Journal of Research Practice
Volume 3, Issue 2, Article M21, 2007

ISSN: 1712-851X

Main Article:

Interdisciplinarity, Transdisciplinarity, and Beyond: The Brain, Story Sharing, and Social Organization

Paul Grobstein
Bryn Mawr College, Bryn Mawr, PA 19010, USA
pgrobste@brynmawr.edu

Abstract

An apparent conflict between preferences for hierarchical as opposed to distributed organizations is evident in arguments about disciplinary and interdisciplinary organization. It characterizes as well a wide array of other arenas ranging from the biological to the political. In this article, parallels between biological, neurobiological, and social observations are explored in an effort to outline a general approach that may be useful in thinking about interdisciplinary and transdisciplinary activities as well as forms of social organization in general. A key element in the approach is an ongoing individual and collective process of story creation, sharing, and revising. The article is offered both as a contribution to better understanding interdisciplinary and transdisciplinary work and as an illustrative example of the potentials and problems of such work.

Keywords: inquiry; brain; emergence; hierarchy; distributed organization; story

Suggested Citation: Grobstein, P. (2007). Interdisciplinarity, transdisciplinarity, and beyond: The brain, story sharing, and social organization. *Journal of Research Practice, 3*(2), Article M21. Retrieved [date of access], from http://jrp.icaap.org/index.php/jrp/article/view/98/92

Imagine a group of geese flying across the sky. One goose is in front, and the others successively further behind on each side in a V-formation. Many presume that the front bird is the leader, a distinctive goose who has special characteristics that it uses to keep the other geese in line. A presumption that collective organization like the V-formation depends on a leader in the sense just described, that is, on a hierarchical organization,

seems deeply engrained in human thought. This hierarchical image of a collective process is depicted in Figure 1A.

Now imagine a group of local representatives to a national constitutional convention. Each representative harbors, to one degree or another, a conviction that each one is the best judge of the potentials and needs of the constituency it represents; each representative also fears it will be disadvantaged by any centralized authority and thus prefers untrammeled self-determination. This image of a collective process is depicted in Figure 1B. An inclination to resist hierarchical organization is perhaps as ingrained in humans as is the presumption that such hierarchy must exist.

In this essay, I aim to unsettle the notion that a hierarchical organization of the sort presumed in the case of flying geese (or feared in the case of the constitutional convention) is either desirable or inevitable. I also aim to unsettle the idea that the only alternative to such a hierarchical organization is a feared or fancied anarchy, in the sense of either unbridled "relativism" (Grobstein, 2005b) or completely decentralized egalitarianism (cf. Brafman & Beckstrom, 2006). The most common and most successful organizations known, those typical of the biological world, are in general neither hierarchical nor anarchic but involve instead what I will call *distributed interactive architectures* (Figure 1C). The human brain itself displays a distinctive multilevel version, what I will call a *bipartite* or *hybrid* (Grobstein, in press) architecture (Figure 1D), which I will argue provides an exemplary model not only for academic multidisciplinary work but for human social organization in a wide variety of circumstances.

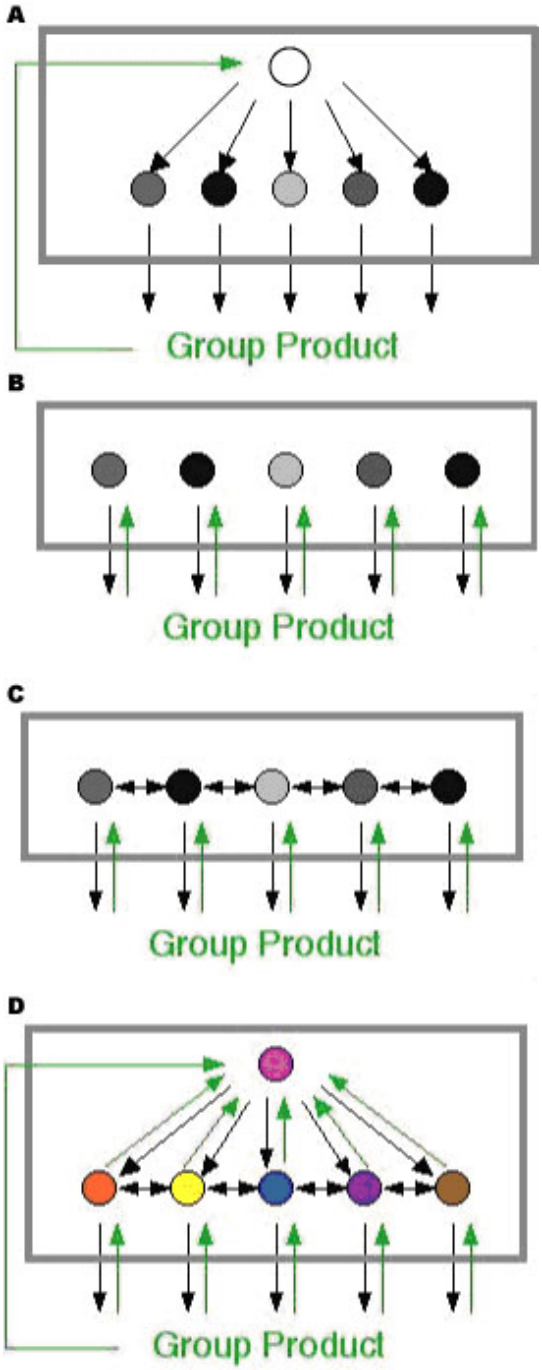

Figure 1. Schematic information flow architectures. Dots are processing elements; arrows show the patterns of information flow between them; boxes demarcate the structures from the surroundings. "Group Product" is the outcome of the collective activity of the elements that interact directly with the surroundings. Part A shows hierarchical organization, Part B shows anarchic organization, Part C shows distributed interactive organization, and Part D shows a bipartite or hybrid distributed interactive organization, including the *fuschia dot* at the top.
(Adapted from http://serendip.brynmawr.edu/local/scisoc/leadership04/leadership.html)

In making this argument, I will draw not only on biological, neurobiological, and computer modeling observations but also on my own experiences in the social arena, particularly 7 years as founding director of the multidisciplinary Center for Science in Society at Bryn Mawr College, USA. The Center was founded to promote "the broad conversations . . . which are essential to continuing exploration of . . . the natural world and humanity's place in it" (Center for Science in Society, n.d.; Dalke, Grobstein, & McCormack, 2006a, 2006b). As such, the Center has served as a laboratory for exploring, developing, and testing ways of encouraging and supporting broad conversations, and assessing their usefulness. I offer this essay in the same spirit. If multidisciplinary work is meaningful in its own right, a minimum requirement is to show that disparate perspectives can be productively brought together to suggest ways of understanding that would be less likely to evolve from particular disciplinary perspectives. Beyond this, it needs to be demonstrated that such understandings are in turn not only relevant to a wide array of both disciplinary and practical human problems but also create new directions, questions, and problems worth further exploration. It also needs to be demonstrated that interdisciplinary conversations are not only achievable but can be sustained. I hope readers will engage with this essay not only in terms of its particular arguments about academic and social organization but also viewing it as a sample of what interdisciplinary work makes possible and hence its associated potentials and problems.

