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Revisiting Science in Culture: Science as Story Telling and Story Revising

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Abstract

Both science itself, and the human culture of which it is a part, would benefit from a story of science that encourages wider engagement with and participation in the processes of scientific exploration. Such a story, based on a close analysis of scientific method, is presented here. It is the story of science as story telling and story revising. The story of science as story suggests that science can and should serve three distinctive functions for humanity: providing stories that may increase (but never guarantee) human well-being, serving as a supportive nexus for human exploration and story telling in general, and exemplifying a commitment to skepticism and a resulting open-ended and continuing exploration of what might yet be. Some practical considerations that would further the development and acceptance of such a story of science as a widely shared nexus of human activity are described.

Keywords: scientific method; culture; truth; skepticism; story

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Both “scientists” and “non-scientists” have a tendency to regard science and culture as different and parallel (if not competing) things, between which one can (or must) choose. In the story I will offer here, science is not conceived of as an alternative (either neutral or competitive) to culture but rather as a central component of a human culture more broadly understood--a component that existed long before the term ‘science’ was coined and will long outlast current understandings of science as a specialized or privileged activity that can be engaged in only by members of a self-perpetuating professional community.

My objective in developing a story of *science as story* is not to attack science but rather to encourage the same kind of critical examination of our understandings of science that science itself promotes in its examination of other phenomena. A critical perspective associated with the practice of science as story telling is, I will argue, the source of science's demonstrable power. That perspective, turned on science itself, is needed for the continuing productive evolution of the distinctive and valued role science plays in human culture.

The needed critique of science is necessarily also a rethinking of the role of science in culture and hence of culture itself. It cannot be achieved without a very substantial blurring of the borders between those who think of themselves as scientists and those who think of themselves as something else. And the rethinking will, I believe, result in a further blurring of those borders in a way needed to make science an even more important contributor to the human culture, of which it is a part.

1. The Need for a Story

More than 50 years ago, the British scientist and novelist C. P. Snow, called attention to what he referred to as a "two cultures" divide:

> I believe the intellectual life of the whole of western society is increasingly being split into two groups. When I say the intellectual life, I mean to include also a large part of our practical life, because I should be the last person to suggest the two can at the deepest level be distinguished... Between the two a gulf of mutual incomprehension--sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding... This polarisation is sheer loss to us all. To us as people, and to our society. It is at the same time practical and intellectual and creative loss, and I repeat that it is false to imagine that those three considerations are clearly separable (Snow, 1963).

While there have been extensive discussions about what exactly constitutes the divide, there is no question that it relates to science. And there is no question that a divide between people who are comfortably engaged with science and people who are not persists today. In 2004, the *New York Times* celebrated the 25th anniversary of its weekly *Science Times* with a lead article entitled "Does Science Matter?" The authors wrote:

> [T]here are new troubles in the peculiar form of paradise that science has created as well as new questions about whether it has the popular support to meet the future challenges... Science has also provoked a deeper unease by disturbing traditional beliefs... (Broad & Glantz, 2003).

The tension between those who are comfortable with science and those who aren't may have been at one point primarily a disagreement among western intellectuals but it is now, as Snow forecast, increasingly significant in practical life worldwide, at scales

ranging from international conflict to national policy to interactions between individuals in educational and other contexts. A few comments I have recently collected in an educational context (Diversity and Discovery Institute, 2000) will illustrate the point:

> My personal view of science for many years was, well, summed up with one word, 'Yuck!'; in primary school it was indistinguishable from the morass of general information we learned from uninspiring textbooks and well-meaning, but insipid teachers. Middle school was worse: sterile classrooms in which science was lectured at us... Then came the nightmarish annual science project... Along with college pretty much came the exit of science from my life... *High school teacher*
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> Science came from a textbook with very little experimentation or discovery because all of the answers were written on paper, you just needed to read and understand them... There are teacher preparation programs that continue to steer clear of the subject unless you have declared science to be your area of certification... This in turn becomes apparent in some classrooms where we continue to breed a group of young people who are phobic about science... *Middle school teacher*
>
> Science has always been regarded as a very different approach to life. In fact, I used to think that it was a way of life for some weird people. Actually people see scientists as nerds in the society... *High school teacher*

Are we (both those of us who are scientists and those of us who are not but are engaged with and have some understanding of it) fully aware of what many people think about science? Of how many different stories about science there actually are? Of how remote those stories may be from the ones we have? And of what the consequences of that are, for us, for them, and for others (particularly, but not only, in the context of generating expectations in the future generations)?

