

**BEHIND ANY SUCCESS STORY,
YOU WILL FIND AMAZING PEOPLE.**

iCORE 2003-04 Year in Review

Moving forward in an uncertain world is a heady commitment, especially when it involves new discoveries on the frontier of frontiers. This year, the iCORE Year in Review stimulates thinking about informatics and its people – for example, the collaborative process of doing research, the dynamic uncertainties that underpin every intellectual quest, and the social impact of a sector that can positively affect the lives of every individual. Informatics is an enabler for improvements for the business owner, the farmer, the miner, the doctor and patient, the home schooler, the telecommuter, the student. Informatics is all about ideas. **This Year in Review makes some of those connections.**



Dr Hong Zhang
INTELLIGENT SENSING SYSTEMS



Dr Barry Sanders
QUANTUM INFORMATION SCIENCE



Dr Michael Brett
THIN FILM ENGINEERING



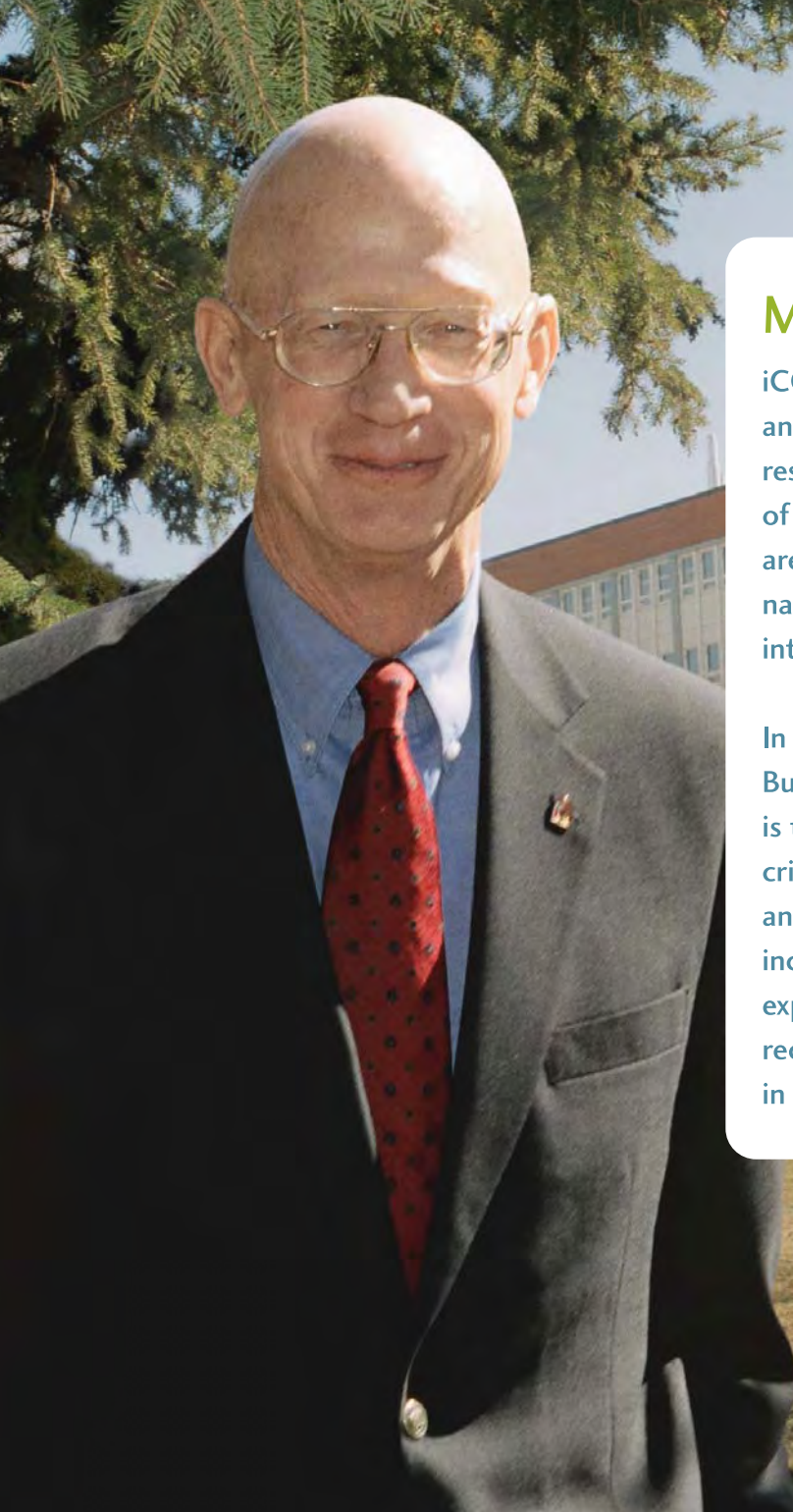
Dr Rich Sutton
REINFORCEMENT LEARNING
AND ARTIFICIAL INTELLIGENCE



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4 new teams at the forefront of discovery.



Message from the Chair

iCORE's focused approach to attract, retain and support outstanding researchers has resulted in phenomenal momentum. Clusters of research excellence are emerging in three areas: networks and wireless communications, nanoscale and quantum informatics, and intelligent software systems.

In a short time, we have achieved a great deal. But there is much more to do. Our challenge is to remain a leader, to continue to add to the critical mass with new research appointments and the best graduate students, and to increase our funding base. At this rate, we expect Alberta will soon be among the well-recognized informatics research communities in the world.

Five Key Factors to iCORE's Success

1 Focused Mandate

From the beginning, iCORE's mandate has been clear: to bring the best information science and engineering researchers to Alberta. An unwavering commitment to a few well-defined objectives has kept us on track, allowing us to build critical mass in key areas.

2 Government Support

The Alberta government was with us from the beginning, and we continue to benefit from its support. Alberta Innovation and Science's vision and goals guide us as we move forward.

3 Scientific Credibility

People remain critical to iCORE's success. Our Informatics Research Advisory Committee (IRAC) continues to provide intellectual leadership to iCORE's mandate, ensuring we stay focused on areas where we can contribute. In May 2003, IRAC identified energy as a high priority because of the unique role it plays in the Alberta economy. Our Internal Review Committee is a collection of some of the best minds in industry and academia. This group reviews proposals, ensuring we focus on areas that are key to Albertans and that link ICT research with sectors such as energy and life sciences. We rely on the External Review Committee to provide arms-length peer review to ensure iCORE award recipients are among the best in their areas of research in the world.

4 Involvement with Alberta Universities

iCORE remains focused on strengthening partnerships with Alberta's universities. Whether it is enhancing existing relationships or fostering new ones, together we have achieved a real culture of collaboration and sharing. Intellectual silos are crumbling, enabling unforeseen research success.

5 External Focus

Our external partnerships – with organizations such as Alberta Ingenuity, Netera Alliance, TRILabs, WestGrid, NSERC, the National Institute for Nanotechnology and industry – play a major role in strengthening ICT research and research infrastructure. Strong infrastructure and partnerships are attracting both new funding and researchers to our province.

Roger Smith

CHAIR OF THE BOARD, iCORE

WHETHER IT IS ENHANCING EXISTING RELATIONSHIPS OR FOSTERING NEW ONES, TOGETHER WE HAVE ACHIEVED A REAL CULTURE OF COLLABORATION AND SHARING.

Message from the President

iCORE was created with a clear goal: to attract and support exceptional research leaders in information science and engineering. Now in its fifth year, it is clear that iCORE is meeting this goal, and we are also pleased to see new, unanticipated positive results.

It is evident that iCORE has surpassed expectations. All research teams are thriving. Our current challenge is to secure the increased funding required to renew awards and continue our most successful programs at current levels.



Accomplishments of 2003-2004

1 Meeting Targets

Attracting and supporting exceptional people

iCORE's objective is to make four new awards each year. In 2003-2004, we met this target, attracting top Canadian and international talent from places such as the United States and Australia. I am particularly pleased to welcome Dr Richard Sutton as a new computing science Chair, a key position we have sought to fill since iCORE's inception. Dr Sutton left AT&T Labs to become the first iCORE Chair that we have recruited in computing science. We have also funded a new research team in quantum information science, led by Dr Barry Sanders. This initiative is bringing together computing scientists, theoretical and experimental physicists and mathematicians – all working on the mind-bending frontiers of quantum computation and cryptography.

