THE KILLAM TRUSTS

2003 KILLAM ANNUAL LECTURE

The Challenges of Educating the Next Generation of the Professoriate

Shirley M. Tilghman, Ph.D.

President, Princeton University
Professor of Molecular Biology, Princeton University

Published by the Trustees of the Killam Trusts

Izaak Walton Killam

Born in 1885 at Yarmouth, Nova Scotia

Died in 1955 at his Quebec fishing lodge

Dorothy Brooks Killam, née Johnston

Born in St. Louis, Missouri in 1899

Died in 1965 at La Leopolda, her villa in France

FOREWORD

Canadian and US universities are facing a staffing crunch. They are paying the price now for their huge expansion in the late 1960's and early 1970's, as large numbers of faculty from the "baby boom" generation hired in those heady, far off days reach retirement age during the first ten years of the 21^{st} Century. In fact, if you add to these retirees the numbers of additional faculty needed to teach the swelling ranks of students expected during the current decade, plus those needed to backfill the thousands of positions left unfilled during the past twenty years or so of university under-funding, according to some estimates the number of new professors needed in Canada between 2000 and 2010 is equal to the total number of faculty on staff at all Canadian universities at the end of the 1990's – in the order of 30,000. Add to this the need to keep the ranks of natural scientists and engineers growing, if we are to maintain our North American lifestyle, and one can readily judge how important to all of us is the theme of Dr. Shirley Tilghman's 2003 Killam Annual Lecture: How to prepare the next generation of scientists and scholars who will join the professoriate.

Dr. Tilghman's qualifications to speak on this subject are without equal in either the US or Canada. As a Canadian with continuing close ties – Dr. Tilghman's mother lives in Vancouver – and as a world renowned researcher and academic administrator at a pre-eminent US research university, she can certainly be expected to "know the score". But there is more. For Dr. Tilghman is a leader in both countries in promoting ways to help the careers of young scientists and researchers, particularly women. She chaired a National Research Council (US) committee which received continent-wide attention for its 1998 report, "Trends in the Careers of Life Scientists". And to hear her speak about her conversations with students and young faculty at her own university, Princeton, is to understand why she is so passionate in pursuing her goal of more flexible workplace arrangements for PhD students and young faculty, the better to attract and hold them. For Dr. Tilghman, success in this goal would be marked by an educational system from primary school through to postdoctoral work that opens the minds of young people from all quarters (especially women and minorities) to the excitement of exploring the secrets of the universe, combined with practical measures that allow them a full life outside the lab and lecture hall.

We are most grateful to Dr. Tilghman for her insights into this vital subject. They are both inspiring and timely.

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You can get extra copies of Dr. Tilghman's Lecture, and others in this series, by writing to the Administrative Officer of the Killam Trusts, whose address is on the back of this booklet. The Lectures are also published on the Killam website: www.killamtrusts.ca

For a list of the previous Lectures and Lecture titles, see inside the back cover.

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The Killam Trusts

The Killam Trusts were established through the generosity of one of Canada's leading business figures, Izaak Walton Killam, who died in 1955, and his wife, Dorothy Johnston Killam, who died in 1965. The gifts were made by Mrs. Killam both during her lifetime and by Will, according to a general plan conceived by the Killams during their joint lifetimes. They are held by five Canadian universities and the Canada Council for the Arts. The universities are The University of British Columbia, University of Alberta, The University of Calgary, Montreal Neurological Institute of McGill University, and Dalhousie University.

The Killam Trusts support Killam Chairs, professors' salaries, and general university purposes; but the most important part of the Killam Program is support for graduate and post-graduate work at Canadian universities through the Killam Scholarships. In each of the Killam universities and at the Canada Council, they are the most prestigious awards of their kind.

The Canada Council also awards five Killam Prizes annually, in Health Sciences, Natural Sciences, Engineering, Social Sciences and Humanities. Worth $100,000 each, thay are as a group Canada's premier awards in these fields.

To date, close to 5,000 Killam Scholarships have been awarded and 68 Killam Prize winners chosen. The current market value of the Killam endowments approaches $400 million.