Science education can, of course, be done in a way that presents a different story of science, but one still runs into problems. In a college introductory biology course, I suggested that the *Times* article misrepresented the terms on which science ought to be evaluated, and offered the following as a correction:

> The distinctive role that science has played in our culture... is to be the embodiment of permanent skepticism, of a persistent doubt about the validity of any given set of understandings reached by whatever means (including those of science itself). It is the insistence on doubting existing understandings, not the wish to eliminate human ills nor to find 'answers' that has always animated science and has always been the source of its power and successes (Grobstein, 2003c).

This elicited a prompt response from a particularly thoughtful student:

> This is a stirring appraisal of science and one that I would very much like to believe. But I'm beginning to have my doubts. In my conversations with others about the natural sciences and the social sciences, I have represented the views that you express in class--about the noble skepticism of science--as those of the scientific community at large. Now I sense my own naïveté in having done so. The tale that Broad and Glantz weave is a misguided one, so you say, but my question is this: you and what army? Are all scientists as given to reflection about what it is they are trying to achieve? Would every scientist agree that it is Broad and Glantz who are misguided? I feel there is a strong dichotomy between the doers and the thinkers, and it is the thinking minority that allows science to remain, in large part, unaccountable for what it has brought about (Su-Lyn Poon, Introductory biology student).

Su-Lyn's challenges were the stimulus for this essay. There is a need, both within science and in culture in general, for a less divisive and more widely engaging story of science. And it is a practical need, one that must be met not only in the classroom but in each of the many arenas where science is impacting on culture. It requires not only deliberate thinking about science but also acting deliberately in ways that reflect those thoughts.

Moreover, I strongly believe that the evolution of understandings of science is too important to be left solely in the hands of a closed community of scientists. What is needed is indeed an "army," a more diverse array of human beings who have in common a shared sense of science as a valuable component of human culture and a willingness to shoulder the burden of making it into what it has the capability to become.

Science has the potential to be what we all collectively need as we evolve into a world wide community: a nexus point that encourages and supports the evolution of shared human stories of exploration and growth, an evolution in which all human beings are involved and take pride (Serendip, 2004). For this to happen, we all need to work much harder to not only reduce the perception of science as a specialized and isolated activity of the few but to make it in fact the product and property of all human beings. I think the story of *science as story telling and story revising* can do this. And that the story itself follows straightforwardly from applying to science the same inclinations--to question and to revise our understandings--which have give science its evident power in other realms.

2. Science as Method: Strengths and Limitations

> [T]here has been one transforming change over this thousand years. It is the adoption of the scientific method: the commitment to experiment, to test every hypothesis... It is the open mind, the willingness in all aspects of life to consider possibilities other than the received truth... (Lewis, 1999).

For many, science is the cultural entity whose distinctive property is its claim to be able to uncover "impersonal laws" (Weinberg, 1996; Wilson, 1998), and, ultimately, the

'Truth.' Others see science as distinctive in its ability to enhance human security and well-being. Neither of these actually distinguishes science from other cultural entities. Many religions and political philosophies lay equal claim to providing special access to 'Truth,' along quite different paths and with quite different proposed or anticipated outcomes. And many nations, tribes, service professions, and other organizations regard the provision of safety and the assurance of human well-being as their mission, and may pursue it in quite different directions. Not unreasonably, the conflicting claims for the same turf generate antagonisms between those who are engaged with science and those who are not.

Is there any unique role that science has played in human culture, and should more self-consciously play in the future, perhaps one that could facilitate human community rather than produce divisions within it? Where is the core of science? There are of course no definitive answers to such questions, but let me suggest a direction along which some useful thinking might be done, beginning with a careful look at scientific method.