Our thriving graduate student program continues to draw the best informatics students to Alberta. This year we supported 210 of Canada's top scholars, young women and men who are generating their own momentum in Alberta's ICT-related strengths.

Our goal for the Industrial Chair Establishment grants program is to leverage iCORE funds to a maximum with money from industry and the Natural Science and Engineering Research Council of Canada (NSERC). Dr Hong Zhang is an NSERC/iCORE/Syncrude/Matrikon Industrial Research Chair whose work in intelligent sensing systems has potential for more efficient recovery and processing of oil sands. Dr Carey Williamson's partnership with TELUS Mobility is focused on enhancing wireless web performance in Alberta, Canada and around the world. Dr Mike Brett is supported by NSERC and iCORE to work with Micalyne on nanodevices. These are initiatives with real-world applications that will make a difference in Alberta's future.

2 Building Infrastructure

Participating in the creation of advanced computational research infrastructure

iCORE is actively involved in the development of Alberta's intelligent infrastructure for research through its support of WestGrid, a \$48 million, three-year project that provides access for Alberta researchers, universities and organizations to high performance computers and storage. With this, researchers can address complex scientific problems that have direct applications to all facets of daily life.

3 Creating Synergies

Emerging collaborations

An exciting unanticipated product of iCORE's research and industrial chair award programs is the emerging multidisciplinary cluster in cryptography. Faculty members, postdocs, research staff and graduate students in mathematics, computer science, physics, chemistry, electrical and computer engineering and nanotechnology have begun to communicate and collaborate toward shared goals. For example, Dr Hugh Williams' cryptography group is working with Dr Graham Jullien's electrical and computer engineers to develop a small, wireless medical monitoring device that can be implanted in patients and used to transmit data over short distances. This exemplifies iCORE's vision of finding innovation in the gaps between traditional disciplines, and is just one example of the synergies that are likely to emerge.

Brian Unger

PRESIDENT AND CEO, iCORE

THIS YEAR WE SUPPORTED A TOTAL OF 210 OF CANADA'S TOP SCHOLARS, YOUNG MEN AND WOMEN GENERATING THEIR OWN MOMENTUM IN ALBERTA.



1

2



3

4



**BIG IDEAS, SMALL IDEAS, CRAZY IDEAS,
OBSCURE IDEAS, OLD IDEAS, NEW IDEAS,
COMMERCIAL IDEAS, STRANGE IDEAS,
MIND-ALTERING IDEAS –**

THEY CAN CHANGE THE WORLD.

Expanding Research Teams

iCORE made four new awards in 2003-04 to remarkable researchers

- ① **Rich Sutton** One of the most globally renowned researchers in reinforcement learning and artificial intelligence. iCORE's first Chair attracted in computing science.
- ② **Barry Sanders** Recognized by peers as one of the most prescient scholars in the emerging realm of quantum information science. Recruited from Australia.
- ③ **Hong Zhang** First Industry Research Chair in support of the energy sector. Builds on university commitment to this area and partners with industry leaders Syncrude and Matrikon, as well as NSERC.
- ④ **Michael Brett** Industry Research Chair in explosive growth areas of nanoengineering. Building Alberta teams and talent in nano cluster with industry support from Micralyne and NSERC.



Dr Rich Sutton

iCORE CHAIR, REINFORCEMENT LEARNING
AND ARTIFICIAL INTELLIGENCE



Should you treat your computer as though it has feelings? Should you treat a robot as if it has feelings?

Some people say no, of course not. They are just machines, but Rich Sutton would ask you to think about that. Sutton is a new iCORE Chair at the University of Alberta, and one of the founding fathers of reinforcement learning in artificial intelligence. He is the co-author of the seminal text in the field. He was attracted to the computer science department at the University of Alberta, home of the new Alberta Ingenuity Centre for Machine Learning, by the outstanding people there.

“We should invest our psychological and emotional selves in everything we do, whether it is developing machine intelligence or interacting with it. I think it would be the wrong path to take if we let ourselves off the emotional accountability hook in our human-computer interactions, especially since it can be hard these days to know where computers are at work. What would the consequences be if we acted without emotion around learning machines?” he asks.

Sutton asks some crucial questions and sparks interest in the issues in science that affect us all. With a background in psychology and computer science, he has a vision of computing in an endlessly fascinating social world. With that breadth of mind and conviction of spirit, he is leading a research program in Alberta whose impact will be felt in all walks of life where we interact with computerized systems.

Dr Rich Sutton has been appointed as the iCORE Chair in Reinforcement Learning and Artificial Intelligence in the Department of Computing Science at the University of Alberta. His research program will be a cornerstone of the new Alberta Ingenuity Centre for Machine Learning (AICML), which was recently established in Edmonton. To develop the research program, Dr Sutton has received an iCORE Chair and Professor Establishment (CPE) grant of \$600,000 per year for five years, for a total of \$3 million. This represents roughly 50 percent of the total \$6.75 million budget. The University of Alberta is contributing approximately \$540,000 per year for a total of \$2.7 million.

Learning Definitions

Machine learning is the study of computer algorithms that improve continuously through experience.

Reinforcement learning is defined not by characterizing learning algorithms, but by characterizing a learning problem. The learner is not told which actions to take, as in most forms of machine learning, but instead must discover which actions yield the most reward by trying them.

Reinforcement learning is different from supervised learning, the kind of learning studied in most current research in machine learning, statistical pattern recognition, and artificial neural networks.

Supervised learning is learning from examples provided by some knowledgeable external supervisor. This is an important kind of learning that alone is not adequate for learning from interaction.

In interactive problems it is often impractical to obtain examples of desired behaviour that are both correct and representative of all the situations in which the agent has to act. In uncharted territory – where one would expect learning to be most beneficial – an agent must be able to learn from its own experience.



what can
ANTS
teach us about
artificial intelligence?

COLLECTIVE INTELLIGENCE IN SOCIAL INSECTS

The general idea of taking inspiration from nature is a good one, but can ant algorithms actually contribute to solving routing problems, such as finding the shortest of two paths for a message on a network?

Ants, phones and pheromones

In Brussels, Jean-Louis Deneubourg at the Center for Nonlinear Phenomena and Complex Systems, has shown the ability of ants to collectively find the shortest path to the best source of food. He created an experiment in which one group of ants were offered two branches leading to the same food source, one of them longer than the other. When they first set off, there is a 50 percent chance that an ant will choose either branch, but gradually, more and more ants take the shorter route. Deneubourg hypothesizes that with additional journeys taken on the shorter trail, a denser trail of pheromones is laid. Consequently, the ants begin to choose the shorter trail, and eventually discard the longer one. This is now understood as the mechanism that allows ant colonies to exploit food sources in sequential order, where strong trails are established to the nearest food sources first. When that food supply is gone, and the ants no longer get rewarded by food on that trail, they will explore other trails until the next nearest rewarding source is found, and so on.

Deneubourg showed that social insects like ants are able to succeed in complex activities with minimal individual intelligence by using simple algorithms. But can these approaches help us to understand search and optimization in artificial intelligence?

The possibility derives from similar social-insect-like behaviour in telecommunications networks. For example, a certain web site in the news might be swarmed, causing a rush of visitors to the site, and resulting in traffic that must be routed efficiently to avoid delays and congestion. Networks are set up to dynamically route signals so that the most efficient path for any message is taken, much as ants self-organize to find the shortest route to a food source.

Information networks are far more complex. It is actually very hard to find the shortest route in an even moderately sized network. The pheromone trail idea does not live up to the engineering challenge of routing traffic on today's massive and complex networks. Still, it's a nice idea, and it works for ants.



