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Science and Society: Some “Made-in-Canada” Options for Improving Integration

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In this article, the authors describe relatively recent efforts by scientific research agencies to promote, through various funding programs, the integration of social sciences and humanities with the natural sciences. This “integrated” approach seeks to study science through a broader interdisciplinary lens in order to better anticipate, understand, and address its ethical, legal, and social implications. The authors review the origins and evolution of this trend, as well the arguments which have been formulated by both proponents and critics of integration. By using Genome Canada’s “GE3LS” Research Program as a case study, the authors discuss the successes and continuing challenges of this model based on evaluation results available to date. The authors then go on to examine and compare three possible models for improving the future success of the GE3LS research program, including: 1) enhancing the current integrated research approach through incremental refinements based on concrete evidence and lessons learned; 2) promoting greater interaction and synergy across GE3LS research projects through a deliberate, systematic and coordinated “hub and spoke” approach; and 3) taking a broad programmatic approach to GE3LS research by creating a central resource of available expertise and advisory capacity.

Keywords: ELSI, GE3LS, genomics, integration, science, society

INTRODUCTION

Ever since James Watson, the first Director of the U.S. National Human Genome Research Institute (NHGRI), publicly announced at a press conference in 1988 that the National Institutes of Health (NIH) should direct funds to the study of the ethical, legal, and social implications (ELSI) of the Human Genome Project, a new generation of related research programs eventually...
emerged at the NHGRI and elsewhere in the world (Greely, 2006; NHGRI; Watson, 1996).

Since 2002, the U.K. Economic and Social Research Council has funded a number of centres and institutions across the United Kingdom, all dedicated to examining and addressing the economic and social implications of genomics science and technologies (ESRC Genomics Network). In the Netherlands, the Centre for Society and Genomics was created in 2004 to study, assess, and improve the ethical, legal, and social aspects of genomics and its relationship with society (ELSA) (Centre for Society and Genomics). In 2008, the Research Council of Norway consolidated a research program examining the ELSA aspects of biotechnology, nanotechnology and cognitive science (Research Council of Norway). Austria, Finland, and Germany launched a multinational initiative in 2009 calling for collaborative research projects on ethical, legal, sociocultural, and economic aspects of genomics and related sciences (ELSA-GEN, 2009). Genome Canada, created in 2000, has as one of its objectives to examine and address the ethical, environmental, economic, legal, and social implications of genomics (GE³LS) (Genome Canada), and the Canadian Institutes of Health Research Institute of Genetics has, since its inauguration in 2001, consistently held as one of its strategic research priorities, the study of genetics and its ethical, legal, and social issues (GELS) (CIHR Institute of Genetics).

Whether the recent emergence of such ELSI, ELSA, GE³LS, and other equivalent programs is merely a modern improvisation of how research gets funded in emerging fields such as genomics, or whether they reflect a more fundamental “re-thinking” of how science relates to society more broadly is part of a larger question which is currently being debated (Zwart and Nelis, 2009).

This article is an attempt to contribute further to that debate. Certain limitations, however, must be acknowledged from the outset. First, this article is largely focussed on the Canadian experience, using Genome Canada as a case study, and may, therefore, be limited in its generalizability to other countries. Second, there is an ongoing struggle in Canada, as elsewhere, to determine appropriate measures for evaluating the success of different funding models for addressing the ethical, legal, and social aspects of science, and in many respects, the jury is still out on this question. Third, the authors have selected three Canadian-led innovations as useful models for comparing and contrasting distinct features of integration for discussion purposes only, though we concede that there may be several other valid models not covered here. Finally, given the authors’ experience and background, we take a normative and programmatic approach to exploring the question of how the broader societal implications can best be integrated into genomics research, and leave for others better suited the philosophical and epistemological examination of that question.
BROADER SOCIETAL CONTEXT

As a backdrop to the ongoing debate about ELSA, ELSI, GE3LS, or other equivalent programs, is a larger phenomenon which seeks to “re-contextualize” the role of science within the broader context of the society we live in.1 This emerging “Science in Society” paradigm is continually evolving as major societal trends unfold.2

A stronger culture of public accountability and higher expectation of return on investment now permeate both research institutions and the agencies that fund them. Increasingly, access to scarce funding and justification for its allocation depend on the social relevance of the research and its demonstrable benefits to society.

The ubiquitous nature of information technologies, the web 2.0, and the decentralization of “truth” have transformed institutional, disciplinary, and professional structures of science. The democratization of knowledge and the devolution of decision-making processes generally have broken down the traditional walls around the scientific elite and the claims of exclusivity that once belonged to them.

Increased research collaborations between academic institutions, governments, private sector, and charitable organizations have expanded the number of stakeholders and different perspectives that come to bear on the research. Increased are the voices chiming into the discussion of “social relevance” and actively engaged in shaping strategic research directions and priorities.

All of these societal trends and changing expectations have resulted in what Gibbons coined over a decade ago as “science’s new social contract with society” (Gibbons, 1999). More than merely a “public relations exercise,” the process of contextualizing science in society moves scientists outside their traditional institutions and into what Gibbons calls the “agora”—the public space in which “science meets the public and the public speaks back to science”—where research questions are reformulated and solutions are negotiated. Contextualization urges scientists to think beyond potential applications of their work and “internalize” its broader societal implications in order to earn and maintain its social legitimacy (Gibbons, 1999).

