PRESIDENTIAL ADDRESS: "Changing Geologic Times"

by Fred J. Longstaffe

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Members of the Association and Guests: Last year, about this time, a great epic called The Poetry of Geology "... droppeth as the gentle rain from heaven upon the place beneath."[1] Sadly, the place beneath was me. As I listened then, I wondered how one could ever hope to follow Blackwoodian presidential oratory. Merci beaucoup, M. Frank, merci beaucoup; je me suis perdu!

My growing sense of impending doom was nutured by the helpful asides of many colleagues. These remarks continued long after the President's address last year: "Glad it's you and not me next year," or "You can't possible follow that," or "Maybe you should beg Frank to do yours next year," or "Fasten your seatbelts, no smoking" And then there was this e-mail last week: "See you soon in Victoria; I still remember how inspirational Blackwood was, but I understand completely why you can only talk about isotopes..."

ISOTOPES, FRACTIONATION AND HUMAN NATURE

What is all this prejudice against isotopes? We Isotopists (that's what we call ourselves; there are several of us in this room; you might even be rubbing up against one) are constantly maligned from all directions: "black box geomagic" is the general dismissive tone of my petrographic and sedimentological colleagues. My field-based acquaintances regularly make rude remarks about our extremely effective use of highway maps for locating suitable outcrops, our penchant for non-canvas based accommodation, and our essential visits to Vienna to ensure an adequate supply of appropriately calibrated standards. I was cheered initially to find that my newly found geophysical colleagues at Western were less isotophobic, but only until they discovered that the most complicated functions (mathematical, that is) of the Isotopist involved natural logarithms, that we do our sophisticated computer modelling on a MacIntosh SE, and that for us, a time-series analysis meant alternating the entry of sample and reference gases into the mass-spectrometer every 30 seconds. Neither are spouses and significant others generally impressed by isotopes or, for that matter, Isotopists: mine, for example, has been writing to the Natural Sciences and Engineering Research Council (NSERC) for years to have my research funds cut off.

Yet I can assure you that the supreme position of the Isotopist in the Global Scheme of Things (GST) is assured. For everything is made of isotopes, and one can learn much from them.

Isotopes are like people. Most are stable, but some are not. Those that are not can decay rather remarkably, even exponentially, not to mention all of their peculiar parent-progeny relationships. Most disturbing of all, even the stable isotopes are always separating into groups depending on the conditions under which they exist. We call this behaviour fractionation. As temperatures get lower, the stable isotopes of, let's say oxygen, fractionate more and more, as they strive for glorious separation and independence from their brother and sister isotopes, with whom they originally were well mixed in the cosmic scheme of things.

And isn't it just typical that we focus almost entirely on the differences between the stable isotopes of an element. We even define the unit of measurement — parts per thousand — and formulate the expression to describe isotopic ratios (the delta value) to amplify the magnitude of these small differences. Caught up in the excitement of a 0.5 part per thousand difference in the isotopic composition between two phases in a system, we tend to forget the foundational truth: stable isotopes of oxygen (or other elements) behave very similarly in chemical reactions. Except for very tiny differences, they, in fact, travel together through their geochemical lives. They are very much more the same than they are different.

Isotopes (but not necessarily Isotopists) are very sensible about this fractionation business. They are happy to go their separate ways when things are cool, but when the going gets tough and someone turns up the heat, the ardour to fractionate is quickly dampened. Heat and entropy drive together again that which never was so very different in the first place.

And so too must geoscience and geoscientists return to a well-mixed system, one with much diminished fractionation. We must use the heat of budget reductions and the entropy of reorganization being felt across the country as a catalyst to gather our subdisciplines, scientific societies, and diverse employment sectors to create a coherent, exhilarating and unified identity for the earth sciences in these changing geologic times.

Geoscientists are no strangers to the concept of change. Indeed, change is central to the study of the Earth. Galileo expressed this point rather early on:

> It is my opinion that the Earth is very noble and admirable ... [but] if it had continued an immense globe of crystal, wherein nothing ever changed, I should have esteemed it a wretched lump of no benefit to the Universe.[2]

Now, to borrow a metaphor and mix a few phrases, accepting the clear and present danger that Galileo was forced to recant many of his beliefs when made an offer that he couldn't refuse, I suggest to you that the geoscientist, her institutions, and his attitudes also must change. Most of all, we must combat fractionation and fragmentation within our necessarily broad discipline, lest the valuable voice of the geoscientist in government, industry and academia becomes so muted that it can be ignored with impunity.

