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# Skills and Knowledge

## Government Science and Innovation in the New Normal
## Discussion Paper

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# ABOUT GSINN – CANADA NEEDS A NEW RELATIONSHIP WITH SCIENCE AND INNOVATION THAT REFLECTS OUR TIME

In December 2020, the Institute on Governance launched Government Science and Innovation in the New Normal (GSINN), a multi-year, collaborative research initiative designed to explore the impact of the pandemic on federally-performed science and innovation, to support medium-term planning for federal science and innovation departments and agencies, and to provide insights to help rebuild the relationship between science and society.

Throughout the pandemic, anti-vaxxers – joined by anti-maskers – have challenged scientific evidence and public health officials with a mandate to keep us safe and stop the spread of the disease. This is just one example that demonstrates society's relationship with science is under strain.

But society's relationship with science and innovation did not decline overnight. The governance model that underpins Canada's relationship with science is based on a report called Science: The Endless Frontier (1945). This report outlined a basic compact in which society supports science with public funds and assures the scientific community a great deal of autonomy in exchange for the considerable but unpredictable benefits that can flow from the scientific enterprise.

Today, many of the underlying social, economic, and political assumptions in the postwar compact are outdated. This project examines the relationship between science and society and begins to imagine a new relationship, through nine specific themes:

- Equity, Diversity, and Inclusion;
- Global Research Collaboration and Infrastructure;
- Inclusive Innovation;
- Interdisciplinary Collaboration;
- Indigenous and Other Ways of Knowing;
- Mission-Driven Research and Innovation;
- Science Communications, Outreach, and Public Engagement;
- Skills and Knowledge; and,
- Trust, Integrity, and Science Ethics

Taken together, these themes suggest elements of a new governance framework for science and innovation in Canada that embraces our current social, cultural and political realities, that recognizes the opportunities and limits of science. Perhaps most importantly, the project reinforces the role of science as part of society, and a tool ready to serve the needs of society.

Findings of the GSINN initiative were developed as a result of extensive research and engagement that included: a hindsight exercise, multiple foresight workshops, eight multisectoral roundtable discussions, and expert consultations that fed into this collection of 10 papers (one for each of the themes above and one capstone paper). Each discussion paper has been peer reviewed and explores a facet of how the relationship between government science, innovation, and society needs to be repaired in order to ensure science remains relevant in the new reality.

IOG extends its heartiest thanks to the eight federal departments and agencies that supported this work: Agriculture and Agri-Food Canada, Health Canada, Innovation, Science and Economic Development Canada, National Research Council, Natural Resources Canada, Public Health Agency of Canada, Public Services and Procurement Canada, and Transport Canada.  We also wish to thank all of the individuals who participated in the workshops and roundtables whose input helped clarify and develop the project themes and findings. Finally, we want to acknowledge the following reviewers whose thoughtful feedback improved this paper: Elie Chamoun, Christine Doyle, Barbara Haidn, Luke Ignaczak, and Shannon Mezzetta.

# INTRODUCTION

Scientific knowledge has the potential to inform and to improve our everyday lives. This is the premise of Dr. Vannevar Bush's report *The Endless Frontier* (1945), which envisioned a world where science would pursue the challenges facing society in exchange for autonomy to conduct those pursuits. While the scientific enterprise has indeed delivered untold benefits for society since the tenets of Dr. Bush's report were adopted, this social contract has come at a significant price: the divorce of science from society. (Douglas, 2021)

This divorce or – to use the words of Holden Thorpe (2020) – drifting apart of science from society is in part due to the nature of the design of the scientific enterprise. In *The Endless Frontier,* Dr. Bush capitalized on what Thorpe (2020) calls "a high-water mark for […] trust in science" to design a system that could operate with minimal oversight, and at arms' length from public scrutiny. Since the growth of the sociological study of science in the 1960s, academics have explored and examined this relationship between science and society, chronicling the many tensions that existed before and after the "high water mark" at the end of the second World War, to what is now a relationship qualified by distrust.

As science and society drifted apart, a few accomplished scientists – such as Carl Sagan, Paul Ehrlich, and Margaret Mead – sought roles as interlocutors to popularize scientific information and the scientific process. These individuals were largely shunned by their community who believe the real role of scientists is in the lab. (Fahy, 2015)

Today, large portions of our contemporary society have rejected science as an enterprise and a way of knowing. In some ways it should come as no surprise to see acts of violence and aggression committed on Capitol Hill in 2021 or Parliament Hill in 2022. Though these acts became co-opted by other agendas they originated as campaigns based on the rejection of science and decisions based on scientific evidence.

If we work under the assumption that it is not too late to renew the relationship between science and society, we must ask ourselves: what skills do scientists require to renew a relationship with a party whose trust of science is at risk?

This paper will discuss a) the drivers that are demanding changes to the science and policy relationship and the science and society relationship b) some of the ways that the practice of science is changing, c) the kinds of skills that scientists need to navigate these two changing environments, and d) the barriers that exist within the Government of Canada that may prevent them from doing so. The paper concludes with questions for further discussion.

This paper focuses on the Canadian federal scientific enterprise; although some of its messages may apply to the scientific enterprise in academia, the private sector, and civil society, these are not the focus.

