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Science and Public Discourse

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Abstract

This paper explores the relationship between science and public discourse as an issue of interdisciplinarity. It asks three questions: can scientists speak to non-scientists in such a way that non-scientists truly understand what is being said; can there be a genuine transfer of knowledge between the two; and how fungible are the boundaries between science and public discourse? It argues that most people dealing with these questions are informed by an old model of communication — one that sees it in terms of moving messages from sender to receiver, not as social interaction. It questions whether there is, or indeed should be, an eager audience for scientific information. Finally, it suggests that only mandated scientists take up the challenge of communicating science to the public, but it notes that the efforts of mandated scientists in this regard are rarely endorsed by working scientists. By reconceiving communication, and emphasizing audience needs, one can answer the first two questions positively. But problems still remain in the relationship between working and mandated scientists, and these still pose a challenge for interdisciplinary research.

Introduction

As I look back on twenty years of literature on interdisciplinarity, I see that it has not grown large, but it represents a respectable collection of intellectually challenging work.[1] Studies of interdisciplinarity will never be popular; they require too much introspection, and too many report cards on the work of one's colleagues. They also involve too much meta-theory written by people with little academic interest in philosophy.[2] Still, this literature suggests that disciplines each have their own register, and that disciplines operate as self-policing speech communities.[3] Disciplines constitute their work according to conventions they themselves have developed, rendering some topics and methodologies marginal to the main thrust of their scholarly work.[4]

Seen in this light, interdisciplinarity is an inevitable result of the organization of knowledge into disciplines represented quite neatly by university departments and faculties. Interdisciplinarity is nothing more or less than a challenge to the status quo. The challenge can take many forms: it can involve questioning the policing of disciplinary community boundaries,[5] or disciplinarians' self-absorption with a small number of intellectual problems, or

any discipline's obscure and occasionally arcane uses of language, or any discipline's failure to deal with social problems.

Meanwhile, the world outside the literature has also changed to the point where interdisciplinarity is now mainstream. For example, the Canadian research funding councils have made interdisciplinarity a prerequisite for some of their funding programs.[6] To qualify for these grants, colleagues from different disciplines must prove they have viable working relationships with each other. Many large research projects must have non-academic partners. As well, interdisciplinary university departments and programs have been set up around such themes as communication, science policy, risk assessment, and cognitive science. Women's Studies graduate degrees are now commonplace; the challenges now come from gays and lesbians. It would be hard to argue that academic writers caused all this to happen, but we have been here all along — prodding and pushing, providing intellectual rationales for initiatives that were usually made for political purposes rather than academic ones.

With interdisciplinarity now firmly anchored in the intellectual landscape, the challenge that animated early writers has been quieted. This is not to say that nothing remains to be said. On the contrary, now that the basic contours of the landscape are known, it is possible to address more interesting questions about the "hows and whys" of interdisciplinarity. Questions about the founding presumptions of interdisciplinarity were mainly not addressed because our emphasis was on definitions, descriptions, typologies, and prescriptions. The task was to get the terminology right, defining "interdisciplinarity" and asking whether there is any difference between metadisciplinarity, transdisciplinarity, and interdisciplinarity. Writers on interdisciplinarity constructed numerous typologies, as is always done in the early stages of an intellectual endeavour. They told others in the university and on funding councils what they should be doing.

It is time to return to the original formulations in the literature, and ask the questions its authors, including myself, did not ask in their first round of exploration. For example, it would be worth asking now whether physicists and biologists understand science differently, and if so, what the implications of a genuine collaboration are for the content of their science. It would be worth systematically comparing "partnered" research with non-partnered research to see what impact, if any, the partnering has had on how science is done or written about. Do teams of researchers from different disciplines produce something different by virtue of their co-operation, or are these research "teams" merely managerial arrangements? Which terminology is locked into a discipline, fundamental to how it constructs the main line of its research? Which terminology can be appropriated and properly used in an interdisciplinary endeavour? How significant are metaphors, which travel easily from discipline to interdiscipline, in rigorously conducted scientific work? The list of work yet to be done is long and challenging.

This paper takes up one item from the list of new questions. It asks three questions: Can scholars speak to non-scholars in such a way that non-scholars can truly appreciate and actually use what they hear? Can there be a transfer of expertise between scientists and non-scientists? How fungible are the boundaries between scientific and public discourse? The early literature on interdisciplinarity was unequivocal in its response to these questions. Not only was it possible to transfer expertise, but also it was the duty of academics everywhere to do so — that

is, to communicate science to the public. This answer was good enough for its day, but it will not suffice now.

The research granting councils in Canada now require academics to spend ten per cent of their research budgets on communicating their results to the public. This has proven a thankless task. Focused on the conduct and content of their research, researchers are hard pressed to identify who this public might be, and there is precious little guidance available. Academics know best how to talk to fellow academics and students. They are rarely good public communicators. Traces of the old disciplinary mentality remain even in the newest interdisciplines. A scholar who spends the majority of her time talking to the public, especially via the media, is suspect as a poor scholar.

The result of all this so-called communicating-science-to-the-public has been (with a few notable exceptions) conferences and workshops to which government officials (and a few advocate group leaders) are invited. Reports have been written. Gray masses of text dissuade anyone from reading beyond the title page. Occasionally, these reports are peppered with clip-art, cartoons, and decoration, in the manner of "academic research for dummies." Is this what the research councils had in mind? Who reads the reports? Who attends the workshops, and who cares?

Meanwhile, many public-interest advocates claim that science is no longer properly only the prerogative of scientists.[7] Public discourse about important issues, such as environmentalism, economic development, globalization, and the like, is shot through with something that approximates scientific debate, within which non-scientists are expected to play a major role. The tag-line "science is imbued with social values" is everywhere in evidence, giving license to non-scientists to comment upon even the most intimately scientific matters.[8] Patience with purely academic discourse is possibly at an all-time low.