Figure 1 contrasts two descriptions of scientific method, one that was taught to me when I was an elementary school student decades ago, and a second that I currently use in my own teaching. There are several important differences. The earlier description uses words ('hypothesis', 'experiment') conveying a message that science is a specialized activity that can't be engaged in until one has, at least, learned the meaning of the words (which may themselves in some cases inspire further arcane images of white coats, laboratories, and so on). I'll return to the significance of this in the next section. Here I want to focus on two other comparisons: the use of the terms 'conclusion' and 'true' in the earlier description and their absence in the later one, and the linearity of the earlier description in contrast to the circularity of the second.

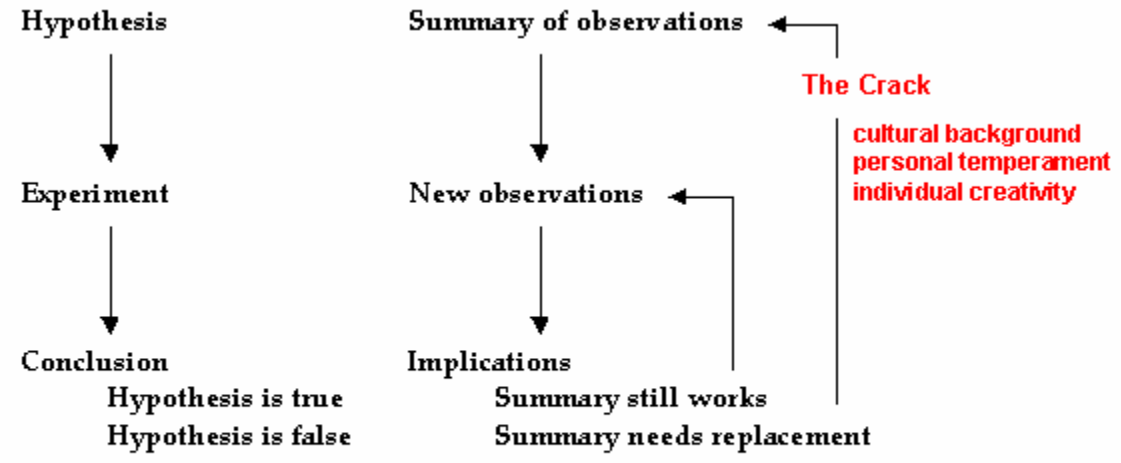

Figure 1. Schematic illustration showing more traditional (left) and more contemporary (right) ways of describing the "scientific method" (Grobstein, 2005a)

The scientific method, which I take as very close to the core of science, is very much *not* about determining 'Truth', nor even, except in a very limited sense, 'truth'. As indicated

in the right side of the figure, a hypothesis is nothing more (and nothing less) than a *useful way to summarize observations*. It is useful in the sense that it is shorter and hence more convenient than listing all previous observations. More importantly, it characterizes the observations in terms of some underlying pattern or principle that yields predictions about future observations. In this very real sense, the summary is a story--a way to make sense of observations made to date that provides a guide for future behavior. And, like all stories, it is inherently provisional. An experiment is nothing more (and nothing less) than the making of a new observation to see whether it matches the predictions made by the previously existing summary. It necessarily follows that no hypothesis can ever be proven true. A new observation can show that a previous story is no longer adequate (*falsify* the hypothesis); it can never show that a given summary will continue to be appropriate forever.

In short, the scientific method cannot validate universal claims (Popper, 1959); so scientific stories should never be regarded as candidates (or competitors) for 'Truth'. And they are true only insofar as one is satisfied with the provisional, i.e., with a story that summarizes all observations made up to the present. I don't deny the value of such stories in many practical circumstances, and certainly not the historical (and continuing) importance of replacing dogmatic stories with stories based on observations. I do think though that many people (even some scientists) tend to treat scientific stories as something more than summaries of observations to date, and that we need to work harder to make the inappropriateness of doing so generally understood. Science is not religion, nor is it mathematics (where truth plays an important but quite different role). Science generates stories from observations and, in this context, 'true,' if the term is to be used at all, means nothing more (and nothing less) than consistent with all observations *so far*. There is no conclusion in science; it is a continual and recursive process of story testing.

