ABOUT FRASER MUSTARD

Fraser Mustard has had a diverse and distinguished career in the health sciences, research and cross-disciplinary studies in the private sector.

After earning his MD from the University of Toronto, and PhD from the University of Cambridge, Dr. Mustard moved from the medical faculty of the University of Toronto to help establish the new school of Medicine and Health Sciences at McMaster University.

In 1982, he took on the task of creating and establishing a unique Canadian institute, The Canadian Institute for Advanced Research (CIFAR), to promote interdisciplinary research among research centres in Canada and other countries. The institute's programs have had a major focus on science, technology, innovation and economic growth and the effect of economic change on the social environment and the health and well-being of individuals and populations.

Dr. Mustard remains a leader and authority in Canada on the socio-economic determinants of human development and health, with particular emphasis on early childhood and developmental neurobiology. He is involved with governments in Canada and Australia, the World Bank, the Inter-American Development Bank, UNICEF and the Aga Khan University in Pakistan and East Africa, in emphasizing the importance to society of early human development.

Dr. Mustard has received numerous awards and honours for his work including the Companion of the Order of Canada, the Order of Ontario, and a number of awards in the fields of medicine and research including the Gairdner Foundation International Award for Medical Research. He has also been inducted into the Canadian Medical Hall of Fame.

Dr. Mustard currently leads The Founders' Network, which links together a thousand or more individuals in the private and public sectors in Canada and other countries who helped him build CIFAR.

Your professional background was originally in the field of medicine. How did your work and your interests evolve into early childhood development and education?

Well, the first answer I would give you is that I don't distinguish between the two in the way you might expect. Health and the capacity to learn are both part and parcel of human development. And they are inextricably linked. It would be an error to look at the determinants of health, the determinants of our capacity for learning, and the determinants of our behaviour, as if they were somehow separate processes. They are not. These outcomes are determined collectively through a single process – the process of early human development. And so I would suggest that my interest in medicine and health and my interest in early childhood development and education are, in fact, two complementary components of a much larger picture – a field of study that can and should encompass both.

Yet, in the operational world, these are distinct professions with distinct training, distinct points of view, distinct bodies of knowledge.

Yes. And that leads to the second answer I would give you as to how my interests and work have developed – and this revolves around my belief in the critical importance of trans-disciplinary approaches to solving our most pressing problems. We have traditionally looked to universities to build our knowledge and find innovative solutions. But universities typically partition knowledge into three branches – the natural sciences, the social sciences and the humanities. The fact is that the world we live in today demands solutions that cannot be arrived at easily – if at all – within this traditional structure.

At one point in my career I had come to believe, for example, that there was something about the social environment that determined health risks, and I became interested in studying the health of populations. I tried several times to initiate this kind of work, unsuccessfully, within the structures universities have to offer. And that led me to take on what some might describe as a "high risk" question – whether it was possible to approach the intellectual development work that we need to do in a trans-disciplinary way, and outside the conventional university structure. And that is how the Canadian Institute for Advanced Research (CIFAR) came into being.

DIGGING DEEPER

The Canadian Institute for Advanced Research (CIFAR) brings together leading researchers from across Canada and around the world to work collaboratively on complex, advanced research projects. CIFAR identifies areas of inquiry where it believes that significant new knowledge – perhaps even revolutionary ideas – can be created by bringing together the world's best thinkers to focus over a period of five years on a well-defined "big question." Currently, more than 350 researchers are affiliated with CIFAR's 12 research programs which include Experience-Based Brain and Biological Development (EBBD); Organizations and Growth (IOG); Identity and Well-Being (SIIWB); and Successful Societies. Find out more about CIFAR at **www.cifar.ca**.

The institute, then, led to your work on the social determinants of health.

Among other things, yes. We had initially brought together 23 people from diverse disciplines to identify the research directions the institute would take. We subsequently did some very successful work, for example, in the areas of artificial intelligence and robotics, in astrophysics, in evolutionary biology, in economic growth and policy, in the area of law and society and many other fields – and we drew on some of the best minds across a wide variety of disciplines to do so. It was in the late 80s that we initiated our work on the social determinants of health and well-being. And it's important to point out, again, that this unique work was carried out by specialists across a vast range of disciplines – from social scientists, political scientists, statisticians and health economists to experts in biostatics and epidemiology, occupational and environmental health, medicine and public health. These are individuals who would otherwise be unaware of each other's work and so again, we were crossing many, many traditional boundaries.