Perhaps Will Durant's proclamation that "Civilization exists by geological consent, subject to change without notice"[3] is stretching a point, and no doubt, I am distorting his meaning by taking it to emphasize that a healthy geoscience community in all sectors is core to national well being. But it is time to become a wee bit more forceful and effective in our demonstration that Canadian geoscience is much more than a nice but not so necessary activity, as is so tacitly implied by many recent big and small decisions taken by governments, univer-

sities and the private sector alike.

Our country's wealth and future still rest in large part with hydrocarbon and coal accumulations, deposits of metals, aggregates and industrial minerals, and fresh water[4]. Civilization, as we know it, demands these natural resources. Civilization doesn't ask much of today's geoscientist. We are charged simply to deliver these commodities at a profit, at low cost, and in abundance, to develop new earth materials, to do so in real harmony with the environment, to monitor and evaluate the longer-term effects of human exploitation of earth resources, to find ways to remediate past environmental damage, to predict natural disasters, to keep the temperature, water level and purity in our planetary bathtub just right, to keep the methane in the wetlands and the carbon-dioxide in the colas, to explain why our sunburns are getting worse, and to do something about it.

In other words, earth scientists have an especially demanding role to fill and extremely important leadership to provide. The challenges are particularly acute in Canada. Canadian geoscientists know very well that vast areas of our country, such as the northern peatlands and Arctic terranes, not to mention our coastlines, are unique and ecologically very sensitive[4]. It should be unquestionable that Canada educate a strong cadre of new geoscientists for whom resource and environmental geosciences represent an integrated continuum, not disparate disciplines.

INTEGRATION, CO-OPERATION AND COLLABORATION IN GEOSCIENCE EDUCATION

Now, everyone has their opinions on university education, and more specifically, education in the geosciences. I dare say that some of you agree more or less with Stephen Leacock's viewpoint:

> If I were founding a university, I would found first a smoking room; then when I had a little more money in hand I would found a dormitory; then after that, or more probably with it, a decent reading room and a library. After that, if I still had more money that I couldn't use, I would hire a professor and get some textbooks.[5]

Well, what are we to do with geoscience education in our universities? First, I submit to you, the principles of the so-called "traditional" geological education must remain and be reinforced. Yes, we need more paleontologists, petrologists, mineralogists, biostratigraphers and in general, field-based researchers. Recently, at the University of Western Ontario, we appointed a paleontologist. Those believers in the reductionist trend for paleontology were shocked. But my colleagues and I at Western all agreed; time as recorded in the rocks is the third dimension that gives the geosciences their most unique character. How could you not have a paleontologist?!

In fairness, those who would strike paleontology from the books respond that it is not that paleontology is unimportant, but that the geosciences have expanded to embrace many new subdisciplines that require faculty appointments. In other words, trade-offs must be made, given that faculty numbers are static at best, and most commonly shrinking in Canadian earth sciences departments. Our department's hydrogeologist was so pleased when we appointed a paleontologist. "I'm absolved," he said, "of my portion of the collective guilt for the pseudomorphic replacement of paleontologists by hydrogeologists across North America over the last ten years."

Yes, we have our new paleontologist, but that appointment doesn't alter the fact that the geosciences have changed. The need to rigorously and vigorously blend the qualitative and the quantitative, and to incorporate substantial aspects of biology, ecology, aqueous, organic and atmospheric chemistry, climatology, mathematics, remote sensing, GIS and so on, into the education of the modern geoscientist simply is not debatable. University departments, their professors, their deans, and their presidents must acknowledge and support this expanded character of geoscience education and research. Indeed, they are negligent if they do not insist on, and substantially assist with, the necessary pedagogical revolution.

But how can we do it all? In these changing geologic times, how can we hope to properly ground geoscience students in all necessary areas of solid and environmental earth sciences?

One approach would be to diminish the fractionation among us. Industry and government geoscientists could and should be much more closely involved in teaching and training the new generation of geoscience students. For instance, many of us worry that basic training in field geology, so central to an earth-sciences education, is no longer adequate in the absence of the plentiful and varied summer field work experience once provided by industry and government. So let us co-operate to establish some permanent, regional field schools in suitable locations that properly represent a good diversity of geological settings. By "us," I mean a co-operative project of university, industry and government-based geoscience institutions. How can it not make sense, not to mention a wise investment, to have the most experienced field geologists teach and demonstrate field geology?