1. Distributed Interactive Architectures

A major general insight of the twentieth-century and early twentyfirst-century science, itself the product of interdisciplinary work including computer modeling, is that a highly adaptive collective organization can result from interactions among entities none of which function as a leader (Dalke, Cassidy, Grobstein, & Blank, 2007; Grobstein, in press; Johnson, 2001; Keller, 2003; Resnick, 1994; Serendip, n.d.). Flocking behaviors in birds and other organisms can be accounted for in terms of interactions among individuals all of whom are equivalent and follow the same internal instructions (cf. Wilensky, 1998). The same is true of, for example, task allocation in ant colonies (cf. Cyckowski & Grobstein, 2006) and synchronization of flashing displays in some species of fireflies (Strogatz, 2003). Humans are by no means unusual in this regard. The "wave" displayed by audiences at many sporting events reflects a collective order created by individuals all following the same internal instructions (get up after people to your left get up, then sit down). There are a variety of more ordinary social and economic phenomena where collective organization seems to have a similar "emergent" character (Gladwell, 2000; cf. Emergent Systems Working Group, 2004). Indeed, Adam Smith's "invisible hand," the core of the capitalist economic theory of market exchange, is appropriately thought of as an expression of coordinated collective behavior in the absence of a leader.

What is particularly germane in the present context is that "leaderless" organization, reflecting distributed interactive architectures, seems to be very much the norm rather than the exception in biological systems generally, at all levels of organization from the social to the molecular. DNA, to take one example, is increasingly understood to be not the "organizer" or "blueprint" of living organisms but rather a particular molecular array

that interacts with a variety of other molecular arrays in such a way that particular organisms "emerge." Similarly, neither the heart nor the brain is the "leader" of a multicellular organism like a human; instead each of them interacts with each other and a variety of other entities to yield the phenomenon we call life (Grobstein, 1988). The same holds for the brain itself; it consists of a larger number of interacting regions from which emerges, for example, the picture we see when we look at the world and, more generally, consciousness (Grobstein, 2003a, 2005c, in press).

These examples differ from the simpler forms of collective order involved in flocking, ant colonies, and the like, in that the interacting elements are heterogeneous rather than indistinguishable. At the same time, they share with them the essential characteristics of distributed interactive architectures (Figure 1C):

(a) No element is *in control*; instead each influences and, in turn, is influenced by other elements. Causal relationships are bi-directional rather than one way.

(b) No element has complete information about the functioning of the assembly as a whole; instead each element acts in terms of partial information and its own organization, sharing information about its own activity with the other elements.

(c) No element represents an unchallengeable *objective* for the assembly as a whole; instead the appearance of an overall objective exists only for an observer and reflects simply the semi-independent activities of the elements as modified by their patterns of information sharing.

The characteristic that distinguishes these systems from anarchistic ones (Figure 1B) is not the presence or absence of a leader but rather the extensive and reciprocal interconnections that distinctively characterize them. That distributed interactive architectures, rather than hierarchical organization, is the norm in the biological world raises some very interesting questions about why humans tend to presume that organization depends on a leader. Perhaps more importantly, it suggests that the presumption needs serious reexamination (Brafman & Beckstrom, 2006; Surowiecki, 2004). Biological systems are themselves the product of evolution, of billions of years of trial and error, in which more effective organizations persist while less effective ones disappear. It is hard to escape the conclusion from biology that by and large systems involving distributed interactive architectures work better than hierarchical ones, at least in the kinds of continually, somewhat unpredictably changing environments in which evolution has been occurring.

2. Bipartite or Hybrid Architectures Having Story Tellers

A significant and, in evolutionary terms, apparently quite recent variant of distributed interactive architectures is exemplified by the human brain (and probably that of most mammals). As illustrated in the lower part of Figure 2, the human nervous system can be usefully thought of, for the most part, as consisting of a large number of relatively specialized modules (Fodor, 1983; Minsky, 1986) that interact with the outside world and

display some significant collective coordination due to the kind of information sharing that characterizes distributed interactive architectures in general. Like other instances of such organizations, the assembly appears to an external observer to have "objectives," without in fact having any such thing explicitly represented in any single element of the assembly, each of which functions in terms of local information and organization.

There is, of course, a potential disjunction between such a characterization of the human brain and the experiences one has of a distinctive and unitary *self* who is both coherent and has objectives. Some people are more aware of their internal multiplicity--what Marvin Minsky termed "the society of mind" (Minsky, 1986), some are less so. Regardless, it is probably the sense of a more or less coherent self, who is (or is supposed to be) "in charge" of what we do and expects it to be done in line with its own "objectives" that inclines us to presume hierarchical organizations involving leaders as the norm.

Among the reasons for our misleading experiences with ourselves is that the human brain includes, in addition to an array of interacting specialized modules that function largely without our awareness of them, a second architectural layer (probably the *neocortex*, upper part of Figure 2) that appears to have been enabled by evolution to achieve a single, coherent representation of the collective entity that consists of itself and the rest of the nervous system. This representation constitutes one's conscious experience, one's description of oneself, and one's relation to the world, including one's sense of objectives and of alternatives that might be pursued to achieve them (Grobstein 2003a, 2005c, in press).