Nowotny et al. describe this shift in thinking about science from one previously preoccupied with scientifically “reliable” knowledge, to one which seeks to ensure that new knowledge is also “socially robust” (Nowotny et al., 2002, 2006; Gibbons et al., 1994). Whereas scientific “reliability” is a judgement that resides with scientific peers having the requisite specialized expertise, “social robustness” is an enhanced form of reliability within a broader societal context which must be judged by a more expansive community of disciplines and stakeholders with highly distributed knowledge, perspectives, and interests. Nowotny contends “that the more highly contextualized the knowledge the more reliable it is likely to be—not necessarily within the reductionist...
framework of disciplinary science which defines reliability almost exclusively in terms of replicability, but because it maintains valid (sic) outside these ‘sterile spaces’ created by experimental and theoretical science, a condition we have described as ‘socially robust’” (Nowotny, 2000).

Accordingly, scientists have had to respond to these emerging trends and changing expectations, by becoming more reflexive about their own roles and impacts on society (European Communities, 2009). Social science and humanities (SSH) research projects, which have traditionally been funded through separate streams and viewed as necessarily external and distant critics of science, are becoming increasingly integrated into large-scale science projects and/or programs. While these are fields of scholarly research in their own right, they tend, in their integrated form, to be more specific in their examination of new technologies, their practical applications, and their implications for society.

ARGUMENTS FOR AND AGAINST INTEGRATION

Many of these integrated science and society research programs are relatively novel and still in the process of exploration, assessment, and refinement. While some view these programs as laudable attempts to anticipate the broader societal aspects of science, better understand their implications from multiple perspectives, and take responsibility for addressing them, others have been sceptical of their track record to date (Yesley, 2008; Huijer, 2006).

Notwithstanding the ostensible efforts made at the funding and programmatic level to integrate science and society in research and the challenges associated with implementing these, there is still a perception that the work of SSH researchers is relegated to a secondary role in relation to the primary aims and objectives of science. Critics contend that SSH researchers risk becoming too close to the large-scale science and vulnerable to becoming mere promotional instruments or handmaidens of science, lacking the critical independence, academic freedom, and intellectual autonomy to contribute meaningfully or credibly to the advancement of scholarly knowledge in their respective disciplines (Macilwain, 2009; Zwart and Nelis, 2009). Others take a more cynical view, seeing science-society integration as but a rhetorical construct to deflect challenge and gain political support of government funders and the general populace, with little serious influence or impact in practice (Yesley, 2008; Kitcher, 2001, cited in Penders et al., 2008).

On the other hand, those who hold a more optimistic view of science and society models recognize the many virtues of integration worth pursuing and improving upon. Zwart and Nelis have described the integrated “ELSA” genomics approach as having four important features (Zwart and Nelis, 2009): 1) Proximity allows ELSA researchers to become better informed of the science
and of the concrete issues at stake, which in turn enhances the relevance, specificity, and timeliness of their work; 2) Early anticipation moves upstream the critical reflection needed to identify both desirable and undesirable impacts on society, providing sufficient margin of time to guide and influence change at the forefront of emerging technologies; 3) Interactivity broadens the agenda-setting process by inviting various stakeholders and publics to the table and encouraging them to take on a more active role in shaping both policy and research through early identification of relevant ethical, legal, and social issues; and 4) Interdisciplinarity allows for synergistic and complementary perspectives to ensure that both the scientific and normative dimensions of knowledge creation evolve in step with one another. All four of these features help contextualize science in society and achieve that higher level of “social robustness” which Nowotny, Gibbons, and others referred to.

Acknowledging some of the arguments against integration, and in particular, the charge that the virtues of integration come at the cost of independence, Zwart and Nelis contend that these are not either–or propositions. Integrated ELSA researchers can and should exercise their intellectual autonomy in shaping the research questions, and retain a critical and reflexive perspective in answering them. They suggest “something similar to participatory criticism is a viable option” (Zwart and Nelis, 2009). Along the same lines, other authors suggest that “[a]lthough crossing the ocean of cultural divide between the sciences remains their overall goal, ELSA researchers still have to take care of their own research,” keeping up with developments and advancing knowledge as independent and productive scholars in their own fields (Penders et al., 2008).

GENOME CANADA’S GE3LS PROGRAM: A CASE STUDY

Genome Canada is the Canadian Government’s main strategic investor in genomics research. Created as an independent, not-for-profit corporation in 2000, Genome Canada funds large-scale, genomics and proteomics projects across various sectors critical to Canada’s economy: human health, forestry, fisheries, agriculture, and the environment. Genome Canada also provides access to leading-edge technology through its Science and Technology Innovation Centres. At time of publication, Genome Canada, the six regional Genome Centres across the country and the research community had raised over $1.7 billion in funding for genomics research in Canada, of which $915 million represents the Federal Government’s investment alone.

Federal funding is contingent upon the terms and conditions of a funding agreement between Genome Canada and the Federal Government, through Industry Canada. This funding agreement sets out five (5) corporate objectives of Genome Canada, including “the assumption of leadership in the area
of ethical, environmental, economic, legal, social and other issues related to genomics research (GE³LS) and the communication of the relative risks, rewards, and successes of genomics to the Canadian public.”

