2011

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Professor Simon Thompson

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Fellow of the Royal Society

Professor Simon Tavare

Wellcome Trust Principal Research Fellowship

Professor David G Clayton
Professor David Rubinsztein

Wellcome Trust Senior Research Fellowship

Dr Sergey Nejentsev

MRC Senior Clinical Research Fellowship

Dr Stefan Marciniak (March 2012)

Pilkington Teaching Prize 2011

Dr Mark Gurnell
Dr David Perry

2011 Medical Research Society Young Investigator award

Dr Ferdinandos Skoulidis

Juvenile Diabetes Research Foundation's David Rumbough Award for Scientific Excellence

Professor John Todd

Ian McDonald Award of the MS Society of Great Britain and Northern Ireland

Professor Alastair Compston

Robert H Pudenz Award for Excellence in CSF Physiology

Dr Marek Czosnyka

Colworth medal of the Biochemical Society

Dr Akhilesh Reddy

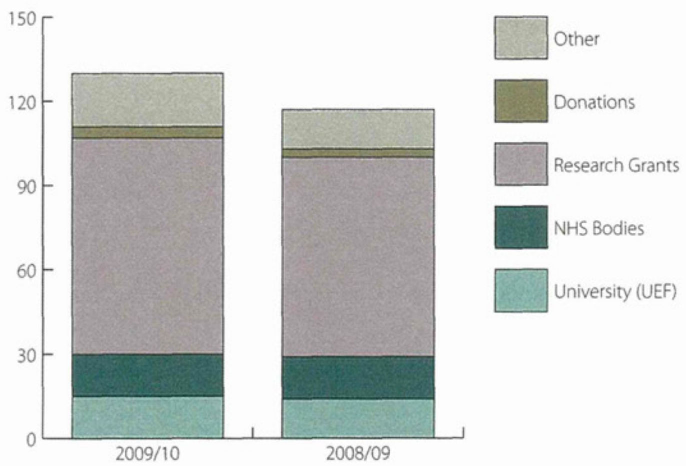
Membership of the European Molecular Biology Organisation

Professor David Owen
Professor David Ron
Professor David Rubinsztein

Finance report

The Clinical School at a glance

Total income increased to £131m in the last financial year (2009 – 10), compared to £117m in 2009. Expenditure is generally incurred to match the level of income, although new permanent endowments received during the year increased the School's total funds to £107m – the vast majority of which are held in specific trust funds which are invested in the Cambridge University Endowment Fund.



Research grant expenditure increased by 10% from £71m in 2009 to £77m in 2010. A significant proportion of this was due to increased activity with the Medical Research Council, as well as continued expansion in the charities sector. Both the Comprehensive Biomedical Research Centre partnership with Cambridge University NHS Foundation Trust and the Collaboration for Leadership in Applied Health Research and Care (CLAHRC) with Cambridgeshire and Peterborough NHS Foundation Trust underpin the growth in UK Government research income. Research expenditure accounted for 59% of School activity, compared to 23% for the University as a whole.

The School continues to receive support from local NHS organisations, particularly those associated with Cambridge University Health Partners. The School has commenced discussions about the future of the Anglia Clinical Academic Reserve which is funded until March 2013 and underpins a significant number of the School's academic positions.

2009–2011 under review

Growth in research grant income

Despite the economic downturn experienced since the last report, the School has continued to benefit from growth in research funding from all major sponsors, noticeably the Medical Research Council and UK charities, which have perhaps been less affected than other areas by funding reductions over that period. Research funded by the European Commission represents a potential area for future growth, although UK charities still provide the majority – 47% – of the School's research income.

Building developments

During the last two years, the West Forvie Building has been occupied by researchers from different departments across the School – particularly those working in stem cells and cardiovascular medicine. The refurbishment work to the University's Herchel Smith Building has been completed and the building is now in full operation, providing collaborative research space for the University, Medical Research Council and the NHS. Further expansion plans are currently being finalised for space in the MRC's new Laboratory of Molecular Biology and in the NHS Blood and Transplant Centre, whilst planning continues for the Cambridge Cardio-Respiratory Institute associated with the move of Papworth Hospital to the Campus.

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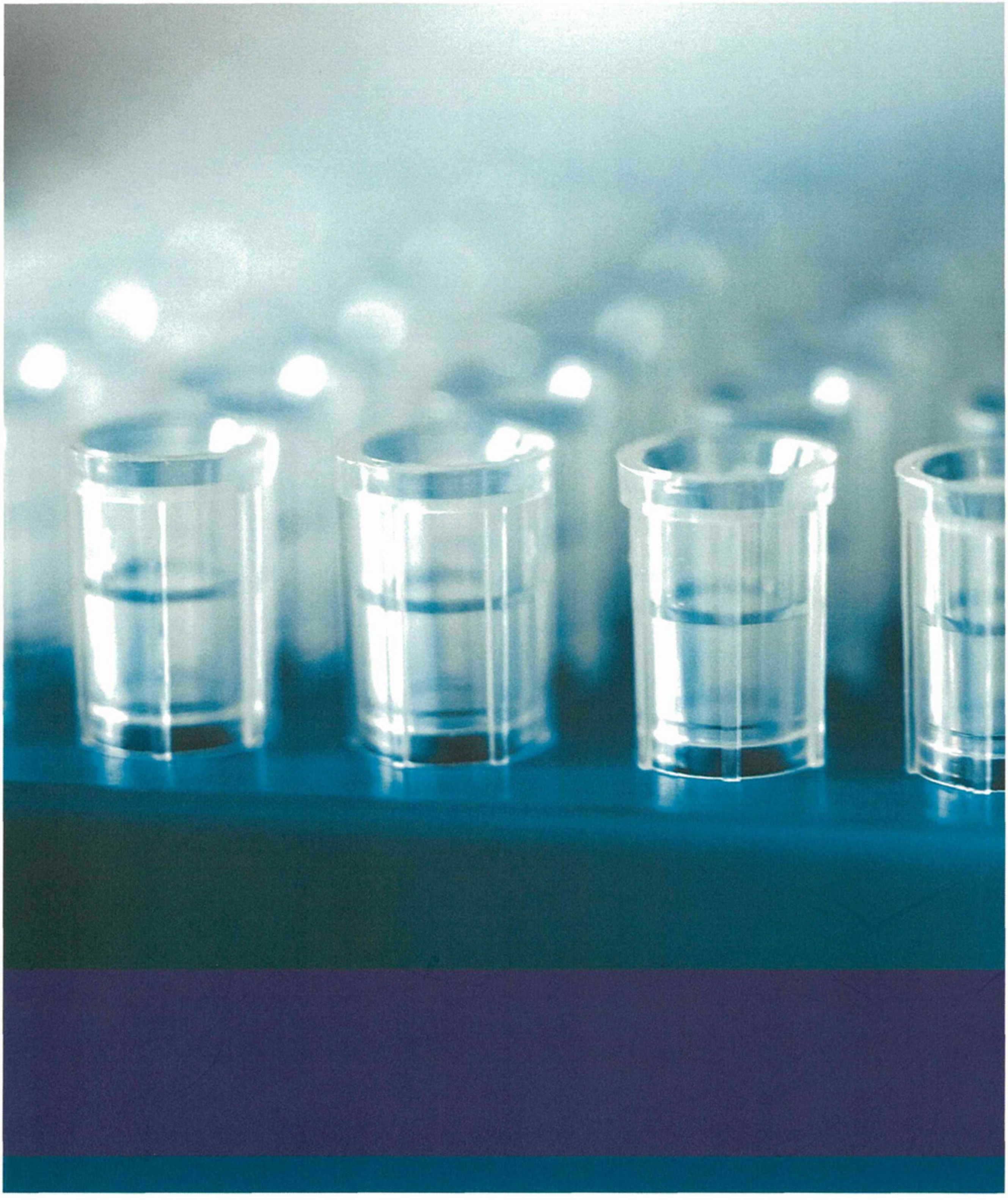