DIGGING DEEPER

Social determinants of health include education, the nature of jobs, living conditions such as housing and availability of nutritious food, and access to quality health care. Learn more about the work of Sir Michael Marmot and the World Health Organization's (WHO) Commission on the Social Determinants of Health Commission at **www.who.int**.

Can you tell us about some of the highlights of this work?

Well, one of the things we have come to learn is that, if you plot population health – measured by the number of deaths in the population – against where people are socio-economically in society, you find a perfect gradient – an absolutely reliable relationship. That is, the worse off you are by social economic criteria, the higher the mortality rate.

One piece of work that really points up this relationship is a study done by Sir Michael Marmot in the U.K. which looked at mortality rates in the civil service by job classification. What he found is that those at the top of the civil service – people with very demanding and stressful jobs – had a much lower mortality rate than people at the bottom of the civil service. And this is not disease-specific. It's across the board.

We also know now that these socio-economic gradients in health can be detected by the age of three. So what does that tell us? It tells us that the health status of adults has its antecedent in early childhood. The conclusion we ultimately came to – and of course I am oversimplifying a great deal of very complex work here – is that there is only one organ in the human body that can account for the gradients – the brain.

So we brought in some neurobiologists and we worked through some of the potential pathways of brain function that could be contributing to

DIGGING DEEPER

A socio-economic gradient depicts the relationship between a social outcome and socio-economic status. It is simply a descriptive summary of the levels of social outcomes for people from differing socio-economic backgrounds. Socio-economic gradients and school profiles can be used as powerful evaluation tools for characterizing the performance of a school system. They cause us to think about how we might raise and level the learning bar.

Source: *Vulnerable Children* edited by Doug Willms, 2002

this. And, referring back to your first question, this I think is where the picture becomes clearer across the traditional silos of health and education. Because early brain development is a determinant not only of health, but of visual, auditory, verbal, behavioural, cognitive and learning functions as well. Every child's capacity in each of these areas is predicated on his or her early experiences.

INSIGHT

"You are your brain BUT your brain is not just produced by your genes. Your brain is sculpted by a lifetime of experiences. The most important time in brain development is the first few years of life but growth is not done until at least age 20."

Dr. Jean Clinton, 2009

You mention early experiences. Is it not the case that these functions are largely "hard wired" and determined or at least pre-disposed by genetics? You seem to be suggesting that the situation is much more fluid than that.

Absolutely, and that's really at the heart of why this is such revolutionary work, with such enormous implications. The pathways for these functions are not pre-determined. Genetics play a role, of course, but a child's capacities for learning and behaviour – and the trajectory for his or her health as well – are not primarily predicted by the child's genetic makeup. They are actively developed during early childhood, to the extent that the verbal capacities you find by the age of four, for example, are basically the child's literacy and verbal capacities for life. That's a pretty remarkable finding, and one that has huge implications for education.

How do these processes take place? How are those capacities stimulated to develop?

Well, there are complex processes involved, but in everyday language, it comes down to nurturing. The fact is that you have about a hundred billion neurons in your brain, and each has exactly the same gene coding – the same DNA. So the question is: how do these neurons become differentiated – for vision, for language and so on – and how are these pathways in the brain created? The answer is that they are differentiated through experience – that is, through stimuli transmitted to the brain both pre- and post-natally, and in the later stages of life. The very architecture and function of the brain is shaped this way.

INSIGHT

Contrary to popular belief, the genes inherited from one's parents do not set a child's future development in stone

New scientific research shows that environmental influences can actually affect whether and how genes are expressed. Thus, the old ideas that genes are "set in stone" or that they alone determine development have been disproved. In fact, scientists have discovered that early experiences can determine how genes are turned on and off and even whether some are expressed at all. Therefore, the experiences children have early in life – and the environments in which they have them – shape their developing brain architecture and strongly affect whether they grow up to be healthy, productive members of society. This growing scientific evidence supports the need for society to re-examine the way it thinks about the circumstances and experiences to which young children are exposed.