Needless to say, there are brilliant science writers who turn complicated matters into language and concepts readily grasped by non-scientists. Their work is nothing new; great (and not so great) science writing accompanies modern science. And there are readers like my Aunt Flossie, whose curiosity drives them far beyond the limits of their formal education to become devotees of such writing. This is not where the granting councils thought they were spending their precious resources. Aunt Flossie is not their intended audience. Nor is Aunt Flossie one of the new non-experts who expect to play a role in public policy. The reason is simple. Aunt Flossie is a generalist. An article on physics is really no different to her than one on biology. She reads the brilliant science writers to expand her own horizons, to appreciate the complexities of the world around her. She would never think to speak about science being imbued with social values because she has no political use for the science she assimilates, now with relative ease. She is not challenging the expertise of scientists testifying before an environmental assessment board, nor is she launching a campaign against the impotence of science to deal with the matters she most cares about. To Aunt Flossie, science communication provides a window into a world that she feels privileged to access. She would not think of suggesting that science be differently oriented.

In Canada at least, the research granting councils, academics, and public interest advocates all agreed: Science should not only be communicated, but it should also be reconfigured to deal with the kinds of questions scientists rarely had asked. Relevancy was the watchword of this

interdisciplinary challenge. The goal was not so much for everyone to understand (or even just to appreciate) science as it was to share scientific expertise, dissolving the seemingly impenetrable barriers between science and the public. The authority of science was no longer to be taken for granted. The formerly closeted community of scholars needed to earn it by interacting with a politically engaged public. Breaking down disciplinary borders meant bringing together not just sociologists and political scientists (hardly much of a challenge, as it turns out), but experts and non-experts in a single debate inside and outside the academy.

No one thought it was going to be easy, this particular challenge of interdisciplinarity. But it is surprising how hard it has turned out to be. Today, the boundaries between science and public discourse are as contested as they ever were, and the results of all this science communication are paltry. Assuming there is a willing body of scientists (as there now is) and a public increasingly engaged with matters previously accorded to science (which there also is), what is it that gives rise to the difficulties?

This is the question I will now address. I will not cover old ground in arguing for the relevance of science or the significance of public contributions to matters scientists have long held as their own. I take it for granted that increasing the connections between scientific and public discourse is worthwhile, perhaps even beneficial to science proper, and essential for a healthy public sphere. I want to move beyond the easy, prescriptive version of interdisciplinarity into the much messier issues that underlie boundary-making where the public is involved.

I will make three arguments. First, most of those speaking about communicating science to the public are working with an out-of-date and impoverished model of communication, one hardly ever taken seriously within communication studies today. The old model saw a sender of information connected to a receiver of information by means of a message and medium. The flow of information was inherently one way, although allowance was made for feedback loops. Communication theory today places as much emphasis on the "reader" of information as on its author, and as much upon the context in which the communication occurs as on the message. It is also all about language and discourse. I will suggest that research granting councils and scientists need to take seriously this new version of communication theory.

The second argument is that it is wrong to presume an eager audience for the information generated by researchers. Importance is no guarantee of anything, as far as members of the public and public discourse are concerned. The issue is not apathy, nor is it that members of the public lack the interest and intellectual skill to deal with matters of substance.[9] On the contrary, matters of substance are dealt with all the time. The issue is instead that insiders to the academy and outsiders do not agree about what is important. Points of connection are missing. Communicators of science rarely take seriously the good reasons that members of the public have for relying on the information they already have.[10] So, attention must be paid to the problem of audience. What does this public understand to be their information needs? When (and why) do they think they need information?

The third argument is more directly focused on science. There are three fundamentally different notions of science at play in discussions about science and public discourse. Science in the realm of practicing scientists bears almost no resemblance to science understood as collections of interesting facts about the natural world, human health, and the like. It differs yet

again from what might be called mandated science,[11] the science that accompanies both policymaking and public controversies. Mandated science, at its best, is interdisciplinary in the sense I am using it here. It is, or at least it can be, about sharing expertise, about relevancy, and about a relationship between science and public discourse. The problem is that mandated science and working science — that is, science as conventionally practiced in the academy — are hardly easy companions. Mandated science's "differently oriented science" has almost no impact on working science. Moreover, the sensibilities of working science barely carry over to mandated science, with the result that many working scientists do not consider mandated science to be science at all.

It is worth stating the obvious before proceeding with these arguments. Nothing precludes scientists from talking to non-scientists or vice versa. At this level of generality, achieving interdisciplinarity poses no special problems. It requires only time, resources, and an effective mode of translation so that the two speech communities can learn to share a common language for their conversation.[12] To go beyond generality and seek a genuine and extended public discourse informed by science, and to want to see scientific work (in its turn) open to questions, insights, and demands from the public, means moving into a different territory. Understanding this kind of interdisciplinarity and getting it right in practice, will require rigorous attention to the particularities of this interaction, and a great deal of creativity. It will mean re-thinking the implications of communicating science to the public in every instance.

This article is comprised of three mini-essays. Each can be read separately as a discussion of the problems of communicating science to the public. Each ends with something akin to recommendations. The three mini-essays can also be read together as a discussion of interdisciplinarity. Taken together, they answer the three questions posed here about the relationship of science and public discourse.

The article is also based on two types of data that are very different from each other. The first and third mini-essays rest on academic studies that I have completed previously. I will provide only the briefest of summaries here; references are the guide to a more comprehensive view. The second argument, about information and audiences, is based on work done over the past five years by a community group called "Plainspeak." Plainspeak works with public interest advocate groups and First Nations to make the information required for their decision-making accessible, intelligible, and beautifully seductive. The goal is to get people to reach for, assimilate, and use the information they themselves say they need. Plainspeak writes "plain language," but it focuses most of its efforts on community engagement and on information graphics. Plainspeak represents what is often called "action-research,"[13] and this article represents my first attempt to synthesize its findings for an academic audience interested in interdisciplinarity.

Finally, I have already spoken about "science," "the public," and "communicating science to the public" without yet defining my terms. I will use "science" throughout this article as a synonym for academic research, including research in the social sciences (and even in the humanities). The distinguishing feature of "science" for my purposes is its academic credibility. My use of "public" will become clear in the arguments I make below. "Communicating science to the public" refers to the interdisciplinary challenge of bringing science into a relationship with public discourse.