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Research Perspectives

Our post-human future

uOttawa

Mona Nemer
Professor and Vice-President, Research

Humanity 2.0

Adenine. Cytosine. Guanine. Thymine. It's still rather hard to believe, but on June 26, 2000, the entire human genome—over 3 billion pairings of these four base molecules—was decoded by the Human Genome Project. Little more than ten years later, due to continued groundbreaking scientific advancements in biotechnology, subjects normally relegated to the pages of science fiction such as human perfection and even immortality have become topics of renewed interest and serious debate.

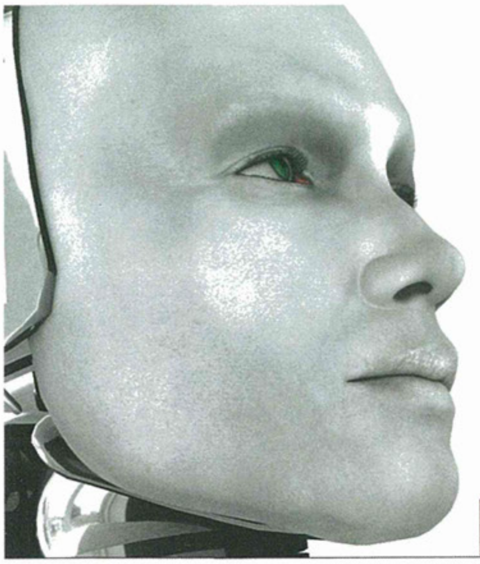
The quest for human improvement through biomedicial means indeed appears to be unstoppable in the developed world, and the promises of transhumanism—slowing or eliminating aging, and greatly enhancing human intellectual, physical, and psychological capacities—are now much more tangible and achievable goals than ever before.

The imperfect human clay that has thus far given shape to our minds and bodies is now in the midst of profound potential transformations. With startling advances in robotics, artificial intelligence, telecommunications, and genetic engineering, to name only a few, we are entering an age where technology isn't merely an extension of ourselves, but a part of ourselves.

Yet this drive towards the "post-human" has also raised red flags and given rise to heated discussions, debates, conflicts, and a great deal of research on the future of the human species. Should there be a limit to human improvement? Are "upgrades" going to be available for everyone, or only the rich? How far are we willing to go in order to change ourselves? Are we ready for these changes? Will they alter human nature?

In this issue of *Research Perspectives,* "Our post-human future," our researchers will explore these questions and other key issues associated with emerging technologies, in light of the game-changing developments that are occurring—both in their respective fields, and in their research here at the University of Ottawa—developments that promise to fundamentally change individuals, communities, and perhaps even humanity itself.

It is my hope that the thought-provoking discussions presented in this issue give you the opportunity to reflect on our post-human future.



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Robots and the rest of us

by Tim Lougheed

Just as we now spend a large part of our lives interacting with electronic equipment that helps us communicate with one another, we will soon be interacting with robots and learning how to communicate with them.

If Lewis Carroll had been more mechanically inclined, *Alice in Wonderland* would likely have resembled a trip through **Emil Petriu**'s laboratory in the University's School of Electrical Engineering and Computer Science. All around the lab are scattered the carcasses of automated wheelchairs, vacuum cleaners and lawnmowers, along with the skeletons of would-be humanoid robots.

Meanwhile, Petriu eagerly shows off one of his latest purchases, which is far from high-tech. He holds an anatomically correct model of a human skull, complete with a spring-loaded jaw that authentically replicates the movement of the lower face.

This feature is what appeals to him as he plans to mount a set of actuators on various parts of the skull surface, which will then be covered with an elastic skin. The goal is a mechanical yet highly lifelike face, capable of representing human expressions ranging from surprise to anger.

Petriu and his colleagues are at the forefront of an emerging society that will be populated not just by people, but also by machines—and combinations of both. They are hard at work designing some of the fundamental mechatronics elements that will usher in this development, such as intricate prosthetic limbs and sensors that can convey large amounts of information through a sense of touch.

"We are using biology as our source of inspiration, noting that human beings are most comfortable interacting with devices that move and respond the same way we do," the professor says. Nevertheless, Petriu sets aside the worst fears of science-fiction writers, insisting that we will always be able to tell even the most lifelike robots from human beings. Nor does he even believe that robots need to look like human beings. Instead, they must be user-friendly in some important ways.

For instance, a prosthetic hand may be able to replicate all the functions of the original, but if it feels cold, it will never seem like an adequate replacement. Petriu suggests that it would be relatively simple to warm up the surface of the prosthesis to match our skin temperature, and so make it feel more like a part of the body.

A similar consideration will apply for the robots that are expected to be put into service for nursing or home-care assistance. If a robot has to come into physical contact with a person, the interaction will be much more comfortable if their "skin" is warm to our touch.

Petriu makes a similar case about providing a robot with a detailed face, regardless of how little the rest of the machine might resemble a person. He cites no less an authority than Charles Darwin as one of the first scientists to identify the primary value of facial expression for interpersonal communication. A field that later created a formal coding system to link various expressions with particular combinations of muscles. This same system provides the basis for programming the movements of the artificial skin over Petriu's newly acquired test skull, so that the resulting expressions strike us as familiar and authentic.