In the words of Mrs. Killam's Will:

> "My purpose in establishing the Killam Trusts is to help in the building of Canada's future by encouraging advanced study. Thereby I hope, in some measure, to increase the scientific and scholastic attainments of Canadians, to develop and expand the work of Canadian universities, and to promote sympathetic understanding between Canadians and the peoples of other countries."

John H. Matthews
W. Robert Wyman, LLD, Chancellor Emeritus,
The University of British Columbia
M. Ann McCaig, LLD, Chancellor Emeritus,
The University of Calgary
George T.H. Cooper, QC, Managing Trustee

Trustees of the Killam Trusts
November 2003

Shirley M. Tilghman, PhD

President, Princeton University
Professor of Molecular Biology, Princeton University

Shirley M. Tilghman was elected Princeton University's 19th president on May 5, 2001, and assumed office on June 15, 2001. An exceptional teacher and a world-renowned scholar and leader in the field of molecular biology, she served on the Princeton faculty for 15 years before being named president.

Tilghman, a native of Canada, received her Honors B.Sc. in chemistry from Queen's University in Kingston, Ontario, in 1968. After two years of secondary school teaching in Sierra Leone, West Africa, she obtained her PhD in biochemistry from Temple University in Philadelphia.

During postdoctoral studies at the National Institutes of Health, she made a number of groundbreaking discoveries while participating in cloning the first mammalian gene, and then continued to make scientific breakthroughs as an independent investigator at the Institute for Cancer Research in Philadelphia and an adjunct associate professor of human genetics and biochemistry and biophysics at the University of Pennsylvania.

Tilghman came to Princeton in 1986 as the Howard A. Prior Professor of the Life Sciences. Two years later, she also joined the Howard Hughes Medical Institute as an investigator and began serving as an adjunct professor in the department of biochemistry at the University of Medicine and Dentistry of New Jersey-Robert Wood Johnson Medical School. In 1998, she took on additional responsibilities as the founding director of Princeton's multi-disciplinary Lewis-Sigler Institute for Integrative Genomics.

A member of the National Research Council's committee that set the blueprint for the US effort in the Human Genome Project, Tilghman also was one of the founding members of the National Advisory Council of the Human Genome Project Initiative for the National Institutes of Health.

She is renowned not only for her pioneering research, but for her national leadership on behalf of women in science and for promoting efforts to make the early careers of young scientists as meaningful and productive as possible. She received national attention for a report on *Trends in the Careers of Life Scientists* that was issued in 1998 by a committee she chaired for the National Research Council, and she has helped launch the careers of many scholars as a member of the Pew Charitable Trusts Scholars Program in the Biomedical Sciences Selection Committee and the Lucille P. Markey Charitable Trust Scholar Selection Committee.

From 1993 through 2000, Tilghman chaired Princeton's Council on Science and Technology, which encourages the teaching of science and technology to students outside the sciences, and in 1996 she received Princeton's President's Award for Distinguished Teaching. She initiated the Princeton Postdoctoral Teaching Fellowship, a program across all the science and engineering disciplines that brings postdoctoral students to Princeton each year to gain experience in both research and teaching.

Tilghman also has participated in teaching and other programs for alumni on campus and across the country on such topics as science and technology in the liberal arts curriculum, behavioral genetics and the human genome project.

A member of the American Philosophical Society, the National Academy of Sciences, the Institute of Medicine and the Royal Society of London, she serves as a Trustee of the Jackson Laboratory, a mammalian genetics institute in Bar Harbor, Maine. She has also been a trustee of Rockefeller University in New York, Cold Spring Harbor Laboratory on Long Island, a member of the Advisory Council to the Director of the National Institutes of Health and a member of the Scientific Advisory Board of the Whitehead Institute for Biomedical Sciences at the Massachusetts Institute of Technology.

The 2003 Killam Lecture

The Challenges of Educating the Next Generation of the Professoriate

October 23, 2003

Shirley M. Tilghman, PhD

The annual Killam Lecture, named in honour of Izaak Walton Killam and his wife Dorothy Killam, recognizes two individuals who achieved extraordinary success in the financial world. Through their vision and extraordinary generosity, the Killam Trusts have supported graduate and postgraduate education in Canada since their inception in 1965. By the awarding of Killam Chairs and Prizes to senior scholars and Fellowships and Scholarships to promising young students, the Trusts have expressed their faith in the importance of higher education.