One: Information versus communication

In the early days of communication theory — for example, when Lasswell[14] made his first contributions — the model of communication was a simple one. It saw a sender and a receiver of information, and connected the sender and receiver by a message. From his close reading of Harold Innis, among others, James Carey added an important dimension to the model of communication, even while he critiqued its premises.[15] The result was a more sophisticated model. The medium was not a neutral element in a system of communication, Carey said. The medium biased information as surely as do the personal opinions of the communicators. Added to the model, then, were multiple feedback loops — that is, ways in which the sender and the receiver might each intervene in the transmission of a message, changing the content of the message along the way. The old model became very versatile.

To be sure, there were challenges to this orthodox version of communication theory,[16] but the old model accommodated the more practical ones, and its proponents ignored the rest. Events outside the academy did not stand still, however. The development of machine-based communication spawned a whole new discipline (or was it an interdiscipline?) of information science, and from this even more interdisciplines, such as cognitive science and artificial intelligence. The old model of communication worked especially well in the new interdisciplines, given their emphasis on information and its increasingly complex modes of transmission.

The success of the model for information science helped prod communication scholars to distinguish what they do from information science. After all, communication theory is only marginally about information.[17] Its emphasis is on how communities of people establish sense and meaning from the experiences they have and from the language they use. Seen in this light, a lack of information (or silence) can be a message too. Moreover, communication theorists today believe that information does not readily translate into messages moving swiftly and intelligibly from sender to receiver. Power, class, race, and gender intervene. Identity matters. History tells in every interaction. Context provides meaning. At some point, communication theorists began to look away from information towards theories of language. Saussure, dead for many years, became the theorist to contend with. Foucault and Habermas, among others, moved to centre stage (for better or worse).

It is absurd to speak of communication theory today as a single body of work, all driven by the same impetus and dependent upon the same conceptual models. Adherence to the ideas of one founding "father" or another has produced different strains of theory that can hardly be encompassed in a single volume, let alone in an article about an obscure topic like interdisciplinarity. At the same time, it is safe to say that communication theorists today take it as axiomatic that information is not the central concept to be explored. They speak instead about *vershtenen* — that is, understanding, sense-making, or discourse. In doing so, they shift the emphasis to the roles that social context, power relations, and audience alike play in shaping both the model and the content of communication.

In my view, there are three main strains of thought within the corpus of modern communication theory, all somewhat related. In some senses, what separates their proponents is a matter of emphasis. One strain of theory takes its cue from early symbolic interactionism[18] to suggest that communication can best be understood as a process of sense-making. Both

individuals and social context are factored into this sense-making process; the focus of study is the points of interaction — that is, examining how shared conceptions of reality are constructed. Another strain of theory places greater emphasis on the social context — the ways in which historical, social, and contingent factors shape people's understanding of what they experience.[19] Here, the focus is not on individual communication so much as on frameworks of thought and action. Although theorists in this strain are concerned with the meaning that individuals take from their experience, they believe that such experience is always mediated by social context, so much so that research should focus on social context even to the exclusion of individual interactions. A third strain of theory puts more emphasis on language or, more properly, on discourse. Discourse is understood not as information being transmitted, but as the whole ethos of social and personal interchange made manifest through language.[20] Discourse is deeply reflective of historical and social conditions, even while it shapes consciousness.

The old model of communication saw the relationship between sender and receiver as a one-way street. When the old model was reformulated to take feedback into account in a meaningful way, this became a two-way street. Once the concept of discourse is introduced, the metaphor of street directions will no longer suffice. Discourse is bent and shaped in many directions all at once. It can be compared to the air we breathe. It lies outside the individual, but it is absorbed. It can be discerned in how individuals talk about and understand their world and their experience. Nothing can be presumed about the meaning of any particular sentence or interaction without appreciating how it is read (and experienced) by those who speak and hear it. No sentence stands on its own but, instead, all sentences are part of a long trajectory of concept-formation.

The old model of communication lent itself easily to the task of communicating science to the public. Think of it this way. Scientists are the senders of messages; members of the public are the receivers. The message is the content of research. The mode of transmission is typically the conference, workshop, or report. In this formulation, communication can be stripped of its relationship to power, class, race, and anything interesting about identity. Indeed, no transfer of power is intended between sender and receiver — that is, between scientists and members of the public. It is simply presumed that scientists have something to say, by virtue of their expertise, and that members of the public have something to learn. As noted above, the old model is well suited (once further developed) to the interdisciplines of information science and artificial intelligence precisely because it deals with information as opposed to communication. It is also well suited to the sub-discipline of science education, inasmuch as it focuses on the core curriculum to be taught in the schools — that is, on the content of information to be transmitted to a captive audience.[21]

The old model of communication is also very attractive to research funding councils and even to some researchers. They too are preoccupied with the content of information — their research findings, so to speak. Their presumption is that the audience for research outside the academy should come later, once the basic job of theory-critique-research is done and once the main issues have been resolved. Surrounded by a world that seems to worship information (the "information revolution" and all that), they easily confuse information with communication and believe that transmitting information is a relatively straightforward process once the techniques (even including PowerPoint) are known.

In my view, proponents of the new model of communication also have themselves to blame for the fact that most people outside the academy rely upon the old model. The new model is rich and complex — so rich and complex that even academically trained readers cannot read it easily. It is strewn with jargon of the most unintelligible kind, and with special words used in special ways.[22] Reading communication theory today requires learning a foreign language, not so much French or German as "Foucault" and "Habermas." One speaks "Baudrillard," "Barthes," and "Bakhtin," not English. Continual reference is made to these and other founding "fathers," even though few scholars have read their work. Everything is contested; every situation or fact is "constructed." Every word carries an electric charge — that is, references to battles between and among proponents of one strain of theory or another. Long-established canons of academic discourse, argumentation, and even methodology have been thrust aside.[23] Little wonder, then, that few outside communication studies have picked up and used the new model of communication in their thinking about communicating science to the public.