In fulfilling this objective, Genome Canada innovated in several respects from other ELSA, ELSI, or equivalent such programs that existed elsewhere in the world. First, in creating its GE³LS program, Genome Canada added two more “E’s” in its acronym, namely, economic and environmental implications of genomics. In so doing, it urged the research community to explicitly consider not only the ethical, legal, and social aspects of genomics science, but also potential trade-offs and longer-term impacts on the economy and the environment, thereby expanding the “contextualization” process and the “social robustness” of the research that it funds.

Second, Genome Canada, from its inception, made GE³LS-related projects eligible for receiving large-scale grants. As a result, ten large-scale GE³LS projects have been funded since 2000 providing close to $40 million in Genome Canada funding and co-funding to support some of the largest projects Canada had ever seen in these related disciplines. By sheer virtue of their scale, these stand-alone GE³LS projects created the much-needed impetus to consolidate GE³LS capacity at a critical juncture in the history of genomics funding in Canada, and helped advance knowledge and leadership both nationally and internationally.

Third, Genome Canada also funds smaller GE³LS projects that are integrated as part of other large-scale genomics science projects. While applicants from the natural sciences have always been expected to consider the ethical, economic, environmental, legal, and social aspects of their proposed research, the level of expectation has become more definitive from competition to competition. Likewise, the clarity of the expectation has been refined over the course of time.

A 2006 study conducted by the European Research Area on Societal Aspects of Genomics (ERASAGE) found Canada to be a “benchmark country” with its GE³LS research programs among the most “strongly developed” (Nelis et al., 2006). A commissioned bibliometric analysis concluded that Canada ranks 4th overall in GE³LS research using multicriteria rating from 1996–2007, on par with Australia, and behind the U.S., U.K., and Denmark (Campbell et al., 2008). More recently, an external evaluation of Genome Canada in May of 2009, which included a survey of a subsample of Genome Canada-funded genomics scientists, GE³LS leaders of stand-alone projects, technology platform leaders, peer reviewers, and other genomics research funders, measured Genome Canada’s performance against all five of its corporate objectives, including leadership in GE³LS (KPMG, 2009). This KPMG report found that Canada’s leadership in GE³LS research had improved substantially since Genome Canada was created, from an average rating of “fair to good” prior to Genome Canada, to an average rating of “excellent” now (KPMG,
2009). While several federal and provincial initiatives have contributed to enhancing Canada’s leadership position in the area of GE3LS, a majority of respondents believed that this change was either completely (8%), mainly (38%), or partially (23%) due to Genome Canada and the regional Genome Centres (KPMG, 2009).

In respect of the integration of GE3LS into large-scale genomics research projects, 47% of respondents believed that Canada has done this well or very well (KPMG, 2009). Much of this enthusiasm can be attributed particularly to the international respondents who regarded Canada’s experience with GE3LS integration as faring better than that of their own countries. International reviewers saw GE3LS integration “as a key defining characteristic of Genome Canada and very valuable” (KPMG, 2009). The results among Canadian respondents, however, were more mixed:

...GE3LS leaders commented that they are often not as integrated into genomics science projects as they could be. They observed that they were sometimes “thrown together” with genomics scientists, with insufficient time for real teams to form, or to develop research themes in an ‘organic’ way. They further commented that collaborations among the GE3LS scientists themselves were often accidental and usually regional, not national. Several GE3LS leaders felt isolated from each other, or noted the need for more internal capacity in their field...

On the genomics scientists’ part, a significant number were not very convinced of the usefulness of GE3LS. These topics were often considered a “tax” on the science, and suffering from the GE3LS leaders not understanding genomics sufficiently well, a possible over-emphasis on ethical aspects (with not enough on socio-economic and environmental factors), and overall not being seen to have much impact on Canadian genomics credibility (though, as noted earlier, many of the internationals would not agree). It was noted, however, that GE3LS topics that were well integrated with the science did, in fact, work well and were useful...

The tensions articulated above are also reflected in feedback received by Genome Canada during various workshop consultations with the Canadian research community and other stakeholders over the years (Green and Hartley, 2007; Genome Canada, 2007; Williams, 2006; Hartley and Williams-Jones, 2006; Sheremeta and Williams-Jones, 2002). Consultations revealed that GE3LS integration has not always proceeded so smoothly or uniformly, resulting in varying levels of collaboration between GE3LS and genomics researchers. In practice, the integrated GE3LS components were regarded by some as being “tacked on” to a genomics project in a last-minute rush to meet application deadlines or as involving “forced marriages” between genomics and GE3LS researchers in order to fulfil funding conditions. A limited pool of GE3LS capacity in Canada, aggravated by institutional barriers to interdisciplinary training and promotional opportunities, made it
difficult to identify—let alone integrate—GE3LS researchers as project co-investigators. Communication difficulties, cultural gaps, geographic distances, diverse methodological approaches, and general mistrust of the unknown all further added to the challenges of interdisciplinary team-building—particularly in the early days.

Based on experience to date, those involved—either from the “science” or “society” side—have had competing, sometimes colliding, expectations of what should be the role of integrated GE3LS researchers in the context of large-scale genomics research projects. These diverse expectations appear to be rooted in different underlying assumptions of what GE3LS is intended to accomplish.