Science is importantly a continual and recursive process of not only story testing but also story revision, as indicated by the outer loop in the right-hand side of Figure 1. An observation that is not consistent with the story falsifies the hypothesis or, in our terms, shows the summary/story to be no longer adequate and creates a requirement for a new summary/story, one that accounts the new observations as well as the previous ones.

Such falsification is actually the most productive case in terms of science itself (as opposed, perhaps, to practical uses to which scientific stories might be put). Without falsifying observations, stories would become static, and science would end. What is important is making the unexpected observations. Science evolves more by being *wrong* than by being right. It is for this reason that a scientific hypothesis/summary/story remains necessarily *testable*; it should not only appropriately summarize observations to date but motivate new observations that may result in its replacement by a better story.

This point too deserves much more attention than it normally receives, both in classrooms and in other contexts. When given to believe that science is about getting things right, students (and others) are being seriously misled about the fundamental character of the scientific process. Like 'true,' 'right' has, at best, a very local and restricted meaning in

science: both refer to stories that have not yet been proven wrong. It is the wrong stories that actually advance the process of exploration and evolving understanding that is the objective of scientific method. Being wrong is to be celebrated for its *generativity*, rather than denigrated or discouraged as error, in classrooms and elsewhere.

Recognizing the importance of story revision in scientific method helps to further clarify both the limitations and the effectiveness of science more generally. Since there is no way scientific method can establish 'Truth' there is also no way to evaluate whether scientific stories are getting closer to it. On the other hand, the scientific method is, properly used, fully capable of supporting a process of becoming "progressively less wrong" (Grobstein, 1993). Each iteration of story revision requires accounting for a progressively increasing number of observations, including ones that were adequately accounted for by a previous story and new ones that weren't.

Science is continually testing not only its understandings of material under investigation but also its own ways of making sense of things it is investigating. A good example of the resulting changes in story telling *style*, in a field of research close to my own, comes from the beginning lines of a recent paper:

> We believe that names have a powerful influence on the experiments we do and the way in which we think. For this reason, and in the light of new evidence about the function and evolution of the vertebrate brain, an international consortium of neuroscientists has reconsidered the traditional, 100-year-old terminology that is used to describe the avian cerebrum (Avian Brain Nomenclature Association, 2005).

Clearly, what is important in science is not only observations but also stories, the sense that is made of the observations as reflected in, among other things, the names we use.

Albert Einstein's well known remark, "Physical concepts are free creations of the human mind, and are not, however it may seem, uniquely determined by the external world" (Einstein & Infeld, 1938) is relevant here. There is always more than one possible summary/story that will fit any given set of observations (Grobstein, 2003a). And so there is always a choice (conscious or unconscious) to further pursue one or another way of several alternative ways of *making sense of the world*. It is through this *crack* (see Figure 1) that science is perhaps most strongly affected by the individual temperament and cultural background of its practitioners. Many people regard that crack as a weak point of science, the place where the scientific claim of objectivity fails. I think it should be instead regarded as an asset: it is not only a place for individual creativity but also one that, as I'll discuss further below, contributes importantly to transforming individual efforts into collective ones. Regardless, what is being tested in scientific method is necessarily not only the nature of things being investigated but also the stories chosen to further investigate them.

Periodically, declarations of the "end of science" (Horgan, 1997; Stent, 1969) suggest either that the process of science has converged to a final answer or that the process itself is no longer adequate to contend with new observations. These invariably prove actually to be claims about current limitations of the way scientists pose questions, make observations, and/or develop new stories. That limits are noticed and efforts subsequently made to get beyond them further establishes profound questioning as the core of science--questioning not only what is being observed, but also the known processes of creation and revision of stories about them.

What follows from this consideration of scientific method is that scientific statements are not either claims or approximations to 'Truth,' but provisional stories, reflecting human perspectives, that get progressively less wrong. Whatever practical usefulness the stories have derives from and needs always to be understood in light of their provisional character. Scientists, perhaps more than most, recognize the likelihood that the universe was not made for human beings and so neither perfect knowledge nor absolute safety are achievable. Science is therefore fundamentally not about security but about doubt, not about knowing but about asking, not about certainty but about skepticism. Scientific stories are written not to be *believed* but to be understood, made use of as appropriate, and revised.

