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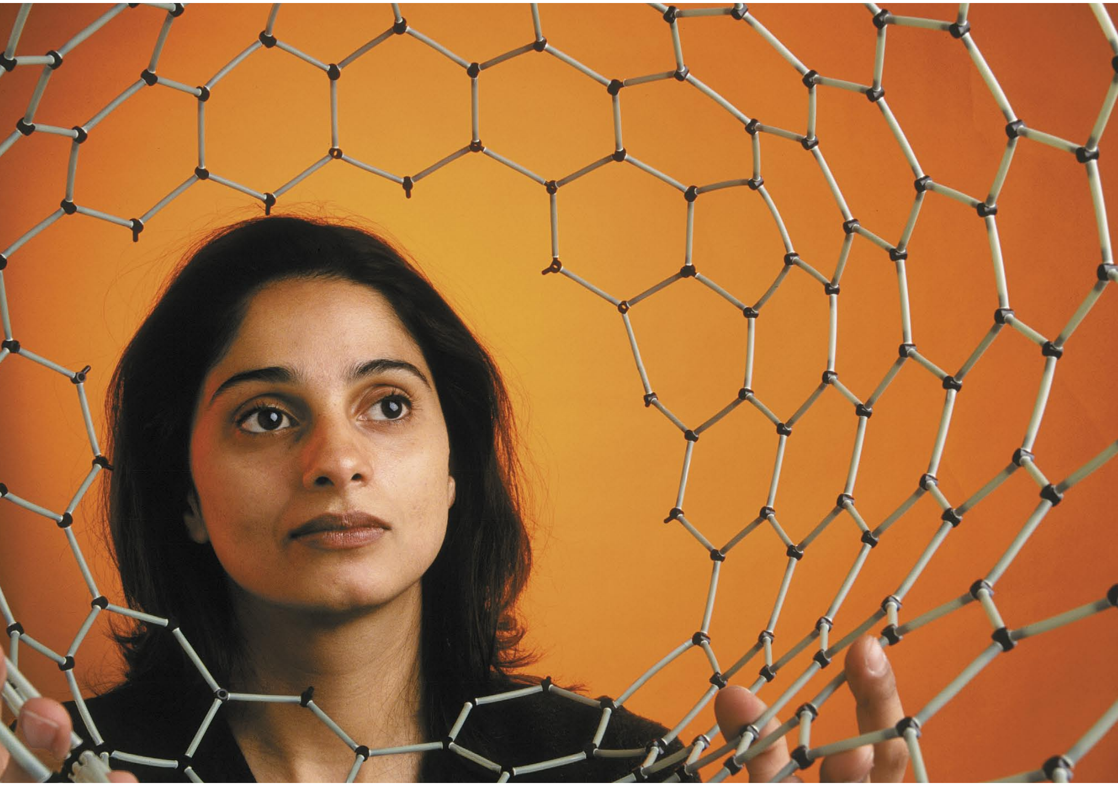
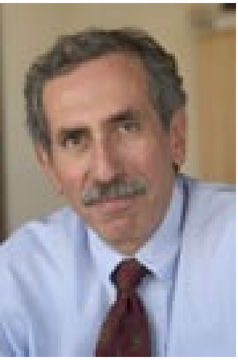
Regenerative medicine & Nanomedicine:



Investing today in the promise of tomorrow

Canada

Regenerative Medicine and



Investing today in the promise of tomorrow

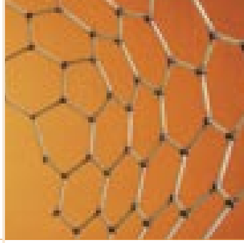
Regenerative medicine and nanomedicine are truly the new frontiers of health research. Together, these two areas of research have the potential to dramatically transform the way we prevent, diagnose and treat disease.

Together with our partners, CIHR is providing Canadian researchers with the support they need to become world leaders in these emerging areas of research.

A wide range of partners is leveraging the federal investment in regenerative medicine and nanomedicine, while participating in setting a strategic agenda that builds on opportunities as well as minimizing overlap and duplication. Researchers are joining forces across disciplines to make groundbreaking advances in these emerging sciences.