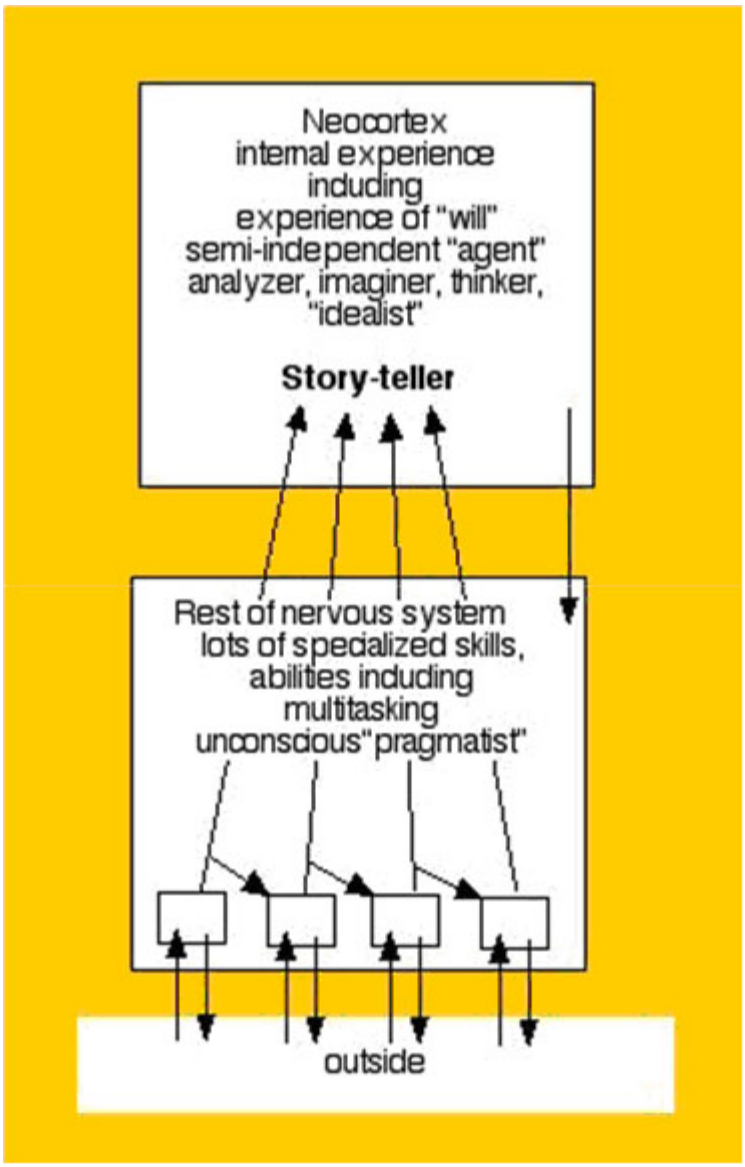

Figure 2. Schematic illustration of the bipartite illustration of the human brain. The upper and lower boxes represent the unconscious and conscious (the "story teller") respectively, with the former consisting of a number of specialized discrete modules that interact with the outside world (arrows at the bottom of the figure). Additional arrows show the general patterns of information flow within the brain.
(Adapted from http://serendip.brynmawr.edu/bb/bipartitebrain)

I will, in the following, refer to this representation as a *story*, to emphasize that it is "made up" to account for observations of oneself and one's relations to other things, rather than being a definitive description of either oneself or of things outside oneself (Grobstein, 2003a, 2005c, in press). Hence it is always subject to challenge and revision. I will refer to the elaborator of that story, from the information it gets from other elements of the society of mind, as the *story teller*. The resulting *bipartite* organization, with our conscious experience consisting only of stories, makes us largely unaware of the

collective that gives rise to our own behavior and to our experiences both of ourselves and of the world around us, and also makes us inclined to attribute hierarchical organization not only to ourselves but to other things as well. The human brain is actually a special kind of interactive distributed system--one that includes an element specialized to try and achieve global coherence and elaborate at least transient global objectives.

In fact, as we experience to varying degrees, our conscious selves are rarely "in control"--to the extent they think they are (cf. Kolata, 2007). Furthermore, they are, in many circumstances, a less trustworthy guide to adaptive behavior than is the unconscious community with which they interact (cf. Gladwell, 2005). To put it differently, the story telling part of the brain does not, despite our perceptions, actually function as a hierarchical leader. It is instead simply an additional specialized element of a distributed interactive architecture, with our behavior reflecting sometimes our conscious objectives, sometimes the outputs of the differently specialized diverse elements that make up the brain, and most often interactions among them.

The distinctive specialization of the story teller follows from its architectural relations to the rest of the brain. As illustrated in Figure 1D, the story telling element (the fuschia colored dot at the top does not have any direct connection with the outside world. It receives information about things outside the nervous system (i.e., the rest of the body and the external world) only from other elements of the nervous system and acts on things outside the nervous system only through them. It is, in this architectural sense (and this architectural sense alone), an upper level element, strictly dependent on the other elements for interactions with things outside the nervous system. While other elements interact with and are modified by interactions with things outside, the story teller interacts with and is modified only by interactions with things inside the nervous system.

The effective function of the *fuschia dot* (a neologism that I shall use in the following to refer to the story-telling layer of hybrid architectures, whether occurring in the brain or elsewhere) thus depends fundamentally on receiving continuous and convergent information from an unusually wide array of the other elements of the society of mind, reporting not only their activities but the analyses they have made of the local information they have. These constitute feelings, intuition, emotions, and the like. It is from these inputs that the *fuschia dot* creates its stories--coherent ways of making sense of the cacophony of signals it gets from the other elements of the society of mind. Just as the lower level elements work to make sense of aspects of the body and world to achieve local objectives, so does the story teller work to make sense of the array of signals it gets from the society of mind in terms of global objectives it synthesizes from the reports it gets about the success and failures of other elements.

It is the existence of this upper level story generating capability, in the bipartite architecture, that gives the human brain capacities that extend beyond those of simpler distributed interactive architectures. The story is at any given time, and with varying degrees of consensus, a representation of the assembly as a whole, of a global objective that can in turn be used to assess the performance of the assembly as a whole. The story, redistributed through the assembly, is also a way to suggest modifications in the

performance of parts, based on a wider array of information than is available at any given time to any given part. Most importantly, perhaps, the story is phrased in more abstract and general terms that allow for its ready modification by imagining simple "what if?" conditions. The upshot is that the story becomes itself a significant influence on the behavior of an organism, as does the capability to conceive and try out things that have not yet existed. The brain is an interactive distributed system, but one with a specialized element that creates broad pictures of itself and the world not only as they have been experienced but also as they might conceivably be, and does so in terms of a small number of more or less consistent global understandings rather than a large number of potentially competing local ones. The relatively small number of interacting features and their easy recombination gives the *fuschia dot* a distinctive ability to conceive new possibilities.