This is a message that can and should be more actively and deliberately conveyed, and will be heard, even with appreciation, if we put our minds to it:

> [T]he prof asked a question in class. It was after our conclusion that doctors and scientists don't really *know* anything. That there are no 'truths'... how does that make us feel?... I really think that I feel good about knowing that. If I believed everything I was told by a scientist or a group of doctors, and acted on whatever it was that they concluded, then my life really wouldn't be my own. I would be controlled by this outside authority (Introductory biology student).
>
> We just discussed in class whether a conclusion can ever be true, definitive. Realizing that the answer is 'no' opens a whole new door to science... Science can be as analytically inviting as any novel or poem I will read in an English class (Introductory biology student).
>
> Oh, if we became scientists with sentiment and excitement [in] fantasy as well as [in] 'truth' what a world, what a universe! --Middle school teacher (Diversity and Discovery Institute, 2000)

Scientific stories are, in these examples, not heard as competitors in the arena of 'Truth,' nor as guarantors of human safety and well being, but rather as valuable contributors to the diversity of influences on individual lives. "The strength of science lies in its provisional nature, its open-mindedness, its capacity for doubt and uncertainty" (Quigg, 2003). This is both the core of science and the source of the appeal that it most reliably promises to other human beings.

3. Science as Story: Requirements for Participation?

Science as story telling provides a suggested answer to the question: *What is science?* as well as to two additional questions: *Who is it for? And who gets to say?* With regard to the stories science tells, both answers are: *the more the better*. I will first consider the extent to which all humans are qualified to participate in the story evolving process, and then discuss the benefits of wider involvement, not only for individuals but also for the process of science itself.

Some people (in the US, at least) think of science, and their own involvement in it as natural, others don't. This is, I think, largely a result of how science is presented, and provides another concrete example of what needs to be actively and deliberately changed if science is to fulfill its promise for human culture.

Science, in the terms characterized in the previous section, ought not to be defined by laboratories or white coats, nor by knowing certain things (or having a skill at memorizing), nor by compulsive information gathering, the use of mathematical tools, or logical rigor. It is instead nothing more (or less) than the dynamic combination of curiosity and skepticism that fuels virtually all *productive inquiry*, and is inherent in all humans from the time they are born. Babies arrive in the world as scientists in the universal sense of the previous section. They make observations, test those observations, and learn from unexpected results. They create and revise stories. In short, the underpinnings of science are a set of skills and inclinations that everyone comes equipped with and needs only to be encouraged to continue becoming better at using.

It is not my intent to suggest that professional scientists don't need professional skills, nor that anyone and everyone should (or would want to) regard themselves as a professional scientist. It is, however, very much my intent to challenge the notion that professional scientists are, by either birth or training, an entirely different form of humanity. Between professional scientists and others there is a deep core of commonality, not only of intention but also of method. Recognizing and building on that core could enable science to play a more effective role as a needed nexus for humans of all backgrounds.

A specific example may help here. As professional scientists, many of us have some tendency to equate science with quantification and, more generally, with mathematics. Advances along many lines of inquiry have certainly been greatly enhanced by using these tools, and anyone aspiring to work in these areas needs to acquire them. But it is equally important to bear in mind that other important areas of exploration relied less on them (Darwin and Freud come to mind). Moreover, quantification and mathematics are rather recent additions to the tool box of science and are themselves continuing to evolve (discrete mathematics, for example, is emerging as more useful in many fields than the more traditional continuous mathematics of calculus, cf. Wolfram, 2004). Furthermore, both have limitations of their own (cf. Newman & Nagel, 1958; Chaitin, 2004). Finally, mathematical ability, irrespective of education, is not evenly distributed across the human population, and those lacking it have other quite successful ways to make observations

and to tell and revise stories about them. To the extent that we equate science with mathematical sophistication, and so portray science or allow others to do so, we are discouraging many otherwise competent people from becoming involved with science and depriving science of valuable potential insights from those who are more effective exploring in other ways.