This is a serious problem, to say the least. How can there be forward movement in communicating science to the public if those who propose it are mired in inadequate notions of communication on one hand, and impenetrable debates on the other? Ironically, proponents of the new model of communication are far more likely to share the goal of "relevancy" than proponents of the old. Despite their many differences, almost all believe that expertise must be shared and that scientific and public discourse must take place on common ground.

A translation is needed. For the purposes of this article, I will make the attempt. Let me begin this translation by noting something interesting. In the old model of communication, there is hardly a trace of sociology, even though its adherents often claim to be interdisciplinary in their approach and count sociology as one of the elements of an adequate interdisciplinarity. By contrast, the new model of communication is shot through with sociology (and linguistics). If I strip down the new model by outlining some of its basic elements, it will become obvious how sociology has now been factored in. It will become far less obscure. Its elements are as follows:

First, any communicative relationship is a relationship. Its constituent elements cannot be studied properly apart from the relationship they make up.

Second, as a crucial element in the relationship, the reader or audience must be factored in, not just as a source of feedback, but also as a founding partner in the relationship. Communication is an evolving dialogue between author and reader. Indeed, each participant is both author and reader.

Third, information becomes meaningful only in context, and only when there are supporting cues (within the environment, between the parties, and especially within the discourse itself) to what is being said or heard. These cues frame interaction, and provide points of reference for it.

Fourth, nothing is preordained about the directionality of interaction, since information moves back and forth, in and out, around and through relationships in ways that even their participants barely (if at all) recognize.

Finally, all communication is based on language, and human language is shot through with symbolic and iconic elements. No utterance or gesture can be disconnected from the baggage it

carries: historical baggage, social baggage, psychological baggage, political baggage, and of course power relations.

This is, as I just said, just plain sociology, but it will serve as a recipe for making today's communication theory accessible to those who are neither sociologists nor communication theorists, and more importantly, to those who want to communicate science to the public. Let's see how it works:

First, attention must be paid to bringing scientists and the public into the same sphere, so that a relationship is possible. It cannot be presumed that either will get there on their own — that is, that scientists will leave the secure nest of the academy, or that members of the public will seek out science, putting aside all their own prejudices and predispositions. The point seems self-evident, almost tautological: there is no relationship without a relationship.

Second, much more attention must be paid to the question of audience — that is, those who are founding members of the relationship. Who is this "public"? The question must be answered specifically, not in general. Which individuals can be imagined as participating fully in the relationship?

Third, there is a need to figure out what would bring these members of the public into the relationship we want to foster. Under what conditions might members of the public want to reach out for scientific information? What is in this relationship for them? Information? Where do they usually get the information they use now? What good reasons do they have for relying on what they already know, and are there good reasons for them to seek change?

Fourth, there is also a need to figure out what brings scientists into the relationship that we want to foster. Under what conditions do (or would) scientists reach out for interaction with the public, especially given all the disincentives in the academy for doing so? What is in this relationship for them? What information might properly come from members of the public to enrich scientific work? How can scientists factor in such information, given that it rarely takes the form of data they know how to handle?

Fifth, I have been talking about sharing expertise, at least to the extent that it is needed and possible. There is a power dynamic in any relationship involving expertise. It revolves around the authority and privilege accorded to experts. Interestingly, the power dynamic does not stop there. It also revolves around the kinds of pressures that members of the public can bring to bear upon science, especially in the heat of public controversy. The power dynamic needs to be taken into account when talking about a relationship between science and public discourse.

Sixth, there is a need to unpack the language of both science and public discourse. Again, translation is needed. Keep in mind that choice of language is not a matter solely of individual discretion, but always reflects social, historical, and political factors. There is a need to translate more than the words on the page, and to pay attention to the presumptions and ideas that lie behind them. The history of ideas and the substance of history must be factored in.

Two: Making information important

In the introduction to this article, I indicated that it is partly based on experience with Plainspeak, a non-profit organization founded with the mission of communicating complex information, such as information about science. Thus far, I have spoken mainly as an academic,

speaking to other academics in a language that should seem familiar. Let me add now a few stories from the trenches.[24]

When Plainspeak was first set up, some five years ago, everyone said that there would be a line-up at the door, provided the job was done well. Plainspeak's services were cheap by comparison with commercial graphics and plain language services. Its work was of demonstrably high quality. Members of the group had absorbed the lessons from Edward Tufte's *Envisioning Information*[25] well and were quite prepared to put them into practice. The group included senior academics and lawyers, so it could reasonably take command of the complex information it might be asked to deal with. And all of the group members had long-standing relationships with First Nations and community groups — that is, credibility in the world of advocacy politics.

Plainspeak has proven a hard sell (if this is the right term). Not only has there been no line-up, but also this group has continually been asked to do something other than to fulfill the original mandate of Plainspeak. It has been asked to write fund-raising materials for advocacy groups, for example, and to assist in campaigns packaging persuasive rhetoric (about important issues, to be sure) for general consumption in the style of social marketing. It has rounded up lots of work, which it proudly displays on a website,[26] but it has had limited success in getting many groups to focus on generating informed debate. Plainspeak set out to support informed public debate about complex issues by using its graphics and writing skills, and it has ended up mainly being called upon to do PR instead. Meanwhile, it has yet to be asked to create public dialogue about research findings. It has not even yet been asked to illustrate a report.

This litany of difficulties should not disguise the successes that Plainspeak has had with groups who do want plainspeak, not PR. From both successes and failures, group members have learned the following: Plainspeak must be driven by need. That is, members of the public must have specific needs before they will reach for new information. A decision pending, a vote on an Aboriginal land claim settlement, a court decision affecting rights and benefits — these are instances where communication between experts and non-experts is desired, and thus becomes possible.

In working with public interest advocates, the group has also learned that few of them pay much attention to their audience, although they certainly claim the opposite. They think of their audience in terms of "everyone," but address no one in particular. Most of the work Plainspeak needs to do, well before anyone draws a sketch or writes a word, is bound up in discussions about the who, why, how, and when of the audience.