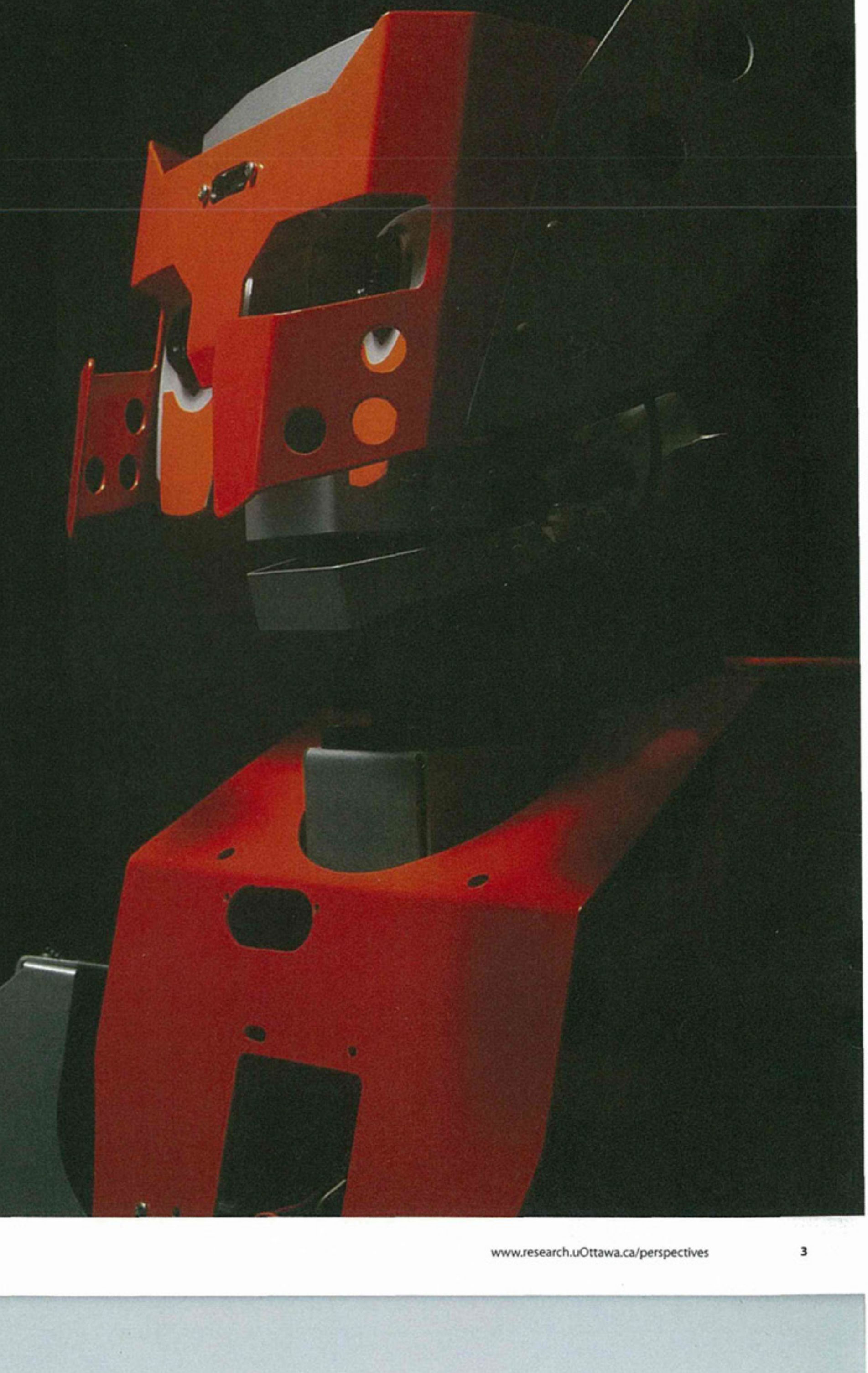
Petriu considers this step a major leap toward incorporating robots into networking technologies that are shaping how we socialize. "Our society is becoming more and more disconnected," he suggests, pointing to a new generation of individuals who spend much of their time socializing without actually being in the presence of other people. If those individuals find that they miss the physical companionship of others, the presence of a robot could meet this need—without any of the complications of a typical human relationship. "We are, after all, still social beings," Petriu observes.

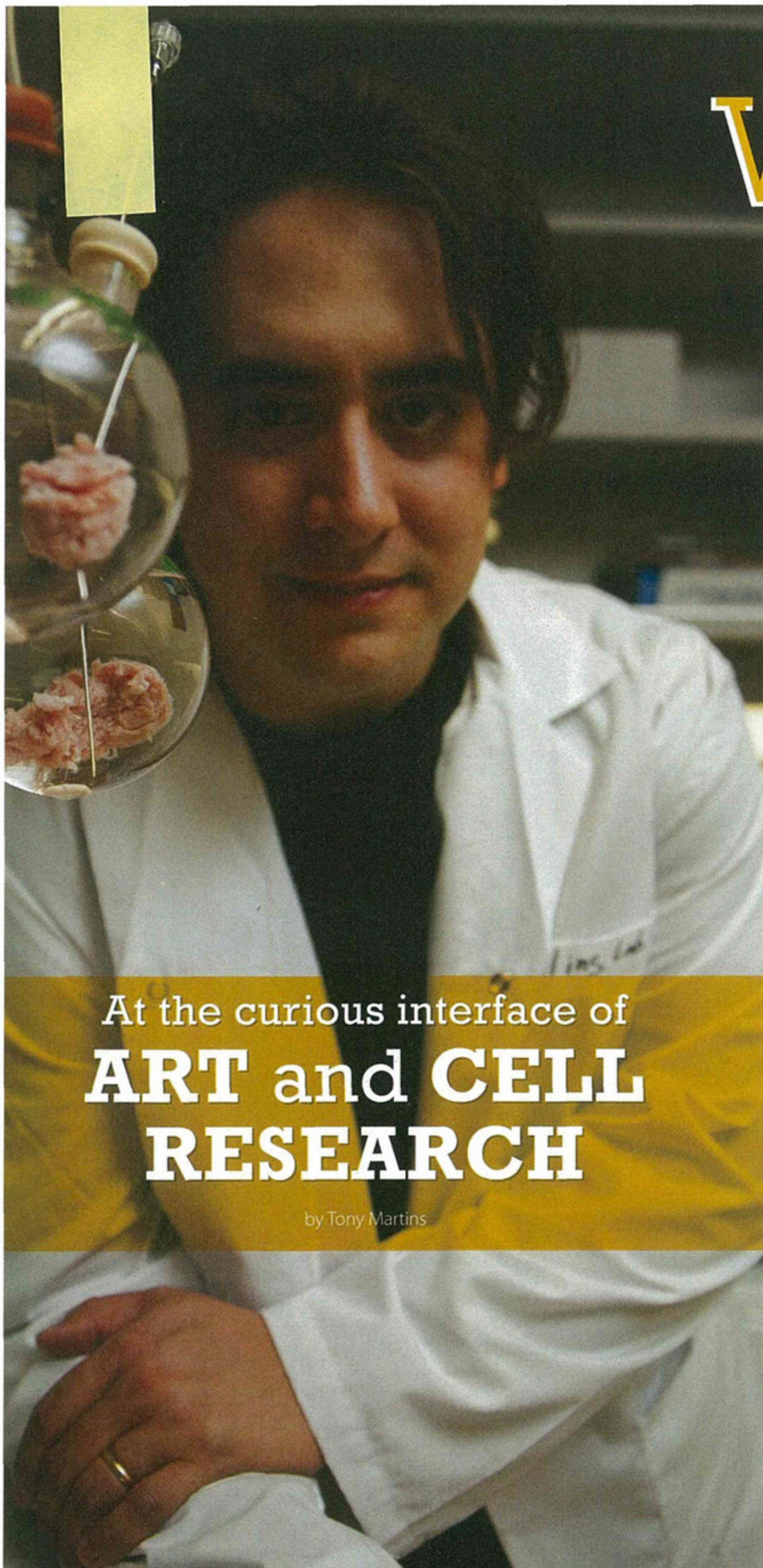
In fact, Petriu believes, this relationship may ultimately become a symbiotic one—with robots acquiring new human-like capabilities, even as we obtain new services from them. Such an idea may seem surprising, or even disturbing, for those of us who still inhabit a largely robot-free social sphere, but from Petriu's cyborg-society vantage point, it makes perfect sense.

"You can do this work theoretically, but you get a different perspective," he says. "We have real things here, real problems. In trying to solve them, you wind up making real contributions." RP

"we are using biology as our source of inspiration."