## SCIENCE, SCIENCE LITERACY, AND WHY THEY MATTER

Science – as a type of evidence and a dominant methodology in the Western knowledge system – has held a privileged place in Canada, as demonstrated by the role it plays in primary, secondary and tertiary education systems, in academic research, and how it informs governance at the national, regional, and municipal levels. According to Miller and Munoz-Erickson (2018), knowledge systems are the organizational practices and routines that make, validate, communicate, and apply knowledge. Building on that definition, Mthembu (2020) explains that a knowledge system comprises many aspects within a sphere of influence, including social and cultural norms, ethical values, beliefs, and even technology. In the Canadian context, science is both a specific way of generating knowledge and the product of that process.

Science literacy is “the ability to engage with science-related issues, and with ideas of science. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires the competencies to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically.” (OECD 2019: 15)

Scientific literacy also includes the application of science to provide solutions to dynamic social, economic, political, and cultural issues (for further discussion on science literacy, see: Sharon and Baram-Tsabari 2020, Reddy 2021, Holbrook and Rannikmae 2009, Feinstein 2010, He *et al*. 2021, Roos 2014, OECD 2019).

The OECD measures scientific literacy of 15-year-olds in schools through its Programme for International Student Assessment (PISA). According to the OECD, "three science-specific competencies are required to understand and engage in critical discussion about issues that involve science and technology" (OECD 2019: 98). These are knowledge-based competencies. All require "content knowledge" and "epistemic knowledge" – understanding the rationale behind scientific enquiry. Evaluation and interpretation also require "procedural knowledge" – processes and procedures used to develop scientific knowledge (OECD 2019: 99).

Science (or scientific) literacy matters because this is a type of knowledge upon which our governments make decisions. In order to have "reasoned discourse" (OECD 2019), all parties to a discussion must have a foundation of knowledge in the subject at hand. When that foundation is lacking, an imbalance occurs between those who have knowledge and those who do not, between those who have legitimacy in the decision-making process and those who do not.

Science literacy matters in Canada because policy is increasingly turning to science for evidence, guidance, advice, and answers to wicked and complex problems. But when decisions are taken based on information that is inaccessible to those on behalf of whom the decision is made, governments can be perceived as not acting in the interest of the public. Whether decisions to wear masks, to be vaccinated, to quarantine or not to quarantine, the pandemic has demonstrated countless examples where decisions informed by science were challenged (for many reasons,) by those who rejected the underlying scientific information.

The pandemic is but one example of a challenge facing levels of government in Canada where science can offer evidence. Other examples include and are not limited to ensuring sustainable food supply, clean water, reducing carbon footprints while meeting demand for energy, and mitigating and or adapting to climate change.

# THE CHANGING NATURE OF GOVERNMENT SCIENCE

Between March and May 2021, the Institute on Governance hosted ten foresight workshops. These workshops explored each of the eight themes that make up the GSINN initiative. While only one focused explicitly on the theme of skills and knowledge, participants in all workshops discussed the changing nature of science, and the ways in which government science – and government scientists – must adapt to the changing societal environment in which science finds itself.

This section draws from those workshops to present a short list summary of the kinds of changes that Government of Canada employees, including scientists, are observing and experiencing firsthand, in the context of the types of skills and knowledge they now need to do their jobs. An earlier version of this paper was circulated to federal government stakeholders who validated many of the foresight findings, and built upon them. Feedback from all groups informs the following sections.

The changing nature of science (changes inside the scientific community)

- Greater digitization and digitalization (Bloomberg, 2018) of the scientific and innovation enterprise, referring to both the migration of scientific information online as well as increased access to larger data sets that require specialized knowledge to organize and manipulate, and or the ability to interpret findings and then integrate them into decision making.
- Concerted efforts to increase and promote multi-disciplinary / Interdisciplinary / Transdisciplinary approaches to generating new knowledge (see GSINN discussion paper *Interdisciplinary, Indigenous and Other Ways of Knowing*)
- More open science initiatives (see GSINN discussion paper *Science Communication, Outreach, and Public Engagement*)
- Greater emphasis on strategies to improve participation by women and equity-seeking communities (see GSINN discussion paper *Equity, Diversity, and Inclusion*)

Between science and policy and science and society

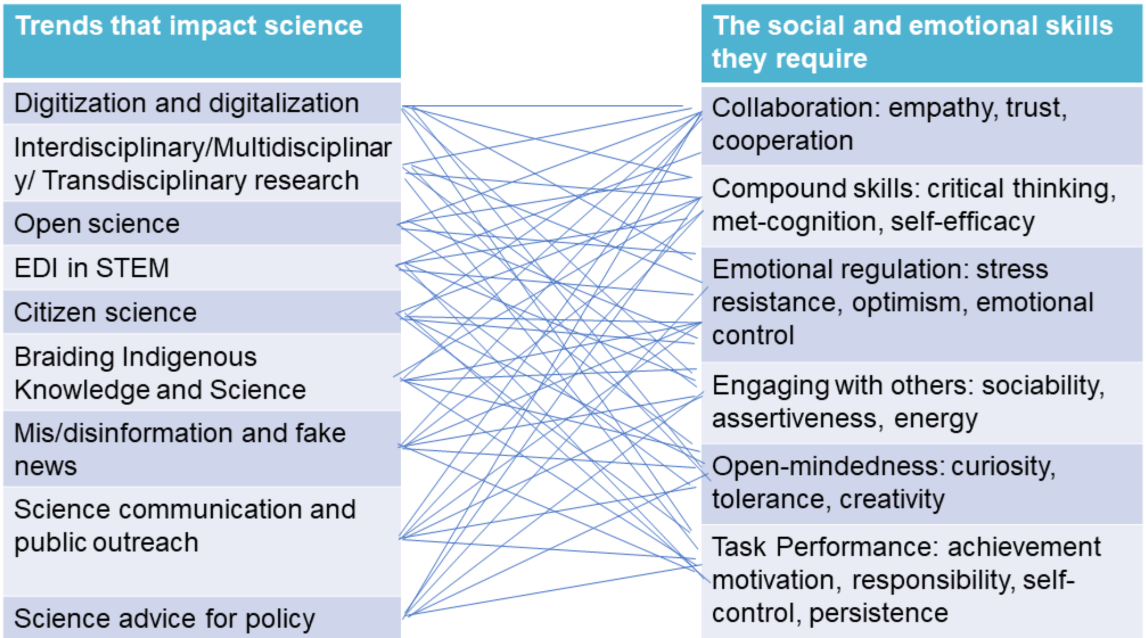
- Growing demands for and numbers of citizen science initiatives (see GSINN discussion paper *Science Communication, Outreach, and Public Engagement*)