I have no doubt that those communicating science to the public fall victim to the same problem. To the extent that they think of audience at all, they too think it is "everybody." And because "everybody" is never available (indeed inaccessible, by definition), a crude substitution is performed. "Everybody" becomes government bureaucrats, corporation officials, and a sprinkling of advocate group leaders — a worthwhile audience to be sure, but hardly representative of public discourse.

Back to Plainspeak. Assuming there is an answer to questions about audience, Plainspeak spends days asking questions about where and how these people get their information, and about the role that such information actually plays (and does not play) in their deliberations. Plainspeak tries to imagine someone actually glancing at or picking up something it produces,

taking the time to assimilate what is being said, interpreting for themselves what is on offer, and walking away somehow changed in the process.

Long before Plainspeak was set up, I was sobered by a visit to a hospital waiting room. Wonderfully illustrated brochures sat in neat racks. They dealt with all aspects of health, and they offered genuine assistance, or so it seemed. They were written in many languages, and they showed brown faces as well as white ones, men and women, old and young, fit and fat alike. This was a hospital; surely here was an attentive public, at least as far as matters of health were concerned. In six hours, not one person so much as wandered over to the rack. Not one person picked up a brochure and scanned it. If I needed a lesson that important messages do not create or find their natural audiences, even in hospitable circumstances, I got it here.

In truth, Aunt Flossie is rare. The eager audience for communication about research findings is a limited one.[27] And even if it were not, communication about science addressed to her has a limited value from the perspective of "relevancy" of research. Remember, I am talking about sharing expertise, while Aunt Flossie's interest is only in appreciating what science can produce. For this purpose, no one can assume a willing audience.

There is a marvelous self-discipline to this exercise of audience-determination. That is, thinking about who might actually use the information, and under what conditions, is tremendously useful. It sharpens the research focus. It improves the writing. It generates metaphors. It calls to mind examples. It enriches theory with good stories. It forces writers to step outside the bounds of specialized language and to explain concepts in ways that outsiders to their intimate circle of colleagues can understand.

Only when it is clear who the audience is intended to be (where it currently gets its information, what it thinks it needs in terms of new information, etc.) is it possible to devise communication strategies. Instead of reaching automatically for the report and the PowerPoint slides, it is possible to think creatively about which medium to use. This is what is meant by communications strategy. What media would such people encounter in the routine of their daily lives? What might cause these particular people to pause long enough to scan what is on offer? How much can these particular people assimilate at first glance, and what needs to be saved for later? How can this information be saved in a form that is useful later? Are these people Internet users or not?

Answering these questions has dramatic results. Gone are the long grey reports illustrated by clip art that is incompatible in style and content with what is being said. Gone are the glossy brochures with too little information to be useful. Gone are most video and short educational films, because no one goes home at the end of a long day's work, turns on the video recorder, and plugs in an educational video. Gone are conferences and workshops for people we already know — gatherings of insiders designed for other insiders. Gone is tokenism — invitations extended to particular outsiders in the hope that they represent designated groups within the public.

No one can say in advance what replaces the almost useless products of contemporary efforts to communicate the results of scientific research to the public. The answers always come from the initial exercise of thinking hard about the intended audience.

Three: The many faces of science

I have been talking about refashioning communication of science[28] to the public as a means of embracing true interdisciplinarity. Thus far, I have concentrated mainly on communication. I have suggested that the old model of communication (sender/receiver/message/feedback) needs to be put aside and replaced with insights from today's communication theory. Today's communication theorists are less helpful in this task than they should be, so I have attempted a crude translation, identifying the basic elements of a new model of communication.

I have also spoken briefly about the "public." In doing so, I performed a sleight of hand; I have substituted "audience" for the notion of the public. In other words, instead of speaking broadly about public discourse, I have drawn attention to the specific individuals who might be, given the right circumstances, brought into a relationship with science. Seen in this light, public discourse becomes a pragmatic concept. I am thinking about identifiable members of the public, who inhabit real lives and have real needs. These people sometimes need new information, but they already get by quite well with what they have. Such people come into contact with new information in some locations, but not others, and routinely pay attention to some media, but not others.

In dealing with science, I propose a similar sleight of hand. I propose to treat scientific discourse in a very practical way. Needless to say, my discussion will not put to rest the larger questions raised in sociology and philosophy of science about the relationship between science and public discourse. I leave these larger questions to other writers on interdisciplinarity.

Pragmatically, science operates in three distinct realms.[29] The first is familiar to anyone who has watched Discovery Channel on television, or browsed the shelves of a local bookstore. Call this realm of science, for lack of a better term, *discovery science*. At one extreme, discovery science shades into self-help manuals, where facts (from science or not) spawn advice for living. At the other extreme, discovery science shades into scientific treatises, in the manner of Stephen Hawking's books. Hawking notwithstanding, observation drives most discovery science. Natural phenomena are described and explained. Facts are the purpose of science. Scientists are authority figures, responsible for making the observations and producing the facts. The audience for discovery science is Aunt Flossie and her many less intellectually rigorous nieces and nephews.

The second realm of science is that of *working science*.[30] This is the science of the academy, of disciplines, and of serious research and scholarship. It is best reflected in journals, where articles have been peer-reviewed, and where academic debates centre on seemingly arcane arguments about theories and research findings. Findings in such journals seldom have direct relevance (at least in the first instance) to anyone other than working scientists. Narrow in its focus, working science often uses models, simulations, statistical indicators, and theoretical constructs. It rarely deals in plain facts. Indeed, working science is characterized by its preoccupation with uncertainty and probability: debate is endemic; conflict is commonplace.

Working scientists must be properly trained and qualified. Training ensures that scientists fully appreciate the nuances and subtleties of the words on the pages of scientific reports. To appreciate what is really being said, working scientists must be intimate with the trajectory of research that supports their research findings.

The third realm of science is *mandated science* — that is, science closely aligned with public policy decisions. Mandated science is much more narrowly construed than working science. Its goal is to conduct research or interpret scientific studies for public purposes. Its primary audience is advocate groups, government officials, company spokespersons, and regulators, not working scientists.