A brief history of (machine) intelligence

- 300 BC** Evidence of artificial intelligence folklore
- 1941** First electronic computer invented
- 1948** Norbert Wiener develops the principle of feedback theory
- 1955** Newell and Simon developed The Logic Theorist, considered by many to be the first AI program
- 1956** John McCarthy organizes a conference in Dartmouth, Vermont. The term artificial intelligence is coined.
- 1959** McCarthy announced the LISP language (LISt Processing), which was soon adopted as the language of choice among most AI developers
- 1963** MIT receives a \$2.2 million grant from the United States government to use in researching Machine-Aided Cognition (artificial intelligence); headed by Marvin Minsky
- 1970s** Advent of the expert system
- 1980s** AI moves into the corporate sector. In 1986, US sales of AI-related hardware and software surged to \$425 million
- 1990s** AI decreases in popularity
- 2000s** AI recovers
- 2003** Alberta Ingenuity Centre for Machine Intelligence established in Alberta

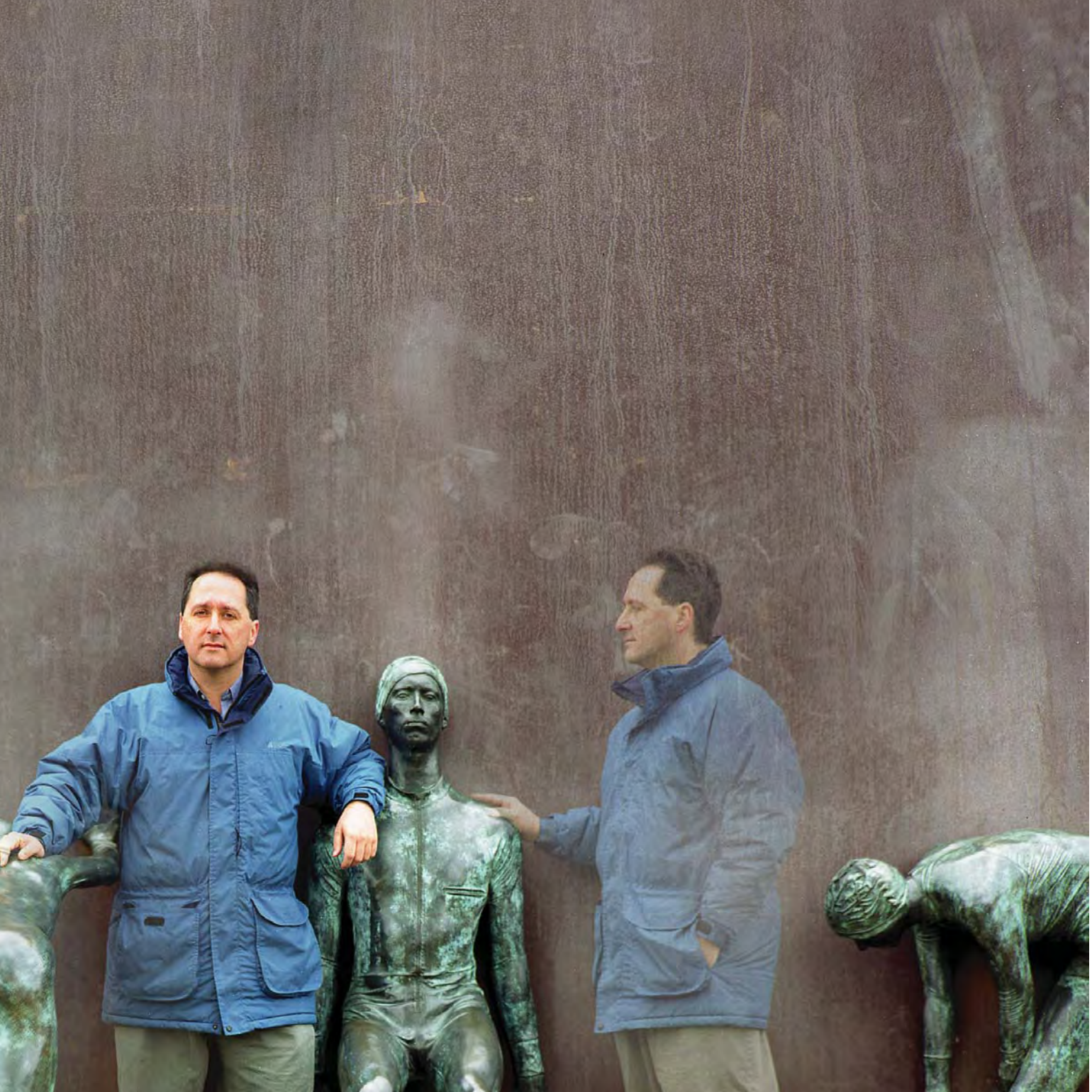
THE MACHINE'S MOST INTELLIGENT MOMENTS

May 1977

IBM computer beats world's best chess player in Deep Blue vs Kasparov match. Dr William Pulleyblank, Director of IBM Exploratory Systems at IBM Research, was there in 1977. He is now Chair of iCORE's Research Advisory Committee.

August 1994

Chinook declared the Man-Machine World Checkers Champion, the first computer program to win a human world championship. Chinook was developed by a team of researchers led by iCORE Chair Dr Jonathan Schaeffer.



Dr Barry Sanders

iCORE PROFESSOR, QUANTUM INFORMATION SCIENCE

Today's society has a low threshold for uncertainty. We want science to find answers – concrete solutions, cures. It takes risk-taking physicists with expansive minds like Barry Sanders to dwell in the uncertainties of a field like quantum information science.

Dr Barry Sanders is the new iCORE Professor putting together the pieces of quantum information science. "I purposefully avoid using the term quantum computing," Sanders explains, "because it makes people think of that final solution. We are a long ways from that yet. We are still piecing together the parts of the puzzle and need to focus on the science of this uncertainty, not an outcome just yet."

Quantum information science is mind-boggling, but it is science, and not science fiction. It requires thinking and working in new ways. Sanders suggests we should think about what this means for how we could better understand other supposedly immutable laws of nature. Sanders is embracing the challenge.

Sanders has been appointed iCORE Professor in Quantum Information Science in the Department of Physics at the University of Calgary. The research project is funded for approximately \$460,000 per year for five years, for a total of \$2.3 million. This represents roughly 40 percent of the total \$5.5 million budget. The University of Calgary is contributing approximately \$1.3 million over the five years in cash and in kind.

Quantum Information Science Research Team

Richard Cleve, Department of Computer Science
David Feder, Department of Physics and Astronomy
David Hobill, Department of Physics and Astronomy
Peter Høyer, Department of Computer Science
Barry Sanders, Department of Physics and Astronomy
Robert Thompson, Department of Physics and Astronomy
John Watrous, Department of Computer Science

Three examples of the paradigm shift that quantum information has introduced by combining computer science and quantum physics:

1) Quantum cryptography

Security can be guaranteed by the laws of physics, rather than principles of mathematical complexity as in standard cryptography. This now it is of considerable industrial and commercial interest.

2) Quantum computation

Some problems that have long been believed to be intractable in standard computing are efficiently solvable with quantum algorithms, which render all current public-key cryptographic protocols insecure to attackers with quantum computers.

3) Quantum communication

Significantly reduces communication costs for operations within quantum networks such as quantum computers and quantum cryptography.

THE CERTAINTY *of uncertainty*



Tired of the same old choice between on or off, one or zero, true or false?
with quantum physics, we can have both (or neither).

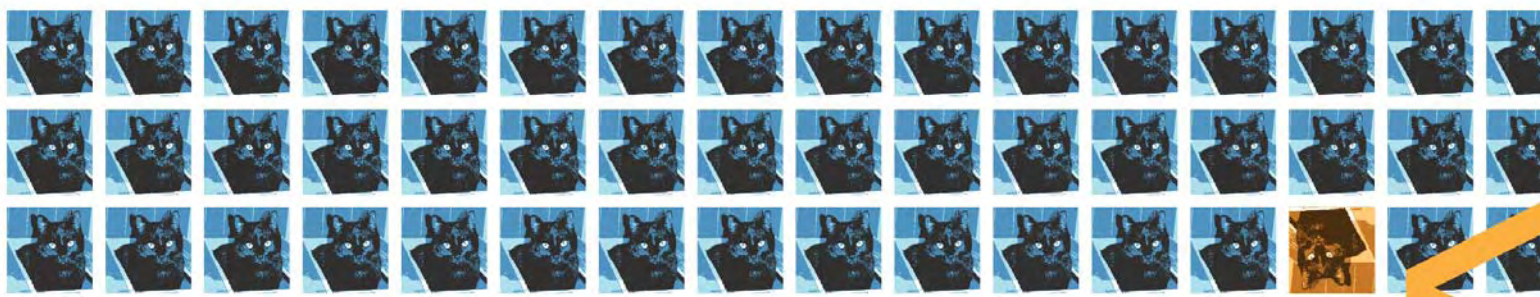
3 things you should know you don't know

- 1) How exactly do the laws of Classical Physics interact with the principles of Quantum Physics
- 2) How does energy, such as light, exist simultaneously in two states?
- 3) How does the act of observing one thing change our knowledge of something else?