- emil petriu





At the curious interface of ART and CELL RESEARCH

by Tony Martins

What predicts the function and fate of a living cell? **Andrew Pelling** and his team work and play at the interface of art and biophysics to examine rarely explored factors in cell function equations—the mechanical factors.

As a Canada Research Chair cross-appointed to the physics and biology departments at uOttawa, Andrew Pelling heads up a busy lab on the cutting edge of multidisciplinary cell research. Pelling also makes time to pursue related interests in bioart—that strange conjoining of imagination and hard science.

Pelling often collaborates with German media artist Anne Niemetz and was a visiting professor this spring at SymbioticA, an artistic laboratory of life sciences at the University of Western Australia.

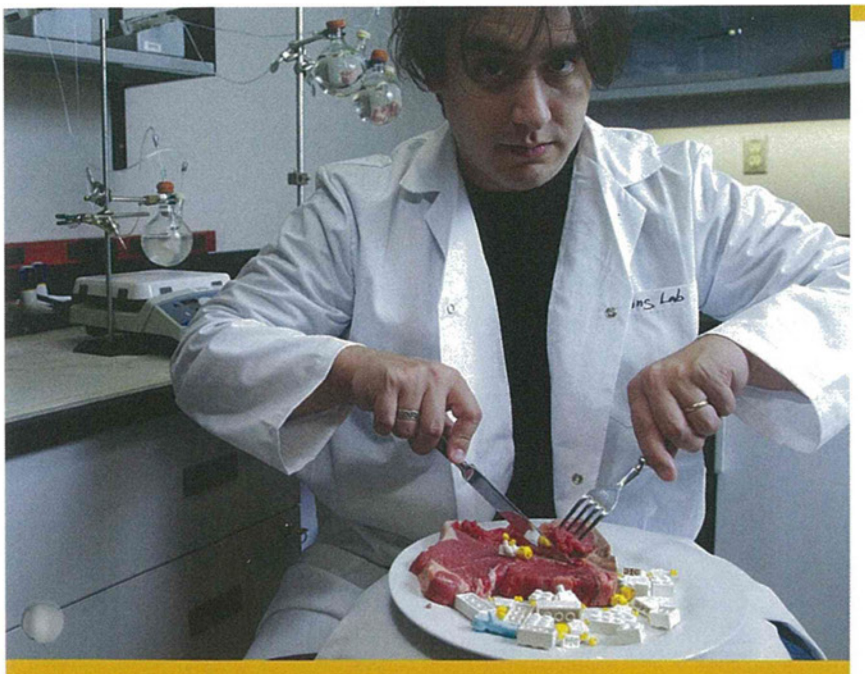
"Admittedly, the boundaries between all these projects and disciplines become blurry," says the inquisitive researcher. "Often my students are helping out on the bioart stuff as well," Pelling says. "It's fun for everybody."

Although the outcomes of his research may hold serious benefits for human health and longevity, the words "fun" and "play" are important in Pelling's vocabulary.

"I love exploratory, curiosity-driven research, and I think I'm good at working that way," he explains. "The world needs specialists, but there is still a lot of room for play—especially in a lab… I think this only creates more interesting ideas and innovations."

One way that Pelling and colleagues seek to innovate is through an exploration of how the mechanical forces at work in the movement of muscles, organs and blood affect cells. They examine such questions as the impact of the stretching and contracting of lung tissue during breathing and of high blood pressure on the aorta.

"It's been shown, for example, that stem cells respond to the stiffness of their microenvironment," Pelling explains. "We can cause them to follow different fates just by changing how soft or stiff their microenvironment is. No drugs, no chemicals, no gene transfer. Just mechanics regulating stem cell fate."



"I love exploratory, curiosity-driven research, and I think I'm good at working that way. The world needs specialists, but there is still a lot of room for play—especially in a lab."
– Andrew Pelling

"Some require physical stretch—not a biochemically induced conformational change—to expose a binding site in order to do their job," Pelling says. "The shape of many cellular structures, for example the flagella, have evolved the way they have because any other shape would not have worked. This is due directly to the physics of the environment."

Among the obvious applications for Pelling's research are the detection of and treatments for diseases that stem from inhibited mechanical properties, genetic mutations or biochemical cues. The less obvious applications, however, are what really pique this scientist's curiosity.

"What is most interesting to me is the use of mechanical, topological and physical stimuli to dictate or control cell fate, differentiation and morphogenesis," Pelling states. "The end game is designer organs or hybrid bio-silicon-electronic devices, not necessarily for transplanting into humans but as tools."

To indulge these curiosities, Pelling's lab applies a range of cellular manipulation techniques, such as gene insertion to tag proteins, as well as the use of scanning probes, optical microscopes and a range of custom-built "stretchers."

Pelling is quick to point out that mechanical forces affecting cells are not necessarily a bad thing. In fact, the opposite is usually true. Our bodies require these mechanical dynamics to function normally.

"Where things get problematic," adds Pelling, "is when a cell loses its ability to respond properly to these mechanical forces and cues or loses sensitivity to the properties of the mechanical microenvironment."

In addition, when forces within the body become unbalanced (as happens with high blood pressure), cells can respond adversely.

"The effects of higher blood pressure are numerous," Pelling explains, "but one is that the pressure weakens the structure and mechanical properties of the aorta—often resulting in aneurysm."

Pelling's mechanical investigations are somewhat unusual because science has traditionally focused on biochemical factors, such as the genome, when studying cell behaviour.

"Although a tremendous amount of information has come from these efforts, the picture is extremely one-sided, and we are missing a wealth of mechanical information," Pelling contends.

"We now know, for instance, that many proteins have evolved to be activated by a physical force," says Pelling.