Canadian researchers made Canada a world leader in biotechnology in the 20th century. Now, in the 21st century, they are poised to do the same with regenerative medicine and nanomedicine, making a direct contribution to the health of all Canadians.

Alan Bernstein, O.C., FRSC
President, Canadian Institutes of Health Research



CIHR at a glance

Founded in 2000, the Canadian Institutes of Health Research (CIHR) is Canada's response to the global revolution in health research. CIHR's mandate is to create new knowledge – and translate that knowledge into improved health, a strengthened health care system and new health products and services for Canadians.

CIHR takes a problem-based, multidisciplinary approach to the health challenges facing Canadians. Its inclusive approach brings together researchers from all disciplines, from the social sciences to biomedical sciences, informatics and engineering.

By building partnerships, national and international, CIHR brings new perspectives to health and ensures that research findings are applied where they are needed.

The majority of CIHR funding goes toward supporting investigator-initiated research. A proportion, however, is set aside for strategic initiatives, intended to pursue areas of research where the need is great and the likelihood of results promising. Regenerative medicine and nanomedicine are two such areas that hold tremendous potential for Canadians.

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Building on Partnerships

The CIHR Regenerative Medicine and Nanomedicine Initiative is co-led by its Institutes of Neurosciences, Mental Health and Addiction (INMHA) and of Genetics (IG), with overall leadership provided by Dr. Rémi Quirion, Scientific Director of INMHA. CIHR cannot achieve success alone, however, and partnerships are the supporting pillars of the initiative – with government agencies, networks of centres of excellence and voluntary health organizations all contributing. While the list of partners is constantly growing, partners as of June 2005 are:

CIHR institutes

- Neurosciences, Mental Health and Addiction (co-lead)
- Genetics (co-lead)
- Aboriginal Peoples' Health
- Aging
- Cancer Research
- Circulatory and Respiratory Health
- Infection and Immunity
- Musculoskeletal Health and Arthritis

Partner organizations

- ALS Society of Canada
- Canadian Space Agency
- Canadian Stroke Network
- Foundation Fighting Blindness
- Heart and Stroke Foundation
- Jacob's Ladder
- Juvenile Diabetes Research Foundation International
- National Research Council Canada
- Natural Sciences and Engineering Research Council of Canada
- NeuroScience Canada
- Ontario Neurotrauma Foundation
- Stem Cell Network

"Regenerative medicine and nanomedicine hold the same potential for advances that biotechnology demonstrated in the last century. Their promise is monumental. So are the challenges inherent in realizing that promise."

Dr. Rémi Quirion
Scientific Director, CIHR Institute of Neurosciences, Mental Health and Addiction

The Promise

What if donor organ shortages could be made a thing of the past?

some movement? What if doctors could find and destroy cancer cel

tumours? And what if microscopic implants could deliver life-savin

It may be many years before any of these may happen. But researchers are working toward these goals – goals that embody the potential and the promise of regenerative medicine and nanomedicine – today.

"Much of the future of health research will depend on critical contributions from the physical and applied sciences. For example, advances in proteomics and genomics have greatly benefited from engineering initiatives in nanotechnology, robotics, imaging technologies and surface chemistry."

Dr. Roderick McInnes
Scientific Director, CIHR
Institute of Genetics

Regenerative medicine encompasses a wide range of health research fields that share the goal of stimulating the renewal of bodily tissues and organs or the restoration of function, through both natural and bioengineered means. Regenerative medicine also focuses on strategies that promote health and prevent disease. Its ultimate goal is to develop innovative and socially validated treatment approaches that will improve the quality of life of individuals and populations.

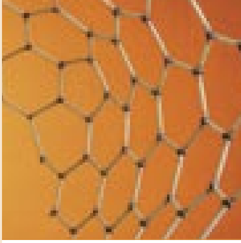
Nanomedicine is the application of nanotechnology to health research – specialized biomedical measurements or interventions at a molecular scale that are used to diagnose and treat diseases or restore function to damaged tissues or organs. Many phenomena and materials are known to have unique properties at the nanometer scale – one billionth of a metre, or one 80,000th the width of a human hair. These properties have given rise to nanotechnology – the design and manufacture of extremely small materials and devices built at the molecular level of matter. These developments are primarily the result of advances in the physical and applied sciences.