- Interweaving Indigenous Knowledge and Science as a means to realize self-determination and reconciliation with Indigenous Peoples (see GSINN discussion paper *Interdisciplinary, Indigenous and Other Ways of Knowing*)
- A mass proliferation of misinformation, fake news, alternative facts, disinformation. (see GSINN discussion paper *Science Communication, Outreach, and Public Engagement*)
- Growing demand for science communication and public engagement on scientific issues (see GSINN discussion paper *Science Communication, Outreach, and Public Engagement*)
- Greater demand for scientific information to inform policy making/ political[1] decision making.

What skills and knowledge do scientists need to succeed in these changing environments? The following table summarizes the information collected during the IOG workshops. In short, all of the trends identified in the workshop demands competencies in each of the social and emotional skills (SES) categories. (OECD, ND).

[1] Throughout this document the terms political is used to refer to both the policy environment and the political environment with the implicit understanding that science informs policy, and policy work serves to inform or is a result of Political mandates.

Figure 1. Mapping trends that impact science against demand for social and emotional skills




Source: IOG roundtables, 2021 adapted to OECD, undated

As demonstrated in Figure 1, all drivers impacting changes to the scientific enterprise, and which inform the science-policy or science-society relationship require social and emotional skills. What are social and emotional skills and why are they important? This is explored in the next section.

## GROWING DEMAND FOR SOCIAL AND EMOTIONAL SKILLS

Social and emotional skills "refer to the abilities to regulate one's thoughts, emotions and behaviour" (OECD, ND: 4). These skills can be linked to the broad domains of the "Big Five" framework of personality traits: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. (OECD, ND)

The first two behavioural traits, openness and conscientiousness are closely associated with scientific occupations. Creativity, tolerance, and curiosity are attributes of openness or open-mindedness which is further characterized by flexibility, ability to deal with rapidly changing environments, enthusiasm for learning and exploring new ideas or ways of doing things (OECD, ND: 13). Conscientiousness or task performance is a sign of self-discipline, persistence, motivation, critical thinking (thinking things through) and problem-solving, all essential skills for scientists (OECD, ND:13).

The other three traits are required for working with others and are, either individually or compounded with other behavioural traits, important for scientific career progression and science advisory functions. Engaging with others (extraversion) is viewed as a positive and energetic trait distinguished by the ability to rapidly integrate into new teams or networks (effective teamwork, public speaking, leadership), and assertiveness by confidently and respectfully voicing opinions. Agreeableness, equated with collaboration, comprises co-operation, trust and empathy.

Collaboration is seen as a pro-social behaviour based on strong inter-personal relationships and ability to respect group decisions. Emotional regulation (neuroticism) refers to the ability to deal with negative or high-stress situations, or in other words, self-awareness and self-direction or regulating emotional responses to work situations (OECD 2021: 21 & 34). High achievers are characterized in part by their belief in their abilities to meet lofty or stretch goals and being able to deliver high quality work on time. Finally, social and emotional skills such as optimism and empathy are related to personal well-being and job-satisfaction (OECD, ND; 14 & 17).

Why are social and emotional skills important? Kinder (2013) adapts CP Snow's famous lecture about the two cultures of science and the arts to discuss the two cultures of science and policy (Figure 2). Kinder's examination demonstrates that science and policy operate with different languages (jargon), different tolerances for uncertainty, and on very different time horizons. Taking policy as a proxy for society reinforces Douglas' (2021) notion that science is becoming divorced from society.

In order to rekindle the relationship between science, policy and society, these cultures have to get to know each other. Building relationships requires a common language, patience, a willingness to learn, respect, trust, motivation, critical thinking, emotional intelligence, creativity, tolerance, openness…in short, social and emotional skills.

Relationships build on mutual respect and reciprocity require information flows that go both ways. The next section discusses how the role of the scientist is evolving in response to digitalization as well as to facilitate the translation and mobilization of scientific knowledge between these two cultures. The paper posits that two such roles could also be positioned to renew the science-society relationship.

Figure 2: The two cultures of science and policy

| Science | | Policy |
|---|---|---|
| Often very long | Time horizon | Often very short |
| Seeks precision | Language | Seeks flexibility |
| Scientific jargon | Lexicon | Policy jargon |
| Tolerant | Uncertainty | Discomfort |
| Peers | Audience | Public |
| Horizontal | Accountability | Vertical |
| Specialists | Practitioners | Generalists |
| Usually open | Transparency | Often closed |
| 30 years | Tenure | 30 months |
| In the regions | Location | At “HQ” Ottawa |

Source: Adapted from Kinder, 2013.