Let me illustrate another realm in which it is important to remember that participation in creating scientific stories should not be presumed to depend on any litmus test other than the ability and inclination to be curious and skeptical. In the United States, the issue of teaching biological evolution in the schools has been a major *cause célèbre,* i.e., a case that excites widespread interest (cf. Dean, 2005), and people on both sides of the divide have suggested that those on the other are unqualified to participate in the ongoing process of writing and revising the story of evolution. If evolution were discussed not in terms of true or false but rather as scientific story ("The Story," 2004), a summary of observations, it would lead to more productive exchange:

> [P]resenting it as a story is, I think, very useful and diffuses the potential for damage in espousing evolution as the version "smart" people believe. --Middle school teacher (Exploration and Emergence Institute, 2003)

Presenting science = summary = story makes it possible for everyone to connect it to their own curiosities, and to become a part of the larger process of making sense of things, using their own tools, observations and story telling styles. The likelihood that everyone will become engaged, to one degree or another, with science and its stories will increase if we avoid not only the claim to 'Truth' but also various litmus tests for participation. Mathematical ability, willingness to deny the existence of an eternal being, particular varieties of "smartness" (cf. Gardner, 1983), socioeconomic status, nationality or other tribal identity are frequently, if unconsciously, use to decide who can make meaningful contributions to scientific stories. The lack of particular backgrounds or skills may prevent productive involved in *particular* activities within science, but the enterprise itself can be made broad enough to involve anyone interested in participating. There is no risk in doing so and a great deal to be gained, not only in relieving unnecessary tensions between science and other aspects of culture but also in terms of science itself.

4. Science as a Deeply Social Activity

C. P. Snow urged a convergence between the "two cultures," to be achieved in part by "non-scientists" becoming more familiar with "science" (Snow, 1963). More recently, E. O. Wilson encouraged a "unity of knowledge," based on a "conviction... that the world is orderly and can be explained by a small number of natural laws" (Wilson, 1998). John Brockman has written of a "third culture" in which "scientists are communicating directly with the general public" (Brockman, 1991).

The story I am offering here, of all of humanity engaged with science, is similar to these but for one important point. Snow, Wilson, and Brockman have all been read by some as

telling stories of the colonization of humanity by science. The present story is more like one offered by Stephen J. Gould (2003). The stories science has to tell should of course be made more widely available and accessible, but not simply to enlighten non-scientists. Equally important is the central role that all of humanity needs to continue to play in the stories that science evolves, both about the world and about itself.

As summaries of observations, scientific stories are only as good as the breadth of observations they summarize, so the more people contributing observations the better. In addition to the observations, however, one needs the stories to summarize them, stories that in turn influence what new observations are made and what significance is attached to them. Since these stories are "not uniquely determined by the external world" (Einstein & Infeld, 1938), there is everything to be gained by having available the widest possible array of not only observations but of *candidate stories* as well. By so doing, science maximizes not only the breadth of observations but also the *repertoire* of story telling styles with which new stories can be elaborated. The more people, the more observations, the more stories the better.

This may seem to some (again, significantly both scientists and non-scientists) counter-intuitive, but it follows directly from the earlier discussion of scientific method. Much of the power of science has always derived from its public character, involving the collection of observations and creation of stories in open forums where they can be used and criticized by others. The resulting assailability, conflicts, and resolutions, concerning both observations and stories told about them, are as much a part of the successes of science as any other feature of the scientific method.

As a young research scientist, I was involved in a conflict between the proponents of two competing stories about how the nervous system develops. Each group *tested* its story by collecting new observations that seemed relevant given its story, and each challenged the validity of observations made by the other that seemed to conflict with its story. What emerged was a new, more comprehensive, and ultimately more useful story that accepted and made sense of both sets of observations and led on to new questions, observations, and stories (Grobstein, 1988).

The pattern I am describing characterizes science at all levels of detail. A second example with which I am familiar relates to the appropriateness or inappropriateness of including observations on internal experience (consciousness) as opposed to externally observable ('objective') characteristics in developing stories about the brain (and mind). Here too there have been competing groups developing different stories based on distinct sets of observation, each motivated by their respective stories. Here too, the likely outcome is a new story, one that aspires to make sense of both sets of observation (Grobstein, 2005b, 2005c).