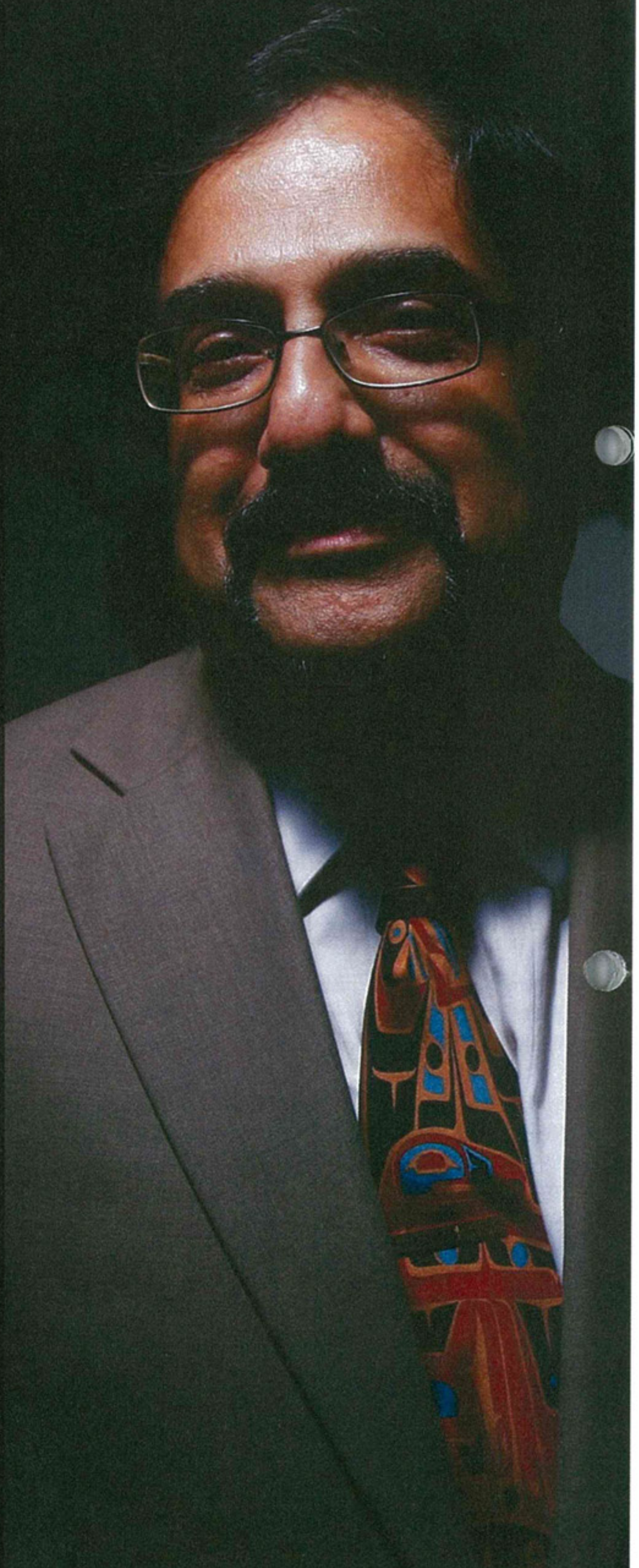
"It's amazing how poking, pulling and stretching these things has so many effects, all of which are extremely complicated," says Pelling. "They are really naive, even simplistic, experiments that have immensely complicated outcomes. That's what's so fun about this stuff."

"I say this all the time," concludes Pelling. "I wish I had more people in the lab because we are always stumbling across interesting phenomena and don't have enough people to pursue all the possible leads. It seems like every week there is an interesting result from my group that blows my mind."

What kind of a post-human world might Pelling envision? He says, "I mean, why just stop at a perfect copy of a human heart? Not that making such a thing is trivial, to begin with, but what about creating a new organ we don't currently possess? Maybe an organ with four small lungs, an IP address and a Twitter account. I know this sounds completely mad, but why stop where human evolution did?" RP

DISCRIMINATION shouldn't run in the family

by Matthew Bonsall



Law professor **Errol Mendes** calls for a regulatory framework to protect human rights in the new age of genetic testing.

A simple blood test could soon see Canadians being turned down for a job, passed over for a promotion, or refused insurance. Already, evidence is mounting that being predisposed to developing certain diseases carries more than just health risks: it could also affect their civic rights.

A 2009 study from the University of British Columbia surveyed Canadians at risk of developing Huntington's—a degenerative brain disease with no cure or treatment. Forty percent of the respondents said they had experienced discrimination because of their risk of developing Huntington's, though none of the respondents showed any signs of the disease. Their family history was cited as the main reason for discrimination.

Since then, genetic testing has only gathered momentum. Today, Canadians can bypass doctors and use direct-to-consumer genetic screening for as little as $200. But what society will do with the results poses some troubling questions. In the future, will people, even entire ethnic groups—be categorized into social and economic streams that predetermine their lives?

"If we do not start thinking seriously about the potential for genetic testing to result in social engineering, then what seems like a science fiction dream today may turn into a nightmare tomorrow," says Errol Mendes, a professor in the Faculty of Law at the University of Ottawa. He also serves as a commissioner on the Ontario Human Rights Commission.

Genetic discrimination is already well documented in the United States, where genetic testing has been available for longer. The Council for

Responsible Genetics has recorded more than 500 cases of genetic discrimination, where people have been barred from employment, or lost their health and life insurance based on a perceived genetic abnormality.

Mendes' experience blending theory and practice to study human rights questions as a law professor and human rights commissioner has him deeply concerned by the pace of change and society's ability to protect people. "By the time a case comes before the Ontario Human Rights Tribunal of Ontario, four or five years may have passed since the initial complaint," he says. "By then, it can often be too late to help someone who has been passed over for a job, or denied insurance."

The marriage of cheap genetic tests and the power of the Internet also concerns Mendes. "We could face grave threats to privacy from appropriation of confidential information on the Web."

Despite his misgivings, Mendes is quick to acknowledge that genetic testing holds huge promise for healthcare policy and personal health choices. That's why he suggests that we should take certain steps to ensure that genetic testing is a blessing, not a curse.

In Canada, scientific progress appears to be rendering legislation outdated. *The Canadian Human Rights Act* was written in 1985 and the Human Genome Project, the international research project to map human DNA, began in 1989. In the last session of Parliament, a private members' bill, C-536, asked to add genetic characteristics to the Act. Mendes supports this approach but cautions that it won't be enough by itself.

Another aspect of genetic discrimination, he points out, is that substantial numbers of people who have suffered from it may be afraid to start the process out of fear that it may endanger their future job prospects or access to insurance. "Support organizations for diseases such as Huntington's have received reports that their members have suffered genetic discrimination but have not wanted to trigger the human rights process. This means we need a regulatory framework to deal with genetic testing."

Several European countries, including Austria, Belgium and Norway, have mandated that insurance companies cannot ask for predictive testing or ask for results already in existing medical files. Mendes says that a comprehensive framework of stand-alone legislation could include establishing a specialized oversight body, along the lines of the Human Genetics Commission. He also points to the *United States Genetic Information Non-Discrimination Act*, passed in 2008, and the efforts of at least 45 states to regulate the use of genetic data, including 35 states who explicitly prohibit genetic discrimination in employment.

"There is no doubt that pre-emptive regulation is far better than dealing with a potentially huge backlog of individual complaints before human rights tribunals or privacy commissioners," Mendes says.

No matter what course Canada chooses to take, equality will have to remain at the core of our understanding of human rights if we are to safely unlock the huge potential of genetic testing. "If, as has been predicted, at birth all humans had a genetic profile which will predict their entire life's health history, that would pose the ultimate test of society's commitment to the ultimate test of human dignity—to be fully human is not to be genetically perfect." RP

GENETIC TESTING AND YOU

We all have dozens of genetic differences that could increase or decrease our chances of developing a disease like cancer, diabetes, heart disease, multiple sclerosis or Alzheimer's. Knowing the risk could help improve your health.

But if you opt to get yourself tested, could it mean that your results could be used to justify higher insurance rates? Or deny coverage? The answer is yes.

"The industry's policy is that insurers would not require an applicant for insurance to undergo genetic testing. However, if genetic testing has been done, and the information is available to the applicant for insurance and/or the applicant's physician, the insurer would request access to that information just as it would for other aspects of the applicant's health history."

– Canadian Life and Health Insurance Association position statement on genetic testing, April 2010

PROCEED WITH CAUTION

Why technology should undergo in-depth analysis

by Dana Yates

Technology surrounds us. When we text, surf, download apps or upload files, we are constantly interacting with technology. But before buying the latest gadget we should ponder its impact, says **Rocci Luppicini**.

An associate professor in the Department of Communication, Luppicini examines various facets of technology, including social networking, virtual communities, the relationship between identity and technology, and the influence of technological advances on education and work. He is also interested in technoethics, which focuses on the ethical aspects of technology in life and society.