## NEW “TYPES” OF SCIENTISTS EMERGE

Discussions during the IOG workshops demonstrate that the kinds of demands placed upon scientists is growing to reflect both a changing work environment and increasing demands for information and transparency on the part of society. At the same time, the challenges that science is pursuing are ever more complex, and informing an equally complex policy and political environment. The workshop conversations reflect the work of Gluckman (2018) who details the emergence of four types of scientists:

- Knowledge generator: scientists and researchers who generate new knowledge
- Knowledge synthesizer: these individuals or teams aggregate knowledge in order to determine the significance of the knowledge or what it means. In our contemporary context, data scientists are a new type of knowledge synthesizer for which there is growing demand.
- Knowledge broker: individuals who translate scientific findings for the benefit of policy makers, political officials, and members of society.

Policy evaluation: individuals or teams performing this role review the outputs or results of programs, services or policy decisions to measure the extent to which they achieved their intended purpose. (these individuals will not be discussed in this paper.)

## KNOWLEDGE GENERATOR

The framework for research scientists in the federal government is the SE-RES Framework (Research Community Advisory Committee, 2006). For the purpose of this discussion, the SE-RES Framework is adopted as the default framework for all scientific knowledge generators, and it is through this lens that skills development and training will be discussed.

## KNOWLEDGE SYNTHESIZERS

A Guide to Knowledge Synthesis for researchers (CIHR, 2010) defines knowledge synthesis as:

> "The contextualization and integration of research findings of individual research studies within the larger body of knowledge on the topic. A synthesis must be reproducible and transparent in its methods, using quantitative and/or qualitative methods. It could take the form of a systematic review; follow the methods developed by The Cochrane Collaboration; result from a consensus conference or expert panel and may synthesize qualitative or quantitative results. Realist syntheses, narrative syntheses, meta-analyses, meta-syntheses and practice guidelines are all forms of synthesis."

Speaking plainly, Gluckman (2018) describes knowledge synthesizers as "the scientists and units that aggregate the knowledge and try to make sense of what it means."

Given that expanding scientific knowledge is a cumulative process, synthesizing and integrating knowledge from multiple studies and disciplines generates key observations from national and international sources of evidence upon which new research can be developed. Knowledge synthesis for decision making goes beyond reporting on knowledge surrounding a specific issue to include engaging decision-making stakeholders in developing the main and related research questions and approaches and the interpretation and contextualization of the results and recommendations with appropriate caveats on uncertainty and quality (CIHR Guide, 2010; Gluckman et al. 2021:2).

According to Mulgan (2021), government must invest in developing internal capacity to build teams of knowledge synthesizers who work across several disciplines to weave various types of evidence and knowledge together to enable the government of the day to "see things in the round" (Mulgan, 2021). In this way, knowledge synthesis offers a focus and function for scientists and researchers already operating and seeking to advance interdisciplinary, multidisciplinary and transdisciplinary approaches to the pursuit of science to address complex, wicked problems, such as responses to the COVID19 pandemic and climate change.

Obermeister (2020) takes the concept of knowledge synthesis one step further, suggesting that having only scientific information in policy advice is not always “desirable”, a prescient reflection for Canadian scientists and policy makers living in a time when our country is on a journey of reconciliation with Indigenous Peoples. As the political class drives this journey, it looks to the public service to deliver on this mandate. In this context, knowledge synthesizers offer a means to integrate various types of scientific evidence, and indeed, different knowledge systems. (To dive deeper into this topic, please consult the GSINN discussion paper *Interdisciplinary, Indigenous and Other Ways of Knowing*.)

Government of Canada scientists and social scientists are committed to knowledge synthesis. However, knowledge synthesis alone “tends to have little direct impact on public policy” (Gluckman et *al*. 2021:3). Transmitting the results of knowledge synthesis to policy decision-makers requires the expertise of knowledge brokers.

## DATA SCIENTISTS

Data science is an emerging area of practice – whose definition continues to evolve – which originated from statistics, and has been heavily influenced by computer science, business, math, and can be applied in various domains, as demonstrated in Figure 3.

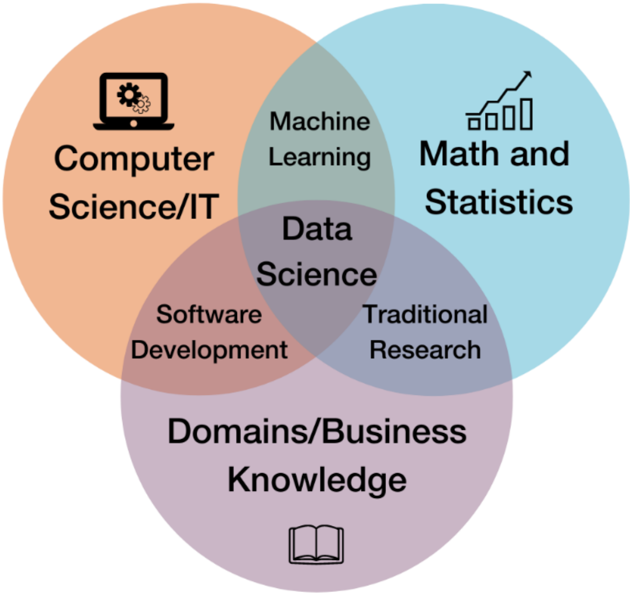
In the context of Gluckman’s four types of scientists, data scientists are a specific type of knowledge synthesizer for which there is rapidly growing demand.

Digitalisation has transformed how scientists work with data; many scientists and researchers – not just in the Government of Canada – contribute to massive data sets, stored in the cloud and accessible to teams around the world. This transformation in how data is stored and accessed has created a growing need for data scientists. But what are data scientists and how do they differ from data analysts or database administrators/data architects? (A visual representation of the following discussion is available in Figure 4.)