Source: *Early Experiences Can Alter Gene Expression and Affect Long-Term Development* (Center on the Developing Child, Harvard University, 2010)

DIGGING DEEPER

We now know that nurture in early life as well as nature is important in early human development and that nurture in the early years has major effects on learning and physical and mental health throughout the life cycle. Learn more about the way in which the early years of human development establish the basic function of the brain in:

- *Early Years Study 2: Putting Science into Action* by McCain, Mustard and Shanker, 2007
- 'Early Brain Development and Human Development' by Mustard, 2010
- Articles and presentations of Dr. Jean Clinton posted at www.offordcentre.com

This process is predictable?
It's predictable in spades. Which is why understanding the process is so critically important. We know from experiments in rats that the degree of licking the mother rat gives to her offspring in the first six days of life determines the behaviour of those rats in adult life.

Without going into the biological detail, we know from these experiments, for example, that rat pups that are not well groomed by the mother will develop a deficiency in the brain's receptor for cortisol – and this is something we can actually see. It's a permanent alteration in the DNA that results in particular behaviour patterns. And those patterns will persist throughout the rat's adult life.

And you can see these patterns in everyday experience if you know where to look. One example that comes to mind is a young kitten, up on my farm that had suffered trauma early in life. In fact, he had fallen and become trapped behind a pile of hay bales seven bales deep. I came along one morning and heard this squeaking sound. We got out the tractor and rescued the kitten, which I subsequently brought here to live in the office in Toronto, quite early in life, just after he was weaned. Now the interesting thing is that for three whole weeks this cat couldn't associate with human beings easily. But the ladies here gave him lots of tender loving care, and at this point he is totally addicted to us. But – he's still frightened. If a strange noise occurs, he'll go and hide. He still carries the trauma of his kittenhood. Now, if we hadn't given him the care we did, as early as we did, we would never have been able to help him.

So you are suggesting that something as simple as nurturing sets our trajectory for life.
Yes. Sounds, touch, vision, smell, food – these experiences stimulate the neurons in the brain through sensing pathways and determine their functions.

The development of the pathways for vision, hearing, touch, and other sensing pathways begins before birth and is largely finished by the time a child is four years old. The development of these sensing pathways is important for the development of language, which starts after the sensing pathways for sound and vision are established. That means the basic capability for language, as I mentioned earlier, is largely set by four years of age.

It is also very important to understand that the higher cognitive functions – which is where education programs have typically begun to enter the picture – are built on the neural pathways that are started earlier. In other words, these developing functions are cumulative and additive. Deficient development of the sensing pathways will naturally have an adverse effect on language development which, in turn, will predict a child's capacity for developing higher cognitive function.

INSIGHT

Six fundamental principles guide the *Full-Day Early Learning-Kindergarten Program* reflecting the current research findings.

They are based on the overarching principles outlined in *Early Learning for Every Child Today* (ELECT).

The six principles are:

1. Early child development sets the foundation for lifelong learning, behaviour and health.
2. Partnerships with families and communities strengthen the ability of early childhood settings to meet the needs of young children.
3. Respect for diversity, equity, and inclusion are prerequisites for honouring children's rights, optimal development and learning.
4. A planned curriculum supports early learning.
5. Play is a means to early learning that capitalizes on children's natural curiosity and exuberance.
6. Knowledgeable, responsive educators are essential.

Source: *The Full-Day Early Learning-Kindergarten Program. Draft Version,* 2010

INSIGHT

The Full-Day Early Learning-Kindergarten program is informed by the work of many pre-eminent researchers, including:

- Lev Vygotsky's social constructivist theory, e.g., social interaction plays a fundamental role in the process of cognitive development.
- Urie Bronfenbrenner's groundbreaking concept of the ecology of human development.

DIGGING DEEPER

With Our Best Future in Mind (Pascal, 2009) has brought self-regulation to the fore of Ontario's early learning initiative. In the simplest terms, self-regulation can be defined as the ability to stay calmly focused and alert, which often involves – but cannot be reduced to – self-control. Learn more about self-regulation and the way in which it serves as a lens for understanding a child, individual strengths and the areas that need work, and thus as a lens for understanding teaching and learning in the early years in the writings of Dr. Stuart Shanker, York University.

So children who arrive in the school system at the age of four have already, essentially, pre-determined capacities for learning, as well as for behavior and health.