In fact, Luppicini is editor-in-chief of the *International Journal of Technoethics,* and editor of the upcoming *Handbook of Research on Technoself: Identity in a Technological Society.* A self-described "technology enthusiast," he has a big-picture perspective of high-tech innovations. And there are countless ultra-modern devices and capabilities to consider—from bionic exoskeleton suits to embryo screening, and everything in between.

"We must have a sobering outlook on technology," Luppicini says. "That way we can capitalize on the opportunities that technologies provide, and counteract their potentially negative consequences."

Consider, for example, the widespread use of the Internet and smartphones. They keep us accessible to friends and family, but the trade-off is that it's now possible to work around the clock. This loss of leisure time (the "good life," according to Luppicini) blurs the boundary between the professional and personal spheres—which can lead to workplace burnout. As well, our continually evolving relationship with technology has contributed to the development of humans as "technoselves."

"The close connectedness of technology within human life and society is a complex state of affairs," Luppicini says. "Originally, we used technology to build our homes and plough the fields. Now technology is part of the human condition. It's transforming how we live, and even altering our human makeup."

That last aspect is one Luppicini is particularly concerned about. Examples include laser eye surgery, cosmetic procedures, reproductive technologies, and implanted microchips that monitor brain activity. And while these advancements offer benefits—enabling infertile couples to have children, and leading to new drugs for neurodegenerative diseases—Luppicini says the "inward turn of technology" also raises tough questions. Where do we draw the line? Who is morally responsible when technologies go awry?

As science progresses, for example, a number of helpful biomedical devices already exist, such as artificial hearts, prosthetic limbs, and cochlear implants. In future, perhaps cyborgs will become increasingly commonplace. But Luppicini wonders what would happen if someone with a neural implant committed a crime. Where would the blame lie: on the individual who physically performed the act, or on the biomedical engineers who created the implant?

These queries, and others like them, form the basis of the interdisciplinary field of technoethics, which considers the responsible use of technology. It also helps to guide ethical problem-solving related to the development of

> "We must have a sobering outlook on technology. That way we can capitalize on the opportunities that technologies provide and reverse their potentially negative consequences." - Rocci Luppicini

new technologies. For instance, thanks to technoethics, it's now widely accepted that engineers and designers are partly responsible for the impact of their inventions.

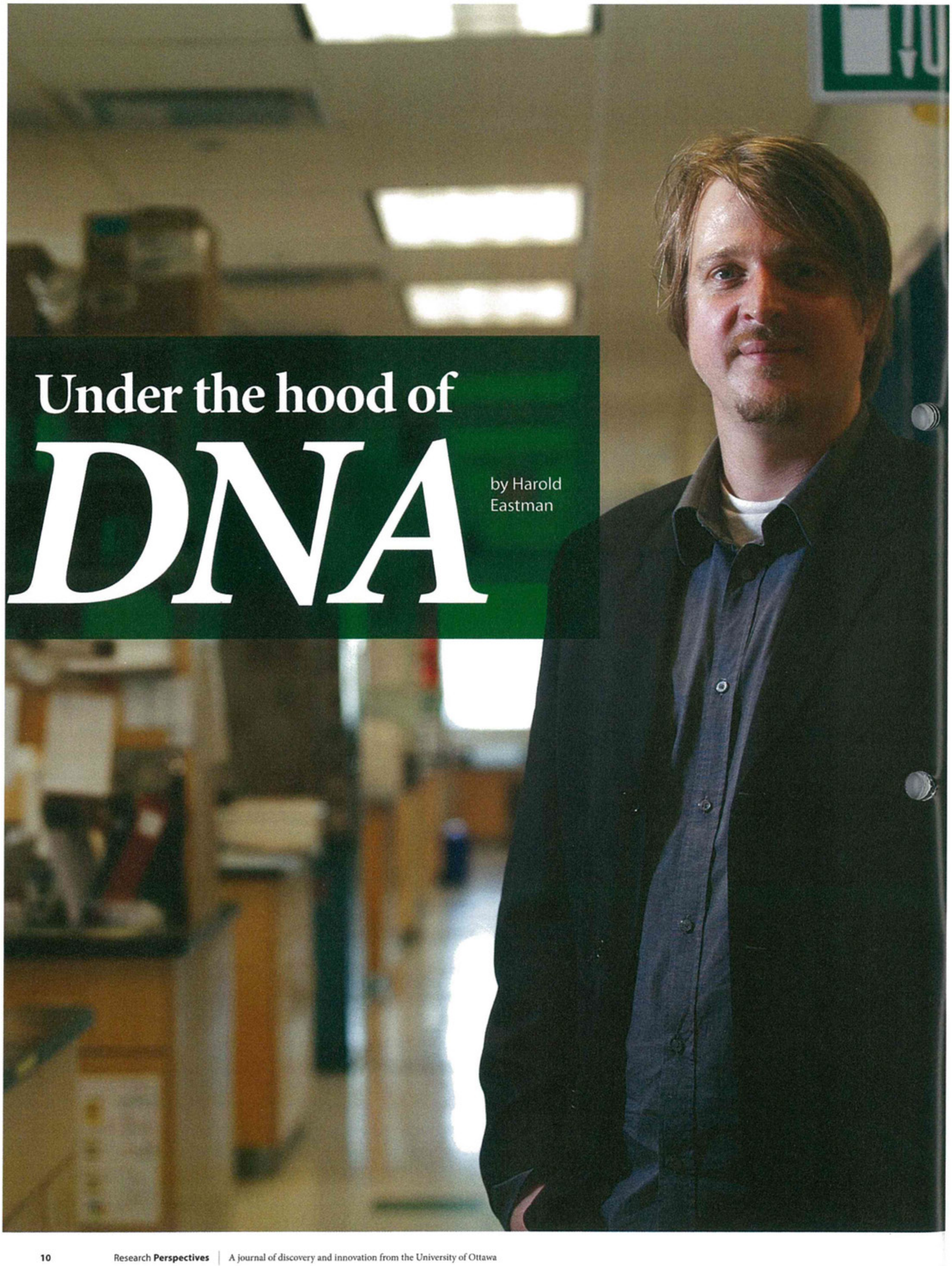
But that doesn't mean forethought is happening in every area of technological innovation, says Luppicini. "We're fascinated with bells and whistles, and in our consumer culture, new technologies are viewed as status symbols," he points out. "For that reason, no one wants to ask questions. You risk being seen as outdated or standing in the way of progress."

As a result, society delays discussions about the misuse or abuse of technology—often until after disaster strikes. Luppicini points to the recent nuclear crisis in Japan, deaths related to police use of Tasers, and issues of cyber-bullying and online identity theft.

So what can the public do to prevent problems in the future? "Teach media literacy to children so they can spot, for example, Internet luring techniques. Also, ask more questions—of yourself, corporations, the government and the military," Luppicini says. "Ask if a new technology is worth it. And if so, what are the drawbacks?"

Of course, he acknowledges, this process isn't easy, given the breakneck speed of technology development. But without critical assessment from a social and ethical standpoint, Luppicini says, we risk losing the most important thing of all: the human race.