Mandated science may be narrowly construed as far as its intended audience is concerned, but it is often broad and interdisciplinary with respect to the subjects it deals with, and polymorphous in terms of its methods of research. In academe, mandated science is sometimes labeled "strategic research," and teams of researchers working with non-academic partners commonly conduct it. All mandated science is infused with social values, and explicitly so, even if some mandated scientists take care not to let such values bias the conduct of their work.

At one extreme of mandated science, there is little difference between it and discovery science. Facts churned up to assist policy-makers find their way onto the bookshelves of the local bookstore and into the self-help guides. At the other extreme, mandated science can barely be distinguished from working science. That said, mandated science is different from working science only because of the wide lens it applies to research, and the willingness of its practitioners to engage in public discourse.

In this article, there is no need to deal with the relationship between these three realms of science. Suffice to say here that they are very different from each other, and that these differences bear examination. Here the focus is communicating science to the public, not in the conventional sense of educating the public about science, but in the interdisciplinary sense of developing relationships between science and public discourse based on shared expertise. A comparison between the three realms of science is in order, as are comments about the relationships among them.

As noted earlier, discovery science is all about communicating science to the public. It offers a picture window view upon science and a distillation of scientific findings in a format readily assimilated by non-experts. Theoretically, members of the public who follow discovery science will be better attuned to what working science has to offer, having developed an appreciation for what scientists actually do and how they do it. They will be less likely to misread science when it is reported in the newspaper if they follow discovery science. They will exercise informed judgements about claims being made in the name of science, especially in public controversies. In discovery science, however, little effort is made to dislodge the authority of science or scientists. On the contrary, discovery science is about instilling admiration and respect for science. It is not intended as an exercise in sharing expertise.

Working science is not about communicating science to the public (despite all the talk about communicating research findings to the public). Indeed, working scientists presume the opposite: they presume that a great gulf should exist between what scientists do and how science is spoken about in public discourse. While a few working scientists endorse the idea of "relevancy," all working scientists shape their research agendas with reference to the academic literature and on the basis of their discussions with other working scientists, not on the basis of public discourse. Working scientists believe that proper qualifications and expertise are required before anyone can truly understand the implications of any particular piece of

research. In other words, in working science, it is presumed that expertise cannot be shared and that scientific discourse and public discourse are fundamentally different.

As a result of this, there is a natural affinity between discovery science and working science. They can be seen as two sides of the same coin. Working science produces the research; discovery science packages data from working science so that a non-expert public can easily assimilate them. Discovery science also produces an appreciative audience and supportive atmosphere for working science. Public recognition and increased financing for working science should result. Indeed, one rationale for communicating science to the public is that such communication makes it possible for working scientists to garner support (and thus funding) from politicians.[31]

Mandated science is something quite different. Mandated science is all about communication. From the perspective of policy makers, it is about creating a variant of science that is compatible with their needs. In this context, mandated scientists act as translators of working science, providing evaluation and status reports in support of recommendations for policy. From the perspective of the public involved in controversies about public policy, mandated science represents the fusion of science with social values. Because of this, mandated science can be used by expert witnesses in regulatory or environmental hearings, in support of campaigns for more enlightened public policy, or even to launch radical critiques (say, deep ecology and the like).

In some senses, then, mandated science represents the interdisciplinarian's dream come true. Here is science that is truly fused with public discourse. Mandated science even needs public contributions, because it includes discussion about social values. Members of the public are experts on social values, both their own and those of others.

Entering the debate about public issues, policy makers and members of the public alike can learn to read mandated science properly. Once they have understood what mandated scientists have to say about the scientific underpinnings of global warming, genetically modified foods, or geological formations affecting hydro dam sites, they can cite science credibly, almost as if they themselves were scientists. The barriers between experts and non-experts, while not fully dissolved, become much less important.

All should be well, but it is not. The most difficult challenge of interdisciplinarity would be met, were it not for the significant gulf between mandated science and working science. After all, the promise of mandated science is that it encompasses credible science, finding ways to make working science amenable to a close relationship between scientific discourse and public discourse. If, however, mandated science is not regarded as credible science, a necessary element in the relationship between scientific discourse and public discourse — that is, credibility — is missing.

Why would mandated science not be credible as science? There are many reasons. Science is supposed to be internally driven and self-regulated, but mandated science responds to demands from policy makers and advocates. Working scientists make it a point to address their colleagues in the first instance, and the public and the media only after the main controversies have been settled. Mandated science is public in the first instance, and none of its participants would have it otherwise. Mandated science claims to be more democratic than working science. Working science never made any claim to being democratic in the first place. Mandated science

makes explicit the links between science and social values, even if care is taken by some mandated scientists to protect their research from bias. Working scientists rarely speak about their work as being objective or value-free when they meet among themselves, but very few of them would be prepared to engage in a discussion about the role of social values in science. Mandated scientists tackle broader topics than most working scientists, embracing interdisciplinarity in creating new fields of study and new working relationships between established disciplines. Working science pays attention to problems identified in debates within disciplinary journals. Because mandated science deals with policy, it is often surrounded by, and indeed also a participant in, public controversies. Working science avoids heat where possible, having enough conflict within science to keep it in action. Mandated science tends to produce predictable and polarized debates; these are seen as having no place in working science. Mandated science is accused of being science for hire. Working science avoids the courtroom at all costs.

This list goes on and on. It hardly matters that some mandated science is conducted according to the strictest canons of science. It does not even matter that the funding councils in Canada and elsewhere have embraced mandated science by allocating a major portion of their funds to "strategic" and interdisciplinary research, and requiring partnerships with non-experts. It does not matter that Royal Society reports are carefully constructed to be both scientific reports and reports to the public.[32] The relationship between mandated and working science remains uneasy, with many working scientists being prepared to dismiss mandated science out of hand.