Thus it seems fitting that I have chosen to discuss some of the challenges that face research universities in both Canada and the United States in preparing the next generation of scientists and scholars who will join the professoriate, and carry on the mission that the Killams believed in so passionately. I will restrict my remarks to the natural sciences and engineering, as the issues in these fields are somewhat different from those in the humanities and social sciences. The focus will also be tilted more toward the US than Canada, as it is the university system in which I have spent the last 33 years of my life.

The message I hope to deliver is the over-riding importance to Canada and the US of attracting the brightest and ablest of our undergraduates into careers in scientific research in general and into our university faculties in particular. The reasons are straightforward enough. First, research universities have assumed the role of research engines for our countries; they are the sources of innovation and future prosperity. If the universities falter, so do the future health and wellbeing of our countries. Second, as I reminded members of Princeton's board of trustees recently when they were questioning why we spend so much time and resources vying with other universities for the very best faculty, a university in which the students are smarter than the faculty is not an attractive model for excellence in education.

At the outset it is worth reminding ourselves of something that the Killams themselves clearly understood. Universities and colleges hold a highly privileged place in our society because of a longstanding consensus about the value of education. North Americans have an almost childlike faith in what formal education can do for them. In the United States that faith is based on the conviction that the vitality of the country, its creative and diverse cultural life, its staggeringly inventive economy and the robustness of its democratic institutions owe much to the quality of its institutions of higher education. That confidence is expressed in the investments by our federal, provincial and state governments, and in the private philanthropy exhibited by individuals like the Killams.

In return for this broad support, society rightfully expects certain things from its universities. Simply put, they expect the generation of new ideas and the discovery of new knowledge that metamorphoses into future jobs and economic growth and prosperity. It also expects the exploration of complex issues in an open and collegial manner and, finally and most importantly, the preparation of the next generation of citizens and leaders.

Modern research universities, in this respect, are decidedly not ivory towers, nor would we want them to be. They are very much "of the world" – in fact, they shape the world through the students they educate, the knowledge they discover, and the ideas they generate. The research conducted by faculty and students aims to gain insight and to find solutions to pressing problems that range from discovering the molecular basis of cancer to inventing new computer algorithms for air traffic control, providing new insight into great works of art, uncovering the meaning of historical events, proposing global governance strategies, devising better heath care policies, and addressing thousands of other issues that confront us as nations and as a global society. Universities are essential if we are to meet a broad range of human, social, scientific, environmental and other needs, and to fulfill their missions universities must engage the world through their scholars, their students, and their alumni.

These fundamental purposes – research, teaching and the dissemination of knowledge for the benefit of society – form a seamless continuum, so tightly interlocked at the best universities that it is not possible to tell when one stops and the next begins. Our goal is not simply to discover new knowledge; we also have an obligation as a university to encourage the application of knowledge to help meet the challenges of the world in which we live, and to help meet the needs of those with whom we share this precious planet. This is why our faculty and students publish books and papers, write op-ed pieces and columns in newspapers, give public lectures, advise members of local, state, provincial and federal governments, speak to primary school students and senior citizens'groups, and work with companies, civil society organizations, advocacy and public interest groups, and other entities that have the capacity to effect positive and meaningful change.

In the fields of science and technology, the great American research universities became the research engines of the country only relatively recently – in fact they can trace the origin to a social contract they entered into with the federal government about 50 years ago with the formation of the National Science Foundation and, several years later, the National Institutes of Health. Although it is hard to imagine it today, prior to the Second World War no government invested to any significant extent in fundamental scientific research. In those days private foundations like the Rockefeller Foundation were important supporters of research in universities, with state and federal governments providing relatively modest funds. The war changed everything, as the government turned to academic scientists, particularly physicists, to develop the weapons that would win the war. National research laboratories were created at Oak Ridge and Los Alamos, and others that already existed were greatly expanded. The idea that egghead academics could make a substantive contribution to the national good was now firmly on the table.

So when President Harry Truman turned to Vannevar Bush, the science advisor to Presidents Roosevelt and Truman during the war, to advise him on how to sustain future scientific advances, Bush was faced with a critical choice. In the end he changed history by writing a highly influential report called *Science – the Endless Frontier* where he laid out the principles by which the US federal government would link its future investments in fundamental research with education, particularly the education of graduate students. Bush's other critical recommendation was to make peer review the central dogma for awarding research funds.