Some projects include GE3LS expertise on their Scientific Advisory Boards to provide an external, independent, and critical perspective on the genomics project during its design and implementation thereby creating the checks and balances necessary to enhance the social legitimacy of the research (oversight). Others view the role of GE3LS researchers as providing internal advisory services to the project scientists on what have primarily been legal, ethical, and sociocultural issues requiring resolution in order to move the project forward (advice). There are those who see integrated GE3LS as a way of facilitating the interface between science and various end-users by, for example, encouraging uptake of technology by practitioners, informing evidence-based policies, regulations, and governance frameworks, enhancing science literacy of the media, gauging public opinion, educating and engaging communities to participate in relevant public debates (knowledge translation).

Some regard GE3LS integration as an opportunity for academics working in GE3LS-related fields to conduct embedded research of their own, using large-scale genomics projects as practical case studies and contributing to the advancement of knowledge in their respective disciplines (embedded research). Still others see it as an opportunity for both natural scientists and social scientists/humanists to work together iteratively as part of an integrated, interdisciplinary research team from the very outset, conceiving the research proposal, shaping research questions, influencing research directions, carrying out complementary research methods, and working in step to reach common milestones (integrated research). More often than not, integrated GE3LS research is seen as some combination of these various purposes.

**MOVING FORWARD**

Despite the challenges and differences of opinion, what is more commonly recognized is that successful integration of GE3LS research takes time. Truly collaborative, trusting, and productive relationships need to be nurtured well in advance of funding competitions to enable communication across different disciplines, help bridge the cultural gaps between them, and match up
expectations. Time was a key theme emerging from the Genome Canada’s informal workshop consultations (Green and Hartley, 2007) as well as KPMG’s formal evaluation of Genome Canada (KPMG, 2009).

Genome Canada and the regional Genome Centres are not alone in working through these challenges. Other funding programs in other countries are also facing many of the same issues, recognizing that resolution will take time. Although cultural, communication, and credibility issues continue to persist in the sometimes “prickly” relationship between natural scientists and social scientists/humanists, some have observed “chinks” slowly beginning to appear in the figurative wall which has traditionally divided these disciplines (Macilwain, 2009).

Indeed, there are signs that science-society integration efforts can get better over time. A valuable example of how integration models improve iteratively through experience is illustrated by the improvements that were made to the “Science and Society” component of European Commission’s Sixth Framework Programme of 2002–2006.

The Sixth Framework Programme dedicated €88 million to “Science and Society” research and activities aimed at developing more constructive and effective communication and dialogue between the scientific community and society at large (European Commission, 2002). An evaluation of the “Science and Society” component of the Programme conducted in 2007 found, among other things, that:

1. Only a minority of projects had addressed science and society issues, and of those that did, significant variations existed in terms of how much attention was dedicated for that purpose;
2. Science and society issues were only vaguely addressed in formal program documents (program descriptions, guidance for applicants, evaluation criteria, reporting requirements, etc.) and informal guidance offered by program staff, while clearly significant, varied in terms of quality and influence;
3. The relevance of science and society issues varied across different themes and instruments; and
4. The general framing of the research agenda was an important factor in the successful integration of science and society issues (European Commission, 2007).

The Evaluation Report recommended that: 1) definitions of science and society issues should be made clearer and more precise; 2) convincing arguments should be brought forward to demonstrate the relevance of science and society issues in strengthening research capacity, achieving scientific excellence, and having ultimate impact; and 3) practical examples should be provided
to illustrate concretely how science and society issues can be addressed with useful links to further information and tools. The Report also recommended improving program descriptions, guidance documents, evaluation criteria and procedures, monitoring systems, project proposal requirements, project officer training and capacity, and project reporting mechanisms (European Commission, 2007).

At its conception, the Sixth Framework Programme set forth to bridge the gap between science and society, implying a vision of science and society as two distinct and separate entities which needed to be brought closer together. Over time, however, it became evident that such a vision could not be achieved by having scientists unilaterally disseminate information about their scientific advances through broad public media. More needed to be done to break down the barriers between scientists and citizens. Conceptually, the vision evolved into one which regards scientists as forming an integral part of society and having equally as much to learn about the world outside their laboratory. Hence, the Seventh Framework Programme of 2007–2013 took a more inclusive perspective of research within a wider societal and policy context by adopting a “Science in Society” Work Programme. More than €330 million have been dedicated towards relevant activities aimed at more meaningfully involving citizens and civil society in research and research-based policies, and promoting more effective two-way dialogue that enables the public to engage with science and vice versa (European Commission, 2007; European Commission, 2007–2013; Gannon, 2006). Even with these improvements to the 7th Framework Programme, the European Commission recognizes that the science-society debate is an ongoing one which continues to evolve and cannot be conclusively closed one way or another (European Communities, 2009).

POSSIBLE MODELS FOR IMPROVING GENOME CANADA’S INTEGRATED GE³LS RESEARCH PROGRAM

In light of all of the above, there are several options for improving GE³LS integration going forward, recognizing that it will take time to get it right, that the debate about how best to do it continues and that we should strive to find practical solutions, while remaining open to alternatives.8 Below are simplified models of integration, illustrated by existing programs in Canada which highlight basic differences in orientation. These models are summarized in Table 1.