"We're now at a critical mass where technology could be used to destroy the planet and ourselves," he warns. "We need to step back to step forward." RP



Under the hood of DNA

by Harold Eastman

The human genome has been fully mapped, but working with it is still a daunting task. **Mads Kaern** is devoted to finding out how all the genetic components interact and respond as a system.

Here is possibly the most difficult, inefficient and just plain bone-headed way to learn how a modern car works: take out one part at a time, and see what happens.

Yet according to Mads Kaern, this is more or less how genetics research—by necessity—used to be done. "In the past, we analyzed genes by removing them, and then seeing what the effect was," he explains. "That's a bit like trying to understand how a car works by pulling out a cable."

The approach doesn't work for cars, because they comprise many complex systems that communicate with each other and modify each other's behaviour, based on changing conditions. Information from a sensor in a labouring engine causes the automatic transmission to downshift on a hill; a signal from the accelerator pedal tells the fuel injectors to go faster. To really understand that shiny beauty in the driveway, you have to know how all those components interact and respond as a system when the car is in motion.

That's roughly what professor Kaern is trying to do with genes.

Somewhat like the parts in a car, interacting components within our cells control how our genes operate. These "gene regulatory networks" consist of proteins, molecules of the chemical RNA and even other genes. In response to various kinds of stimuli, the networks generate signals that determine how (or if) a particular gene will "express" itself—whether it will trigger the creation of a protein or an enzyme, or if it will signal another gene to act, or even do nothing at all.

And the outcome isn't trivial. The way our genes express themselves controls to a great extent whether we're healthy or sick. The more we understand how gene regulatory networks operate, the more control we'll have over a multitude of diseases.

Kaern focuses on understanding the principles that govern the design of these networks. But working with the human genome, mapped as it may be, is still a very daunting task. "It's very difficult to analyze these systems in a human setting," Kaern explains. "We haven't identified all the genes yet, and we haven't identified all the factors that contribute to these systems."

To simplify the problem, he's currently working with yeast—a single-celled organism with a relatively small genome. And he's using the emerging tools of synthetic biology to create simple artificial regulatory networks he can introduce into yeast cells, and then observe the results. "High-throughput" technologies enable him to create, test, and analyze thousands of variations at a time.

But—of course—there's a further complication. To return to the auto analogy: car components can be relied on to work the same way over and over again (until they wear out). In the language of statistical science, their behaviour is deterministic. Genes are less predictable. Even if the signals from the regulatory networks are the same, there isn't a certainty that a given gene in cell A will respond the same way as its counterpart in cell B—there's only a probability.

To take this into account, Kaern uses sophisticated statistical approaches developed for the study of physics—a discipline in which he is cross-appointed at the University of Ottawa.

The goal, of course, is not simply to understand regulatory networks. "We want to be able to modify these networks so they can respond to the specific signals we choose, and trigger the behaviours we want," Kaern explains. "And we want to be able to design new regulatory systems too."

Some of the early applications he foresees include engineering specialized organisms to create biofuels out of different kinds of waste products. But the holy grail is human application. "If you could design and deliver the appropriate regulatory network to cells, you could trigger drug production right inside cancerous cells," he says.

"If you could design and deliver the appropriate regulatory network, you could trigger drug production right inside cancerous cells."

– Mads Kaern

Delivering these custom-designed networks will be a big challenge. Gene therapy is the enabling technology that will make it possible, yet barriers in that field are still formidable. Nevertheless, Mads Kaern is confident that in perhaps a decade, when his research is ready for human application, gene therapy will be ready too.

And that's going to mean that many of us will eventually be able to get the genetic overhauls we need to keep us purring like a Rolls along the highway of life. RP

More HUMAN than HUMAN

PREPARING FOR A POST-HUMAN FUTURE

by Sean Rushton

The Republic, Utopia, Brave New World, Avatar—Exploring fantastic societies of the future has been a hallmark of great fiction for centuries, and emerging technologies have influenced these speculative works since the Industrial Revolution. However, what is emerging from today's science and technology not only promises to fundamentally change the world around us, but to transform ourselves as well. The time has come to broaden the dialogue the authors began—we all have a stake in our post-human future.

Marc Saner has been pursuing multidisciplinary work at the intersection of science, ethics and governance for the better part of a decade and keeping a very close eye on game-altering technological developments. He believes that it's one thing if technology changes objects around us—like computers, cars or hockey sticks—but quite another if these changes affect our bodies and minds.

On the threshold of advances in genetics, neurotechnology and robotics that promise (or threaten) fundamental changes to us and how we see ourselves, Saner believes that the clouds of a perfect storm between science and decisions about humanity's future are forming on the horizon.

"To me, this storm is just as much an opportunity as it is a threat," says Saner, inaugural director of uOttawa's Institute for Science, Society and Policy (ISSP), and associate professor in the Department of Geography. "What is now required is to become explicit about where we want to go, to discuss which risks are necessary or worth taking and to put the topic of moral limits on the table."

From new prosthetics for people with disabilities to improved therapies to combat illnesses of the mind and the mapping of the human genome, we are undoubtedly increasing our ability to "fix" ourselves—both inside and out, significantly extending human life and improving human performance across the board. But important social questions arise from this re-imagining of what it means to be human, including what the limits should be when it comes to human improvement and who may (or may not) have the means to afford possible human perfection.

"The potential of neurobiology and neurotechnology, for example, are real game changers," says Saner. "A lot of benefits will come out of this research, but we will also have to increasingly

"We may never be able to control broad technological developments, but we can steer science and technology by allocating subsidies smartly, regulating the most important aspects of these developments and planning how we will adapt to a new technological world." — Marc Saner

face the reality that our consciousness is not what it seems to be, that personalities and capacities can be changed and that we may continually have to redefine our concepts of free will and responsibility."

Saner's interest in the impact of technology on society began when he worked as a risk assessor and regulator of biological and chemical products—an activity that brings home how difficult it is to combine scientific predictions, values and social considerations into practical decisions. These experiences directly led to his interest in the ethics of emerging technologies, risk management and broader governance issues. He is especially interested in the interface between scientists and decision-makers and has worked on how to combine risk and ethics in public debates, decisions and policies.

"We may never be able to control broad technological developments, but we can steer science and technology by allocating subsidies smartly, regulating the most important aspects of those developments and planning how we will adapt to a new technological world," says Saner. "All this requires dialogue, and I think we need to start now."

Saner doesn't believe in wasting any time. As director of the ISSP, he is busy bringing together multidisciplinary teams to address issues at the interface of science and society. The ISSP recently hosted an international conference on the topic of synthetic biology and its policy implications. It is also a partner in the development of the 13th annual Frontiers in Research lectures, *Our Post-Human Future,* designed to spur debate on these pressing socio-technological issues.