As we look back on that seminal decision, it is amazing to see how non-obvious the choice was. Bush could have advised Truman to invest in the national government laboratories that were already in place or in the private research institutes like Cold Spring Harbor Laboratory or the Carnegie Institute. These institutions had the necessary scientific infrastructure in place, and teams of well-trained scientists ready to go. Instead Bush chose a system in which the science itself was going to be conducted by beginners, amateurs; in other words, students whose inexperience would surely bring substantial efficiency costs. What Vannevar Bush understood so brilliantly is that the efficiency costs were more than compensated for by the continual flow of young, imaginative, bold and perhaps naïve minds through the scientific enterprise. By betting on the young the system acquired a vitality and energy, together with a capacity to continually change, that would make it the envy of the world.

And that envy is well justified, as is clear by almost any metric you choose. Whether it is Nobel prizes in physics, chemistry or medicine, the positive impact on the economy, the number of foreign students who aspire to study in our universities, all the evidence points to the great wisdom of choosing a system for federal R&D that combines education and research.

A very similar set of decisions was being taken in Canada after the Second World War, and the conclusion was the same; that linking research with training would provide a lasting benefit to the scientific and technological infrastructure of the country. Although the Canadian National Research Council had been in existence since 1916, it was largely an advisory body to the government, and oversaw a number of government laboratories without ties to universities. It was during the science and technological boom of the 1950s and 1960s that the Council formed its own social contract with universities in earnest, and thereby made a lasting investment in scientific discovery and thus the future.

The social contract between the federal government and universities allowed for the enormous expansion in the number of graduate students trained in the sciences. This expansion in the 1950s and 1960s occurred to meet two needs: students became the unit of scientific work – they were the workers who carried out the research agenda of the country. At the same time the expansion created the next generation of scientists and faculty members, who were badly needed as the research enterprise expanded in the 1960s. Eventually, however, this exponentially growing apparatus – a classical Malthusian system – had to slow down. The problem became: how could it slow down, that is, produce fewer students, without having a negative effect on scientific progress?

The answer to this question has been resolved in different ways in different fields. In physics, a field which is relatively small and coherent as a discipline, and where funding has been relatively constant over the last few decades, there was a nation-wide effort by the American Physical Society to decrease graduate admissions over the period of the 1980s and early 1990s, to adjust to the fact that there were no longer enough jobs for all PhDs in the field.

In my own field of life sciences – a much larger and more diverse intellectual landscape that includes everything from evolutionary biology to public health – no such agreement could be reached. The number of students didn't simply remain constant, but, fueled by additional funds from the National Institutes of Health, continued to grow faster than the number of available jobs. Something had to give, and what gave was the length of time that students spent in training. Since I was a graduate student in the 1970s, the average time it takes to obtain a PhD in molecular biology has expanded by two years, from four to over six years - and the length of postdoctoral training has extended at least that many years. This has resulted in young scientists who are in "training" well into their 30s, while their classmates from college are settling down, raising families and adding to their pension plans. I have referred to this phenomenon as the "LaGuardia effect". Students stayed longer and longer in graduate school, as they metaphorically circled LaGuardia airport, waiting for their turn to land in a job.

Aside from the personal cost to individual students, should we be worried that 30-somethings are still in training positions? I think the answer is yes, and the most important reason comes from conversations that I have had with undergraduates at Princeton over the last ten years. Princeton attracts some of the most talented students in the world; and for those who concentrate in molecular biology many have the intellectual potential to become world class scientists. Yet every year they look at their options – which are infinite – and conclude that the long and indeterminate training regimen that leads to a very difficult job market simply doesn't stack up against their other options, where the training may be long but at least they know how long, and the job prospects are much brighter. I hasten to add that this is not about money, but about a sense of fairness in the trade-off they are being asked to make between lost incomes while they train, versus the likelihood of finding the job of their dreams.

There is no surer way to strike the death knell of science than to have a career path that discourages highly qualified students from entering the field. If we continue to do this, scientific innovation and the discovery of new knowledge – which is so dependent upon the research universities – will surely be diminished and our children and grandchildren will be the poorer for it.