Is it truly impossible to cross sectoral boundaries to collaborate in field instruction? Are there really too many levels of management or government to convince? Are there really too many unenlightened professors or faculty associations to block the way? Is it too expensive? No, from my perspective, the real obstacle is nothing more than the established patterns that partition and compartmentalize industry, government and university geoscientists when it comes to geoscience education. Another avenue already explored by some, but still far too few, are work-study terms in industry and government for earth sciences students. Would student demand exceed the potential supply of placements? Would such ventures on a wider scale displace practising geoscientists who rely on contract positions? I don't think so, but a national work study scheme, as well as the questions that it raises, deserves consideration now, not in a piecemeal way, but through a nationally co-ordinated, co-operative venture.

Our institutions, and especially our universities, must adapt quickly to permit and encourage these kinds of co-operation. George Bernard Shaw, always ready with a solution to any problem, said that "In England, we always let an institution strain itself until it breaks."[6] Well this ain't England, and we daren't wait; the pending rupture could be catastrophic. We need to instigate the change now, ourselves. Let it not come to pass that the existing fractionation born of tradition and habit forever inhibit real educational collaboration and other forms of co-operation among industry, government and universities.

And if a modern geoscience education requires a longer time at the baccalaureate level, so be it. If an adequate geoscience education is better achieved by replacing the

thesis approach to the M.Sc. degree with a series of advanced courses that both widen a student's geoscientific horizons, as well as deepening their understanding and facility in some aspect of earth sciences, then I'm very much in favour of that, too. There are research opportunities enough at the Ph.D level. If delivering the necessary breadth of subject material in the earth sciences requires that some departments should band together to present the spectrum of instruction required, let's get on with it quickly, seizing the opportunity to make such changes under our own initiative.

But let us do all of these things, not for the principal motive of cutting costs, reducing payroll units, or appeasing the plethora of lateral, vertical and biased (no pun intended) cutters that seem to dominate the landscape these days. Let the goal be to enhance the excellence and sophistication of the education needed in a modern, broadly based geosciences programme.

And when it comes to pass, as it will, that professional accreditation of geoscience programmes and professional registration of geoscientists extend across the land, let it not be that the schedules of accreditation requirements be so narrow and inert that they discriminate against students of the earth who have embraced the expanded horizons and intellectual adventures demanded by our dynamically evolving discipline. We must never let it come to pass that Canadian geoscience education be the "wretched lump" of Galilean ignominy.

ACCOUNTABILITY AND SUPPORT OF RESEARCH IN THE GEOSCIENCES

At this point in preparing my remarks, it seemed destined that I should shift back to the safer, more comfortable ground of oxygen-isotope fractionation in the gibbsite-water and rutile-water system at 25°C. No doubt, you earnestly wish me to do so! But one of my now retired colleagues (who happens to be an invertebrate — oops, I mean — inveterate snoozer in departmental seminars), reminded me of the observation (again Shaw's) that "A nap, my friend, is a brief period of sleep which overtakes superannuated persons when they endeavour to entertain unwelcome visitors or to listen to scientific lectures."[7]

Quite clearly, it would be most unacceptable to have many of you left sleeping here, missing the GAC annual luncheon and medal presentations that follow immediately. But still, aren't scientific lectures a great part of what a learned society should be all about? We gather to present our latest facts and interpretations, and need and should expect to be criticized during those performances. Review by our peers, especially those penetrating and oft-embarassing questions at the end of your talk (and really, if you don't leave time for questions, you should be ashamed!) is one of the most essential ingredients for progress in science. Charles Darwin explained this philosophy much more eloquently:

> False facts are highly injurious to the progress of science, for they often endure long; but false views, if supported by some evidence, do little harm, for every one takes a salutary pleasure in proving their falseness.[8]

May I request then that, right after lunch, each of us returns to the scientific sessions more cognizant of our responsibilities, and willing to take the mandatory pleasure from our colleagues' talks?

While we are doing so, let us remember that an abundance of the research presented at the annual meetings of the Geological and Mineralogical Associations of Canada, at least for university-based researchers, is spawned from the womb of the NSERC Research Grant. Now, in frank and open disagreement with the recent protestations of some members of certain political parties of a somewhat western persuasion, I submit to you that these are tough dollars to get, and tougher dollars to keep. We can argue interminably (or at least until lunch) over the merits of the NSERC granting system, but I for one do not know of a better way for fostering university-based scientific enterprise, and for helping to maintain a healthy platform for research in this country.