The goal of data analysis is to answer immediate policy questions or solve problems using available data or information (historical data). Some data analysts are accustomed to analyzing structured and unstructured data using statistical techniques and increasingly machine learning techniques, with an emphasis on visualizations and tabulations for policy and decision-making purposes. These data analysts may have hybrid skills that overlap those of data scientists such as experience in extracting information from large data sets, problem solving, and data storytelling or programming in SAS, R, Python or other languages. Data analysts require specialized subject matter domain or field of study knowledge, statistics and statistical packages for analysis, visualization and tabulations, and strong communications skills (storytelling).

Database administrators, data architects or data engineers use computer science to process large datasets. They focus on coding, cleaning data sets, and responding to data requests from data scientists and data analysts. Database administrators require knowledge of computer programming and architecture for structured, unstructured and big data.

Figure 3: Data science




Source: IOG, adapted from Anugar Ghandi

Data scientists are able to manage projects involving large amounts of, often complex, data. They create routines and processes to structure and store data which provides them with a strong understanding of the underlying data required for data analysis. They also solve business problems by creating predictive modelling processes using machine learning algorithms or other statistical techniques for data analysis. Data scientists use both structured and unstructured data in their analysis and are required to communicate their results to audiences composed of peers and generalists. Data scientists' knowledge and ability requirements often include advanced mathematics and statistics, computer programming, big data tools, general subject matter or domain knowledge and communications skills for non-specialist audiences. These individuals often explore new questions to drive innovation for future trends.

Figure 4: How do the skills of data scientists and data analysts differ?

| Skills | Data Scientist | Data Analyst |
|---|---|---|
| Data processing and database management | Asset | Asset |
| Data cleaning, transforming and analysis | Essential | Essential |
| Advanced statistical, l techniques (application) | Essential | Asset |
| Intermediate statistical techniques (application) | Essential | Essential |
| Programming Languages | Essential | Asset |
| Big Data Methods | Essential | Asset |
| Structured data (use) | Essential | Essential |
| Unstructured data (use) | Essential | Asset |
| Specialized policy domain knowledge | Asset | Essential |
| Predictive modelling (use) | Essential | Asset |
| Data visualization | Asset | Essential |
| Policy advice, storytelling | Asset | Essential |

Source: Adapted from Kinder, 2013.

## KNOWLEDGE BROKERS

"At its simplest, policy making is about making choices between different options," (Gluckman, 2018), and science has a role to play in most contemporary policy problems by presenting a type of evidence that is unique among other inputs to policy, be they political, social, legal, diplomatic or cultural, for example. Scientific information or evidence is both able to broaden and limit the scope of decision making, depending on the question. It has the opportunity to inform results and allow a decision maker to choose between options to select a path forward that is most likely to achieve a desired outcome.

According to Gluckman (2018: 97-8), knowledge brokerage transmits as far as possible values-free knowledge to policymakers who insert their expertise including values judgements. Brokerage presents what is known, what the consensus is and what is unknown – risks, options, trade-offs (Gluckman 2018: 99). A scientist, as knowledge broker, can bring clarity to a complex situation; may narrow or broaden the scope of the problem accordingly; and may offer various types of scientific input depending on the nature of the challenge.  (Pielke, 2007; Gluckman, 2018)

Political decision-making is a complex series of negotiations based upon a variety of factors such as values, ethics, risk…which are highly specific to individual context. According to Mulgan (2021), designing a system where experts synthesize all relevant types of evidence would involve designing a process that "[maps and ranks, in the case of the COVID19 pandemic] relevant factors (from potential impacts on hospital capacity to the long-run effects of isolation); using formal and informal models to capture feedbacks, trade-offs and synergies; and more creative work to shape options."

As knowledge brokers, scientists become a boundary object, requiring simultaneously to be aware of the latest relevant evidence as well as the contextual factors that will inform how and what evidence they present to their advisees. According to Obermeister (2020), science advice is perpetually situated in an evolving "ecosystem that expert advisors must become part of and to which they must continually adapt…[as] political expectations of science…are constantly being renegotiated and reconstituted by changing values and perceptions of the role of science in society." (2020, 2) In such situations, knowledge brokers must rely on their sense of what Obermeister calls the demand for science, and what their advisees regard as "credible, salient and legitimate advice." (Obermeister 2020, 3)

**Impact of pandemic: interface of science advice and public engagement**

"The public has witnessed the role of scientists in advising government, particularly the complexities of that role: diverse groups of scientists advising through formal and other routes, disagreement between groups of scientists on modelling the pandemic and its likely evolution, and measures to combat the spread of the pandemic and treat the seriously infected. This has been good, from the point of view of broader society, which has been able to witness firsthand, as it were, the complexities of science advice in action during an emergency." (Reddy, 2021: 21)

Knowledge brokers become part of an elaborate organization with others of their own kind as well as multiple people being advised by knowledge brokers, with no one at the centre, but a continuously evolving environment where all actors must be aware of the latest evidence as well as the political, diplomatic and other important contextual factors that inform the environment in which they are operate. To succeed in such environments, knowledge brokers require the trust of their colleagues, developed capacity in the areas of diplomacy, openness to new ideas and experiences, conscientiousness, flexibility, and humility. (Gluckman 2016, Gluckman 2018, Gluckman et al 2021)

# EMPOWERING NEW “TYPES” OF SCIENTISTS IN THE GOC LANSCAPE

“The art and craft of science advice is not innately known by those scientists who choose to step out of the lab or the university to engage with the world of policy” (Obermeister, 2020). The complex series of factors that inform policy making demonstrate the ongoing negotiations that are at play in the policy environment, which, as previously discussed is a culture foreign to those who are trained to work in the sciences.