In my own view, it is the responsibility of universities and professional scientific societies to strike the right balance between the conduct of research on the one hand, and the education of graduate students on the other. This cannot be accomplished without paying close attention to trends in the labor market. A graduate student rightfully expects to be educated by the faculty; otherwise we should not call them students but workers. Graduate education must become more focused on what a student needs to learn in order to become a scientist, and less focused on how much they are able to produce over longer periods of time. Our 50-year-old system that links fundamental and applied research with graduate education has created the best engine for innovation and training in the world. In order to maintain that preeminence, however, we must continually attract the very best and ablest students into the profession. Paying close attention to the quality of graduate education we deliver, and to the career prospects of our graduates, we will preserve the health and vitality of this extraordinarily exciting profession.

Attracting the best and the brightest into a life in science also means having the doors as open and welcoming as possible to men, women and under-represented minorities. Here research universities have clearly not done as well as they should in creating a culture of inclusion. There are at least four compelling arguments why we should care about diversity in science. First, if we are not tapping into the entire talent pool that is available to make a contribution to science, the enterprise will by definition be under-performing its potential. Second, I think it is possible that the scientific interests of women and minorities do not completely coincide with those of their majority male colleagues. I am not arguing that women or members of underrepresented minorities do science differently; rather I'm arguing that what intrigues women and minorities about the natural world occasionally differs from what attracts their majority male colleagues. By encouraging a broader cross-section of the population to become scientists, we potentially increase the range of problems that are under investigation.

Third, science will look increasingly anachronistic if women and minorities are not participants in the enterprise. As other professions move successfully toward a goal of inclusiveness, science will appear increasingly backward looking, and will be less attractive to talented students of all stripes. This argument is reminiscent of the rationale offered by several presidents of Ivy League universities at the time they were considering coeducation. They admitted that they were motivated by the fear that they would lose the most talented male applicants to co-ed schools. As a reason to admit women it may not ring with high principle, but it was a realistic concern.

Finally, it is simply unjust for a profession to organize itself, intentionally or unintentionally, in such a way as to exclude a significant proportion of the population. This is an argument based on fairness and justice.

While the 20-year track record for under-represented minorities has been unremittingly dismal in the US, there are some very promising signs that women are increasingly attracted to careers in science. Over the last twenty-five years there has been a steady increase in the number of women completing bachelor's degrees in all branches of science. In biological sciences and in chemistry, for example, women now earn 50% of the bachelor's degrees. In the physical sciences women's participation is lagging well behind, but the trends are in the right direction, with women earning 19% percent of bachelor's degrees in physics and 18% of undergraduate engineering degrees.

The other good news is that there has been a steady increase in the number of women completing PhDs in all of the sciences. In biological sciences women now earn over 40% of doctorates, and in chemistry a remarkable 33% of doctorates are awarded to women - a threefold increase in 25 years. In the physical sciences, 12% of doctoral degrees are awarded to women and in engineering there has been a fivefold increase, from a barely detectable 2% in 1975 up to 11% in 2001.

Because of these gains at the PhD level, women are entering the faculty in increasing numbers at every rank, although even today they tend to be over-represented in the junior ranks, especially in instructor/lecturer positions, which at most institutions come with the least job security. Women PhDs are also not distributing evenly across different kinds of academic institutions. They are more likely to be found at community colleges and non-research-intensive universities, and less likely to be found at research universities. Some of the skewing toward the junior ranks, particularly in the physical sciences and engineering, can be explained by the infamous "pipeline". That would argue that if we gather in another ten years, we will see further progress and eventually women will be full and equal participants in science, engineering and mathematics. However in my own field the historic PhD pipeline cannot explain the fact that, while 45% of PhDs are awarded to women, when we advertise for a junior faculty position at Princeton only 25% of the applicants are women.

This isn't a leaky pipeline – it is a gush. How can we understand this precipitous drop, which also occurs in chemistry? One answer lies in the ways in which women scientists experience a life in science differently from their male colleagues. Over one third of women scientists and engineers are unmarried compared to 17% of men. Ten percent of married women scientists and engineers have an unemployed spouse compared to 38% of men. In a survey conducted by the American Chemical Society 21% percent of women scientists and engineers identified balancing family and work as a career obstacle compared to 2.8% of men. These statistics vividly capture how the professional landscape for women in science and engineering differs from that of men.