So does it matter that working scientists often regard mandated science with suspicion? Given the choice, who would not want science infused with democracy? Experimenting with new methodologies should be a good thing, a sign that scientists can break free from old conventions and still produce peer- reviewed publications in highly reputable journals. Surely one would want to know what scientists have found out before making public policy decisions. That much of mandated science occurs within the academy, in new interdisciplinary departments and programs, should be cause for celebration.

And so it is. But two worries remain. The first I have already dealt with at some length. Mandated science generally operates in a different sphere than working science, with precious little communication between the two. The interdisciplinary challenge has indeed produced a "differently-oriented" science, as I suggested earlier was its goal. But it has done so by creating a new stream of work outside the boundaries of working science — a body of work subject to its own rules and conventions.

Second, I have been mainly speaking about the most carefully constructed research within the broad corpus of mandated science. There are lots of examples of mandated science that involve much less rigorous research. They also go by the name of "science." There are also many instances where value debates drown out anything that science might contribute. Here, mandated science retains the label "science," but it is really just advocacy. Furthermore, mandated science is dragged into all kinds of forums where neither scientific methods nor working scientists are respected. The quality of "scientific debate" in most courtrooms, policy briefing sessions, and public controversies leaves much to be desired. It hardly qualifies as science at all. To an outsider, it has the look of science, but it would never pass muster in the

peer-reviewed journals of reputable science. In short, despite the exceptions, it would be hard to claim that mandated science reflects a merger between the best that working science has to offer and public discourse.

In the end, I am stuck with a stubborn contradiction. Through mandated science, communicating-science-to-the-public has finally reached the point where it represents a viable option, yet working science remains largely unchanged and unchallenged. The interdisciplinarity that I have been speaking about here has been achieved, but only at the cost of creating a separate sphere of research-related activity that can only sometimes claim credibility as science. In making science more compatible with public discourse, something important may have been lost along the way.

Conclusion

This paper proposed three questions. It is time to bring together the three very different strains of analysis within it to answer these questions.

The first question is whether scientists can speak to non-scientists. The answer is a qualified yes. Scientists generally speak to non-scientists through the intermediaries of science writers and discovery science. Asking working scientists to communicate their research findings to the public without such translators is probably an exercise in futility. With these translators, of course, anything is possible. At best, they know how to transcend the limits of the old model of communication and how to create the illusion, if not the fact, of a relationship between science and public discourse. They know all about identifying audiences and responding to needs.

The second question is whether there can be a transfer of expertise from science to the public. This answer is even more qualified. Working science has resisted (and will continue to resist) the interdisciplinary challenge. It has no place for the public and its concerns, except as an appreciative audience for what science produces. Mandated science does presume that transfer of expertise is possible and desirable, but it is beset with its own limitations, not the least of which is its lack of credibility with working scientists.

However, even mandated science cannot take its relationship to the public for granted. Far too often, mandated scientists also adhere to the old model of communication, presuming they are communicating their research findings *to* the public, and that there is a ready and willing audience waiting for new information. Much attention is paid to the relationship between science and public discourse, but little is done to create this relationship and to bring all the necessary elements into it, including good science, to meet the real needs of specific people. Information is deemed important enough in its own right to attract an audience — the right audience of policy makers and members of the public. The relationship so central to mandated science — its interdisciplinary ethos — is often stillborn, due to bad science, thoughtless public advocacy, over-estimation of the power of information, and poor understandings of communication.

The third question is the toughest to answer. Can the boundaries of science be made fungible to public discourse? I am speaking about working science here. So far, the prognosis is poor. Those who are most needed to make it happen — that is, working scientists — are not involved at all. Those who are most enthusiastic are still outsiders, despite their serious and sustained efforts.

So much has changed in the last twenty years, and yet this last interdisciplinary challenge remains on the agenda of work to be done.

Notes

1. For a lengthy bibliography on interdisciplinarity, updated to 1994-95, see Liora Salter and Alison Hearn, *Outside the Lines: Issues and Problems in Interdisciplinary Research* (Montreal: McGill Queen's Press, 1996). Other works of note include Julie Thompson Klein, *Crossing Boundaries: Knowledge, Disciplinarities, and Interdisciplinarities* (Charlottesville, VA: University of Virginia Press, 1996); Julie Thompson Klein, "The Discourse of Transdisciplinarity: An Expanding Global Field," *Transdisciplinarity: Joint Problem Solving Among Science, Technology and Society: An Effective Way for Managing Complexity*, ed. Julie Thompson Klein et al. (Basel: Birkhauser, 2000), 35-44; Carole L. Palmer, *Work at the Boundaries of Science* (Dordrecht: Kluwer Academic Press, 2001); Elizabeth Minnich, *Transforming Knowledge* (Philadelphia: Temple University Press, 1990); and Peter Weingart and Nico Stehr, *Practicing Interdisciplinarity* (Toronto: University of Toronto Press, 2000).
2. Liora Salter and Alison Hearn, *Outside the Lines*.
3. See Salter and Hearn, *Outside the Lines*.
4. See, for example, Trevor Pinch, "The Culture of Scientists and Disciplinary Rhetoric," *European Journal of Education* 25(3) (1990): 295-304.
5. Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review* 48(6) (1983): 781-795.
6. Social Sciences and Humanities Research Council of Canada: Both the Standard Research Grants (see especially Committee 15 of the Standards Research Grants and the Major Collaborative Research Initiatives) and Strategic Research Grants make provision for collaborative, "multidisciplinary" research.
7. Leiss deals with this at length in William Leiss, "Between Expertise and Bureaucracy: Risk Management Trapped at the Science-Policy Interface," in *Risky Business: Canada's Changing Science-based Policy and Regulatory Regime*, ed. Bruce Doern and Ted Reed (Toronto: University of Toronto Press, 2000), 49-74, especially 57-58. Note that Leiss takes issue with this view, suggesting that the two domains should be kept separate as much as possible (see especially 49). Also in this volume, Doern and Reed, in "Conclusions: New Institutions and Prospects for Change," argue that science has become more pluralistic (see especially 377, 446-7, and 450).
8. See, for example, Ted Schrecker, "Using Science in Environmental Policy: Can Canada do Better?" in *Governing for the Environment: Persistent Challenges, Uncertain Innovations*, ed. Edward A. Parsons (Toronto: University of Toronto Press, 2001), 31-72, especially 47.
9. For arguments about the contributions that citizens can (and should) make to science-intensive debates, see Sheila Jasanoff, "Citizens at Risk: Cultures of Modernity in the US and EU," *Science as Culture* 11(3) (2002): 363-380. See also Michael P. McDonald and Samuel L. Popkin, "The Myth of the Vanishing Voter," *American Political Science Review* 95(4) (2001): 963-974.
10. Brian Wynne, "Creating Public Alienation: Expert Cultures of Risk and Ethics on GMOs," *Science as Culture* 10(4) (2001): 445-481.
11. Liora Salter, *Mandated Science: Science and Scientists in the Making of Standards*, with the assistance of William Leiss and Edwin Levy (Dordrecht: Kluwer Academic Publishers, 1988).
12. This was a major recommendation in Salter and Hearn, *Outside the Lines*.