Such a system has superficial similarities to a hierarchical system (compare Figures 1A and 1D), but is in fact quite different. The story teller or *fuschia dot* has no more inherent power or authority than the rest of the elements of the community of mind. Its "upper level" character is entirely an architectural feature; it is a generalist whose capabilities depend on the wide array of inputs it gets from more specialized systems and whose effectiveness depends entirely on its ability to create from them stories that they can accept and work with. Its stories are neither inevitable nor "true" (Grobstein, 2004a, 2005a, in press), being instead constantly subject to revision based on the information it receives from other elements. The stories provide a mechanism to improve coordination within the community of mind as a whole and, perhaps even more importantly, have the potential to alter the organization and performance of the other elements, so as to create behaviors that would not otherwise exist. The organization is neither anarchic nor that of a hierarchy with a leader, nor is it a fully distributed system lacking any localized representation of the system as a whole. Instead it is a *hybrid*--a distributed system with specialized elements including ones distinctively specialized to create and revise candidate stories for the assembly as a whole. It is an architecture within which there is continuing report and negotiation, with some elements focused on more local tasks and associated processes of information gathering, synthesis, evaluation, and creation related to them, and others (the *fuschia dots*) on similar tasks of information gathering, synthesis, evaluation, and creation operating over wider terrains.

Such bipartite or hybrid architectures, just like the broader category of distributed interactive systems of which they are a subset, are a product of evolution, suggesting that they too work better than hierarchical architectures, at least in continually changing, somewhat unpredictable environments. This raises the question of whether they might not work better in human social contexts as well.

3. From the Brain to Social Organization: Interdisciplinary Conversation and Academic Structures

It is no coincidence that the picture of brain architecture described in the preceding section emerged in my own brain during a period when I was engaged in active exploration of not only the brain and computer models of emergence but also of academic

structures that would provide greater support and encouragement for interdisciplinary conversations. In dealing with emergent systems, with the brain, and with academic structures, I could not help but notice a similar need to find ways to think in one framework about both local and global processing (cf. Burke & Grobstein, 2003).

Anyone having experience with modern academic institutions will recognize their tendency to organize around disciplines, that is, around focused and specialized engagement with relatively narrow processes of information gathering, synthesis, evaluation, and creation--and also to resist, both intellectually and politically, equally significant efforts to work and make common cause over broader terrains. The tensions are frequently expressed in terms not unlike those used in constitutional conventions, substituting disciplines for "states rights" and interdisciplinary for "federalism" (Grobstein, 2003c).

My own instincts as a scientist and intellectual have always been otherwise (Grobstein, 2007, in press), and it was for this reason that I became involved in the creation of the interdisciplinary Center for Science in Society. In so doing, I found myself resisting giving an announced mission for the Center more specific than "to facilitate broad conversations . . . essential to continuing explorations of . . . the natural world and humanity's place in it," despite expressions of concern that such a statement was too diffused to be either understood or meaningful. Whatever the problems, the Center evolved successfully (Dalke, Grobstein, & McCormack, 2006a, 2006b), perhaps in ways that it might not otherwise have done. That in turn contributed to an emerging recognition that what I was interested in was a victory for neither disciplinarity nor interdisciplinarity, but rather a way to productively associate the two.

The notions of story, the *fuschia dot*, story sharing, and conversations seem to me to provide a valuable key to associating disciplinarity and interdisciplinarity. What is in academia less understood than it perhaps ought to be is that, in the last analysis, all disciplines are components of a common process of inquiry, and all share what are, at the deepest level, common practices not only of observing but also of story telling, story sharing, and story revising. Viewed in this light, it would seem obvious that interdisciplinary work can and should be valued in the academy. That it is less so than it might be relates, as I have come to believe, to architectural challenges, not unlike those influencing the evolution of the bipartite brain.

It is reasonable to think of disciplines as analogous to the components of the society of mind that are most directly in contact with the outside world, the specialized entities that are indeed often in the best position to evaluate the products and needs of their own activities in terms of their own experiences. One might in practice, as well as in principle, leave it to these entities and the interactions among them (as in Figure 1C) to evolve what is, at any given time, the state of the common practice of inquiry--both the "group product" and the group objectives.

In practice, though, this leads to problems, some obvious and others perhaps less so. The most obvious problems relate to disciplinary rivalry, which in turn directly reflects the

absence of any mechanism to effectively adjudicate resource allotment in terms of a shared group objective. The upshot is that the disciplines, particularly in times of limited resources, come to find themselves in competition with one another with no shared basis for evaluation of respective contributions and needs. In such an environment, an obvious way for a discipline to be more successful is to denigrate the value of the work of other disciplines. This tendency is exacerbated by a genuine need of the disciplines to acculturate practitioners in the standards of the respective disciplinary communities. In times of stress, this is often done in a way that conveys, explicitly or implicitly, that those standards provide a unique and privileged access to understanding and truth, or the stories of the particular discipline are superior to those of any other. The result is a tendency for the participants of a discipline to believe that their own ways of understanding are rooted in clear observations and appropriate interpretations of those observations, while those of other disciplines are "just stories" and so can be ignored.

It is particularly at this point that the recognition that all understandings are "stories" seems to me a point of great significance, not only intellectually but also politically and practically. I argued in the previous section that because of the way the brain is organized, all understandings are stories (see also Grobstein, in press) in two important senses. First, they represent an effort to make sense of observations without being precisely sure of exactly what was being observed and to what extent the observations were influenced by the observer/story teller. Second, they are inevitably only one of multiple possible ways of making sense of the observations and serve primarily not so much to understand what is as to conceive what might be, to motivate new questions and new observations (see also Dalke & McCormack, 2007). Hence, stories have value somewhat independently of the observations that give rise to them. New stories, and therefore new possibilities for further exploration, can arise as readily from comparing stories against one another as by comparing stories with new observations. The justification for interdisciplinary exchange and the distinctive role of the *fuschia dot* relates to the new things that may arise not only from combining distinct sets of observations but equally from hearing and contrasting distinct sets of stories. Stories are never "just stories"; rather they are, or at least should be, as integral to academic practice, to the business of inquiry, as observations, critique, and the other apparatus of intellectual activity.