The larger question must be: Should a modern society support university- (or for that matter) government-based research from the public purse? We could choose to get sidetracked by lively, dare I say, even heated, discussions on the relative merits of applied *versus* fundamental research. I'm not sure that I could provide an adequate definition of either, or even whether I believe that such characterizations are realistic. I'm persuaded instead that these terms are only hypothetical end members in the research continuum required by a modern society. What matters is that we fund research, and I propose to you that NSERC funding, in particular, is an investment in research of incredibly modest cost for its ultimate spinoff in society.

For not only are the research papers valuable, but so also is the learning by students that is made possible using these funds. Furthermore, I've not even begun to consider the very real and immediate return to the economy in the form of highly effective job creation and training of highly skilled Canadians that springs from these competitively earned funds, as staff are employed to assist with the research projects. NSERC grants, I believe, rival many programmes in which job creation is the principal goal, rather than a by-product. Let me emphasize again that public support for research is a proper goal for prudent and responsible government. A return to pseudo-Victorian values, espoused in some quarters these days, also carries with it a return to economic, social and political conditions that, at least to my way of thinking, should despoil any romantic or nostalgic notions about those being the good old days!

That is not to say that public accountability is not important. Shaw expressed it this way:

> Every person who owes his life to civilized society and who has enjoyed since his childhood its very costly protections and advantages should appear at reasonable intervals before a properly qualified jury to justify his existence, which should be summarily and painlessly terminated if he fails to justify it and it develops that he is a positive nuisance and more trouble than he is worth.[9]

Well, that might be a little bit much, even in these changing geologic times. Perhaps, there should be somewhat more latitude in the vigour with which we pursue this Grail of Accountability. For measuring the health of a scientific field for such accounting exercises is no simple matter. As Richard Zare recently pointed out in a United States National Academy report, it is very hard to find absolute standards or one size of standards that will fit all fields.

> It is seductive to imagine that a set of metrics exists that, when tracked over time, will enable predicting with confidence the future prospects of a scientific field or subfield. ... We must avoid allowing what can be measured to become what mat-

> ters, rather than seeking to measure what matters, which frequently are attributes that cannot be measured.[10]

Wise words for the next NSERC Allocations Committee exercise, I believe, but more on that later.

Deficits are driving accountability measurements of all sorts, and whether we agree with the parameters used to take decisions, they are exacting their price. Far be it for me to instruct many of you that the Geological Survey of Canada has received a 32% reduction in overall resources over the next three years. So, too, shall the funds available to university-based researchers continue to shrink considerably. NSERC's research funding level for 1995-96 was reduced recently by $24.4 million, and budget levels for 1996-97 and 1997-98 will be $48.2 and $69.7 million lower, respectively. In other words, over three years, the NSERC budget will be reduced from a projected $497.8 million to $428.1 million. If ever there was a need and impetus for university-, government- and industry-based geoscientists to explore ways of effecting collective economies through collaboration and cooperation in research, it is now.

SOME BATTLE WOUNDS – THE 1994 FUNDING COMPETITION AMONG SCIENCE AND ENGINEERING DISCIPLINES

Many of you have heard more than enough of cuts! Well, it is not on these general cuts that I want to focus your attention today. Perhaps lost in the blinding glare of the federal budget reductions was a quieter but more profound set of decisions taken by NSERC's Allocations Committee.

Regrettably, I bring their recent judgements of the Canadian earth sciences community and its research effort to your attention. Darwin would have put it more simply: "We will now discuss in a little more detail the Struggle for Existence."[11]

For those of you who have read my last Presidential Preamble in GEOLOG[12], the words that follow may come as somewhat of an echo. So be it, for the echo of these allocation decisions ought to be a trumpet call for action by the Canadian geoscience community from all sectors, and hopefully one that lets the walls between them come tumbling down.

The NSERC Allocations Committee's task was the redistribution of NSERC's 1994-95 budget for the Research and Infrastructure Grants Programme. This Programme is the foundation of university-based research in science and engineering in Canada, and is the largest, and to my mind, the most important of the programmes delivered by NSERC ($195.9 million for 1995-96). Simply put, a competition was held among NSERC's some 20 discipline-based, research grant selection committees for up to 10% of the funds that each committee currently distributes. *We lost.*

The Allocations Committee based its decisions on a variety of information, including reports prepared by the grant selection committees, international external reviews, internal review, and a variety of statistics gathered by NSERC. Central to the decision-making process were assessments of the overall quality of research in a discipline, the discipline dynamics (that is, the relative growth of the area, including development of new research areas and the national interest therein), and the perceived need for training of highly qualified personnel.