That darn cat

His cat was both dead and alive
'Til Schrödinger's guests would arrive.
Then he'd open the box. And toss in some lox –
And the cat would both lay there and thrive.

- Schrödinger Cat Limerick Challenge
"From the Editors", *Scientific American*, October 1999



Schrödinger's Cat

A tale of quantum misbehaviour

In 1935, Erwin Schrödinger described a "thought experiment," or hypothetical scenario to demonstrate how quantum mechanics seems to defy what we experience as reality. His scenario involves placing a cat in a box with a vial of cyanide and a radioactive atom. The radioactive atom has a 50 percent probability of decaying in one hour. If it decays, the cyanide is released and the cat dies; if it does not decay, the cyanide is not released and the cat is alive.

The laws of quantum mechanics also allow the radioactive atom to be placed in a "superposition" of the two states, in which the two states both exist. Until the particle is disturbed by an outside agent – for example, someone looks in the box to see if the cat is dead or alive – there is an equal probability that it is in either state, and thus it is considered to be in both states – both dead and alive.

It is said that Schrödinger later regretted making this analogy because it was so divorced from real life.

The Quantum Computer

What can the cat tell us about the future of computing?

In a quantum computer, the fundamental unit of information (called a quantum bit or qubit), is not binary but rather more quaternary in nature. This qubit property arises as a direct consequence of its adherence to the laws of quantum mechanics which differ radically from the laws of classical physics. A qubit can exist not only in a state corresponding to the logical state 0 or 1 as in a classical bit, but also in states corresponding to a blend or superposition of these classical states. In other words, a qubit can exist as a zero, a one, or simultaneously as both 0 and 1, with a numerical coefficient representing the probability for each state. This may seem counter intuitive because everyday phenomenon are governed by classical physics, not quantum mechanics – which takes over at the atomic level.

Jacob West, *The Quantum Computer: An Introduction*
2000 (www.cs.caltech.edu/~westside)

Dr Hong Zhang

iCORE/NSERC/SYNCRUDE/MATRIKON INDUSTRIAL RESEARCH CHAIR

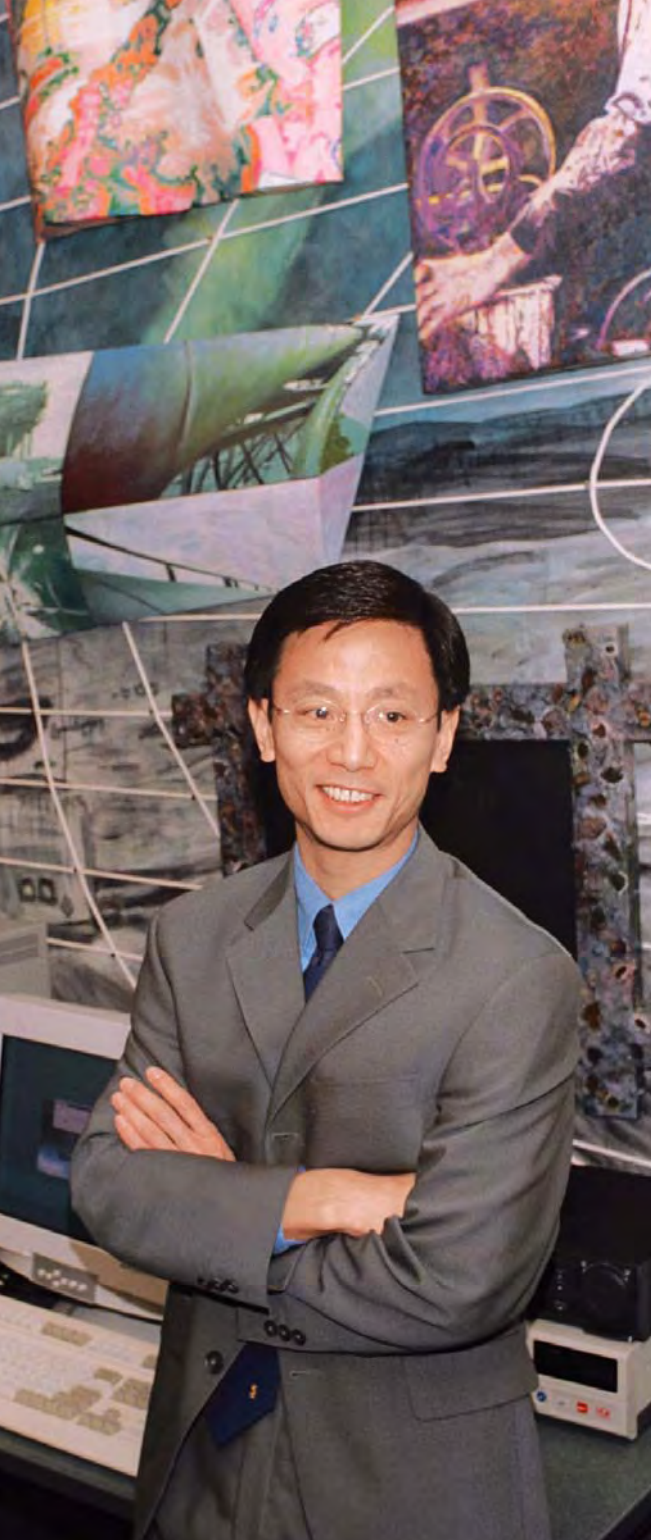
There are 300 billion barrels of recoverable bitumen in northern Alberta. The oil sands industry plays an important role in Alberta's economy as well as Canada's future energy supply.

But mining can be hard on the environment and on human safety. How can its impact be minimized?

Hong Zhang's research team, supported directly by Syncrude Canada and Matrikon, is working to analyze, measure, monitor and model processes that can help with:

- accurate measurement of the sizes of oil sand fragments
- real-time monitoring of mining equipment
- analytical modeling of mining activities

Dr Hong Zhang has been awarded an iCORE / NSERC / Syncrude / Matrikon Industrial Chair in the Department of Computing Science at the University of Alberta. The research project is funded by iCORE for \$150,000 per year for five years, for a total of \$750,000. This represents roughly 15 percent of the total. NSERC, which now operates under the new name of Science and Engineering Research Canada, is contributing \$800,000. The University of Alberta is contributing \$100,000 in cash and \$800,000 in kind. There are two private companies involved in the creation of this initiative. Syncrude is contributing \$500,000 in cash and \$1.35 million in kind. Matrikon is contributing \$250,000 in cash and \$350,000 in kind.





What is dirt tv?

A massive dedicated optical network connects 12 cameras at the Syncrude operations in Fort McMurray with a high-tech computer lab at the University of Alberta. A steady stream of video images is sent to the lab for analysis and remote monitoring research. This is Dirt TV.

This new research initiative, undertaken by Hong Zhang and the Centre for Intelligent Mining Systems at the University of Alberta, marries information technology with traditional mining methods to analyze oil sands fragments and monitor equipment so that less waste, safer practices, and lower environment impact can be achieved.

