail to include the organizational and managerial context in which the science was applied.

It is a tribute to the individuals and organizations involved that despite managerial and organizational problems, science, and often superb science, gets done. Scientists in training will bear an enormous amount of conflict, ambiguity and heavy-handed manipulation in order to achieve their educational and professional goals. Unfortunately, in addition to acquiring superb technical skills, trainees frequently are imprinted with the same dysfunctional managerial skills as their mentors. . If we take the view that work style is as important for scientific and business success as technological methods and approaches, this is a serious deficiency.

The opportunity lies in increasing the scope of scientific training in the service of improved communication, greater productivity and, from the perspective of the private sector, greater return on investment. Seizing the opportunity requires an explicit recognition that much current biological science is inherently a team, group or organizational activity done in the context of economic, business and social constraints. Training scientists without attention to this larger context makes no more sense than training soldiers in the use of automatic weapons without simultaneous training in teamwork and group tactics.

To improve the social context of science we must first understand it.

The biological science community itself needs to pay as much attention to how science is done as it does to the technologies used to do it. Moreover, it needs to teach its students the skills to do science with as much diligence as it teaches the science.

Scientists attend meetings and read journals to learn about new techniques, tools and discoveries to accelerate and inform their work. But there is no way for them to evaluate, acquire or learn new or different ways to organize and manage a research effort. In some cases, popular accounts of scientific endeavors such as Watson's "The Double Helix," (5) depicting the academic realm, and Werth's "The Billion Dollar Molecule," (6) following the birth of a Biotechnology company, expose the broader context in which the science was done. But these accounts are typically more entertaining than informative or instructive.

How can the scientific community develop a deeper understanding of the impact of social context in the scientific workplace? A useful approach might be what Cohen and Gooch (4) have called "applied historical studies," which they advocate as a method to uncover the social and organizational roots of complex events. Such studies could document, in addition to the science, the social, group and organizational context of projects selected for their didactic utility and can be organized as case studies.

The use of case studies to teach by example

Carefully prepared case studies of scientific successes and failures, which address technical, organizational and economic factors, can be as useful in science education as they are in law and business. Biological science graduate programs typically have a required graduate course focused on analysis and critique of scientific publications. Here the focus is, and appropriately so, on the technical aspects of the work. Imagine expanding the context in which this work is studied to include discussion of the following topics:

- ❖ This work represents collaboration between two groups at different institutions. How did the collaboration with the other institution go? Were there problems? What were they? How were they resolved?

- How was the order of authorship determined? What kinds of discussions or negotiations were involved? Was this problematic?
- Did the project proceed down unproductive paths along the way? What were they?
- Were there turf issues during the project? How were they dealt with?
- Did the team function smoothly? If not why not? How were conflicts handled?

Short of summoning authors of scientific papers before panels of inquisitive graduate students eager to learn from their success and failures (possibly a good idea), thoughtfully prepared case studies can supply the needed data. The preparation of useful case studies is in itself no trivial matter. The identification and avoidance of pitfalls in the preparation of such studies can be abstracted from work in other fields (7).

By the same token, it is increasingly common to find that students receive instruction in writing an effective grant proposal. Why not an effective business plan? Here the added dimension is the economic viability of a project as impacted by relevance to a health problem, intellectual property protection, regulatory issues, and market factors. Here also, case studies of research projects or companies that succeeded or failed as a result of economic, regulatory, or other non-technical reasons can be developed. Students do not need to become experts in any of these themes to gain an appreciation for these issues. Moreover, with increasing frequency even those who aspire to a career in academia need more than technical skills, as academics who have dealt with technology transfer offices can attest.

While there are lessons to be learned and paradigms to be uncovered from such studies, the objective is not to provide rigid rules to be followed. The goal is to foster an increased awareness of and attention to dimensions of science in which we have all been working but which we acknowledge only when their impact is so extreme as to result in startling failure.

The use of workshops to teach by experience.

Experiential learning is the most effective approach for acquiring or improving interpersonal, managerial and organizational skills because what needs to be learned are not concepts but behaviors. Learning behaviors requires insight, practice and feedback. Insight because, as suggested by Daniel Goleman in "Emotional Intelligence" (8), if you are not aware of the behaviors you exhibit you will be unlikely to be able to evaluate their effectiveness or alter them. Practice because current behaviors are deeply embedded and are difficult to change by simply thinking about change. Feedback, because few of us are able to accurately gauge the effectiveness of our own behaviors. Such learning can be imparted through workshops incorporating role-playing and feedback. Institutional and regional workshops focused on those issues listed in Box 1 seem an appropriate place to start.

Box 1.

Some of the themes that should be addressed as part of the educational process include:

1. Managing the R&D process: setting goals and communicating them clearly; project lifecycle; project management.
2. Negotiation skills for scientists: reaching an agreement without a fight
3. Conflict resolution in the science workplace: recognizing that conflict as inevitable and addressing it in an open collaborative manner.
4. Leading science meetings and teams: respect for time, agenda and task.
5. Understanding and dealing with cultural and gender diversity in the scientific workplace: a reality that is almost universally ignored in the scientific workplace.
6. Communication: writing and speaking skills. The distinctions between addressing technical, business and lay audiences. This is a theme that needs to be addressed on an ongoing basis in all years of graduate education.

The principal challenge in teaching such skills are time and staff. Graduate programs are already crammed with courses of instruction, seminars, lab rotations and more. The pressure to enter a lab and start producing results is at times overwhelming. Even if time could be made however, who would do the teaching? There is no pre-existing cadre of people who have a sufficient understanding of the scientific work place as well as a strong grasp of the above skills to do the job. Moreover, it would be a mistake to recruit organizational consultants who teach analogous skills to the business community. The paradigms, social mores and needs of the scientific workplace are different from those of the "business" sector. Moreover, scientists are a notoriously unforgiving group when lectured by those who don't understand the business of science.

I suggest that a cadre of scientists can be trained as trainers, possibly at a national level sponsored by the NIH, the Hughes Institute or other agencies, within 18-24 months. Initial introduction of the above themes into graduate programs can begin by having these trainers run workshops within their own organizations or regions.

Over time literature can be developed by and for science practitioners that addresses the social context of specific scientific disciplines. However, many good written sources of guidance are available now. In Box 2 I have listed four books that may be useful supplements to those seeking to expand the scope of their science skills.

Box 2

Book	Comment
"Emotional Intelligence" Goleman (8)	Start by becoming self-aware. A good place to start learning about your behavior, what influences it and how it influences others
"Getting Past No" Ury (9)	Loaded with practical nuts and bolts tips on how to deal with human beings.
"Managing Scientists" Sapienza (10)	Possibly the only book written in this topic. Worth reading.
"Complete idiots guide to project management" Baker and Baker (11)	90% of what you need to know is here. Leave the rest to professionals.

Conclusion

The biotechnology and pharmaceutical industries, and by extension American health-care, have the most to gain from expanding the scope of science training into the social dimension. These industries employ thousands of scientists and spend billions annually on health-related research. If expanding the scope of science training has even a small impact on any one project or in any one organization, the overall social and economic impact can be significant. Moreover, public and private organizations that support academic research have a strong interest in ensuring that their research dollars are spent on those investigators, projects and institutions that maximize the chances for success. Such organizations should encourage, sponsor and fund these expanded educational efforts. By providing paradigms for the study of and improvement of the social and organizational context of life sciences educational institutions can be the catalysts for a new class of breakthroughs in life science discovery and productivity.

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