Exactly. And in that way – and teachers will intuitively know what I'm talking about – education must function in a sort of "remedial" way. Teachers need to adapt to, and accommodate to their students. But the quality of students has already been determined, and cannot be fundamentally altered later. So we are left dealing with the results of early human development, rather than having the opportunity to go back to root causes. Teachers are, in fact, limited in the degree of success they can expect to have, depending on the quality of each student's early childhood experiences.

The same "remedial" role could be ascribed to the medical profession. Medical schools teach us to see the patient, assess the symptoms, make a diagnosis and treat. What medical schools have not traditionally looked at are the root causes of illness in the first place. And so, as medical practitioners, we are dealing with the results of early development, rather than focusing on the process of early development itself.

This is why, by the way, I never use the term "education." Nor do I talk about "public health." Public health has been basically interested in healthy development, but never linked into the brain in terms of healthy development. Likewise, education has never linked into what brain development means in terms of the capacity to learn. You have to bring those two things together. Both of these fields are concerned with – or at least ought to be concerned with – early human development.

DIGGING DEEPER

The Early Development Instrument (EDI) is a short, teacher-completed instrument which measures children's readiness to learn at school in five domains: physical health and well-being; social knowledge and competence; emotional health/maturity; language and cognitive development; and general knowledge and communication skills.

The EDI can:

- Report on populations of children in different communities
- Monitor populations of children over time
- Predict how children will do in elementary school.

A full description of the EDI can be found at **www.offordcentre.com**.

And that presumably requires that there be a continuous and cooperative approach across these fields.

Yes, as a matter of fact, one of the great books that has come out on this subject is *Mothers and Others* by the anthropologist Sarah Blaffer Hrdy. In the book, she argues that our very success as a species arises from the ability of our early ancestors to form social networks for the purpose of collectively raising children. There was huge support for the mothers, and the mothers did not do it on their own.

So that's what we're trying to do – to bring educators into that sort of "mothers and others" scenario. And so when we wrote the early years

DIGGING DEEPER

Beginning in 2007, the Ontario Ministry of Education committed to an annual investment in Parent and Family Literacy Centres (PFLC) which complement full-day learning. PFLCs help prepare children from babies to six-year-olds for school and encourage families to be a part of their children's learning. Centre staff work closely with kindergarten teachers to ensure a positive and welcoming learning environment that will help children make a smooth transition into school. Research on the impact of PFLCs shows the measurable difference that they can make on high-risk students. See for example the winter 2010 issue of the Toronto District School Board's newsletter *Research Today*.

reports we said that we should set up early childhood and parenting centres. We wanted to allow women who are pregnant to join this network of mothers and others, and continue all the way to the end of school. And we didn't want to fragment that. It needs to be meshed together in a cohesive way.

Of course Ontario is moving in this direction, with the introduction of full-day kindergarten and the proposed *Best Start Child and Family Centres.* Are there precedents for this that can help us predict how these types of programs can change the life trajectories of young children and students?
There are many. But the experience of Cuba is perhaps the most instructive. Two studies done by UNESCO demonstrated that, in terms of Grade 3 language scores, Cuba is outperforming not only other Latin American countries but also other developing countries. And the same holds true for numeracy.

What's interesting is that we can plot with some certainty how this came to be. First there was recognition of the importance of health. Medical schools were built, people were trained. And community polyclinics were created to work with women in pregnancy, and with mothers of young children. These clinics provided developmental health, nutritional support, and childcare stimulation. In fact, their care included frequent home visits. So this was a very integrated structure for health and early development. They created family practice doctors who were part of the polyclinics who would work with mothers in terms of healthy development of the child, rather than "what's your problem, here's the treatment".

Now, we were interested in the Grade 3 results, and looking at what was happening back when those children were born. So we wrestled with this, and what we learned made us more confident about experience-based early childhood development, as we've come to call it. This is exactly what the polyclinics were doing. They had well trained staff. They were teaching parents about what the developmental needs of their children were.

The other indicator coming out of Cuba is that mortality rates are low for this group of children. As you move along the timelines, the rates climb. So again, this is a dramatic demonstration of the degree to which developmental neurobiology sets your risk for health problems and mortality. Lower mortality rates are a direct measure of the quality of brain architecture and function that has been developed in these children, early in life.

All of the other Latin American countries are below Cuba in terms of the Grade 3 results. What is interesting is that Chile is not as good as Cuba. But Chile does not start its intense programs until the age of two or three. Cuba is doing it at the correct time – pregnancy.