Scientists who express an interest in transitioning from the role of a knowledge generator to a knowledge synthesizer or broker require training. This idea was reinforced at length by the IOG GSINN workshop participants who work in teams that have great demand for knowledge synthesis, knowledge brokering, and data analysis. Those same discussants point to a general lack of training for scientists who wish to work more closely with policy, politics or communications. The lack of opportunities to fill the demonstrated need is in part a challenge of the framework in which many scientists and researchers operate, and in part a failing of the federal model through which workplace training is provided.

## THE SE-RES FRAMEWORK

In 2006, the Research and Community Advisory Committee developed the *Career Progression Management Framework for Federal Researchers: Application for the SE-RES Community* which was approved by the Deputy Ministers of Agriculture and Agri-Food Canada, Communications Research Centre of Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada, Natural Resources Canada and the Public Health Agency of Canada (signed February 2006) in response to turn of the millennium human resource management practices and strategies (Research Community Advisory Committee 2006).

This framework focuses on career progression. It employs four types of outcomes: innovation, productivity, recognition and impact within the context of three main types of work: research, development and analysis, managing research, and representation and client services (for more about the Framework, consult Appendix 2).

In 2006, the SE-RES Framework represented a cultural shift from individual publication output and knowledge expertise as key criteria for promotion towards greater representation of teamwork/collaboration, leadership, policy influence, communications, stress management, flexibility, adaptability, and responsibility and accountability for outcomes.

Fifteen years later, it may be time to refresh the SE-RES Framework. In response to an increasingly complex world that demands many different types of evidence as input, combined with low science literacy rates among non-scientists, there is growing demand for not just one, but multiple types of scientists. Building on the descriptions in the previous sections, these types of scientists require a deep understanding of the culture and practice of science, and to varying degrees, must demonstrate social and emotional skills in order to effectively synthesize and broker scientific knowledge for the benefit of their policy counterparts and society.

The Framework does not recognize the need for transfer or mobilization of knowledge into other areas of federal departments or agencies (or other departments in a fully integrated model). There is no reference to the function for science-policy integration, or provision of science advice, nor the many skills those functions require. How might the SE-RES Framework be adapted to recognize these emerging science functions and the unique skills each requires? Could it formalize science communications and outreach, public engagement, science advice and science diplomacy as recognized functions for Government of Canada scientists?

## WORKPLACE TRAINING

Workplace training is the process of developing knowledge, skills, and efficiency in the workforce. Workplace training can take many different forms, depending on the nature of the skills or knowledge to be transmitted to the employees in question, and it is often customized for the context or culture in which the training will be applied. As such, workplace training is not a replacement for academic qualifications but a complement to them. (Darrah, 1995)

In the Government of Canada, the provision of workplace training is highly decentralized and determined by individual managers. Even then, training choices reflect the desires of the individual and their manager. There is no requirement to address the demands of clients, citizens, or colleagues in other departments, and no means for tracking trends in demand across a department or multiple departments. For more on the Government of Canada approach to workplace training, see Appendix 3.

# RECOMMENDATIONS FROM THE GSINN SKILLS WORKSHOPS

In April 2021, the Institute on Governance hosted a half-day workshop on Skills and Knowledge. Subject matter experts from eight federal departments – Agriculture and Agri-Food Canada; Health Canada; Innovation, Science and Economic Development Canada; National Research Council of Canada; Natural Resources Canada; Public Health Agency of Canada; Public Services and Procurement Canada; and Transport Canada – participated in the discussion. The workshop employed the seven-question foresight methodology to explore the themes of skills and knowledge. In March 2022, the IOG hosted a multisectoral roundtable with partners of the above listed departments to discuss this topic in the context of relationships with federal departments. Meetings with subject matter experts occurred between these two roundtables, both informally through adhoc phone calls and email exchanges, and formally in the form of written responses to earlier drafts of this paper.

Workshop participants expressed a shared belief that members of the scientific community have an ethical responsibility to make themselves – and their findings – understood by non-technical audiences in order for society to benefit from science. To do so, scientist require training to synthesize findings from many disciplines and translate those findings in ways that are relevant and meaningful for their audiences, whether high school students, Canadian voters, or the policy officials in their department.

Scientists may be provided with some basic level training in social and emotional skills during their formal academic education. Arguably that training is insufficient for both the policy environment of the public service as it lacks information about the context and culture in which the Government of Canada operates, and the political environment which the work of the public service informs on a daily basis. Government staff who participated in the 2021 workshops demonstrated a keen understanding of both the deficit of social and emotional skills in their departments and how adults learn (Kitchenham, 2008). Government stakeholders who participated in the 2022 workshops indicated that while the scientists are generally well versed in the nature of their disciplinary practice, there is a lack of writing skills, knowledge translation and presentation skills (especially towards non-technical audiences) which can have a negative impact on the success of a project and or a stakeholder relationship. Participants from all workshops offered the following recommendations to empower scientists and researchers to better mobilize and translate scientific information for the benefit of various publics:

- **Support a variety of learning styles:** Normalize different learning styles and acknowledge the existence and impact of learning disabilities. For example, communicators need to acknowledge that there is not a one-size-fits-all approach to delivering a message and there needs to be recognition of the audience's capacity and capabilities to receive information. There needs to be constant validation and feedback that the message is being received. Within the public service, this could translate into engaging people who understand how adults learn in order to design courses that play to the various learning styles of adults, to design and offer training through a variety of formats: written materials, workshops, and mentorship that are delivered in-person, online, and in hybrid formats.
- **Encourage mentorship.** Mentorship as a form of education and skills development has become less common in education in recent decades (and as a result several participants indicated it is used sparingly in the federal public service). Mentorship can be multifaceted (different mentors can teach different skills) and creates focus on the development of long-term goals. Mentorship is an effective way to transmit knowledge and skills that takes focus away from reading and memorization of texts and information. It can be highly context-specific, which makes it ideal for developing a new cadre of knowledge brokers.
- **Map social and emotional skills against the government's priorities** to demonstrate the democratic principles of education and workplace training. This creates a sense of a government-wide priority for all employees to acquire new skills and competencies. In cases where these skills cannot stand alone, they can be mapped against policy priorities as well. For example, effective (science) communication promotes transparency and an open government.
- **Create incentives for scientists** a) to acquire new skills or knowledge outside of their substantive area, b) which allow them to grow into new and different roles, and c) give them an arena in which to practice these skills within their home branch or department to promote a culture of learning at work. These incentives should be codified into their performance agreement.
- **Science in the media:** a) Bring back technical briefings and encourage scientists to participate in those briefings. These interactions can improve science literacy among journalists and give scientists opportunities for plain language speaking. They also serve to demonstrate transparency on the part of the department or agency who provides the media with direct access to subject matter experts. This transparency is mutually beneficial and

reinforcing as journalists can ask their question directly to the subject matter experts and the subject matter experts can respond accordingly. b) List scientists on news releases (knowledge synthesizers or brokers, depending on the issue) as experts available for media questions. c) Empower knowledge synthesizers and knowledge brokers – alongside their media relations counterparts – to proactively communicate scientific findings, and to hold news, media, and social media platforms accountable as publishers for inaccurate information.

# QUESTIONS FOR DISCUSSION

What are the critical needs of the Canadian public from its government science community? What skills do government scientists require to meet these needs?

- How well do Gluckman's four types of scientists reflect changes in how science is conducted and communicated? How might we rethink how scientists are trained and the knowledge they require?
- Consider the section on data scientists. Are there other ways that digitalization has impacted the scientific enterprise? How are other sectors competing for the much-in-demand data scientists?
- What could the Government of Canada learn from stakeholders in other sectors when it comes to the provision of workplace training?
- Consider the recommendations for scientists in the media. What makes a scientist an effective communicator? Traditionally, scientists who embrace plain language and the need to popularize their findings have been shunned by their community (known as the Sagan effect). Does this phenomenon still exist? If so, how might a change in the culture of science be encouraged, even rewarded, so more scientists take up the yoke of plain language communication?
- Indeed, many of the following recommendations embrace principles of the Declaration of Research Assessment (DORA, 2012) which calls for a general improvement on how we evaluate scientific outputs. Before we dive into redesigning skills training, we must first ask ourselves what is the future we want to realize, and what skills do we require to make that future reality?

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# APPENDIX 1: KEY TERMS AND DEFINITIONS

**Adaptability**: "the capacity to modify behaviour to suit changing work responsibilities, methods and environment" (Research Community Advisory Committee 2006: 24).

**Career progression (promotability), SE-RES**: encourages "the continuous development of competencies of researchers in order for them to assume more responsibilities" (Research Community Advisory Committee 2006: 2).

**Coaching**: A reflective and co-creative process that uses open-ended questions to offer an individual a different way of observing and interpreting situations and the opportunity to tap into their full potential. (Government of Canada, 2021)

**Communication**: ability to a) "communicate with clients and stakeholders, and adapt communications style to the target audience"; b) "communicate effectively in the form of written and oral presentations"; and c) "extract, comprehend and absorb information" (Research Community Advisory Committee 2006: 24).

**Competency**: "any observable and/or measurable knowledge, skill, ability or behaviour that contributes to job performance" (Government of Canada, 2021b) or "characteristics of an individual which underlie performance or behaviour at work" (CIHR, 2010.)

**Creativity**: "ability to have an innovative approach to research by creating new or modified current concepts, theories, approaches and/or solutions "(Research Community Advisory Committee 2006: 23).

**Critical thinking**: "ability to reflect on information, interpret it in a new context and find solutions to novels problems based on existing knowledge. (cognitive abilities such as using rules of logic, cost-benefit analysis, think strategically and apply rules to new situations and non-cognitive skills such working independently or unconventional applications of knowledge – ability to act independently and reflect critically upon a given reality it is especially important in the fast-changing environment we live in" OECD, 2021: 25-6). (MacMillan, 2013)

**Government research**: provides "high quality of life through science and technology, ensuring the security, health and well-being of Canadian citizens and the environment" through providing "the infrastructure and the long-term expertise needed to understand, interpret and support the policies and directions required domestically and at the international level" (Research Community Advisory Committee 2006: 3).

**Judgement**: "the capacity to recognize relevant information, to identify and evaluate available options, and to choose the best course of action" (Research Community Advisory Committee 2006: 24).

**Mentoring:** A supportive learning relationship between an individual who shares their wisdom, knowledge and experience with another who is willing to benefit from this exchange. (Government of Canada, 2021)

**Networking**: A mutually beneficial relationship with the goal of exchanging information and ideas that will foster individual career development.

**Teamwork**: "the capacity to work collaboratively with others; to draw out the best in others; to be part of (a) team where diversity is accepted, encouraged, valued and fully utilized" (Research Community Advisory Committee 2006: 24).