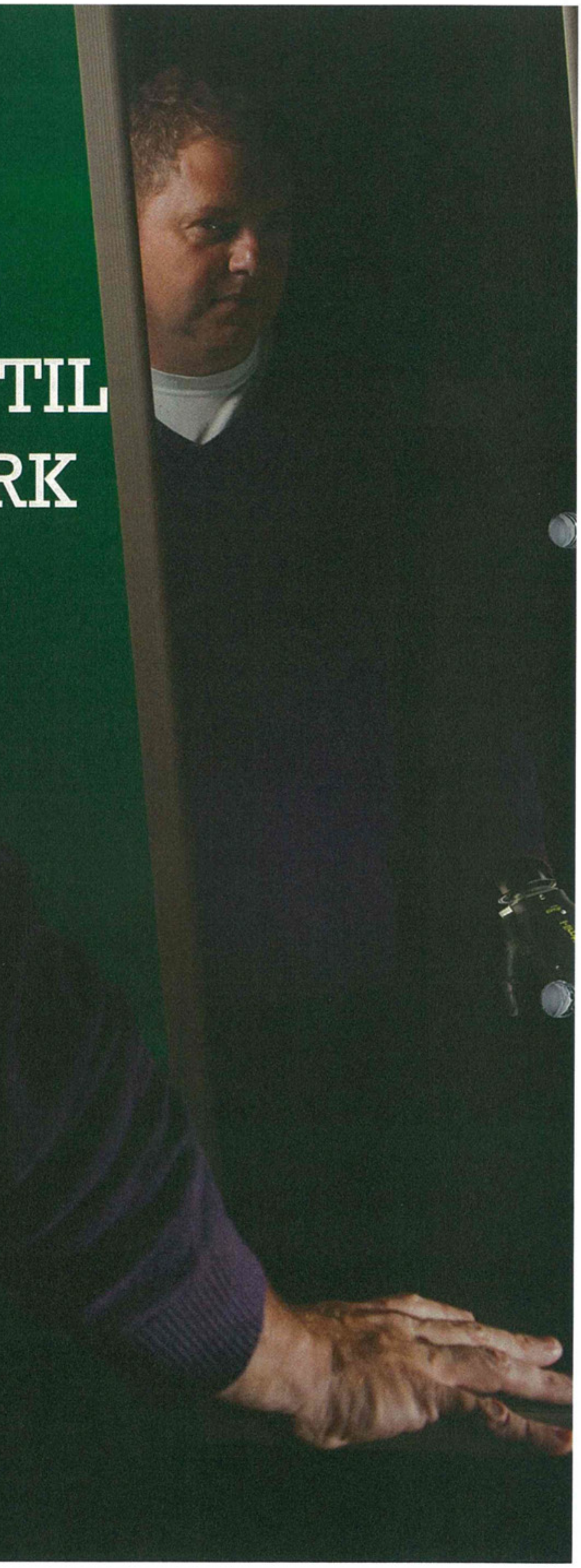
"Emerging technologies and scientific advances promise to radically alter the self, whether we conceive of the self in terms of our mental faculties or our bodies," insists Saner. "Some technological developments can be regulated by the marketplace, but the modification of human nature itself is too big an issue to leave to the 'invisible hand' of the economy."

Saner is convinced that we must engage in societal direction-setting on such big issues before—or at least while—technology is developed, not after the fact. "So, yes, let the scientists and engineers address our problems. But let's not forget that we, as a society, also need to define who we want to be, how we want to treat each other, where we want to aim our efforts and how we can use this new technology to achieve a positive outcome for us all." RP

The University of Ottawa's new Institute for Science, Society and Policy (ISSP) is developing a multidisciplinary and balanced education program on science, technology, innovation and society. Students will receive a broad education at the interface of science and policy provided by experts in science policy and innovation, governance and regulation, as well as from researchers studying the social implications of science and technology. The ISSP believes that such an inclusive and ideologically balanced approach fills a unique niche in Canada and will be valuable to employers in the private, public and NGO sectors. The Institute also conducts significant research, network and outreach activities. Visit the ISSP website at **www.issp.uOttawa.ca.**

THE PROGRESS ISN'T OVER UNTIL THE PAPERWORK IS DONE

by Tim Lougheed



Medicine was originally conceived as a means of keeping us healthy, but as we consider the medical potential to transcend the limits of our natural bodies, unsettling questions are emerging.

We expect health practitioners to do no harm; they swear the Hippocratic Oath as a promise to make the sick and wounded well. But technological innovation challenges the underlying assumptions of the Oath—promising now to do much more than make us well.

For example, today's implantable and wearable medical devices could improve people's health beyond current standards, in effect creating super-human capabilities. Bionic body parts can go beyond replacing the function of lost organs or limbs, making us "better, stronger and faster."

Nevertheless, this exciting prospect is tempered by social, ethical, and even legal conundrums. Bureaucratic oversight of such devices could reduce our capabilities, and ultimately limit our personal autonomy, says **Ian Kerr**, who holds the Canada Research Chair in Ethics, Law and Technology in the Faculty of Law.

"Prosthetics and artificial organs are indeed heading in the direction envisioned by 1970s sci-fi such as the *Six Million Dollar Man,* as he was then valued," says Kerr. But today's price tag of Steve Austin's bionic implants could include some serious ethical quandaries.

"Once you shift the lens of what counts as ability, once health and ability are no longer determined with reference to our species-typical biological norms will start defining normal with reference to consumer goods like iPods and iPads. The agreement allows the manufacturer and its partners to withdraw support for the product if the user violates certain conditions, such as getting the equipment serviced by an unauthorized dealer.

"In the same way that Apple could nullify the warranty on your iPhone if you open it up and alter its components, the company whose equipment allows a deaf person to hear, or an amputee to walk, would no longer support those digital body parts if

"ALLOWING COMPANIES TO LICENSE OUR BODIES IS EXTREMELY DANGEROUS." – IAN KERR

our newly enhanced bodies," Kerr explains. "Then, all of sudden, there's a new class of disabled—what my colleague Gregor Wolbring and I call the 'techno-poor disabled.' "

Kerr and Dr. Wolbring (University of Calgary) suggest that many of us could be left behind in a world where we reject or simply cannot afford a means of extending the limits of our performance. This issue sparked a high-profile legal controversy in 2008, when South African runner Oscar Pistorius was denied the opportunity to try out for his country's Olympic team. His lower legs were amputated when he was an infant, and his sophisticated carbon-fibre bionic replacements were declared to be an unfair advantage over runners with biological legs.

Although the Court of Arbitration for Sport eventually reversed its decision, the case raised some challenging questions about the meanings of "disability" and "normal." Kerr insists that these questions are not confined to Pistorius' story, but will continue to bedevil the frontiers of health research. He and Dr. Wolbring have been exploring the subject with a three-year grant from the Social Sciences and Humanities Research Council. Their project is entitled "Building Better Humans? Health, Enhancements and Human Rights."

Kerr's research has revealed that even the supposedly straightforward paperwork associated with new medical devices can have unsettling implications. For instance, when individuals receive a cochlear implant to compensate for deafness, the manufacturer of the device requires them to sign an end-user licensing agreement—modelled on mass-market the patient plugged them into a peripheral device made by a competitor," Kerr explains. "Only now we are talking about your ears or legs." In this paradigm, our body parts—along with artificial replacements for those parts are legally viewed as commodities, no different than electronic toys purchased at a store.

"Allowing companies to license our bodies is extremely dangerous," Kerr warns. "Although today's end-user licenses may not survive serious legal scrutiny, I don't want to wait a couple of decades until the Supreme Court finally decides whether such contracts are enforceable." Kerr's research seeks to develop legal and ethical principles that would resolve such problems before they ever arise. "I am developing guiding principles that could be used by the federal government for statutory reform in the regulation of medical devices, spirited not just by consumer protection and concepts but also human-rights law. Kind of like a legal cure for an industrial disease." RP