What if people with spinal cord injuries could regain

ls before they have the chance to become life-threatening

g medicines – right where and when they're needed?

Together and separately, regenerative medicine and nanomedicine have the potential to improve the health of Canadians and change the way our health care system protects, maintains and restores health. They also have potential for economic growth arising from rapid and effective transfer of this technology through collaboration with the private sector.



Realizing the Promise

A made-in-Canada approach

The foundation for Canada's success in regenerative medicine and nanomedicine is strong:

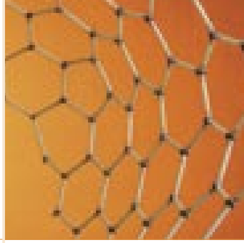
- We have the necessary scientific expertise. Canada has many strengths in areas relevant to regenerative medicine and nanomedicine, including research expertise in stem cell research, biomedical imaging, biophotonics, biodiagnostics, material sciences and rehabilitation sciences, among others.

- We have the ongoing funding support that is critical to success. Canada has made a strong investment in knowledge creation through CIHR and its fellow funding agencies, including a vibrant voluntary health sector.

- We are known throughout the world for creating national networks of multi-disciplinary teams, formed to address specific problems from a multitude of perspectives.

Through its strategic initiative in regenerative medicine and nanomedicine, CIHR and its partners are helping to build on these strengths by creating a critical mass of talent to accelerate research forward in these areas.

The initial focus of the CIHR Regenerative Medicine and Nanomedicine Initiative has been on supporting innovative, high-risk pilot projects and the creation of interdisciplinary research teams in the areas of nanotechnology development and nanomedicine, stem cells, tissue engineering, gene therapy and rehabilitation sciences. As of June 2005, CIHR and its partners



have launched three Requests for Applications in regenerative medicine and nanomedicine. To date, CIHR has committed nearly $30 million over five years to the Initiative, which has leveraged an additional $4.3 million from its partners.

Multi-disciplinarity is the cornerstone of the Regenerative Medicine and Nanomedicine Initiative. Advances in these areas depend on breaking down the barriers among disciplines and encouraging collaboration among the many disciplines involved in these technologies. These include the physical sciences, engineering, chemistry and computer sciences, among others. Consideration of the social, cultural and ethical perspectives of human health is equally critical, to ensure that, as new developments emerge, we are prepared to integrate them into our health care system and fully understand their implications for society.

The Initiative also plays an important role in identifying promising avenues for success. For the past three years, CIHR and its partners have brought together the leaders in nanomedicine to focus on specific issues in the area. These annual nanomedicine workshops are an investment in creating the research links necessary to further our advances in regenerative medicine and nanomedicine.

While the promise of regenerative medicine and nanomedicine belongs to tomorrow, CIHR is building toward it today.

"The CIHR regenerative medicine and nanomedicine program is the largest targeted extramural nanotechnology program in Canada. Exciting applications include the use of quantum dots for tissue remodelling, early cancer diagnosis and stem cells."

Dr. Arthur Carty, National Science Advisor to the Prime Minister of Canada
NanoForum, June 2005

Excellence in Research

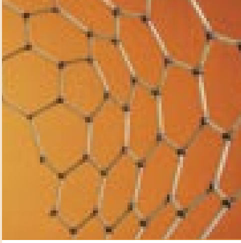
Probing the secrets of cells

Understanding the molecular processes by which cells communicate with each other is central to neuropharmacology – the development of drugs targeted at diseases and conditions that strike the central nervous system. To date, however, to unravel the intricate mechanisms that govern neurochemical interactions researchers have largely been limited to examining individual molecules extracted and preserved in a non-living state. Dr. Yves De Koninck of the Université Laval Robert-Giffard Research Institute (CRULRG) is leading a New Emerging Team that is developing new ways to examine molecular events in living cells, using nanotechnology.

Dr. De Koninck and his team are developing nanotechnology-based sensors and probes that are able to monitor the interactions among nerve cells to learn more about how transmitters and receptors function. The tools also allow the team to intervene in these functions, so that they can investigate the consequences of manipulating nerve cell communications. Examining molecules in isolation has advanced our knowledge tremendously, says Dr. De Koninck. But molecules behave quite differently when they are in action in cells, so being able to probe a live cell means learning about how molecules function "in the right place and at the right time."