10 projects Zhang and his team will undertake

- 1) **Synthetic Ore Model**
Use of computer graphics and simulation techniques to generate realistic synthetic oil sand ore models which readily produce ground truth for the 2D intensity and 3D depth data
- 2) **Oil Sand Ore Size Analysis**
Study of extraction of size information using the frequency domain technique of Fast Fourier Transform on both intensity and range data and the evaluation of the developed algorithms under field conditions
- 3) **Morphology Based Ore Size Analysis**
Study of a series of mathematical morphology based solutions to the problem of ore size analysis, extending success in using this technique to varied environment conditions (light, field of view, depth of field, oil fragment surface properties)
- 4) **ProcessNet and ProcessMonitor Integration**
Integration of Matrikon's software (ProcessNet and ProcessMonitor) and the ore size analysis software developed in Zhang's Centre for Intelligent Mining Systems (CIMS) in order to transfer the technologies to the oil sands industry
- 5) **Oil Sand Ore Size Analysis Using Sensor Data Fusion**
Use of multiple cues (intensity, range, and possibly others) in calculating the size information of oil sand ores and the evaluation of the developed techniques under field conditions
- 6) **Wavelet Oil Sand Ore Size Analysis**
Investigation of using Wavelet-based techniques as a way of extracting size information from intensity and range images of oil sand materials and the evaluation of these techniques under field conditions
- 7) **Screen Condition Monitoring**
Study of image processing techniques to integrate continuous video information and remove obstructing temporal objects (steam and falling oil sand fragments)
- 8) **Internet Video and Virtual Private Network**
Investigation of transmitting oil sand sensory data from the North Mine to CIMS Lab with commercial DSL technologies, and establishing a research infrastructure using the Virtual Private Network (VPN) model linking various field sites and research labs
- 9) **Activity Monitoring and Modeling**
Understanding of the correlation between the activities undertaken by mining equipment and the sensory signals that monitor their operations so that operator behaviours can be properly adjusted in order to optimize equipment performance
- 10) **Mining Process Monitoring**
Modeling of the relationship between ore characteristics and equipment operating conditions and ore size using the sensing software developed in CIMS



OIL & SAND

POWERING THE FUTURE

What are the oil sands?

Oil sands are deposits of bitumen, a heavy black viscous oil that must be rigorously treated to convert it into an upgraded crude oil before it can be used by refineries to produce gasoline and diesel fuels.

Bitumen is best described as a thick, sticky form of crude oil, so heavy and viscous that it will not flow unless heated or diluted with lighter hydrocarbons. At room temperature, it is much like cold molasses.

While conventional crude oil flows naturally or is pumped from the ground, oil sands must be mined or recovered in situ – meaning ‘in place.’ Oil sands recovery processes include extraction and separation systems to remove the bitumen from sand and water.

What role does ICT play in the recovery of the oil sands?

Researchers are involved in the accurate measurement of the sizes of oil sand fragments, the real-time monitoring of mining equipment, as well as analytical modeling of mining activities.

Five reasons it is important to have an accurate measurement of the oil sand ore fragments:

- 1) the optimal size of the holes in the shaking separator screens can be achieved
- 2) with the optimal size opening, less of the oil sands ore will need to be thrown away
- 3) less rock thrown away means better throughput
- 4) better throughput means less impact on the environment
- 5) Less impact on the environment means a better planet for our children



Known North American Oil Reserves 2002

- Under anticipated economic conditions and using current technology, Alberta has about 176 billion barrels of proven oil reserves.
- Total recoverable oil reserves are estimated to equal almost 335 billion barrels.
- While conventional oil reservoirs are scattered throughout the province, oil sands underlie 140,800 square kilometres of primarily northern Alberta – an area larger than the state of Florida.
- Marketable oil sands production for 2002 averaged 740 thousand barrels a day, representing 32% of Canada's crude output.

Location	Billion Barrels
B.C.	0.16
Alberta	175.60
Saskatchewan	1.16
Manitoba	0.02
Ontario	0.01
East Coast Offshore	0.95
Mainland Territories	0.07
Mackenzie Beaufort	0.34
Total Canada	178.31
Total USA	22.44
Total Mexico	12.62
Total North America	213.37



Mike Brett, in front of a directory of the over 400 users of the NanoFab at the University of Alberta. Brett, along with fellow iCORE Professor Mark Freeman, are key architects of the renowned facility.

Dr Michael Brett

MICRALYNE/NSERC/iCORE
INDUSTRIAL RESEARCH CHAIR IN THIN FILM ENGINEERING

Dr Michael Brett has been awarded a Micralyne/NSERC/iCORE Industrial Research Chair in Thin Film Engineering in the Department of Electrical and Computer Engineering at the University of Alberta.

The funding will help Brett and his team take the challenging step from research to commercialization of new technologies. The research will focus on fabrication and characterization of nanoscale materials and devices. A full understanding of the nanoengineering process will enable optimization of materials for device applications, and enhance commercialization prospects.

iCORE is contributing \$100,000 a year for five years. NSERC is contributing \$140,200 per year for five years. Micralyne is contributing \$115,000 per year in cash, \$14,000 in cash-equivalent and \$10,000 in kind. This represents a substantial cash contribution for a company of its size, and points to the substantial effort at commercialization.

Micralyne is a spin-off company from the University of Alberta and is a micro-electro-mechanical systems (MEMS) developer and manufacturer for customers around the world.

Dr Brett is also an iCORE Professor in an interdisciplinary collaboration with Dr Mark Freeman called the Nanoscale Physics Engineering Initiative. Mike Brett's enthusiasm is contagious. His research is lauded for its focus and clarity of vision. His relationships with industry are described as unique and impressive. His students are committed and top achievers.

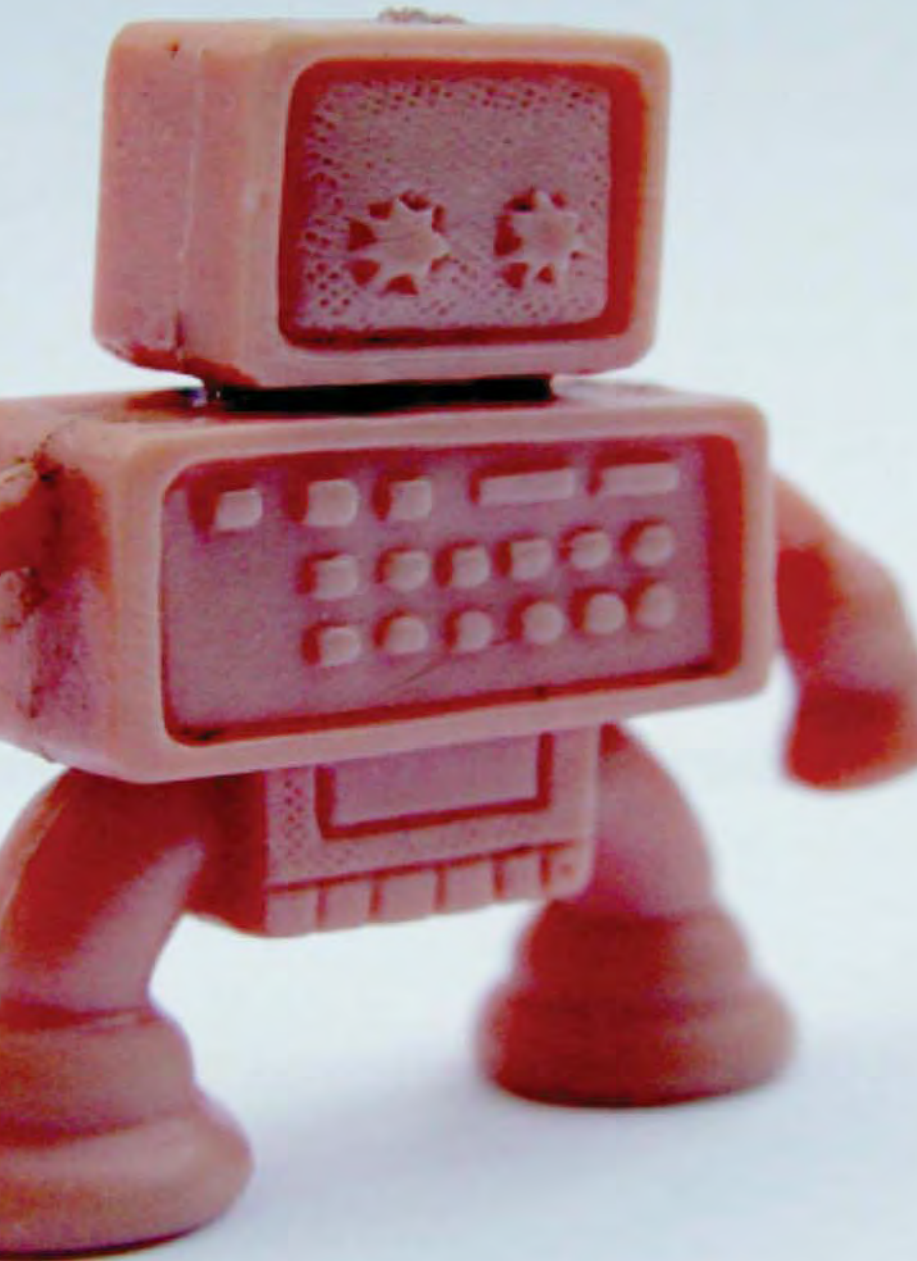
Dr Michael Brett is the 2003 recipient of the ASTech "Outstanding Achievement in Technology" Award.