I should point out also that the OECD actually looked at the correlation in developed countries between literacy and life expectancy. And there's a strong correlation. The same is true of the under five mortality rates – the time in which children are entering the school system.

This of course has been accomplished over an extended period of years.
Oh yes, you're not going to win overnight. In terms of building the structures required, you have to work with people and organizations and help them understand that we are working collectively toward a larger goal.

INSIGHT

How Does Your Kindergarten Classroom Affect Your Earnings, a recent Harvard-led study (Chetty et al, 2010), shows that "what you do in kindergarten really matters." There has been a view that everything has been determined by the time you're four, by who your parents are and how much they read to you. This study provides direct evidence that what happens in your kindergarten class also makes a huge difference.

DIGGING DEEPER

In the Ontario context, the unique professional team in the full-day kindergarten classroom includes an early childhood educator and a teacher who have the benefit of a collaborative and complementary partnership to support children and families in a high-quality, intentional, play-based learning environment. The resource *Full-Day Early Learning Kindergarten Program for Four- and Five-Year-Olds: A Reference Guide for Educators* found at **www.edu.gov.on.ca/eng/curriculum/elementary/kindergarten** is a useful discussion guide developed to support educators in implementing full-day kindergarten.

And what, in your view, is the larger goal of this work?

The goal of this work is to provide social equity for populations – and to develop high quality populations capable of dealing with the problems we face today. That's really the moral imperative.

You know, if you look at the data for the U.S. in regard to literacy, for example, the numbers are quite frightening. Literacy is typically defined across a series of five steps from levels one and two, which represent groups that are quite minimally literate, through to levels four and five, those who attend colleges and universities, right up to our very brightest.

If you look at the work of the OECD and others, you'll see that nearly 50 percent of the U.S. population is at levels one and two, both of which fall below what would be considered a suitable minimum for coping with the demands of everyday life. Only five percent of the population is at level five.

This is frightening data. How do you run a modern democracy when only a small percent of the population have the capacity to understand what is being said? And how does this play out in poverty figures? Since these literacy levels are a display of adult ability, it's not surprising that poverty rises dramatically as literacy decreases. More than 40 percent of Americans at level one literacy are in poverty.

These are substantial issues. And the question is: what sort of population are we supporting and nurturing to solve the problems of a complex world?

DIGGING DEEPER

Ontario is an early leader in extending full-day kindergarten to four- and five-year olds. In 'All-Day Kindergarten Comes to Ontario' an article that appears in *Professionally Speaking* (2010), Jennifer Lewington profiles Ontario's approach as "the new collaborative model" and describes the way in which it "represents a significant cultural shift." In her view "the rest of the country is watching what [Ontario] is doing."

Clearly, educators are a very important part of this enterprise. What advice would you have for educators and educational leaders as we move toward these models of early human development in Ontario?

One piece of advice I might offer is that we're not going to find a solution that will kick in immediately. It will take at least a generation to get it right. At the same time, I think educational leaders in particular have the opportunity to effect change, not only through their efforts to support the success of the province's new early learning program, but also by developing strong relationships with the proposed *Best Start Child and Family Centres*. I think there is a huge opportunity to take advantage of these new structures by building partnerships with parents, early childhood educators, community health practitioners and others who play an important role in human development.

INSIGHT

The Economic and Social Payoffs of Full-Day Early Learning, a recent study conducted by the Centre for Spatial Economics (C4SE), which analysed the recommendations of *With Our Best Future in Mind*, concluded that Ontario will benefit in both the short- and long-term as full-day early learning becomes available in Ontario schools. Specifically:

- Child effects are seen primarily through improved educational achievement – fewer grade repetitions, less draw on special education and lower high school drop-out rates which results in more students attending post-secondary education, and an increase in future employment earnings.
- Health outcomes such as lower smoking rates are also significant.
- Parents, primarily mothers, gain from a stronger labour force attachment and in some cases higher educational attainment, both of which increase parental earning.
- In terms of financial benefits, every $1 invested in early learning generates benefits of $2.42 for the province through increased earnings, improved health outcomes and reduced social costs.

What are your thoughts on the ideas presented in this issue of *In Conversation*? Email your comments and insights to InConversation@ontario.ca.