Preface—Lessons from PEN: Scientific Collaboration and the Search for Synergy

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Synergy, according to the open-source, online encyclopedia Wikipedia (http://en.wikipedia.org/wiki/Main_Page) is defined as follows:

> Synergy or synergism (from the *Greek* synergos meaning working together, circa 1660) refers to the phenomenon in which two or more discrete influences or agents acting together create an effect greater than the sum of the effects each is able to create independently.

When, in 2000, the James S. McDonnell Foundation (JSMF) announced that support for collaborative activities would be a major component of its new 21st Century Research Initiative, JSMF staff spent a fair amount of time and energy discussing the specific qualities that would make proposals successful. In reality, much of the scientific research, especially in areas that are by their very nature multidisciplinary, involves collaborations. Collaborations span the scale from individuals working together in a laboratory to multiinstitutional networks. Even a casual glance at the names and affiliations of the authors of journal articles in, for example, *Nature Neuroscience* indicates that team-based research is increasingly the norm. So in what way would the JSMF collaborative activity awards recognize and encourage a type of collaboration differing from the norm?

Central to our thinking, and derived from the foundation's prior experience with study panels, networks, and centers, was the notion of "synergy." Of course, to seek synergy leaves one open to charges of unacademic trendy thinking or susceptibility to management guru-ese. In our minds, though, there is a difference between the traditional forms of scientific collaboration and what we hope to seed through a new funding initiative. The advantages of standard scientific collaboration tend to be additive. X with expertise Y contributes Z, and A with expertise B contributes C, and so forth. The final product is roughly equivalent to the sum of the parts. Each party contributes what they already know how to do, and the different pieces are stitched together. What JSMF envisioned was supporting collaborative activities whose core characteristic was bringing together carefully selected groups of researchers around a shared problem. In fact, the shared problem, the core set of questions around which the proposed team was centered, had to require

that the combined expertise and knowledge of the group would transcend the sum of the parts. In other words, the proposal would make clear why already too-busy people were willing to take on yet another commitment of time, energy, and resources. Our intent was that the collaborative activity awards would not support the ongoing work each of the collaborators was likely to pursue (and secure funding for) in her or his own laboratory. Rather, the funds would deliberately support the infrastructure required for deeper collaboration to emerge (more on this below) and provide seed money for experimental questions arising in response to group interactions. The collaborative activity award funding was intended to support the "more."

In the years since first announcing the collaborative activity awards program, JSMF has steadily refined the criteria for evaluating collaborative proposals. In addition to the "sum being greater than the parts," the foundation now looks more carefully at not only how synergy emerges from collaboration, but how synergy comes to characterize the very nature of the collaborative group itself. Synergy (continuing with the language of Wikipedia) can create a dynamic state in which combined action is favored over the sum of individual component actions and behavior of whole systems unpredicted by the behavior of their parts taken separately. A willingness to be open and accepting of the unpredictability component is a particularly vital characteristic, in the foundation's experience, of truly successful collaborations.

We still marvel that one of the very first letters of inquiry received by JSMF fulfilled both the letter and the spirit of the collaborative activity initiative. It was submitted by Vanderbilt University on behalf of Isabel Gauthier and the Perceptual Expertise Network (PEN). JSMF anticipated that granting collaborative activity awards would be akin to spotting rare birds—we expected infrequent sightings but ready recognition. PEN is a *rara avis.*

The description of the collaborative activity awards posted on the JSMF website were (and still are) deliberately vague. If, as we hoped, collaborative activities were to be shaped around a particular issue, then it followed that the fabric of each collaborative group proposed would be uniquely woven to fit the need. JSMF intended to leave it up to the investigators to tell us what it was that they needed and how they wanted to structure the work. An attribute of PEN that struck us as remarkable, although less so now in retrospect, was the professional youth of the proposed collaborative's principal investigators, several of whom were, at the time, untenured assistant professors. We had assumed that the risks associated with working collaboratively on difficult problems with unpredictable courses and outcomes would more likely appeal to established scientists seeking opportunities for undertaking new challenges. In hindsight, it makes sense that a group of young scientists would welcome the opportunity to explore new ways of doing science—and to seek funding that would make it possible to both formalize and scale up the ways of working together that they were, informally, already pursuing. PEN was one of the very first collaborative activity awards approved for funding by JSMF. As the papers in this volume attest, PEN represents a remarkably

successful way of doing science. PEN also offers some important lessons for those interested in fostering collaboration.

The various public and private institutions funding science are not immune to following trends, and at the moment supporting collaboration is "in." At science policy forums and scientific meetings there is a fair amount of discussion on why answering many of today's pressing research questions requires teams of people with differing areas of expertise working together. In principle, this may very well be true. In practice, it is not that easy to accomplish primarily because we really do not have a good definition of what it is we mean by "collaboration." As mentioned above, collaboration of a certain kind is typical of how most science gets done. The organizational structure of laboratories, departments, schools, institutes, professional societies, and so on encourages the sharing and dissemination of techniques, tools, information, and personnel. Despite the powerful cultural image of the lone wolf genius, most scientific research is carried out by teams and small groups. It is when the attempt is made to reach across broad disciplinary boundaries or to span levels of analysis that collaboration, and encouraging collaboration via incentives such as grants, becomes tricky. Recognizing variations in experimental traditions, developing a shared language, uncovering hidden assumptions, valuing another's expertise, sharing credit, and trusting one's colleagues takes tremendous commitment. This kind of effort must be driven by the needs of the problem to be solved, it cannot be mandated by institutional administrators or by funding agencies.

PEN's success can be credited, in part, to the problem the group identified. Understanding how the brain acquires perceptual expertise requires the work of cognitive psychologists, neuropsychologists, cognitive neuroscientists, computational modelers, and others. It requires that data obtained from human and animal subjects with a variety of different methods and at different levels of analysis be meaningfully integrated. Members of PEN had to be comfortable constraining one another's explanations and questioning one another's assertions. The research questions were not all mapped out at the beginning of the project; instead, the research questions evolved, new directions unfolded, and new possibilities for experiments were decided on by the group as a whole. Developing the trust that makes shared work possible among researchers occupying physical locations all over the map takes leadership and it takes time. The PEN members recognized this and made it an explicit component of their project. They explored how best to use face to face meetings, web conferences, visits to laboratories, and shared resources to achieve the three aspects of synergy ("more", dynamic action, and unpredictability) discussed above. The evolution of the interactions across laboratories is evidenced by the graphs displayed in the first figure of the Introduction (see page 4). Initially, the formal interactions across laboratories form rather sparse connections but were quickly diversified and strengthened. It is also noteworthy that the connections across laboratories do not resemble a hub and spoke design. The PEN members are not held together because of individual connections with one central group.

What has JSMF learned about supporting collaborations? First and foremost, the fundamental nature of the problem to be solved must require the proposed collaboration. It should be clear how bringing together a group of people is going to achieve more than what could be achieved if the Foundation simply funded each researcher to go on doing what it is they do and share their knowledge through traditional academic routes such as publications and lectures. Second, there must be funds explicitly provided for administrative support, meetings, travel, sharing information, and for pilot experiments so new ideas can be tested quickly. The grant should be flexible in terms of how the funds are expended. Funding should be provided for a reasonable period of time: not less than 5 years, and often as long as a decade. Most importantly, we have found that these awards can be used to encourage the asking of deep questions, tackling difficult problems with uncertain outcomes, pushing the limits of knowledge, and creating new frameworks for the doing of science.

The work in this volume fully attests to the novelty and excitement of both the work being done and with the very process of doing that work. Best of all, this is only the beginning. Expect more.