How Science Informs the Decisions of Government*

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It is a distinct honour and pleasure to address what I believe is central to good governance: *how science informs the decisions of government*. This topic is underscored in how Dr. Amyot approached his work in the service of the public health of this country.

Amyot was a physician and surgeon, distinguished as a practitioner and university lecturer. He also served the country with distinction in our medical services overseas during the First World War. But, above all, Amyot was devoted to, if not downright fanatical about, the public health of Canadians. At the first Canadian conference on medical services held in 1925, he noted in his remarks that “Since 1900, I have spent every hour of the twenty-four thinking of public health.” His promotion of water filtration and chlorination, and milk pasteurization saved innumerable lives.

Amyot’s persistent drive for better public health was based on sound science, and he was proud of his own contributions to that science. At that first conference he also noted “Public health, that branch of medicine which looks towards the prevention of disease, has made immense progress in the last few years since we have had certain scientific facts upon which we can base our action.”

A brief history of science advice for government

For millennia, rulers and governments have called upon wise men who understood (or were thought to understand) the dynamics of the natural world and its social implications to advise them on the creation of policy and laws, and on decisions of national importance. In some cases, these advisors were little more than soothsayers whose advice was founded more in superstition than in science. In other cases, advisors were individuals who were rigorous in their analysis and logic, such as Aristotle, who was the science advisor to Alexander the Great.

As the pace of scientific discoveries escalated, so too did the impact of science on states and their peoples. Continual improvement in time keeping, the discovery of gunpowder, the discovery of the laws of mechanics, the invention of the steam engine, and the discovery of the cause of infectious disease – these and other advances changed peoples’ lives and the rules under which they were governed.

By the 15th century, universities in Europe had become an important source of science advice for government. For example, Isabella of Spain relied heavily on the faculty of the University of Salamanca for advice on scientific issues. Isabella consulted the faculty on Columbus’ proposition that he could reach the Orient by sailing west. The faculty took the position that: they knew the world was round; they had determined that Columbus would never be able to sail that far; so they “advised” Isabella not to fund the voyage. This may have been the original “you can’t get there from here” response. As the story was told to me by colleagues in Salamanca, it was a merchant courtier who convinced Isabella to fund the voyage, arguing that she had little to lose. If Columbus disappeared, she would lose only a small financial stake, but if he made it to the Orient there were great opportunities for trade. You may be thinking “so much for that bit of science advice”... but you know, the faculty were right. Columbus never did get to the Orient.

As early as the 17th century, there were government-sponsored science works. Charles II created the Greenwich Observatory and the position of Astronomer Royal, whose role was to perform science. Unfortunately, that role didn’t always include providing science advice –

the Astronomer Royal was at times discouraged from “speaking his mind”.

By the 17th century, a new source of sound independent science advice became available to governments with the creation of learned societies such as the Royal Society in Britain (1660) and the Académie des sciences in France (1666). Other countries followed – prominent among them was the United States where Lincoln created the National Academy of Science in 1863. From their inception, these bodies have been a source of science advice for governments, although only the American Academy of Sciences was created specifically for that purpose. These academies continue to play an important role as champions for science within their countries and as external “science” advisors to governments on critical issues of public interest.

Until the 20th century, scientific advice to government came primarily from outside the public service. The Second World War changed that situation irrevocably. Governments came to realize that they needed to be involved in performing the science and technology required to meet national objectives. The success of major science projects undertaken to support the war effort set the stage for a build-up of government science capacity in the latter half of the 20th century. This capacity enabled many national governments to become major performers of science. It also enabled government scientists to play a major, if not predominant, role in providing the science advice used to inform governance.

Advances in science and technology since World War II have completely reshaped social and economic structures. National governments now function in a global, knowledge-based economy and society. Scientific advances and new technologies pervade our lives; they increasingly influence our health and safety, and the environments in which we live. They have re-defined our understanding of the physical, biological and social processes that affect human health and the environment.

The future of science advice in government

As the 20th century was an age of physics and chemistry, the 21st century will undoubtedly be an age of biology, wherein the understanding of biological molecules,

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* The lecture can be found in full at: http://www.hc-sc.gc.ca/english/feature/amyot/amyot2001_4.htm

living organisms and ecosystems, and the application of technology associated with them, will change our lives immeasurably. Biotechnology will allow us to use animal cells and bacteria to produce new molecules for therapeutic use. It could allow for the production of “designer organisms” that could be put to both good and evil use. Applying information technology to our improved understanding of biosystems will profoundly influence activities as diverse as pharmacology and the management of fish stocks. Science and technology have contributed to a modern transportation system that presents both benefits and challenges – it allows us to move therapeutic agents to those in need far faster than in the past, but at the same time it allows people who may carry infection to move around quickly and, knowingly or unknowingly, spread disease.