13. For definitions of action research, see M. Morris, "Participatory Research and Action," in *Participatory Research and Action: A Guide to Becoming a Researcher for Social Change,* produced by the Canadian Research Institute for the Advancement of Women (Ottawa: CRIAW/ICREF, 2002), 5; and Jean McNiff, *Action Research: Principles and Practice*, 2nd ed. (London: Routledge, 2002).
14. H. Lasswell, "The Structure and Function of Communication in Society," *The Communication of Ideas,* ed. Lyman Bryson, (n.p.: Institute for Religious and Social Studies, 1948), 37. See also Denis McQuail, *Mass Communication Theory*, 4th ed. (London: Sage, 2000), 52-53.
15. James Carey, "The Communications Revolution and the Professional Communicator," originally written in 1969, reprinted in *James Carey: A Critical Reader* (Minneapolis, MN: University of Minnesota Press, 1997), 128.
16. Dallas Smythe and Trans Van Dinh, "On Critical and Administrative Research: A New Critical Analysis," *Journal of Communication* 33(3) (l983): 117-127.
17. For a different view of information science — one tending to render it similar to communication studies — see Matthias Dorries, *Experimenting in Tongues: Studies in Science and Language* (Stanford, CA: Stanford University Press, 2002). See especially the chapter by Jorg Pfluger on "Language in Computing," 125-162.
18. George Herbert Mead, *Mind Self and Society* (Chicago: University of Chicago Press, 1934).
19. This strain of theory follows closely on Erving Goffman, *Frame Analysis: Essays on the Organization of Experience* (New York: Harper, 1974); and *Forms of Talk* (Pittsburgh: University of Pennsylvania Press, 1981).
20. Examples of communication theorists writing today in this vein are Simon Firth, "Literary Studies as Cultural Studies – Whose literature, Whose Culture?" *Critical Quarterly* 34(1) (1992): 3-26; Robert Hodge and Gunther Kress, *Language as Ideology* (Boston: Routledge and Kegan Paul, 1979); Gunther Kress, "Discourses, Texts, Readers and the Pro-nuclear Argument," in *Language and the Nuclear Arms Race Debate: Nuke-Speak Today*, ed. Paul Chilton (London: Francis Pinter, 1985), 65-87; Robert Hodge, *Social Semiotics* (Ithaca, NY: Cornell University Press, 1988); and Stuart Hall, "Encoding/decoding," in *Culture, Media, Language*, ed. Centre for Contemporary Cultural Studies (London: Hutchinson, 1980), 128-138.
21. There is a journal devoted to the topic: *Public Understanding of Science*. An article typical of the approach taken in this journal is H. Field and P. Powell, " Public Understanding of Science versus Public Understanding of Research," *Public Understanding of Science* 10 (October 2001): 421-426.
22. While many communication scholars have embraced the postmodern turn, or consider themselves to be post-structuralists, this strain of communication theory is broader than either approach and includes scholars who adhere to neither of them.
23. See for example, Dorothy E. Smith, *Texts, Facts and Femininity: Exploring the Relations of Ruling* (London: Routledge, 1990).
24. A similar analysis can be found in the academic literature. See, for example, Susan M. Stockmayer, Michael M. Gore, and Chris Bryant, eds., *Science Communication in Theory and Practice* (Dordrecht: Kluwer Academic Publishers, 2001).
25. Edward R. Tufte, *Envisioning Information* (Cheshire, CT: Graphics Press, 1990).
26. www.plainspeak.ca
27. M. Weigold, "Communicating Science: A Review of the Literature," *Science Communication* 23(2) (2001): 164-193.
28. As should be evident by now, I include both the natural and technical sciences and the social sciences in this discussion.

29. Most of this section builds upon previously published work; see Liora Salter, *Mandated Science,* where the concept of "mandated science" was first introduced. Jasonoff uses "regulatory science" as a synonym for "mandated science," and others have called it "policy science." There is no reason to debate terminology here. See Sheila Jasonoff, "Procedural Choices in Regulatory Science," *Technology in Society* 17(3) (1995): 279-293. "Discovery science" is a new concept, introduced in this article. I have not found an equivalent concept in the literature.
30. Other names for this are "basic science," "research science," and "laboratory science," all of which are too limited for the purposes of the analysis here. "Working science" is science produced in the first instance for an intended audience of scientists and academics, or scientific work designed to meet the criteria of basic, laboratory, or university science. Thus, scientists working in a corporate laboratory are engaged in working science if their studies are suitable for publication in peer-reviewed scientific journals.
31. Michael Shortland and Jane Gregory, *Communicating Science: A Handbook* (Harlow, England: Longman Scientific, 1991), 7. Apparently there is also an Asimov quotation to the effect that "without an informed public, scientists will not only no longer be supported financially, they will also be actively persecuted." (Source unknown)
32. Some recent examples: Royal Society of Canada, *A Review of the Potential Health Risks of Radiofrequency Fields from Wireless Telecommunication Devices* (1999); and *Report of the Panel Monitoring Ontario's Electromagnetic Field Risk Assessment Program* (2000).