The outcome? The two grant selection committees representing solid earth sciences and environmental earth sciences (fractionated in 1988 from one committee) received 3.8% and 4.8% reductions, respectively, in their share of the total budget for the Programme. By comparison, increases were awarded to committees representing engineering disciplines, chemistry, computing and information sciences, statistical sciences, and space and astronomy. On average, the life science committees broke even. Only physics and mathematics committees fared more poorly than the earth sciences.

Let me read to you an only slightly abridged version of the comments that the Allocations Committee asked to be communicated to the geoscience community:

> Solid earth sciences is an area of great importance to Canada. The [Grant Selection Committee] report clearly provided evidence of internationally recognized excellence among senior researchers and programs such as Lithoprobe. However, the views on the future contained in the report failed to show how Canada will maintain its current areas of strength. The vision statements in the report are cause for concern, generating a disappointing and uninspired view of the future. Employment opportunities and student enrolments were also seen to be low.[13]

Minus 3.8% of our share.

And for the environmental earth sciences:

> This is a relatively new discipline with potential for longer term growth and significant contributions for Canada. The [Grant Selection] committee presented evidence of high quality research in certain areas, e.g., geohydrology (Waterloo Centre for Groundwater Research), oceanography. But, overall past performance and the wide dispersion of funding lead to a feeling that a majority of research in this field lacks significant impact. The field is growing in international importance, and particularly to Canada, and Canadian research would benefit from focused support of leaders in the field. The current low demand for personnel was also troubling.[14]

Minus 4.8%.

I was stunned by these judgements, and I hope that you are too! The temptation to challenge, debate and decry these conclusions was almost overwhelming (and yielded to by some others criticized even more severely). But I'm of Sir William Osler's philosophy that:

> Things cannot always go your way. Learn to accept in silence the ... aggravations, cultivate the gift of taciturnity and consume your own smoke with an extra draught of hard work, so that those about you may not be annoyed with the dust and soot of your complaints.[15]

But also, I agree a bit with Emerson, who would have responded: "I hate quotations. Tell me what you know."[16]

I *know* that the health and vigour of the Canadian earth sciences research community is better than this assessment. But we failed to convince those whose task it was to judge.

I *know* that there is an influential body of opinion that research funding should targeted more toward manufacturing and high-technology industries, and that less emphasis than before is required in the resource and environment sector. We must forcefully persuade decision makers otherwise.

I *know* that a challenge has been issued to the Canadian producers and consumers of research in the earth sciences. Our conviction that such activities are of high relevance and priority to the intellectual, social and economic development of Canada is, by itself, not sufficient. Geoscientists from all sectors must shape, balance and refine a powerful statement of our worth, our purpose, and our future, and then convince not only the public, but also colleagues from other disiplines

and sectors, that our arguments are sound. A start has been taken by the CGC working group on "Future Challenges and Trends in the Geosciences in Canada," but responsibility cannot rest there alone. The much wider community must pick up and carry the cause!

I *know* that it is the responsibility of the geoscience community to collect, maintain and report in a much more comprehensive and effective fashion, data on the relevance of the earth sciences to the economy of Canada, on the professional employment and positioning of geoscientists in industry, government and universities, and on employment outside of the geosciences by persons trained in our discipline. That is, we need to demonstrate the general value of an earth sciences educational background beyond the immediate confines of direct, for profit application of that knowledge. We must be prepared to demonstrate at all times, and at all levels, the substance and impact of Canadian geoscience from all sectors, regionally, nationally and internationally.

I *know* that we were disadvantaged by the fractionation of our discipline during the Allocations Committee exercise. Because the two Earth Sciences Grant Selection Committees were evaluated separately, apparent weaknesses of one committee in some aspect were not counterbalanced by obvious strengths of the other committee in the same aspect; we were judged separately, yet we are all earth scientists. In my opinion, the potential and growing significance of the newly developing environmental earth sciences can be coupled effectively with the proven strength of the more mature aspects of the solid earth sciences. We must be viewed as we are, an evolving discipline that has produced, and continues to produce, outstanding and significant solid earth science, but a discipline that also clearly recognizes and is in the process of rapid evolution and expansion into environmental matters that are of societal and scientific concern. Fair and accurate evaluation of the health of our discipline requires its consideration, not in artificially truncated portions, but in its entirety. "We must all hang together," said Benjamin Franklin (paradoxically at the signing of the Declaration of Independence), "or assuredly we shall all hang separately."[17]

A CALL TO ARMS!