Science is not only fundamental to human and ecosystem health, it is the core of our national innovation system. Science is critical to our international competitiveness in the global economy where ideas and knowledge are common currency. Good science is good economics. Countries with transparent advisory processes based on sound science are better positioned in international trade negotiations, particularly in cases where science is central to non-tariff trade issues. And, the government “seal of approval” is likely to be increasingly important for the market success of new, technology-intensive products. Consumers look to government regulators to use science in making decisions about a product’s safety. In the 21st century, governments strive for balance between their stewardship responsibilities and their innovation goals. In addition to using science to ensure the health and safety of citizens and their environment, governments must also ensure that science is used to foster commercial development of benefit to society. Governments that can achieve this balance will engender both public confidence and a vibrant business environment.

Advances in science, and the need for governments and individuals to accommodate them, will continue to accelerate. There are very few areas of government policy and decision-making that are not affected by science. The requirement for sound science advice to ensure good governance has never been greater. As the 21st

century ushers in the biological revolution, governments, more than ever, must be able to respond in an informed and nimble way to matters of national interest. This means that they must be able to perform and harness science for the public good. In the ferment of biotechnology, nanotechnology and climate change, good science will be essential for government effectiveness. But science alone does not provide the solutions needed in governance.

Science is but one of a number of important voices that must be heard. It is increasingly critical to good governance, but rarely sufficient. Decision-makers in government must consider a range of inputs and consult advisors competent in many aspects of public policy.

Economic factors, social and political considerations and public activism should, and do, influence policy and regulatory decisions. At times, they overtake scientific advice. Decision-makers must exercise their legitimate role in weighing these inputs. Einstein was once asked why people could discover atoms but not the means to control them. He replied: “That is simple, my friend, because politics is more difficult than physics”.

In our fervour to respond to the challenges and capitalize on the opportunities afforded by advancements in science, we must not lose sight of the diversity of inputs and advisors needed for good governance.

Science advice and the Government of Canada

The Government of Canada has recognized that science is one of the most powerful tools it has to make sound decisions in an increasingly complex world. Based upon the recommendations of the Council of Science and Technology Advisors (CSTA), an independent advisory group, the Government has adopted a *Framework for Science and Technology Advice*. It provides a series of six principles and operational guides for the effective use of science and technology advice in government decision-making:

- *Early Identification* – anticipating key issues arising from advances in knowledge.
- *Inclusiveness* – ensuring that advice is drawn from a variety of sources and disciplines to capture the full diversity of

challenges and opportunities, and scientific thought and opinion. To be effective, this process must draw upon the necessary range of expertise, regardless of whether it resides in government, in Canadian academe or industry, or internationally.

- *Sound Science and Science Advice* – applying due diligence to ensure the quality, integrity and objectivity of the science and science advice.
- *Uncertainty and Risk* – requiring explicit recognition and communication of scientific uncertainty and risk.
- *Transparency and Openness* – open discussion of scientific problems and experts’ opinions and transparent and easy access to the science and the advisory process.
- *Review* – reviewing decisions based on scientific arguments to ensure that they reflect the most recent knowledge.¹

A recent report of the Institute for Prospective Technological Studies (IPTS) of the European Commission referred to these principles as “the six commandments of the CSTA” because they provide explicit, formal operational guidance on how science advice should be sought and applied for good governance.²

A definition of science and good governance

Let me share with you my definition of science. For me, science includes the full spectrum of activities – from the generation of new knowledge to its many applications. It includes the systematic examination of the natural and social elements of our world, and the translation of the knowledge gained beyond the confines of science itself. In turn, my understanding of governance embraces all the activities of government that affect society, such as the formulation of policies and regulations, the development of advice for citizens, and the passage of laws.

Integrating sound science and sound governance

The goal of governments and scientists should be to integrate sound science and sound governance. Science must be applied in a manner that is accountable, transparent, thorough, impartial and credible, and which will help focus the policy debate on the substance of the issues. This includes

providing quality information, presented in a useable fashion, on what we know, what we do not know, and the extent of the uncertainties and risks involved in various alternatives.

It is important to bring science and science advice to the table early in the policy development process. In the words of the French mathematician, Poincaré: “Science is built with facts as a house is with stone. But a collection of facts is no more a science than a heap of stones is a house.”

To build a house from an accumulation of stone, you need a craftsman – a stone mason. The stone mason will know how to assemble the stone so that the house will withstand the loads imposed on it. The same can be said for the accumulation of scientific facts. It takes a craftsman – in this case a scientist – to interpret and sort through the facts to create a credible scientific structure that will withstand scientific and public scrutiny.