On a still larger scale, Wilson's "conviction... that the world is orderly and can be explained by a small number of natural laws" is most appropriately regarded as a story telling style rather than a litmus test for engagement with science. While a conviction of

this sort is characteristic of many scientists, and has been of great use as a story telling/revising *device* in many areas of science, it is by no means characteristic of all science or scientists (cf. Grobstein, 1996; Schrödinger, 1943). In biology, for example, a central idea in evolution is that biological systems are engaged in a continuing and somewhat arbitrary exploration of an infinite array of possibilities (Dennett, 1995), the outcome of which is in principle *not* derivable in advance from "a small number of natural laws". One of the major intellectual advances of the twentieth century was the demonstration that, even in mathematics, not all significant phenomena can be understood by extension from a small number of fixed starting points. (Chaitin, 2004; Nagel & Newmanl, 1958).

My point here is not to assert that scientists need to give up the aspiration to find a small number of natural laws, but to make it clear that that aspiration should not be taken as a definition of science; it is a story telling style, one of many. Science should never become the advocate either of a particular story about things it is exploring or of any particular *form of exploration*. Beyond an insistence on grounding stories in observations, and on the open and public evaluation of both observations and stories, it is not, and never has been, particular techniques or styles that create the power of science or assure its continuing progress. What does so is the underlying principle of skepticism, of continually questioning both stories and the styles in which they are told.

The same argument holds for the aspiration of objectivity, the wish to achieve an understanding stripped of the particularities of any individual human perspective (and, perhaps, stripped even of any particularities of being human). There are ways to reduce subjectivity (Kosso, 1998) and these have demonstrable value; but the *crack* in scientific method precludes any absolute claim to objectivity. Moreover, as science evolves, it is entering realms where human perspectives (and their effects) appear increasingly to be unavoidably (and perhaps even desirably) intertwined with much of what is being explored. Studies of culture, for example, clearly change the subject of study itself, as do, arguably, studies of the brain. Even in physics, there is a need to face the inevitable *role of the observer* in many observations. Equally importantly, the search for complete objectivity, "the view from nowhere" always risks yielding impoverished stories, stories stripped of particularities relevant to humanness and so barren of "meaning" (Nagel, 1989), as well as no longer generative of new observations and new stories.

Science is much better off aspiring to the *view from everywhere*, to stories that make most sense of the widest array of observations and stories made from unique and different perspectives. Embracing that *diversity* is a challenge for science, as it is for other components of culture. But it is a challenge science is particularly suited by its methods and principles to meet, and it is a challenge that is particularly important to science itself. The greater the diversity embraced the more meaningful and less wrong the stories become, and the more effectively science can contribute to human culture, both by its products and as a cultural nexus.

5. Science as a Distinctive Cultural Component

The story of science as story telling suggests that science can and should be an activity in which all human beings are engaged in one way or another. It can and should be the ongoing creation, revision, and recreation of stories about humanity and its place in the universe, stories that draw from the observations and stories of all humans, and are both useful for and challengeable by all. Science as story implies further that the distinctive feature of science in culture is its commitment to open-ended exploration, to a continuing process not of describing what has been invariant or certain (useful as such efforts might be for other purposes) but rather of imagining *what might yet be* in the future and looking for that. For science, there is only the observations that have been made so far, the always provisional stories that summarize those observations, and, skepticism (Grobstein, 2005), the drive to test those stories and, in so doing, to create new ones.

Although everyone can contribute and draw things of use for themselves from science, science itself is *not*, in this story, something to which everyone should have or would want to have a personal commitment. As a distinctive component of human culture, science is not about stability but about change, because it is not about knowing but rather about *doubting* what is and wondering what might be. And so science is also not about sanctity, or respecting existing understanding. We do no one any good, for example, by pretending that some things are *outside* science. In principle, anything can be subjected to scientific exploration. So science is inevitably a destabilizing and revolutionary force with regard to all existing understandings, including those of the practice of science itself.

On the other hand, science is not about change in general, but about a particular *kind* of change, the kind of change that results from making observations, cataloguing them in a way that makes them publicly available, creating individual and collective stories about those observations, and then using the stories to motivate the collection of more observations that in turn alter both the stories and the ways they are told. In practice, this is often a slow and tedious process of change, one that can be frustrating to people interested in change for other reasons. But the resulting scientific stories have a character of both commonality and assailability that is demonstrably useful in many contexts and frequently more generative of new stories than are more personal and private ones.