> Learning to think like an economist has little value unless it is accompanied by learning how to share the fruits of that analytical approach and enrich its insights through conversation with others. Learning to see the world entirely through the prism of economics makes it nearly impossible to listen to others. (Ross, 2007, Section 1, para. 2)

The same can, of course, be said for physicists, biologists, literary scholars, and so on. Disciplinary focus has demonstrable values but so too does the kinds of broader perspectives that depend on exploring the worth of stories other than one's own. An ability to do so, just like disciplinary expertise, requires appropriate commitment and experience together with a clear recognition that all understandings, including one's own at any given time, are indeed stories, and hence both valuable and revisable. As an

inquirer, one is always playing a contributory role in a larger ongoing process. It is a process that inevitably occurs in a continually changing and unpredictable environment--no matter how clear and compelling the objectives seem at any given time. The *fuschia dot* needs to be particularly aware of this condition.

A similar argument holds in the arena of the political structures of academia. The disciplines have indeed special expertise in their own areas of inquiry--much as the delegates to a constitutional convention have in relation to the localities they represent. At the same time, there is a need for collective stories of the institution and the intellectual enterprise as a whole. These can and should be provided by people whose business it is to listen to and contrast the separate activities of the disciplines and create new and broader stories from that, which can be tried out in more specific contexts. This, rather than being a hierarchical leader, is the role of the *fuschia dot*, not to adjudicate among existing stories but rather to use them to create candidate new stories to be tested in the ongoing flow of continual bidirectional exchange. Both intellectually and politically, a multi-level distributed interactive architecture like that of the human brain can provide advantages in academic contexts missing in either hierarchical, anarchic, or single-layer distributed structures.

For this role, people are needed who have a willingness and inclination to acknowledge, rather than to challenge, the distinctive roles that different elements play in effective interactive systems and the value of the different stories they tell. To be both effective and sustained, interdisciplinary conversation depends on the existence of people whose personal satisfaction derives from hearing a wide-ranging array of stories, not to choose one among them but rather to create from the collection of them new and broader stories that in turn are meaningful for the original story tellers. In this sense, the *fuschia dot* facilitates interdisciplinary conversation because of a personal commitment not only to interdisciplinary conversation but to a more synthetic "transdisciplinarity" (Nicolescu, 2007).

This, in turn, raises some interesting challenges for the academic community, which remains for the most part nearly exclusively committed to the kinds of disciplinary training that have proven effective for intellectual work in the past. *Fuschia dots* or transdisciplinarians have been, for the most part, born rather than made, and have had to stubbornly persist in their activities against substantial discouragement in both academic training and advancement (cf. Grobstein, 1991). This may not be the optimal arrangement for the continuing evolution of the academic enterprise.

Institutional structures are changing in a way that is more encouraging and supportive of interdisciplinary conversation; the existence and ongoing development of the Center for Science in Society is one line of evidence for that (see also Building the Scientific Mind, 2007; National Institutes of Health, 2004; National Science Foundation, 2007; SENCER, n.d.). Whether the encouragement of interdisciplinary conversation around shared objectives agreed upon in advance will prove to be a sufficient mechanism to generate the needed increased numbers of *fuschia dot* and so transform a single layer distributed system into a genuinely multilayered hybrid system remains to be seen.

I think what will be needed is actually a more thorough-going reconsideration of the academic enterprise so as to encourage and support those whose inclinations are to make a career of listening to diverse stories in order to generate new ones and to provide them with the relevant exposure and training (cf. Szostak, 2007). The objective is not at all to eliminate disciplines but rather to acknowledge an equivalent need for transdisciplinarians, people whose inclination and preparation fit them to the task of promoting the much needed new adaptations to "unpredictably changing environments" and so whose work must necessarily be done at the risk of being for many, at any given time, "too diffuse to be either understood or be meaningful."

4. From the Brain to Social Organization: Beyond the Academic

Academic activities and structures may seem like a specialized arena of activity remote from day to day life and its challenges, but a persistent conflict between hierarchical and decentralized approaches is as real for everyday life as it is for the academic world. Here, I describe ways in which the products of multidisciplinary inquiry, in particular the idea of a hybrid distributed architecture involving specialized story tellers, may have relevance in additional, more practical realms and, in turn, be further developed by such applications. My objective is to broaden the concept of interdisciplinarity beyond its typical academic realm (see Cook-Sather & Shore, 2007). In so doing, I draw on my experiences as an educator, parent, and citizen, as well as co-founder of the Serendip Web site, "an expanding forum . . . to support intellectual and social change."

Classrooms and families provide familiar examples of tensions between hierarchical and anarchistic or fully distributed approaches. From a traditional perspective, teachers and parents are in positions of authority, the leaders who organize students and children. As any teacher or parent knows, however, the hierarchical structure is to one degree or another always under challenge, and experienced teachers and parents eventually come to recognize not only that fully hierarchical organization may be impossible to sustain but that trying to do so may in fact impede students and children in terms of their individual development as responsible and creative entities in their own right (Dalke et al., 2007). Single layer fully distributed architectures have their own obvious problems, akin to those seen in academia, including lack of grounds for adjudication of competing claims and a failure to develop and follow up on initiatives broader than those that occur to individuals involved.

Thinking in terms of a two-level interactive and distributed architecture and the sharing of stories offers a new perspective for thinking about classroom organization (Dalke & Grobstein, 2007). It repositions students as also teachers, relieving some of the resistances inherent in hierarchical structures and giving students more meaningful incentive to participate not only in their own education but that of others as well. It also repositions the teacher as not an authority but a resource to support individual explorations and as the "interdisciplinary" story teller who feeds back activities and creations of students as more comprehensive stories that in turn serve as the grist for continuing development of individual stories. Taking on the role of the *fuschia dot* opens the teacher to greater engagement with students and to greater creativity on his or her

own part. One can make similar arguments regarding the relations between parents and children. In both situations, there are gains to be made by choosing two-level interactive and distributed architectures over hierarchical, anarchistic, or single layer distributed structures, particularly if the teacher/parent sees the task as giving students/children the wherewithal to continue creating and revising their own stories in order to deal with a continually and somewhat unpredictably changing environment.