The Distributed Model: Doing it More and Doing it Better

One feasible option going forward is to continue to improve Genome Canada’s current GE³LS integration model by remaining open and responsive to possible improvement. We refer to this current model as the “distributed
Table 1: Summary Table of Some Made-in-Canada Integration Models

| Model Type        | Example                                                                 | Advantages                                                                 |
|-------------------|-------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Distributed       | Genome Canada’s existing GE$3$LS program consisting of both large-scale GE$3$LS projects and integrated GE$3$LS projects | Close proximity between GE3LS researchers and scientists, Enhanced relevance and specificity of GE3LS research, Applied, case-study approach to studying emerging genomics technologies |
|                   |                                                                         | Isolated capacity in individual research projects, Potential duplication and redundancies, Interdisciplinary teaming efforts tend to be limited by regional boundaries |
| Interactive       | VALGEN large-scale GE3LS project funded in 2009 by Genome Canada as part of its ABC Competition | Same advantages above, with added value of horizontal integration and synergy, Reduced potential for duplication, Enhanced potential for national and international collaboration |
|                   |                                                                         | Highly dependent on collaboration with those willing to collaborate, Inherent competition built into the model, Complex intellectual property issues to work through |
| Centralized       | McLaughlin-Rotman Centre (MRC) ESC Program funded in 2005 as part of the Gates’ Foundation Grand Challenges in Global Health Initiative | Relatively close proximity between ESC capacity and scientists, Potential for coordination, without competition, Horizontal overview and understanding of cross-cutting ESC issues, Enabling of project milestones, Flexibility of involving external experts |
|                   |                                                                         | ESC issues addressed among only those projects requesting assistance, Otherwise, no other integrated ESC capacity within the projects, ESC issues identified only after projects have been funded and research methods and objectives have been established |
model” since each large-scale genomics project proposal is expected to have its own integrated GE3LS component. Given its relatively recent confirmation as a mandatory funding criterion made explicit in 2005, there is still much room for incremental enhancement. Similar to the European Framework experience, Canada too can learn from past experiences and improve upon them both operationally and/or conceptually.

For instance, over the course of Genome Canada’s major competitions, the percentage of funded large-scale science projects with integrated GE3LS research plans has consistently increased over the years from 20% in Competition I, 52% in Competition II, 57% in Applied Human Health, 87.5% in Competition III, 100% in the Applied Genomics in Bioproducts or Crops (ABC) Competition, and again 100% in the 2010 Large-Scale Applied Research Competition.9

In Competition III, integrated GE3LS research received 1.6% of the total funding support for all large-scale genomics science projects, and GE3LS research accounted for 5.6% of overall funding if large-scale GE3LS projects are also taken into account. In the ABC competition of 2009, those figures increased to 4.8% and 9.3%, respectively. (At the time of publication, a total of $60 million had been awarded to 16 successful genomics projects as part of Genome Canada’s 2010 Large-Scale Applied Research Competition, but the percentage breakdown representing integrated GE3LS components was not yet known.)

While these figures are promising, they speak only to the quantitative increases in the numbers of integrated GE3LS research projects and levels of funding; they say little about the relative quality of the projects themselves or how the “process” of integration was experienced over time. The challenges of evaluating the quality of the integration experience are exacerbated in part by the heterogeneity with which integration is perceived and operationalized within individual projects.

Despite these evaluation challenges, some recent qualitative data are beginning to demonstrate that the experience of GE3LS integration can get better over time as a function of lessons learned. For instance, Genome B.C. has recently carried out an evaluation comparing researchers’ experiences with integrated GE3LS projects in Genome Canada’s Competition III program (only those projects carried out in British Columbia) and researchers’ experiences with integrated GE3LS projects in Genome B.C.’s Applied Genomics Innovation Program (AGIP), a regional initiative launched three years later in 2007. Interviewees included researchers from the natural sciences and social sciences and humanities, peer reviewers, and funders’ staff.

Preliminary data support the proposition that the integration experience gets better as application guidelines and processes become clearer, review criteria are refined, funders’ staff provide active support for interdisciplinary
team-building, collaborative relationships among researchers strengthen over time, and the research community eventually grows more accustomed to the merits of the integration model. While the data are interim and limited to the B.C. experience, they do sustain the more general hope that perseverance pays off when appropriate incentives and support mechanisms are in place (Rodgers et al., 2009).

Similarly, the most recent conditions and review criteria for GE3LS integration in Genome Canada’s 2010 Large-Scale Applied Research Competition have been significantly strengthened and clarified from previous versions which existed in former competition guidelines. These refinements were a deliberate response to past evaluation results and are the culmination of lessons learned to date. Whether they are effective in better guiding research applicants, strengthening integration efforts, and ultimately enhancing the success of projects remains to be seen.

The principal advantage of this “distributed” model is that it ensures, through built-in incentives and mandatory funding requirements, that every large-scale project consider the societal aspects of the science it proposes, that project leaders present a well-thought out research plan to address these, subject to a rigorous peer review process, and that a specific portion of the overall project budget be dedicated to support the GE3LS related research and activities. GE3LS research, conducted in direct proximity to the projects, is well-informed by the specifics of the science and vice-versa, thereby enhancing the relevance, influence, and ultimate impact of the research.