Dr. Yves De Koninck
Université Laval Robert-Giffard Research Institute (CRULRG)

The knowledge acquired will aid in the design of drugs to counter pain, epilepsy and neurodegenerative diseases such as Alzheimer's disease and Parkinson's disease, as well as learning more about the molecular communications that affect memory.



Repairing spinal cord injuries

Walking away from a spinal cord injury is a tantalizing possibility. Dr. Lynne Weaver and her team at the Robarts Research Institute and the University of Western Ontario are recipients of a New Emerging Teams grant to bring that possibility closer to being realized. Her research to date has focused on an antibody that controls inflammatory cells, limiting the damage caused after an injury has occurred. That's an important first step: the more damage you can prevent, the more likely the ability to repair.

Now, members of her team are focusing on inhibiting the enzymes that lead to scar formation at the site of an injury – another important step in improving the likelihood of regeneration. They are also investigating the use of somatic stem cells, already present in mice, to encourage regeneration. These cells are being tracked with micro-imaging in the mouse to show that they are drawn to the injury site. All these studies, to date, have taken place in rats and mice. Now, in a study of human tissue, Dr. Weaver's laboratory has found that the inflammatory response to cord injury is very similar to that of rats, making the team's rat studies good predictors of human responses. The strategies for rescue and repair that they are developing in rats are likely to translate well to treatments for humans.

Dr. Lynne Weaver
and her team at the Robarts Research Institute

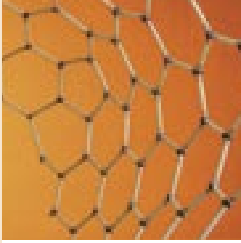
Excellence in Research

Going micro in the search for cancer culprits

Dr. Linda Pilarski and her team at the University of Alberta are using nanotechnology to develop a device the size of a microscope slide that can analyze and monitor cancer cells on the spot quickly and inexpensively. It's a device that could dramatically change health care – imagine someone in a remote area having their cells uploaded and analyzed elsewhere – but that's just the start. The same type of device could measure the presence of a virus in urine that signals kidney transplant rejection. Every single donation of blood could be analyzed for West Nile Virus. Sewage in different parts of a city could be analyzed for the presence of viruses that signal a developing epidemic. The key is the speed and low cost – current methods of accomplishing these same tasks are simply too slow and too expensive to be widely used.

None of it would be possible, Dr. Pilarski says, without the New Emerging Team funding that brings together engineers, a clinician, a medical geneticist, a sociologist and Dr. Pilarski herself, an oncologist, working in the same lab. With the funding, the team has formed the Alberta Cancer Diagnostics Consortium, so that they are ready when the time comes to commercialize their discovery – a stage that should come within the next few years.

Dr. Linda Pilarski
University of Alberta



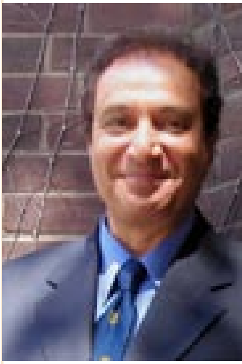
Building equity into emerging areas

Regenerative medicine is usually considered high-tech and expensive – more suitable for the developed world. But the ability to repair or regenerate tissue may be of even greater benefit in the developing world, where the incidence of diseases such as diabetes or heart disease and accidents and burns is greater than in the developed world. Dr. Abdallah Daar, of the University of Toronto's Joint Centre for Bioethics and the McLaughlin Centre for Molecular Medicine, is leading a research network called RMEthnet that wants to maximize the potential and minimize the risks of regenerative medicine worldwide.

His research team includes lawyers, ethicists, social scientists and biomedical researchers. The team is focusing initially on the applications of regenerative medicine that show the most promise for the developing world. Also of interest is how these countries are beginning to actually use regenerative medicine. Other research areas include protecting human subjects of regenerative medicine research, balancing the need to reward innovation with patents while ensuring equity of access to new technologies; regenerative medicine applications in neurological diseases; and enhancing the role of voluntary health organizations in the area of regenerative medicine.

One of the developments driving progress in regenerative medicine is collaboration among researchers from varied disciplines, including tissue engineering, stem cell research, genetic engineering, and ethics. A major focus for RMEthnet is training new researchers to work in this way, with a commitment to train up to 18 graduate students and new investigators.