This last point deserves emphasis: a two-level interactive and distributed architecture is preferable *if* one anticipates a "continually and somewhat unpredictably changing environment." Under such circumstances, "[t]he universe has lost its center overnight, and woken up to find it has countless centers. So that each one can now be seen as the center, or none at all" (Brecht, 1966, p. 86; see also Grobstein, 2004a). While not everyone is, or should be, equipped by background or inclination to function as a *fuschia dot*, that opportunity should be available to anyone who aspires to it. The benefits of a two-level distributed organization should be available to and understood by all. Biological evolution occurring over millions of years has discovered a form of organization appropriate for ongoing change, one giving individuals the capability to recognize that in a world of no fixed centers they and/or others are themselves capable of becoming one. Human cultural evolution has been working for tens of thousands of years at the most and has perhaps yet to recognize that stasis and stability is ephemeral, and that humans have the wherewithal to move beyond it (Grobstein, 2004a, in press). Perhaps it is time, not only in education and childrearing, to bring culture more into line with our biological potentials?

The Serendip Web site is an exploration of the possibility of bringing about such cultural change, on a national and world-wide scale. As "a gathering site for people who suspect that life's instructions are always ambiguous and incomplete" (Serendip, n.d.), materials on Serendip are explicitly non-authoritative, providing not answers but opportunities for people to make use of other peoples' stories to further develop their own--and to leave their own stories for other people to make use of in their own development. It is a place for engaged conversation, for story sharing, on the presumption that it is the business of every individual not to get it right but rather to engage in an ongoing individual and collective process of "getting it less wrong" (Grobstein, 2006) and "finding ways to tell our collective human story from which no one feels estranged" (Grobstein, 2001).

In this context too my experiences suggest that an environment that supports wide participation in a decentralized system is necessary for productive social organization but not sufficient. Yes, "if we can see friends (and students as friends) as far more than ourselves, we may be taking a step necessary to the improvement of education, and the civic condition itself" (Burns, 2005). But in the virtual world, as elsewhere, creating and sustaining productive communities of friends depends on more than a willingness to allow it to happen; it depends as well on an inclination and ability of at least some friends to take on the function of *fuschia dots*, both to instantiate an arena within which people can value and effectively learn from each other and to notice and give voice to the new stories that emerge from such exchange (Grobstein, 2004b, 2004c, 2005d). It requires a developed ability not only to listen to the stories of other people but also to guess the

observations and interpretations underlying them, to deconstruct them, not to be critical but to abstract from them aspects that can be productively joined with aspects of other stories to create new ones.

5. Testing the Ideas

The products of inquiry are properly assessed not only in terms of the observations they effectively summarize but, at least as importantly, in terms of the new directions they suggest for further exploration and the openings they provide to think in new ways in which "stories" play an essential role. Refining the concept of a two-level distributed architecture poses significant new challenges in neurobiology, evolution biology, and computer modeling. Its extension into social organization, however, offers perhaps the most demanding arena in which to further refine the story and test its value.

The tension between the more local and the more global will not go away in culture at large or any part of it, but it can in principle be recognized for what it is: a continual and valuable mechanism for assuring not simply the testing of existing stories but the generation of new and productive stories as well. The key to doing so is to replace the concept of a hierarchy directed by a leader with, neither anarchy nor abject relativism, but rather with that of a multi-level interactive distributed system, one in which more local stories continually and reciprocally interact with more global ones with no a priori assumption that either has over-riding precedence--and to recognize that all individuals have valuable roles to play in such a system, as much because of their differences as because of their similarities (Grobstein, 1989), with some of them focusing more on local stories and others on more global ones.

Could we actually rebuild cultures, not only academic but otherwise, in such a direction (Grobstein, 2003b)? What would it take?

(a) A willingness and ability of individuals to lead lives that are continually in process, lives that they shape themselves in terms of values that are also subject to continual ongoing interaction with those around them, with an enthusiasm for being individually distinctive, not only for one's own enjoyment but for the benefits it provides others. "The more I learn, the more I realize more and more that how I think and feel is different" (Grandin, 2005, p. 168).

(b) A willingness and ability of individuals to tell their own stories as they exist at any given time, indeed an enthusiasm for doing so as a contribution to the stories of others and the collective human story.

(c) A willingness and ability of individuals to hear the stories of others, not as alternatives or competitors to one's own but rather as the essential grist for one's own story revisions and the further evolution of collective stories.

(d) A willingness and commitment to a permanent process of "getting it less wrong" (Grobstein, 2006)--to the evaluation of stories based on their usefulness in the present and their potential for generating new stories in the future.

(e) A socio-political-economic system that discourages hierarchical power relationships as well as anarchy and encourages instead continual bidirectional interaction among all humans, some contributing more local stories and others synthesizing more global ones.

(f) Confidence in the evolution of new and productive stories from such interactions that provide new solutions to existing problems, which requires a commitment to using the past and present to create new futures--rather than trying to shape the present to fit lessons learned from the past.

That may seem, on the face of it, a daunting prescription, one that flies in the face of existing social-political-economic norms, and perhaps even in the face of "human nature" itself. On the other hand, socio-political-economic norms are themselves collective stories and subject to change due to new stories and actions of individuals. My own experiences indicate that it is indeed possible to create environments at local levels that instantiate two-level interactive distributed architectures and that many individuals find, often to their surprise, that they feel more comfortable and productive in such structures. The challenge then is to find ways to scale such arrangements up to larger human groups. It is a challenge that may necessarily be met only with time, as people gain experience in more local settings and so begin expecting similar organization at larger scales.

As for "human nature", a principal theme of this essay is that there is not one, at least not when looking from a sufficiently broad perspective. "I am, and I can think, therefore I can change who I am" (Grobstein, 2004a) and also change things around me as well. Yes, we all start with certain understandings, preferences, biases, and the like (disciplinary or otherwise), including perhaps a wish for something stable and certain on which we can build our lives. But we are also story tellers (see Grobstein, 2007; Rorty, 1999), and that gives us the capacity to conceive what has not yet been and, potentially, to bring it into existence. If nothing else, I hope this essay serves to remind all readers that that capacity is built into their brains and can be used by everyone to create "less wrong" cultures, both small and large, reconfigured around those capabilities. If it actually led to more wide-spread efforts to test the value of trying to implement multi-level distributed systems at all scales, so much the better.

6. Epilogue

This essay is meant to be a sample of what interdisciplinary work makes possible and hence its associated potentials and problems. The essay is indeed a product of multidisciplinary work, one that draws on observations and stories deriving from explorations touching on a variety of disciplinary grounds. It reflects an attempt to construct from them a broader story--that of the significance of a two-level distributed architecture and the role of story telling in it--that might not have emerged from any one.

The broader story is of potential relevance to all disciplines and raises significant new questions in its own right.