How to Create the Best Workplace

The Top Components on a Scientist's List

1. Build collegial relationships
2. Provide appropriate tools and decent work spaces
3. Fill funding gaps to maintain research
4. Fair pay, fair negotiations
5. Provide security today and tomorrow
6. Cultivate tomorrow's researchers
7. Ensure academic freedom
8. Hire effective managers
9. Take down the boundaries and let in other organizations
10. Let scientists share the fruits of their research
11. Make sure scientists have a system to turn to when trouble comes
12. Keep track of the rules

The Scientist, Vol 17, Issue 20 (Oct, 2003)



Nanotechnology: Very big ideas on a very small scale

Since its coming of age, the suggested uses of nanotechnology have often travelled into fantastic realms of science fiction. It has been dreamed that nanotechnology could create armies of nano-robots smaller than a cell that could roam our bodies curing disease – or potentially run amok and pose a serious threat to society. But what are the real prospects for this relatively new science? A recent debate between two well known scientists points to the need for improved understanding and awareness of the realistic strengths, challenges, and ethical issues – not the stuff of fiction.

Attack of the Killer Nanobots?

Nanotechnology pioneer Eric Drexler and Rice University Professor and Nobelist Richard Smalley have engaged in a crucial debate on the feasibility of molecular assembly and the implications for our society.

In his landmark 1986 book, *Engines of Creation: The Coming Era of Nanotechnology*, K. Eric Drexler envisioned a world utterly transformed by such assemblers. They would be able to build anything with absolute precision and no pollution. They would confer something approaching immortality. They would enable the colonization of the solar system.

Drexler, who was then a research affiliate with Massachusetts Institute of Technology's Artificial Intelligence Laboratory, also explored in *Engines of Creation* the potentially devastating negative consequences of such a technology. "Replicating assemblers and thinking machines pose basic threats to people and to life on Earth," he wrote in a chapter titled "Engines of Destruction." Because Drexler sees the development of molecular assemblers and nanotechnology as inevitable, he urged society to thoroughly examine the implications of the technology and develop mechanisms to ensure its benevolent application.

Drexler received a PhD in molecular nanotechnology from MIT in 1991. He is the chair of the board of directors of Foresight Institute, Palo Alto, Calif., which he cofounded. It is an organization dedicated to helping "prepare society for anticipated advanced technologies."

Richard E. Smalley, professor of chemistry, physics, and astronomy at Rice University, Houston, won the 1996 Nobel Prize in Chemistry for the discovery of fullerenes. Much of Smalley's current research focuses on the chemistry, physics, and potential applications of carbon nanotubes. For the past decade, he has been a leading proponent of a coordinated national research effort in nanoscale science and technology.

Like Drexler, Smalley believes the potential of nanotechnology to benefit humanity is almost limitless. But Smalley has a dramatically different conception of nanotechnology from Drexler, one that doesn't include the concept of molecular assemblers. Smalley does not think molecular assemblers as envisioned by Drexler are physically possible. In lectures and in a September 2001 article in *Scientific American*, Smalley outlined his scientific objections to the idea of molecular assemblers, specifically what he called the "fat fingers problem" and the "sticky fingers problem."

Smalley's objections to molecular assemblers go beyond the scientific. He believes that speculation about the potential dangers of nanotechnology threatens public support for it. Notions about the darker side of nanotechnology have rapidly entered the public consciousness. Two notable examples were an April 2000 essay in *Wired* magazine titled "Why the Future Doesn't Need Us" by Sun Microsystems cofounder and chief scientist Bill Joy and the 2002 novel *Prey* by Michael Crichton.

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iCORE Chair Robert Wolkow weighs in:

"There exists a substantial current of misinformation concerning nanotechnology," says Robert Wolkow, iCORE Chair, as the Drexler-Smalley debate makes evident. Dr Wolkow's activities include outreach efforts to lay out more clearly what is possible for science to do today, what they expect to be able to do, and what might never be expected, such as Drexler's nanobots.

iCORE Visiting Professors

Excellence, innovation and global collaboration are particularly dependent on vibrant interaction between researchers coming from different research cultures and residing in different countries. Such collaborations are critical in fast moving and highly competitive areas such as informatics.

iCORE Visiting Professor grants fund world-class researchers to work in Alberta for between six months and two years with Alberta researchers in iCORE's target research areas.

VISITOR

Why Researchers are Attracted to Alberta

- 1) Relationships with colleagues
- 2) Excellent core facilities and infrastructure
- 3) Financial support for research teams

If we provide scientists with the technology and money to support discovery, we will continue to attract the brightest minds to live, work, discover and help grow a prosperous future for our province.

iCORE HOSTED SEVERAL VISITING PROFESSORS IN 2003-04

Dr Jan Bosch

Embedded systems are at the heart of industrial innovation. So many of the devices, appliances and vehicles we use today have computerized components embedded in them. Many of these rely on the same basic hardware, and it is only variability in software that distinguishes one use from another. The same core software can also be used. For a company in this business, the later they can leave design decisions, the greater the potential for widespread application of already developed software. By creating software product "families," the decisions that bind a certain product can be pushed further along in the development cycle.

Dr Jan Bosch, Professor of Software Engineering from the Department of Computing Science at the University of Groningen, the Netherlands, was an iCORE Visiting Professor in the Department of Computing Science at the University of Alberta in 2003 for six months. He is an expert in software product families, and works in an area of software engineering that is often difficult to undertake. He found that his research could be carried out here in Alberta because he has access to commercial software product lines through spin-off companies started by Alberta researchers: Avra Software Lab (www.avrasoft.com) and Oneware Software Corporation (www.oneware.ca).

Dr Ian Witten

Digital libraries have enormous social impact for people without access to traditional libraries found in cities throughout the industrialized world. Dr Ian Witten's work in the nonindustrialized world has been instrumental in bringing information resources, on CR-ROM, to people throughout the world as part of the Greenstone Digital Library project.

Greenstone is a suite of software for building and distributing digital library collections. The aim of the software is to empower users, particularly in universities, libraries, and other public service institutions, to build their own digital libraries. It has been developed under Dr Witten's guidance by the New Zealand Digital Library Project at the University of Waikato, in cooperation with UNESCO and Human Info NGO. The complete Greenstone interface and all documentation is available in English, French, Spanish, Russian and Kazak, and has interfaces in many other languages.

Dr Witten is an iCORE Visiting Professor in Digital Libraries at the University of Lethbridge in the Department of Math and Computer Science from July through October of 2003 and 2004. He is a Professor in the Department of Computer Science at the University of Waikato, New Zealand. In Alberta, he is working to stimulate the computer science research program, lay the groundwork for a Digital Library Centre in Lethbridge, promote collaboration with New Zealand universities, and explore a long-term relationship.

Dr Kamil Zigangirov

Dr Kamil Zigangirov, a Professor in the Department of Information Technology, Lund University, Sweden, was a Visiting Professor in High Capacity Digital Communications in the Department of Electrical and Computer Engineering at the University of Alberta for two months in the fall of 2003. He is a leading expert in the application of algorithmic error control coding, and made early and fundamental contributions to this field.

He has been invited as a visiting professor at some of the leading schools in North America and Europe. During his stay in Alberta, he enhanced the strength of the High Capacity Digital Communications lab in error control techniques. The Alberta team is exploring how to pre-empt bottlenecks and improve efficiency as network use explodes. Dr Zigangirov also provided a valuable resource for the growing number of graduate students who are specializing in error control coding techniques.

Research Clusters

iCORE is directing its support to areas in which Alberta has a chance to develop internationally recognized research teams. It is also focusing on areas where Alberta companies are active, so that intellectual property and valuable knowledge workers resulting from iCORE's investment will have compelling reasons to stay in Alberta.