In little more than three years, the university-based geoscience community will face another allocations exercise, framed against a substantially reduced budget for the total programme. We must begin to prepare now. I accept my responsibility to help organize this effort. *Who among you will serve as well?* All of Canadian geoscience, whether based in university, industry or government, must find a collective and effective method to monitor the vigor of the discipline, to preserve an accurate and accessible record of its development and successes, and to ensure through deed and communication that Canadian geoscience is highly valued nationally and internationally. We must nuture effective pathways and spokespersons to transmit this information regularly and repeatedly to those quarters where the decisions that influence the health of Canadian geosciences in all sectors are taken. *And we must measure what matters!* In the days ahead, even at this meeting, I shall be asking for your ideas, your help, and your commitment to preparation of Canadian geoscience's next submission to the NSERC Allocations Committee.

As a learned society, the Geological Association of Canada (GAC) should take a leadership role in this process. With its breadth of membership from industry, government and academia, it should be placed perfectly to understand the critical interactions amongst the producers and consumers of geoscientists and geoscientific knowledge.

But GAC, while wide in scope, does not reflect the entire spectrum of Canadian earth sciences. There are (believe it or not!) other Canadian geoscience societies. Their number and diversity within our relatively small professional population pay tribute to the breadth and vigor of Canadian geosciences. But it has crossed my mind, more than once, that the fractionation among societies has its pitfalls, especially when faced with harnessing the energies and developing the synergies needed to present the unified national geoscientific identity needed to sustain our roots and fertilize our future. Today's geoscientist, by the very nature of her employment and his interests, must range over a bewildering array of subjects. So also must her learned society. I wonder, is it time perhaps, in these changing geologic times, to consider some consolidation or closer affiliation, to contemplate a Canadian Union of Geosciences Societies?

Members of the Association and guests, I thank you for your patient attention, and for your tolerance. If I have had any luck at all, I will not have left time for any questions! Let me spare you a final isotopic pun by closing instead with two hopefully not too cryptic insights from my favourite oracle. First, "You don't learn to hold your own in the world by standing on guard, but by attacking, and getting well hammered yourself."[6] And second, as I tell my fractionating isotopes and occasionally fractionating colleagues, "Independence? That's middle class blasphemy. We are all dependent on one another, every soul of us on earth." [18]

FOOTNOTES

1 William Shakespeare, in: The Merchant of Venice, Act IV.
2 Galileo, from: Holmes, A., 1965, Principles of Physical Geology.
3 Will Durant, in: What is Civilization?
4 Front-end statement to the 1994 Earth Sciences Allocation Reports to the NSERC Allocations Committee.
5 Stephen Leacock, in: Oxford As I See It.
6 George Bernard Shaw, in: Getting Married: A Disquisitory Play.
7 George Bernard Shaw, in: Tragedy of an Elderly Gentleman.
8 Charles Robert Darwin, in: The Descent of Man, Chapter 21.
9 George Bernard Shaw, Radio Address from London to America on October 11, 1931.
10 Richard N. Zare, as reported in: Physics Today, v. 48, n. 3, p. 78.
11 Charles Robert Darwin, in: The Origin of the Species, Chapter 3.
12 GEOLOG, v. 24, part 1, 1995, p. 6-7.
13 December 20, 1994 communication from NSERC to Solid Earth Sciences Grant Selection Committee Members (GSC 08) and Group Chair.
14 December 20, 1994 communication from NSERC to Environmental Earth Sciences Grant Selection Committee Members (GSC 09) and Group Chair.
15 Sir William Osler, in: Life of Sir William Osler, Chapter 22.
16 Ralph Waldo Emerson, in: Journal, May, 1849.
17 Benjamin Franklin, at the signing of the Declaration of Independence, July 4, 1776.
18 George Bernard Shaw, in: Pygmalion, Act V.

Delivered at the GAC–MAC Annual Meeting
17 May 1995 in Victoria, British Columbia