They also suggest that we need to do some careful thinking about the underlying culture of universities that deters women from either entering PhD programs in the first place, or persisting in the profession once they have been trained. The first, and I think by far the most important, is not unique to science but affects the ability of all women to pursue successful careers, and that is the expectation that women will take on primary responsibility for the raising of children. Obviously, women have the biological necessity of bearing the child, but after the child is born they are expected to take on the primary responsibility of childcare. Despite very encouraging indications that fathers in this generation are far more engaged in parenthood than in the past, studies such as those conducted by Professor Arlie Hochschild at Berkeley continue to document that the balance is still unequal, and that women still bear the greatest responsibility. In her book-length study entitled *The Second Shift: Working Parents and the Revolution at Home*, Hochschild has shown that inequality persists even in families where both partners claim that they shoulder the work equally. And of course, after children leave the home, women also become the primary caretakers of elderly parents. So it never ends.

This imbalance is compounded by the intensification of work expectations in all job sectors. There are many studies that document how members of the US workforce are putting in longer hours and taking fewer vacations. The greater time spent at the workplace, which is coupled with increased expectations of what is required in order to do the job, is especially problematic for women who are already juggling two jobs – one at home and one at work.

The lengthening of the period of training that I discussed a few minutes ago adds one more layer of complexity to the problem by rendering some scientists middle-aged before becoming financially able to begin a family. The fact that these extended years of training coincide with prime childbearing years makes it more difficult for women to contemplate having a successful scientific career if they wish, as the majority of women and men do, to have children.

All of this suggests that the single most effective thing that a university can do to hire and retain faculty in all disciplines is to promote among students, faculty and staff a healthy balance between family and work. At Princeton a two-year study by a faculty task force on the status of women in science and engineering has just issued its report, and at the top of its list of recommendations, right after "hire more women," is the expansion of affordable day care facilities and the institution of tenure and review policies that allow for flexibility in the tenure clock. I would add to their list a focus at the time of tenure on quality rather than quantity. For forward momentum in science is propelled by a small number of seminal pieces of work that are creative and break new ground, not the large number of journeyman papers that fill in the cracks between those discoveries. If we reward quality and not just quantity, women will be competitive.

I have identified two challenges facing research universities in the 21st century – to ensure that the training path of young scientists and engineers is fair and focused on their education, not just on what they can produce, and to hold the doors of the academy wide open to all talented comers. These are certainly necessary conditions, but they are not sufficient to ensure that we are attracting the best and ablest students into careers in science and engineering. We must at the same time convey to students at every level the excitement and profound satisfaction that comes from making a discovery about the natural world. For those of us who have had the great privilege of spending our lives in science, it is difficult to imagine a more rewarding life. Whether watching a sunset and puzzling over the color of the sun as it fades below the horizon, or staring into a tide pool and the profusion of life forms living in harmony within it, or scratching one's head over a contrarian result in the lab that suggests that a favorite model is wrong, it is the drive to understand the mystery of the natural world that sparks scientific curiosity.

By way of illustration, let me relate how I came to be a molecular biologist. I was a chemistry major at Queen's University, and in my junior year I stumbled by chance on a paper in the chemistry library that described a very recent finding of two scientists named Matthew Meselson and Frank Stahl, in which they reported on the mechanism by which DNA, the genetic material, is replicated. The first thing that struck me about the paper was the importance of the question being posed, for each time a cell divides it must faithfully replicate all its DNA and deposit equivalent amounts into each of the two daughter cells. Now there was only a finite number of possibilities for how this could happen, and whether the answer was A, B or C was not what was interesting about the paper. What was absolutely gripping was how Meselson and Stahl discriminated among the options. The experiment they devised was clever, indeed elegant, and it led to an unambiguous answer. What entranced me, what so entranced me that I ran over to the biology department to sign up immediately despite the fact that I had never had a course in biology in my life, was not what they learned, but how they went about it – how they discovered new knowledge about the natural world. It was a thing of beauty, and worthy of a life's work. And, most important, because I understood how they arrived at their answer, I never forgot it.