Even with the most refined incentives and best support mechanisms in place, however, the “distributed” model remains limited in some ways, by virtue of its inherent features. For one, integrated GE3LS projects tend to be isolated from one another, except for the occasional times when GE3LS researchers will sporadically decide to collaborate together across projects. This does not tend to happen very often on its own given that most efforts are already expended as it is on trying to integrate the GE3LS and scientific aspects within the context of each individual large-scale project, leaving little energy or resources available to work laterally across projects. Given the lack of coordination across integrated projects, there is a risk of duplicating efforts, particularly in the context of strategic competitions on targeted themes where many of the societal aspects raised by the science are likely to be similar across projects. And even with the best support mechanisms in place to promote networking and interdisciplinary team building by the regional Genome Centres to increase GE3LS capacity and expand the breadth of GE3LS related disciplines, these tend to be naturally limited by the geographic and jurisdictional boundaries of each region, failing to capitalize on the full capacity and expertise available on a wider, national basis.
The Interactive Model: Integrating the Integrated

Options for enhancing the current Genome Canada GE³LS integration model can be refined not only at the operational level, through incremental improvements over time, but conceptually as well, from fresh and creative ideas brought forward by the research community itself. An example of this is the “Value Addition through Genomics” (VALGEN) project—a large-scale, stand-alone GE³LS project recently funded by Genome Canada as part of its ABC competition. Through their innovative project, VALGEN researchers are attempting to take the current model of GE³LS Integration to the “next level” by horizontally integrating the integrated GE³LS components across the other eleven large-scale genomics projects. With their $5.5M investment, VALGEN researchers have as a primary objective to leverage the existing GE³LS capacity in all projects and add value to the total ABC investment of almost $118M in federal funding and co-funding combined (VALGEN).

VALGEN’s co-principal investigators have conceptualized their project as a potential “dock” for the integrated GE³LS components of the other projects—a national alliance of the willing, comprising a resource base and “virtual common room” to promote networking, outreach, and partnership opportunities. The VALGEN horizontal integration experiment involves a formal network of interested GE³LS researchers across integrated projects, that promotes collaboration on knowledge translation activities across institutions, across the country and supports capacity building through sabbatical fellowships, new researcher training and researcher mobility programs.

In addition, the research component of VALGEN is using social sciences, humanities, and legal scholarship to explore barriers to innovation in agricultural biotechnology. In particular, the research team will focus on three core substantive issues likely to be common across all ABC projects, namely, intellectual property management and technology transfer; regulation and governance; and democratic engagement. VALGEN research is not intended to “supplant or replicate” existing research being conducted by the integrated GE³LS projects funded under the ABC competition, but to synthesize research outcomes specific to the technologies used in individual projects, at a more general level of principle and abstraction, adding value across all projects.

This living laboratory of ‘integration’ will provide interesting outcomes which, over time, may encourage the research community to come forward with equivalent or further-improved proposals in future competitions. Targeted competitions on strategic research themes would lend themselves particularly well to this “next generation” model of integration.

Nevertheless, even this creative model of “interactive integration” has some challenges to overcome. Chief among these is its critical dependence on the willing collaboration of the integrated GE³LS leads in each project to interact with other projects and to “dock” into the national coordinating project. When there is already existing cohesion in the community, this may work
naturally well. Otherwise, it may be challenging to garner the voluntary participation of GE3LS leads horizontally across integrated projects, particularly when these can only be identified after the fact, that is, after funding has been awarded and the successful large-scale projects become known. Moreover, by virtue of its inherent features, this model has built in a certain degree of competition between the research conducted at the individual project level, and the research conducted as part of the larger, stand-alone VALGEN project. This may raise complex intellectual property issues which must be worked out collaboratively in advance in order to clarify and manage expectations among the researchers involved.

The Centralized Model: Taking a Broader, Programmatic Approach

Another innovative variant of the integration model is illustrated by the overarching Ethical, Social, and Cultural (ESC) Program of the Grand Challenges for Global Health (GCGH), initiated by a Canadian team (Singer and Lavery, 2003–2008) and sponsored by the Bill and Melinda Gates Foundation. The GCGH initiative was launched in 2003 to identify and address science and technology obstacles to resolving the fourteen most critical global health challenges in the developing world. In 2005, 44 projects involving scientists from 33 countries around the world received over $436 million in funding to create “deliverable technologies,” defined as “health tools that are not only effective, but also inexpensive to produce, easy to distribute, and simple to use in developing countries” (Grand Challenges in Global Health, 2005). Recognizing that successful completion of the projects depends not only on doing good science, but also on addressing salient ethical, social, and cultural issues, an ESC program was proposed and successfully funded in 2005 to: 1) advise GCGH projects on the ethical, social, and cultural issues that need to be addressed in order to successfully achieve their project milestones; and 2) create a research program that can facilitate appropriate adoption of technologies that may arise from the funded GCGH projects over the long term (Singer et al., 2007). The ESC program is based in Toronto, Canada, at the McLaughlin-Rotman Centre for Global Health, and includes team members in the developing world (McLaughlin-Rotman Centre for Global Health).12

In the first year of operation, the ESC team provided advisory services to 24 of the 44 GCGH projects, and maintained ongoing engagement with the remaining projects. In the second year of operation, the level of integration was enhanced, and the ESC program’s capacity to anticipate and respond to project-specific issues was increased, by assigning an ESC advisory service leader and a lead bioethicist to each project, and instituting regular meetings between ESC program staff and GCGH project officers. The ESC advisory service approach to responding to issues involves: framing the problem in
consultation with the GCGH project teams; identifying resources or materials needed, including the assistance of outside expertise; researching the problem through a review of the literature and other sources; and proposing draft solutions to the GCGH investigators and staff. The ESC program staff then revises the proposed solutions as needed and works with GCGH research teams to implement the recommended actions.