Nano Cluster

Nanoscale and Quantum Informatics

NANOSCALE ENGINEERING PHYSICS

Dr Michael Brett
Dr Mark Freeman
iCORE Professors

NANOSCALE INFORMATION AND COMMUNICATIONS TECHNOLOGY

Dr Robert Wolkow
iCORE Chair

QUANTUM INFORMATION SCIENCE

Dr Barry Sanders
iCORE Professor

THIN FILM ENGINEERING

Dr Michael Brett
Micralyne/NSERC/iCORE Industrial
Research Chair

Wireless Cluster

Networks and Wireless Communications

WIRELESS COMMUNICATIONS LABORATORY

Dr Norman C. Beaulieu
iCORE Chair

WIRELESS LOCATION RESEARCH

Dr Gérard Lachapelle
iCORE Chair

BROADBAND WIRELESS NETWORKS, PROTOCOLS, APPLICATIONS AND PERFORMANCE

Dr Carey Williamson
iCORE Professor

ADVANCED TECHNOLOGY INFORMATION PROCESSING SYSTEMS

Dr Graham Jullien
iCORE Chair

ALGORITHMIC NUMBER THEORY AND CRYPTOGRAPHY

Dr Hugh Williams
iCORE Chair

HIGH CAPACITY DIGITAL COMMUNICATIONS

Dr Christian Schlegel
iCORE Professor

WIRELESS SCIENCE AND TECHNOLOGY

Dr Jim Haslett
iCORE/NSERC/TRILabs Industrial Research Chair

WIRELESS TRAFFIC MODELING

Dr Carey Williamson
iCORE/NSERC/TELUS Mobility Industrial
Research Chair

TURBO CODING

Dr Kamil Zigangirov
iCORE Visiting Professor

Intelligence Cluster

Intelligent Software Systems

HIGH PERFORMANCE ARTIFICIAL INTELLIGENCE

Dr Jonathan Schaeffer
iCORE Chair

SOFTWARE ENGINEERING DECISION SUPPORT

Dr Guenther Ruhe
iCORE Professor

REINFORCEMENT LEARNING AND ARTIFICIAL INTELLIGENCE

Dr Richard Sutton
iCORE Chair

INTELLIGENT SENSING SYSTEMS

Dr Hong Zhang
iCORE/NSERC/Syncrude/Matrikon
Industrial Research Chair

SOFTWARE VARIABILITY MANAGEMENT

Dr Jan Bosch
iCORE Visiting Professor

DIGITAL LIBRARIES

Dr Ian Witten
iCORE Visiting Professor

iCORE Collaborations

Collaborations are an endorsement by other researchers that a researcher brings value to a larger project. iCORE researchers have many connections with colleagues around the world, and are actively involved in collaborative research projects.

iCORE Quick Facts

Current partnerships with researchers

135 national and international research collaborations

Current partnerships with industry

40 researcher-industry projects



Research Connections

iCORE researchers are collaborating with each other and with researchers from around the globe.

"SERENDIPITY IS LOOKING FOR A NEEDLE IN A HAYSTACK AND FINDING THE FARMER'S DAUGHTER."

- Julius H. Comroe, a biomedical researcher

Serendipity in science: Cause for collaboration

Some benefits of collaboration are immediately apparent – more experts make for more expertise. Together they can explore gaps that might have traditionally existed between two areas of expertise. And there is more than that. There might be luck lurking in that gap. Who knows what might be found?

But it is not just about luck. As Louis Pasteur said, "In the fields of observation, chance favours only the prepared mind."

Simon Singh, a physicist, science journalist and student of serendipity, says serendipity also requires an inherent level of genius; namely, the genius to spot the deeper significance of the chance event or fortuitous observation.

What is Serendipity?

The word has its roots in *The Three Princes of Serendip*, a Persian story about three princes who had the knack of discovering things quite by chance.

The Three Princes of Serendip was published in Europe in 1557 by a Venetian, Michele Tramezzino, and eventually was translated into other languages. The British statesman Horace Walpole read the story as a child, and later coined the word serendipity in a letter dated January 28, 1754, sent to Horace Mann (envoy to Florence). Walpole wrote about learning some news quite by chance, and stated that "this discovery, indeed, is almost of that kind which I call Serendipity, a very expressive word."

He explained that this name was part of the title of a "silly fairy tale, called *The Three Princes of Serendip*; as their highnesses travelled, they were always making discoveries, by accidents and sagacity, of things which they were not in quest of..."



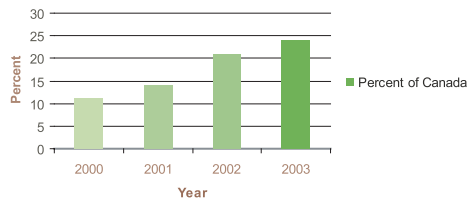
iCORE Graduate Students

Graduate students are important to informatics research in Alberta.

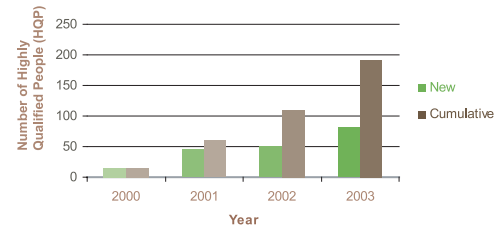
- They contribute to strong informatics research teams.
- This in turn elevates the research reputation of the universities.
- They may also develop important roles in Alberta companies and become active leaders in the emerging information and communications technology (ICT) sector in the province.

iCORE's Graduate Student Scholarships are designed to support outstanding graduate students in information science and engineering at Alberta universities. They are awarded to students who qualify for Natural Sciences and Engineering Research Council (NSERC) awards, Alberta Ingenuity awards, and other major refereed awards, including top-ranked international students.

Percentage of NSERC PGS Awards in CS and ECE held in Alberta



iCORE Graduate Student Scholarships



Where do you see yourself in five years?

Some answers from graduate students in ICT at Alberta universities:

"I would like to be running my own company."

"My main objective for the next five years is to be productive. I believe that big ideas are built from small steps and as long as I keep moving forward I will achieve great things."

"Establishing my own consulting company, likely targeting environmental projects linked to oil sands development."

"Professor of computing science at a university in Alberta."

2003-04 profile of iCORE Graduate Student Scholarship recipients

iCORE-supported graduate students represent the highest achieving Canadian students.

Number of graduate students and postdocs on iCORE research teams 269

Number of iCORE Graduate Student Scholarships awarded to date 276

Profile of active graduate student awards

	Masters	PhD	TOTAL
University of Alberta	68	62	130
University of Calgary	40	39	79
University of Lethbridge	1	0	1
TOTAL	109	101	210

ASTech Leaders of Tomorrow Award

Tim Poon (winner), iCORE graduate student with Dr Norman C. Beaulieu

Konrad Walus (finalist), iCORE graduate student with Dr Graham Jullien

"My career goal is to have a leadership role in the R&D department of a major company or university."

"I see myself building my own company."

"I hope to be a world leader in text mining research."

"Good question."

Smart student survey

24% of Canada's best graduate students in computer science and electrical and computer engineering now come to Alberta, and are recipients of iCORE Graduate Student Scholarships.

We asked them a few questions.

Students said the following factors were important or very important in their decision to study at an Alberta university.

Monetary value of the scholarship	85.7%
Faculty research areas matched my personal research interest	79.3%
Research infrastructure available	69.2%
Reputation of the supervisor	67.3%
Reputation of department faculty	62.1%
Opportunity to build my reputation	60.0%
Reputation of the university	57.6%
Research areas are linked to important issues in the ICT sector	51.5%
Community of graduate students	41.4%

Did iCORE funding affect your decision to pursue studies in Alberta?

Yes	67%
No or unsure	33%

Where do you see yourself in five years?

46%	professor or postdoc
43%	working in industry
7%	still a student
5%	entrepreneur

Do you plan on staying in Alberta after graduation?