# APPENDIX 2: ABOUT THE SE-RES FRAMEWORK

**Incumbent-based approach:** SE-RES is incumbent-based. Public Service Employment Regulation, 34(1) of the Act, the internal appoint process within the Research and University Teaching Groups, if there is a career progression framework established by the deputy head in consultation with the authorized bargaining agents that includes an independent recourse mechanism, is an incumbent-based process" (Research Community Advisory Committee 2006: 4).

**Contexts for SE-RES work**: 1. research, development, and analysis (RDA) (primary); 2. managing research; and 3. representation and client services (Research Community Advisory Committee 2006: 7).

- *Research, development, and analysis (RDA)*: "research is the systematic investigative process of inquiry, including development, testing and analysis, carried out in pursuance of the departmental mandate, in order to discover, interpret or analyze facts, events, or behaviours, to develop and revise theories, or to make practical application with the help of such facts, laws or theories designed to develop or contribute to knowledge" (Research Community Advisory Committee 2006: 11).
- *Managing of research*: "includes the processes related to the planning, organizing, setting objectives, controlling and evaluating RDA activities and their associated human and financial resources. It includes the provision of leadership to, and assessment of, other scientists, engineers, technologists, and/or other staff" (Research Community Advisory Committee 2006: 11).
- *Representation and client services*; "representation is the process of representing and speaking on behalf of the departmental mandate at local and national fora or on behalf of the Canadian government at international fora. Client service is the process of interaction for facilitation of the knowledge/information transfer between the department/the research and clients in pursuance of the departmental mandate" (Research Community Advisory Committee 2006: 11).

**Outcomes (types)**: 1. innovation; 2. productivity; 3. impact; and 4. recognition are distinct yet linked outcomes that replaces number of publications as focus for promotion process with innovation and impact of the research with individual as team contributions included (Research Community Advisory Committee 2006: 7).

*Innovation (outcome):* "is the development of modified or novel approaches, theories, concepts, ideas or solutions, in line with departmental mandate" (Research Community Advisory Committee 2006: 10).

*Productivity (outcome)*: "is the generation of departmental relevant outputs (also called contributions) being produced by the research, in accordance with the rate consistent with the speciality or type of work" (Research Community Advisory Committee 2006: 10). Examples of outputs: "peer-reviewed publications, scientific products, science advice, research proposals, internal scientific reports, datasets, patents, technology transfers, review, books and chapters, expert panels, involvement in advisory committees, policy development, collaborative research and development projects, public outreach, peer-reviewed journals" (individual or team contributions).

*Recognition (outcome)*: "is a measure of credibility and stature of the research within the scientific community, the department and the government, and with its clients and stakeholders, in accordance with the specialty or type of work" (Research Community Advisory Committee 2006: 10).

*Impact (outcome)*: "is the consequence of the research and new knowledge on departmental target results and on the advancement of the speciality" (Research Community Advisory Committee 2006: 10). Examples of outputs: "science-based policies, regulations, service and technology transfers"

**Promotion recourse mechanism**: independent review (impartiality) that is fair, transparent (disclosure), knowledgeable with candidate representation present (Research Community Advisory Committee 2006: 8). Merit PSEA 30(1), 30(2(a)(b) and 30(4)

# APPENDIX 3: WORKPLACE TRAINING

In the Government of Canada, the provision of workplace training is highly decentralized and determined by individual managers. Even then, training choices reflect the desires of the individual and their manager. There is no requirement to address the demands of clients, citizens, or colleagues in other departments, and no means for tracking trends in demand across a department or multiple departments.

Government of Canada departments and agencies follow legislation and regulations for human resource management. Individual departments and agencies can produce and provide to their employees' career progression frameworks, competencies dictionaries with examples by group and level, and generic training or learning plans consisting of core requirements for career management. The annual performance review process includes identifying employees for talent or performance management through action plans (Treasury Board Secretariat, 2020). These action plans commence as non-punitive assistance for employees to meet the requirements of their occupational group and level. If employees persist in not meeting requirements, the action plans can lead to dismissal. On the other hand, talent management plans can lead to promotions through access to supplementary training and learning opportunities including (stretch) assignments and additional responsibilities.

Within the annual performance management process, employees are assessed on four core competencies: demonstrating integrity and respect (values and ethics); thinking things through; working effectively with others; and showing initiative and being action-oriented, which are generically defined within the application. Managers and departments can include additional competencies for all or selected employees. Functional competencies describe the knowledge, skills and abilities essential to fulfilling specific occupations whereas technical competencies are the specialized skills required for the positions. Publicly available GoC resources such as competency dictionaries are difficult to locate as departments and agencies create them for internal review purposes (see for example Government 2021b; this resource provides definitions and examples showing progression along scales).

Furthermore, Government of Canada employees can register for courses along learning paths such as accessibility, coaching, mentoring, and networking, anti-racism, equity, diversity and inclusion (executives), mental health and tailored learning programs for leadership, management, and team building offered by the internal Canada School of the Public Service (CSPS) (Government of Canada, 2021). Also available are massively open online courses (MOOCs) for self-directed learning on covering topics such as reimagining leadership through building self-awareness, working with different personality types and understanding emotions and emotional intelligence in the workplace.

Team and leadership skills for human-centred design concepts and strategies (iterative problem-solving, rapid prototypes, personas, and user experience journeys, agile project management, etc.) or approaches to culture building in distributed / distance work situations and critical group dynamics courses are available through online services (see EdX, for example).