This lesson was reinforced for me recently when I heard Professor Bess Ward of Princeton's Geosciences department give a public lecture about an ice-covered lake in Antarctica, and its very peculiar geochemistry. She told the story like a good mystery writer, with unexpected twists and turns, and a smoking gun at the end. It was a *tour de force* in which she enticed an audience of scholars of English and sociology and computer science into her curious world of very cold water. She had captured the thing that attracted me into science: the beauty and mystery of solving puzzles that matter.

Our challenge as educators is to convey to our students that science is not a set of dry facts that have to be committed to memory, or a series of confusing laboratory exercises whose outcome is self-evident, but a grand adventure worthy of the likes of our great heroes, such as Isaac Newton, Charles Darwin and Albert Einstein. Our best strategy for the future is to ignite the imagination of the best and ablest students, letting them under the tent to see our wares early in their education, by which I mean primary school. If you have ever watched a class of 8- and 9-year-olds as they looked at their first mutant fruit fly with an extra pairs of wings, or a petri dish one day after they had smeared their dirty hands on the agar, or seedlings that grow straighter than others in the light, you know that you don't have to convince them that science is fun.

We must promote and execute a version of science education within our public schools and universities that inspires rather than discourages, that emphasizes the process of scientific inquiry and not just its outcome, that makes connections between the laboratory and problems affecting us all. Only then will we be on the path to guaranteeing that the world our children and grandchildren will inherit is as progressive as the one we now inhabit, and that the work of research universities is directed toward making the world a better place.

The Killam Annual Lectures*

1995 **Dr. David L. Johnston**
Chair, Canadian Institute for Advanced Research;
Former Principal, McGill University

"Research at Canadian Universities and the Knowledge Based Society"

Hart House, University of Toronto

1996 **Dr. Richard A. Murphy, Ph.D.**
Director, Montreal Neurological Institute,
McGill University

"Government Policy and University Science: Starving the Golden Goose"

The University of Calgary

1997 **Hon. Peter Lougheed, P.C., C.C., Q.C.**
Partner, Bennett Jones Verchere; Corporate Director;
Former Premier of Alberta; Chancellor, Queen's University

"The Economic and Employment Impact of Research in Canada"

Reading Room, Houses Of Parliament, Ottawa

1998 **Dr. Michael Smith, C.C., O.B.C., Ph.D., D.U., D.SC., LL.D., D.C.L., F.R.S., F.R.S.C.**
University Killam Professor, and Peter Wall Distinguished Professor of Biotechnology, University of British Columbia;
Nobel Prize Laureate in Chemistry, 1993

"Science and Society in the Forthcoming Millennium"

Hyatt Regency Hotel,Vancouver

1999 **Dr. Björn Svedberg**
Chairman, the Royal Swedish Academy of Engineering Sciences;
Chairman, Chalmers University of Technology, Gothenberg;
Former President and CEO, L.M.. Ericsson AB

"University Research as the Driving Force for the Development of a Modern Nation in the Next Millennium"

Pier 21, Halifax

2000 **Prof. J. Robert S. Prichard**
Prichard-Wilson Professor of Law and Public Policy and President Emeritus, University of Toronto;
Visiting Professor, Harvard Law School

"Federal Support for Higher Education and Research in Canada: The New Paradigm"

St. Boniface General Hospital Research Centre, Winnipeg

2001 **Dr. John R. Evans, C.C.**
President Emeritus, University of Toronto;
Chair, the Canada Foundation for Innovation;
Chair, Torstar Corporation and Alcan Aluminum Ltd.

"Higher Education in the Higher Education Economy: Towards A Public Research Contract"

Montreal Neurological Institute, Montreal

2002 **Dr. Martha C. Piper, D.Sc., LLD**
President and Vice-Chancellor, The University of British Columbia;
Director, Canadian Genetic Diseases Network

"Building a Civil Society: A New Role for the Human Sciences"

National Library of Canada, Ottawa

2003 **Shirley M. Tilghman, Ph.D.**
President, Princeton University
Professor of Molecular Biology, Princeton University

"The Challenges of Educating the Next Generation of the Professoriate"

The University of British Columbia, Vancouver

*NOTE: The positions occupied by the Lecturer are stated as at the date the Lecture was given.