What of the problems? Is the story told here "too diffuse to be either understood or meaningful"? More importantly, is that an inevitable hazard of interdisciplinary work? In some ways, I think the answer to the more general question is clearly, Yes. An important and valuable characteristic of disciplinary organization is the ease of productive interactions within a community of explorers who share a common sense of the current state of understanding, of the methods by which new understandings can be achieved, and of the accessible questions at any given time. Interdisciplinary work, particularly of the transdisciplinary kind exemplified here, does not start with a sense of accessible questions but rather with a commitment to the notion that understandings, whatever their origins, are always incomplete and that the task is to recognize and make productive use of that incompleteness by noticing similar patterns across an array of largely independent lines of inquiry. Work of this kind is as much about creating new questions and associated new lines of exploration as it is about finding answers. So the risk of diffuseness, of creating stories that are neither understandable nor meaningful to others is very real. To the extent disciplines overlook the incompleteness inherent in their own perspectives, the results of transdisciplinary work may not appear meaningful within them.

There is also the risk of inadequate understanding of the disciplinary stories that one uses to detect broader patterns and also the risk of reading those stories through the lens of one's own preoccupations. How completely have I mastered the understandings of any of the disciplines on which I draw? Is my story of the bipartite brain actually a disciplinary story, or an idiosyncratic reading of research on the brain conditioned by other concerns? The answer to the first question is, of course, not completely at all. As to the second question, my characterization of brain organization is indeed an idiosyncratic story and unquestionably reflects influences other than those obtained within a disciplinary context. One cannot avoid either risk in work of this kind.

But none of these difficulties is unique to interdisciplinary or transdisciplinary work. These are occupational hazards of inquiry of any kind, including that conducted within disciplines. Moreover, there is a close parallel between the hazards of interdisciplinary and transdisciplinary work and the hazards the neocortex faces all the time in translating the cacophony of information it gets from our unconscious society of mind into coherent stories. There is a close parallel in the potential benefits as well. We create stories in an effort to generate coherence, to improve coordination at existing tasks, and, at least as importantly, to allow us to conceive new possibilities, ways of thinking that open new avenues of existence and exploration. The price we pay is an acknowledgement that there is no right way (yes, at any given time, there is a large numbers of equally good stories), but we gain in return the satisfaction of not only discovering but creating and recreating things not previously conceived (Grobstein, 2007, in press).

Yes, of course, there are problems in interdisciplinary and transdisciplinary inquiry, as there are in any other kind. They are the risks inherent to all inquiry, perhaps writ clearer

and larger. One never knows with certainty that a particular line of exploration will be fruitful, even in a disciplinary context. The ultimate significance in interdisciplinary and transdisciplinary research, as in disciplinary research, is the significance the work proves to have in advancing future explorations, both by oneself and by others.

Meanwhile, I hope this essay has at least challenged the reader to acknowledge the potential value of interdisciplinary and transdisciplinary research, of using what is currently understood and not understood to ask what new things can be conceived--doing so on whatever scales seem useful. Such inquiries may or may not yield answers to existing questions. They derive not from a commitment to solve any particular problems but rather to the process of inquiry itself. As such, they can and should serve as a reminder, both within the academy and beyond, of inquiry's unending trajectory of questioning and revising, of the value of the individual mind in that process, and as encouragement for all to participate in the ongoing evolution of inquiry.

Acknowledgements

This essay would not exist but for rich conversations with students, faculty, and staff colleagues at the Center for Science and Society, Bryn Mawr College, USA. I am in debt as well for the thoughtful comments of several anonymous reviewers of an earlier draft, as well as the opportunities, encouragement, and comments provided by Anne Dalke and Elizabeth McCormack, the co-editors of this issue, and D. P. Dash, co-editor of the *Journal of Research Practice*. My thanks also to my immediate family (Rose, Joan, Jed, and Rachel Grobstein, Margaret Hollyday, Lucy Kerman) for conversations and experiences that also contributed significantly to the development of ideas outlined here. To support the further evolution of inquiry, a public online forum for conversation related to this paper is available at http://serendip.brynmawr.edu/exchange/PGstories/JRP07

References

Brafman, O., & Beckstrom, R. (2006). *The starfish and the spider:The unstoppable power of leaderless organizations*. New York: Portfolio.

Brecht, B. (1966). *Galileo* (C. Laughton, Trans.). NY: Grove.

Building the Scientific Mind. (2007). Retrieved September 1, 2007, from http://www.learndev.org/BtSM2007.html

Burke, T., & Grobstein, P. (2003) *Emergence and contingency/purpose/agency: An exploration of an intersection between history and biology/neurobiology*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/complexity/mellon/index.html

Burns, W. D. (2005). *With friends like these*. Retrieved September 1, 2007 from http://serendip.brynmawr.edu/sci_cult/scienceis/burns.html

Center for Science in Society (n.d.). *Center for Science in Society*. Retrieved May 15, 2007, from http://serendip.brynmawr.edu/local/scisoc

Cook-Sather, A., & Shore, E. (2007). Breaking the rule of discipline in interdisciplinarity: Redefining professors, students, and staff as faculty. *Journal of Research Practice, 3*(2), Article M15. Retrieved October 30, 2007, from http://jrp.icaap.org/index.php/jrp/issue/view/6

Cyckowski, L., & Grobstein, P. (2006). *Ant colonies: Social organization without a director*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/complexity/models/antcolonies/

Dalke, A., Cassidy, K., Grobstein, P., & Blank, D. (2007). Emergent pedagogy: Learning to enjoy the uncontrollable and make it productive. *Journal of Educational Change, 8*(2), 111-130.

Dalke, A., & Grobstein, P. (2007). Story telling in (at least) three dimensions: An exploration of teaching reading, writing, and beyond, *Journal of Teaching Writing, 23*(1), 91-114.

Dalke, A., Grobstein, P., & McCormack, E. (2006a, May/June). Why and how to be interdisciplinary. *Academe* (Bulletin of the American Association of University Professors [AAUP]). Retrieved October 20, 2007 from http://www.aaup.org/AAUP/pubsres/academe/2006/MJ/feat/dalk.htm

Dalke, A., Grobstein, P., & McCormack, E. (2006b). Exploring interdisciplinarity: The significance of metaphoric and metonymic exchange. *Journal of Research Practice, 2*(2), Article M3. Retrieved October 3, 2007, from http://jrp.icaap.org/index.php/jrp/article/view/43/54

Dalke, A., & McCormack, E. (2007). Synechdoche and surprise: Transdiscipinary knowledge production. *Journal of Research Practice, 3*(2), Article M20.