Science advisors need to be involved in identifying and assessing policy options (from a science perspective) to maintain the integrity of the science advice throughout the development of policy.

Government requires science to:

- support decision-making, policy development and regulations;
- develop and manage standards;
- support public health, safety, environment and defence needs; and,
- enable economic and social development.

But, where does government get the science it needs?

Good governance requires scientists with the ability and credentials to generate and translate scientific findings into sound science advice. In some cases, these scientists will be employed within government; in others, they will not.

Government is no longer the primary performer of research and development in Canada (at present, governments perform 13% of research and development in Canada – this is comparable to the US and OECD averages). Over the past two decades, universities and industry have developed strong research capabilities: approximately 62% of total research and development is performed by the private sector, and universities perform 25% of total research and development. For much of the science and technology required by

government, decision-makers can fund work in universities, contract to industry and increasingly, access knowledge generated in research institutes in Canada and abroad.

As the cost, complexity and pace of advancements in science escalate, individual organizations no longer have the resources or expertise to “go it alone”. We need to find new ways to partner – to bring together multi-disciplinary teams of scientists from across the innovation system. We need new ways to combine their intellectual, financial and physical resources in conducting the science required to better understand the complex, interconnected world in which we live.

Government scientists must be as good and as current as their external colleagues in order to form and contribute to these partnerships. In turn, government must have the in-house capacity required to assimilate, interpret and extrapolate the knowledge obtained through these partnerships into the framework of governance. As a starting point, to improve partnerships and to improve government’s “absorptive capacity for science”, I believe that the government should foster the interchange of scientists among government, academe and the private sector. A freer flow of scientists will enhance the quality of science advice to government, maximize the contribution of Canadian scientists to the national system of innovation, and renew the science base in all sectors.

International partnerships and strategic capacity

It is also important to look beyond our national borders – the processes of science are international. Let me return to the University of Salamanca. As one of the oldest European universities, Salamanca emerged after the severe intellectual restrictions that prevailed during the Dark Ages.

As intellectual life and scientific activity resumed, scholars in European universities, such as the University of Salamanca, had a lot of catching up to do. They did so by drawing on the advances that had continued in other parts of the world, particularly those achieved by Islamic scholars and scientists during the 11th and 12th centuries. We must continue to look outward and to take an inclusive approach to science and science advice. Today, many of the scien-

tific questions that arise in governance are of similar concern to countries around the world. All governments need to look more to international partnerships for the generation of new knowledge. Joint research is feasible and cost-effective. Clearly, the analysis, interpretation and application of that research will need to be informed by our national perspectives and values.

Government cannot obtain all of the science, and especially the science advice, that it needs in a timely fashion from sources outside government. Academe, the private sector, and non-governmental organizations, which can supply outside advice, have philosophies and priorities that are not always compatible with government agendas and requirements for science. And there are times when the government must perform and lead science that is of strategic national importance. When that science and technology cannot be effectively or efficiently obtained from outside of government, the government needs a strategic in-house capacity to conduct first-rate science. This view has also been enunciated by the Council of Science and Technology Advisors.

The key is to ensure the quality, integrity and objectivity of the science and the science advice regardless of its source. Science and technology performed and used by government must be excellent. To perform excellent science, and to distill it into excellent advice, government must maintain a foundation for scientific excellence. This includes: dynamic and knowledgeable scientists; scientific equipment and facilities capable of supporting leading-edge science; predictable, ongoing financial resources; and, an environment that offers the opportunity to conduct challenging science and work with the world’s best scientists. If you think that the cost of doing good science is high, think about the cost of *not* doing it. To *assure* excellence, scientists, decision-makers and the public require validation that data and analyses are first rate. This can best be achieved through expert review by peers and stakeholders.

Progress and uncertainty

Innovation is the touchstone of progress in science. We must be open to new, as well as conventional, ways of interpreting our observations. The scientific method

ensures that progress in science is deliberate and well reasoned. This is fundamental to the development of a credible body of scientific knowledge. Scientific revolutions often come about through radical changes, such as the paradigm shift that came with understanding the structure of DNA.

Somehow we have to balance a stable scientific process of checks and balances with a system that encourages, and is receptive to, these scientific revolutions. Peer review – the test of convincing peers that your view should prevail – has served us well over the years. It has often prevented us from travelling down unproductive paths. But, if conservatism leads to bias or lack of openness to new ideas, the core value of innovation that drives the progress of science can be lost.

We need to recognize that absolute certainties in science are rare. The process of science involves continual questioning of the assumed “truth”. The more that an explanation stands up to new facts, the more scientists become convinced of the validity of that explanation.