The research activities of the ESC program have resulted in, as examples:

1. A series of working papers, conceptual papers, and documentation of ESC program activities to address specific issues that have not been adequately covered in existing literature;
2. Commissioned research on priority issues for successful adoption of technologies coming out of GCGH projects;
3. Global case studies to identify good practices in community engagement and commercialization of health technologies in low-resource settings; and
4. A demonstration project on Web-based public engagement revolving around broad topics that are relevant to the GCGH initiative.

The ESC program aims to integrate its activities with that of the GCGH projects by working closely with investigators to address ESC issues as they arise. In contrast with Genome Canada’s distributed model by which each individual funded genomics project must have an integrated GE3LS research plan with the requisite GE3LS capacity to carry it out, the ESC program is an overarching, “centralized model” which provides advisory services (either directly by the ESC team or through facilitated contact with other appropriate experts) and facilitates necessary research to assist potentially all project investigators in addressing ESC issues within the funded GCGH projects. Whereas the distributed integration model does not actively promote coordination of GE3LS research plans between individual projects, the ESC program coordinates input across GCGH teams and key informants to explore questions around the adoption of new technologies with broad relevance to all GCGH projects.

The centralized ESC program is similar to the interactive VALGEN model in that both have as a key objective to coordinate research on the core ESC or GE3LS-related aspects common to all funded projects. The main differences between the centralized ESC model and the interactive VALGEN model, however, are twofold. First, the ESC model has as one of its primary functions to provide advice to individual projects, which is not one of the stated objectives of VALGEN. Second, the ESC model centralizes all of the ESC research capacity in the overarching ESC Program, whereas the VALGEN model seeks to
“add value” to the already-existing GE3LS capacity which remains integrated within each individual project.

One obvious advantage of the ESC “centralized model” (similar to the VALGEN interactive model) is the coordination it allows across funded projects, identifying common ethical, social, and cultural issues which exist horizontally across projects, thereby reducing the potential for redundancies.

Another advantage of the ESC “centralized model” (similar to the “distributed model”) is the degree of proximity which exists between ESC researchers and interested GCGH project leaders who request ESC assistance in achieving project milestones. While the degree of proximity in the centralized model is not always necessarily as close as that which ideally exists between integrated GE3LS researchers and scientists in the distributed model, it will vary depending on the issues/challenges at stake. For some projects, there may be very deep integration of ESC components, whereas in others where the ESC issues are less intense or complex, the level of ESC involvement, if any, may be more modest. In other words, in the centralized model, the degree of proximity between the ESC team and the project scientists is not dictated by the design of the model itself, but rather, arises organically by virtue of the complexity of the underlying issues or challenges at stake.

Among potential challenges associated with the centralized model is the fact that projects are not required to request assistance in addressing ESC issues. Some may see the absence of such a mandatory funding requirement as a disadvantage resulting in less comprehensive coverage than if projects were in fact required to address ESC issues. Others, however, would contend that this is in fact a benefit since not all projects necessarily raise ESC issues, and should therefore not be artificially forced to construct some. Moreover, those who do come forward voluntarily to request assistance do so more willingly and in a spirit open to collaboration once they themselves come to recognize the critical need for ESC advice and research to assist them in achieving their project objectives.

Another potential challenge associated with the centralized model has to do with the timing with which the funding decisions are made. If a centralized ESC-like program is funded only after or at the same time as the science projects are funded, then any assistance the ESC team may provide the projects in identifying and addressing ESC issues will come necessarily after-the-fact, that is, well after the scientific project methods and objectives have already been established, thereby reducing their anticipatory potential and their ability to shape the science. However, this challenge may be mitigated if the ESC program were funded in advance of making final funding decisions on the science projects. This would allow the centralized ESC team to analyze ESC issues likely to arise, and have impact on how individual project milestones are constructed.
CONCLUSIONS

Whether one is contemplating the distributed model, the interactive model, or the centralized model of GE³LS integration, there is always room for improvement from a funder’s perspective. Strategic measures for improvement could range from incremental refinements on current approaches based on lessons learned and shared among funders (such as Genome B.C.’s AGIP Program), to incentivizing the research community itself to come forward with creative, alternative models (such as the VALGEN project), to developing an innovative, centralized platform for conducting GE³LS research, and providing GE³LS related advice (such as the ESC Program of the Grand Challenges in Global Health).

At the operational level, much can still be done to clarify the purpose of integrated GE³LS and provide more helpful guidance through application guidelines; improve the quality of GE³LS integration through more effective incentives built into evaluation criteria and peer review processes; and provide more staff support to promote interdisciplinary team-building both regionally, and nationally. At the project level, strategic requests for proposals could help encourage other VALGEN-like stand-alone projects to come forward with new and creative ideas for integrating integrated projects in future thematic competitions; integrated GE³LS researchers in individual projects could likewise be incentivized to collaborate with others horizontally across projects as well. At the program level, centralization of GE³LS capacity, similar to the MRC ESC Program, if considered a potential future model, could be well established prior to the call for scientific proposals, encouraging GE³LS consultation further upstream in the project development process and helping guide the determination of research questions, objectives, and methods from the very outset.