Emergent Systems Working Group. (2004). *Thinking about segregation and integration: An interactive scientific exploration using models*. Retrieved September 1, 2007 from http://serendip.brynmawr.edu/complexity/models/seginteg/

Fodor, J. (1983). *The modularity of mind*. Cambridge: MIT Press.

Gladwell, M. (2000). *The tipping point*. Boston, MA: Little, Brown.

Gladwell, M. (2005). *Blink: The power of thinking without thinking*. Boston, MA: Little, Brown.

Grandin, T. (2005). *Thinking in pictures*. New York: Vintage.

Grobstein, P. (1988). From the head to the heart: Some thoughts on similarities between brain function and morphogenesis, and on their significance for research methodology and biological theory. *Experientia, 44*, 961-971.

Grobstein, P. (1989). Diversity and deviance: A biological perspective. *Bryn Mawr Alumnae Bulletin* (Spring Issue), 4-5. Retrieved October 4, 2007, from http://serendip.brynmawr.edu/tide/diversity.html

Grobstein, P. (1991). *This isn't just my problem, friend: Some thoughts on science education, education, American culture, and what to do about it.* Retrieved September 1, 2007, from http://serendip.brynmawr.edu/sci_edu/problem.html

Grobstein, P. (2001). *11 September 2001*. Retrieved May 15, 2007 from http://serendip.brynmawr.edu/serendip/11sept2001/

Grobstein, P. (2003a). Getting it less wrong, the brain's way: Science, pragmatism, and multiplism. In A. Ritvoi (Ed.), *Interpretation and its objects: Studies in the philosophy of Michael Krausz* (pp. 153-166). Amsterdam: Rodopi.

Grobstein, P. (2003b). *Must cultures disable*? Retrieved 15 May, 2007, from http://serendip.brynmawr.edu/forum/viewforum.php?forum_id=205#7367

Grobstein, P. (2003c). *Some thoughts on academic structure (and socio-political structures generally): A biological metaphor as an alternative to both state's rights and federalism at Bryn Mawr College (and elsewhere)*. Retrieved May 15, 2007, from http://serendip.brynmawr.edu/complexity/deptchairs.html

Grobstein, P. (2004a). *Writing Descartes*. Retrieved May 15, 2007, from http://serendip.brynmawr.edu/sci_cult/lesswrong/descartes/

Grobstein, P. (2004b). *An interim reflection on "Writing Descartes"*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/sci_cult/lesswrong/descartes/grobstein2aug04.html

Grobstein, P. (2004c). *The "how" of story sharing - II*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/sci_cult/lesswrong/descartes/grobstein5aug04.html

Grobstein, P. (2005a). Revisiting science in culture: Science as story telling and story revising. *Journal of Research Practice, 1*(1), Article M1. Retrieved October 3, 2007, from http://jrp.icaap.org/index.php/jrp/article/view/9/18

Grobstein, P. (2005b). *Fundamentalism and relativism: Finding a new direction*. Retrieved April 15, 2007, from http://serendip.brynmawr.edu/reflections/pubintell/relativism/

Grobstein, P. (2005c). Making the unconscious conscious, and vice versa: A bi-directional bridge between neuroscience/cognitive science and psychotherapy? *Cortex, 41*(5), 663-668.

Grobstein, P. (2005d). *Intellectual exchange as a medium for community building on the Web and beyond*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/reflections/FAHE05/

Grobstein, P. (2006). *Getting it less wrong*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/sci_cult/lesswrong/lesswrong/

Grobstein, P. (2007). *Paths to story telling as life: Fellow traveling with Richard Rorty*. Retrieved September 1, 2007, from http://serendip.brynmawr.edu/exchange/rorty

Grobstein, P. (in press). From complexity to emergence and beyond: Towards empirical non-foundationalism as a guide to inquiry. *Soundings*.

Johnson, S. (2001). *Emergence: The connected lives of ants, brain, cities, and software*. NY: Simon and Shuster.

Keller, E. F. (2003). *Making sense of life: Explaining develoment with models, metaphors, and machines*. Cambridge, MA: Harvard University Press

Kolata, G. (2007). *Rethinking thin: The new science of weight loss*. NY: Farrar, Straus and Giroux.

Minsky, M. (1986). *Society of mind*. NY: Simon and Schuster.

National Institutes of Health. (2004). *Overview of the NIH roadmap*. Retrieved September 1, 2007, from http://nihroadmap.nih.gov/overview.asp

National Science Foundation. (2007). *Interdisciplinary training for undergraduates in biological and mathematical sciences*. Retrieved September 1, 2007, from http://www.nsf.gov/pubs/2007/nsf07539/nsf07539.htm

Nicolescu, B. (2007). *A new vision of the world transdisciplinarity* (Voss, K.-C., Trans.). Retrieved September 15, 2007, from http://nicol.club.fr/ciret/english/visionen.htm

Resnick, M. (1994). *Turtles, termites, and traffic jams*. Cambridge, MA: MIT Press.

Rorty, R. (1999). *Philosophy and social hope*. NY: Penguin.

Ross, D. (2007). Learning not to think like an economist. *Journal of Research Practice, 3*(2), Article M12. Retrieved October 30, 2007, from http://jrp.icaap.org/index.php/jrp/issue/view/6

SENCER. (n.d.). *About SENCER: Overview*. Retrieved September 1, 2007, from http://www.sencer.net/About/projectoverview.cfm

Serendip (n.d.). *Complex systems*. Retrieved May 15, 2007, from http://serendip.brynmawr.edu/complexity/

Strogatz, S. (2003). *Sync: The emerging science of spontaneous order*. NY: Hyperion.

Surowiecki, J. (2004). *The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business, economies, societies, and nations*. NY: Doubleday.

Szostak, R. (2007). How and why to teach interdisciplinary research practice. *Journal of Research Practice, 3*(2), Article M17. Retrieved October 20, 2007, from http://jrp.icaap.org/index.php/jrp/article/view/92/89

Wilensky, U. (1998). *NetLogo Flocking model*. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL. Retrieved September 1, 2007, from http://ccl.northwestern.edu/netlogo/models/Flocking

Received 15 May 2007

Accepted 21 September 2007