Regardless, scientists need to communicate uncertainty in science. We need to recognize that in science, there can be more than one legitimate set of conclusions drawn from the same facts – just as in the house analogy, where one could make different houses from the same pile of stones. In science, however, the number of options typically narrows as more information becomes available. Scientists must make clear to decision-makers when alternate explanations for observed facts exist or where there is not a consensus on the science. Science advisors may express a preferred interpretation, but they should be clear if it is not the only one. Otherwise, they have failed to provide the best science advice. In turn, decision-makers need to take these factors into account in reaching decisions.

When one has only one fact, one has no choice but to base interpretations on it. When one has many facts, one has to incorporate them all to yield the best explanation of a phenomenon. Science advice needs to be formulated in a way that not only accepts and adapts to new facts, but also anticipates and welcomes them.

Disparate views may exist. They can sometimes be reconciled or a consensus view reached by seeking science advice

widely – from expert panels, advisory boards, or other mechanisms such as consensus conferences. Unfortunately, decisions in government may have to be taken in times of public crisis, which does not allow for a contemplative pace to reach scientific and stakeholder consensus. Sometimes we cannot wait for what Pericles called the wisest of all counsellors – time – so we go with the best we have. But I believe that we should revisit these decisions. Uncertainty in the science and thus uncertainty in advice should alert us to the need for review.

There is an unfortunate tendency for us to ascribe “blame” when advice, and subsequent actions taken, turn out to be wrong in hindsight. Most often, negligence is not the cause, and “blame” is not warranted. This underscores, once again, the importance of communicating what science can and cannot tell us about issues. Certainly a cautious approach to science advice and decision-making is essential. But precaution should not translate into paralysis.

The synergy of science and policy

The cautious approach needed when incorporating science advice into decision-making points to the importance of the relationship between scientists and policy-makers. In the past, these two communities have often worked in separate solitudes, comfortable with the patterns associated with their professions. This is not a new challenge.

In the 1860s, Louis Pasteur invented pasteurization. Because his ideas were revolutionary, they were adopted slowly. The idea of pasteurizing milk didn't arrive in North America until the 1880s – even then, it took another 30 years to find its place in policy.

Acceptance in the U.S. came about largely due to the efforts of Nathan Strauss, co-owner of Macy's department store, who was taken by the theoretical benefits of pasteurization. Strauss overcame the resistance of politicians, milk producers and the public by demonstrating that the pasteurization process dramatically reduced the diseases and deaths resulting from raw milk consumption. He accomplished this by providing subsidized and free pasteurized milk to the people of New York City. In Canada, it was our own John Andrew Amyot who took a lead in introducing the

pasteurization of milk. Here is a case wherein the scientists and the policy-makers failed to achieve a good outcome when they worked in isolation, but succeeded when the science and policy worked in tandem.

Today, almost all policy issues either affect, or are affected by, science and technology. It is more important than ever for governments to ensure a strong and productive bond between science and policy. Our reward will be better policies and stronger political and public confidence in those policies.

The challenges of well-integrated science and policy

There are important challenges in successfully integrating good science into policy:

- science cannot always produce the facts and answers in the time frames needed by policy-makers;
- those involved in policy development and decision-making often seek precision and certainty. While well-established science can sometimes approach the precision, it can never deliver certainty;
- scientific development and validation is typically achieved through broad dissemination and challenge from peers, whereas policy, at least historically within a Westminster model of government, tends to be developed from internal sources; and,
- scientists often become frustrated when policies and government decisions are not consistent with their science and science advice, while policy-makers wrestle with how to balance a diversity of inputs and advice.

Only through ongoing dialogue will these challenges be overcome. Scientists and policy-makers need to gain a better appreciation of their respective roles and the processes and tools they use to fulfill them.

I would suggest some guidelines for this dialogue: Scientists must provide their best scientific judgement and advice, even when significant uncertainty and controversy exist. They must also clearly distinguish scientific fact from judgement and advice. In turn, policy-makers must ensure that scientists are involved in policy formulation throughout the process to maintain the integrity of the science advice.

Communication between scientists and policy-makers is key. Not only must we

speak clearly, we must listen intently. Not only must we think of what we say, but of what others hear.

The government needs to equip itself to secure and use the best science advice. It should attract and support high-calibre scientists, both within and outside of government. It should subject its science and advice to the test of scrutiny by peers and comment from stakeholders. Sound science and science advice are critical to the government's ability to address the science-related opportunities and challenges that

dominate our economy and society. Controversies will continue to arise, but broad application of principles such as inclusiveness, openness and transparency, excellence, and review, will contribute to enhanced confidence among government decision-makers and the public that the best science is being used to guide government decisions.

I will finish with another quote from Amyot. He was referring, not surprisingly, to public health, but the comment applies to all areas of science and governance.

"The public has demanded men who knew more and who could spend more time on public health than it ever did before." He speaks to us yet today. We must respond.

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