Yes	65%
No or unsure	35%



Performance Measures

High Quality People

- 17 Number of iCORE Chair and Professor awards
- 59 Number of additional faculty members
- 269 Number of graduate students and postdocs
- 188 Number of other team members

Technology transfer

- 5 Number of spinout companies

Intellectual Property

- 22 Patents applied for this year
- 4 Patents granted this year

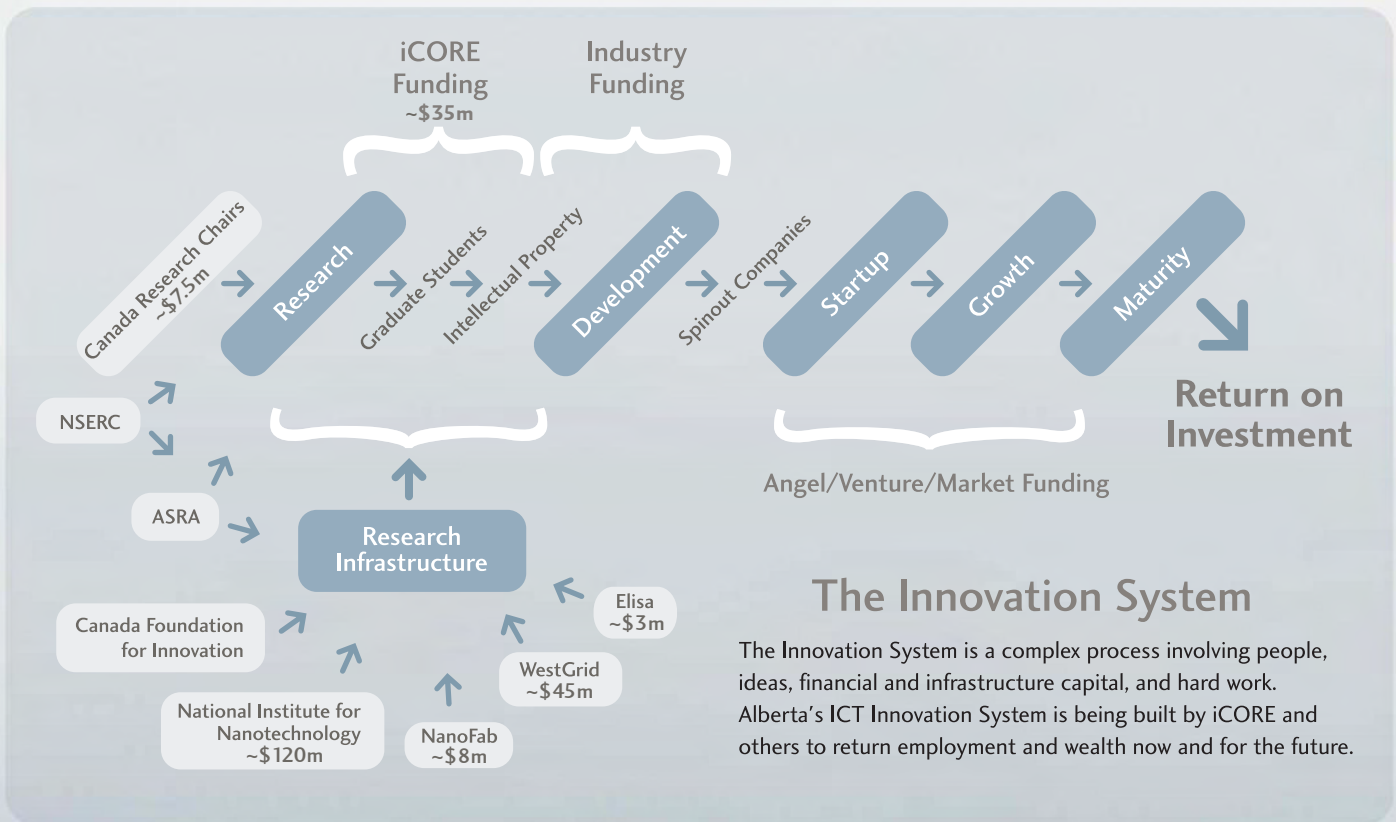
How do we measure performance?

Measuring success is an inexact science. What does success look like? Sometimes it is impossible to imagine success when you are on the flat part of a development curve, despite the fact that necessary groundwork is being done. It can be difficult to recognize success at first even when you have achieved it.

Measuring success or performance is even more challenging in the realms of innovation. By its very newness, innovation may be difficult to access by existing measures, though individuals, organizations and governments are trying to understand this complex process.

Compounding the issue in universities is that critical thinking is a cornerstone of academic culture. When a group of Swiss scientists visited Alberta back in the 1980s and talked about the pictures on the Internet they were trying to transmit, they were dismissed as being unrealistic. These scientists were the founders of the World Wide Web.

What new ideas are being developed in Alberta today that will lead to success in the future? It's difficult to predict, but exciting to participate.



The Innovation System

The Innovation System is a complex process involving people, ideas, financial and infrastructure capital, and hard work. Alberta's ICT Innovation System is being built by iCORE and others to return employment and wealth now and for the future.

Grant Programs

The Alberta Informatics Circle of Research Excellence operates grant programs that cultivate the development of world-class research teams in Alberta.

Informatics – areas of computer science, electrical and computer engineering, physics, mathematics and other disciplines related to information and communications technology – is the focus of iCORE's programs.

Areas of Interest

Networks and Communications

(wireless communications, Internet protocols, protocol design and performance analysis)

High Performance Computing

(grid computing, very large database systems and computational science)

Human and Computer Interfaces

(computer graphics, multimedia, collaboration, privacy, cryptography and secure systems integration)

Intelligent Information Systems

(artificial intelligence, machine learning, data mining and data integration)

Software Systems

(system design, development, tools, and evaluation; embedded and distributed systems)

New Architectures and Devices

(quantum computing, molecular computing and nanocomputing)

Current Grant Programs

Chair Establishment Grants (CPE Grants)

Establishing research positions in ICT at Alberta universities through Chair and Professor Establishment (CPE) grants.

Industrial Chair Establishment Grants (ICE Grants)

Establishing industry-connected research positions in ICT at Alberta universities through Industrial Chair Establishment (ICE) grants.

Graduate Student Scholarships

Supporting graduate students in computer science, electrical and computer engineering who hold an NSERC or equivalent post graduate scholarship.

Visiting Professor Grant Program

Supporting Visiting Professors in information science and engineering at Alberta universities for periods from six months to two years.

Recruitment Grants (ISPR Grants)

ICT Strategy, Planning, and Recruiting (ISPR) Grants of up to \$10,000 are available for university faculty members in Alberta to participate in the recruiting process and increase the visibility of Alberta's informatics research community.

10 Emerging technologies that will change your world

1) distributed storage

Storing data in the nooks and crannies of the Internet, protecting them from obliteration from hardware accidents

2) personal genomics

Understanding the genetic make-up of an individual, not just the human genome in general

3) microfluidic optics

Tiny droplets of fluid inside fibre-optic channels to improve the flow of data-carrying electrons

4) Bayesian learning

Dealing with the conundrum of uncertainty – how to make predictions based on inevitably incomplete knowledge of the real world

6) grid controls

Hardware and software to track real-time control of the power grid system

7) synthetic bio

Assembling genes into networks to perform almost any task their programmer conceives

8) t-rays

Terahertz radiation that uses a slice of the electromagnetic spectrum and promises to be more powerful and less harmful than x-rays

8) nanowires

Long, thin and tiny – one-thousandth the width of a human hair – needed for nanotechnology devices

9) RNA drugs

Blocking harmful diseases caused by our own errant genes by turning them off with RNA interference

10) universal translation

Enabling people from different cultures to communicate via computer-translated communication

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MIT Technology Review, February 2004

A collection of various screws, bolts, nuts, and electrical components scattered on a white surface. The items include different types of screws (Phillips, Torx, hex), nuts, washers, and small electrical components like red and blue terminal blocks. The items are scattered across the frame, with some in sharp focus and others blurred in the background.

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OUR MANDATE: iCORE is an organization that fosters an expanding community of exceptional researchers in the field of informatics – areas of computer science, electrical and computer engineering, physics, mathematics and other disciplines related to information and communications technology (ICT). It operates several grant programs to develop iCORE Chairs at Alberta universities in areas around which world-class research teams are developed. Funding is provided by the Government of Alberta and supported by partners in universities and industry.

INFORMATICS IS PART OF OUR FUTURE. It is an economic sector unto itself, and is central to progress in other areas – medical research, health service delivery, energy extraction, environmental impact reduction, agriculture, forestry and many facets of education. It is part of who we are – how we make our livings, how we interact with each other, how we express ourselves culturally – and part of how we see ourselves as progressive and innovative.