Science is *not* co-extensive with either culture or humanity. There are a variety of individual and cultural aspirations that science is not well-equipped to serve (most notably those that reflect goals of stability and security) and, correspondingly, a number of cultural entities that may do better jobs in relation to those aspirations. The demands of being a practitioner of science are of a sort that is not compatible with the inclinations of all. Many will choose not to function as professional scientists but science can still engage all human beings in the elaboration of scientific stories. Indeed those stories will be most rich, both for science and for culture, precisely insofar as they draw on and contribute to the experiences and stories of those who observe and tell stories out of motivations other than those of professional scientists. Science is a distinctive form of story telling that has the appealing property that its own success necessarily both draws

on and can contribute to many other kinds of human activity. It is by its nature a nexus point that encourages and supports the development of shared human stories of exploration and growth.

Science can best and most distinctively contribute to culture by providing stories that may increase (but never guarantee) human well-being, by serving as a *supportive nexus* for human story telling in general, and, finally, by exemplifying as an available alternative for all humans in their own story telling its most characteristic value: a commitment to skepticism and a resulting open-ended and continuing exploration of what might yet be.

6. The Next Steps

> Just as vigilance becomes the eternal price of liberty in our political slogans, so too must rigorous self-scrutiny represent the cost of fairness... in scientific research. And we scientists can best appreciate both the general principle itself, and the major snares of specific biases, by reading and respecting our colleagues [in other enterprises]... (Gould, 2003, p. 116).

I have tried here to look at science with the kind of skepticism that exemplifies science as I understand and value it, and out of that skepticism to tell a revised story of science. In particular ways for which both scientists and non-scientists share responsibility, science currently falls short of living up to the important and distinctive roles that I suggest it is uniquely fitted to play in human culture. But these are, I believe, correctable shortcomings; the problem is not with the core activity but with the stories that are told about it. My story of science as story is intended to encourage the kind of wider engagement with and commitment to science that I believe is necessary not only for the health of science but for the well-being of the wider culture of which it is a part.

I trust it is obvious to all that what I have presented in this article is not the 'truth' about science. What I have offered is a candidate story about science, a story that summarizes my own scientific practices, and those of many of my scientific colleagues and ancestors. As I read it over, however, I can't help but notice also the extent to which it derives in significant ways from aspects of my particular personality and of the particular cultural context in which I work. Clearly displayed is a mistrust of authority, as well as a strong belief in the value of skepticism, understood not as a source of paralysis but of exploration and creativity (Grobstein, 2004), and a strong conviction that what is not yet known is in some sense more significant than what is.

This story of science is not, and cannot be, by itself the *view from everywhere*. A different person, in a different time and place, might well tell a different story of the need, for example, for science to counter existing authorities of other kinds, of the practical benefits of using observational testing rather than dogma, or of the problems of nurturing a developing scientific community in particular cultural circumstance. I think, though, that the story I have told here is not only supportive of those activities but sets them

usefully in a wider context. In this sense, the story of science as story telling and story revising may provide a foundation for a *less wrong* view of science, one that usefully engages a wider array of experiences and perspectives. That though is for others to decide. As with all scientific stories, the ultimate test of the value of this one is not in the past but in the future, not in whether it is right given the observations, but in what new things happen, what new observations are made, and what new stories develop because of it.

My hope is that the story I have told will help others, both scientists and non-scientists, to develop ways to make better sense of science for themselves. My hope is also that it will encourage the practitioners of science to pay more attention to the values and significance of the enterprise in which they are engaged, to be more attentive to and critical of their own behavior. Should an appreciation of the noble skepticism of science become sufficiently wide-spread to constitute a diverse "army," so much the better. Science is an enormously significant aspect of human culture, and it can be made more so. Telling assailable stories is a critical element of that process. I offer my story here in that spirit, and encourage readers of this paper to join me and others in an on-line forum (Grobstein, 2005d) where we can work together on the kinds of story revisions that emerge from sharing distinctive perspectives.

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