Dr. Abdallah Daar
University of Toronto
(ethical and other aspects of regenerative medicine)



Excellence in Research

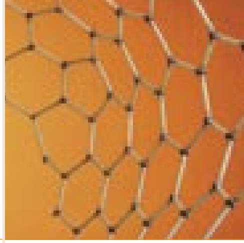
A clear vision

Corneal transplantation can restore vision – but at a cost. Current methods of treatment require a surface incision and manually shaping the new, donated, cornea to match the recipient's eye – an imperfect procedure. This can lead to suture-related complications, instability of the cornea, poor vision, or even rejection. As well, the need for donor corneas results in very long waiting lists for surgery. Dr. Isabelle Brunette of the Maisonneuve-Rosemont Hospital of the Université de Montréal is leading a team that is using femtosecond (one quadrillionth of a second) laser technology to work on the endothelial layer behind the cornea, without affecting the surface of the cornea. With this technique, only the diseased layer is changed instead of the entire cornea, the traditional method. There is no need for an incision or sutures on the cornea and the cornea remains stable, improving outcomes for patients. The procedure also cuts down on the need for donor corneas, increasing access to the procedure while reducing waiting lists.

Dr. Brunette and her team are also using tissue engineering technology to grow the patient's own endothelial cells in culture, so that they can then be transplanted back into the patient in an enriched form. Because no donor is involved, there is no risk of rejection of the transplanted endothelial cells.

Isabelle Brunette
Université de Montréal
(corneal transplantation)

Dr. Brunette credits her team's progress to its multidisciplinary nature and close working ties, because all members understand the surgical problem they are trying to address. Clinical trials in humans, she says, are possible within five years.

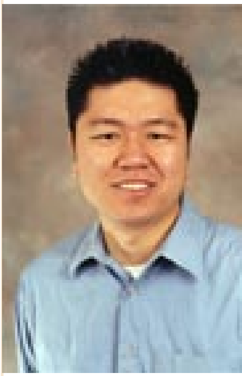


Zeroing in on cancer cells

Quantum dots are tiny (less than 100 nanometres, or smaller than a virus) dots that emit light when excited. The light emission can be tuned by changing their size, shape, and composition, a property that is unique to many nanometre-sized structures. Dr. Warren Chan of the University of Toronto is leading a team that is attempting to harness this unique property of quantum dots to diagnose cancer earlier and more precisely. They are attaching a cancer-seeking molecule, such as an antibody or peptide, to the quantum dot. When injected into the body, this molecule acts as the driver, delivering the quantum dot to the tumour. The colour emission of the quantum dots can detect a tumour and determine its stage of development. For instance, red and green colour emissions from tumor regions could mean normal tissue, blue and green could mean the tumour is in its early stages, while blue, green, and red could mean the tumour is metastasizing, or spreading to other tissues. With this imaging capability, the appropriate drug therapeutics can be used, based on the tumour's molecular information.

The team, which includes biomedical engineers, medical biophysicists, pharmacist, pathologists and a liaison with industry, is also hoping to develop methods of transporting treatments directly to the tumour using quantum dots and to learn more about how these dots circulate in the body and whether they carry a risk of toxicity.

Dr. Warren Chan
University of Toronto
(quantum dot imaging for early cancer diagnosis)



Looking to the Future

CIHR and its partners have taken a major step forward through the creation of this initiative and the funding of highly promising multi-disciplinary health research teams. Much, however, remains to be done. Vital areas of research await exploration, including the largely untapped commercialization potential for these new and emerging technologies.

CIHR is working closely with federal partners, including the Office of the National Science Advisor, Health Canada, Environment Canada and Industry Canada, among others, to ensure the development of an integrated national policy that will allow safe and effective products and therapies to reach the Canadian market. Their goal is to translate innovative health research in regenerative medicine and nanomedicine into a lasting impact on the health and productivity of all Canadians.

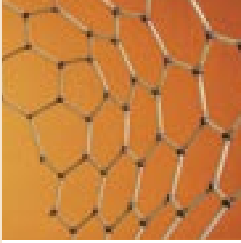


Photo courtesy National Research Council of Canada