Whatever may be the best model for GE³LS integration, it is important not to lose sight of the substance for the form. In characterizing how the relationship between science and society evolved conceptually over time, Frank Gannon reminds us of the conceptual shift that occurred between the “Science and Society” of the Sixth Framework Programme, and the “Science in Society” Work Programme of the Seventh Framework (Gannon, 2006). He goes on to explain, however, that as society becomes more demanding, better at communicating its needs, and stronger in its resolve to hold institutions publicly accountable, science must find a humbler place in this new democratic space; it must open up a new dialogue of trust and understanding, adapt to the choices and priorities of society, and account for whether and how it will meet them. “Science for Society” is how Gannon describes this next generation of dialogue (Gannon, 2006).

Further to Gannon’s “and-in-for” trilogy of conjunctions and prepositions, we wonder if it is not time to usher in a new era of “Science as Society.” Science
and technology have profound and permanent influence in shaping our lives, our very identities, the world around us, and the future of our children. More fundamentally, the ubiquitous nature of science and technology can change the very way we see these things, the expectations we come to have of them, and even our ability to be critical of them. To truly understand these influences, we must reflect on more than what we want and need, and what can be done and how. The dialogue must transcend the here and now, and go beyond the immediate applications of science, to consider its larger implications, not only for our society, but for other societies and future societies. This requires open, inclusive, and participatory debate, further upstream in the development process, to consider the kind of global society we want to live in and leave behind for future generations. This, we believe, is the “function” first and foremost, which discussions about “form” must be made to follow.

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NOTES

1. Though we are not suggesting that the emergence of integration programs is the inevitable outcome of the broader discussion about science and society, we do believe it is informed—if not influenced—by it.

2. The recent Monitoring Activities of Science in Society in Europe (MASIS) Report of the European Research Area provides an extensive discussion of several of these trends (European Communities, 2009).

3. Genome B.C., Genome Alberta, Genome Prairies, Ontario Genome Institute, Genome Québec, Genome Atlantic.

4. The balance of the $1.7 billion is co-funding by provincial governments, charitable organizations, and private sector.

5. http://www.genomecanada.ca/en/ge3ls/research/.

6. Lay summaries of integrated GE3LS projects funded by Genome Canada can be accessed online at http://www.genomecanada.ca/en/portfolio/research/competition3.aspx for Competition III 2005–06 and at http://www.genomecanada.ca/en/portfolio/research/applied.aspx for the Competition in Applied Genomics Research in Bioproducts or Crops (ABC). At the time of publication, lay summaries of the integrated GE3LS components of genomics projects funded as part of the 2010 Large-Scale Applied Research Competition were not yet available.

7. For example, in Competition I (April 2001) and Competition II (July 2001), each regional Centre was responsible for establishing a research program in GE3LS. In the Applied Human Health Competition (May 2003), applicants were asked to take into account any relevant GE3LS issues or considerations. In Competition III (July 2004), applicants had to consider the GE3LS aspects of their proposed research and, where appropriate, seek advice from one or more GE3LS experts to develop a plan to
address those GE3LS issues directly raised by the proposed research. In the Applied Genomics Research in Bioproducts or Crops (ABC) (April 2008), all applicants had to consider the GE3LS issues arising from their proposed research and develop a plan to address them. In the 2010 Large-Scale Applied Research Competition (May 2010), application guidelines were further refined to clarify the role of the GE3LS co-applicant(s), their active engagement throughout the research planning and implementation phases, and their contribution to the overall genomics project as active member(s) of the research team. More specifically, “GE3LS co-applicants are expected to develop a scholarly research plan that is aligned with, and complementary to, the proposed milestones of the overall genomics project. The GE3LS research plan should involve a systematic investigation designed to advance generalizable knowledge in relevant academic fields that can be applied to the proposed genomics project, as well as other similar projects or applications.” And, “GE3LS co-applicants are encouraged to coordinate, wherever possible, with other GE3LS researchers working on similar questions in other Genome Canada-funded projects to maximize opportunities for synergies and minimize potential duplication” (see Genome Canada’s Guidelines for Funding Large-scale Research, May 2010, pp. 5–6: Available at http://www.genomecanada.ca/medias/pdf/en/guidelines-competition-2010.pdf).

8. It is important to recognize that much valuable social sciences and humanities (SSH) research gets done outside integration models. However, for the purposes of this article, we have chosen to focus on integration models as means of conceptualizing, organizing, and funding SSH research in relation to science.

9. Although GE3LS integration has always been encouraged of Genome Canada applicants, the “mandatory” wording of the requirement became clearer in Competition III and clearer still in the ABC Competition, see descriptions above.

10. See as an example, Feature article “To Share or not to share—Should genetic test results be reported back to participants?” in Genome Canada’s electronic GE3LS newsletter, Impact: Genomics and Society. Available at http://www.genomecanada.ca/en/ge3ls/newsletters/fall-2009/feature-stories.aspx#story-3.

11. Peter W. B. Phillips, Professor, Department of Political Studies, University of Saskatchewan, and David Castle, Professor, Department of Philosophy, University of Ottawa.

12. Principal investigators are Dr. Peter Singer and Dr. Abdallah Daar of the University of Toronto and Dr. James Lavery of St. Michael’s Hospital, Toronto.

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