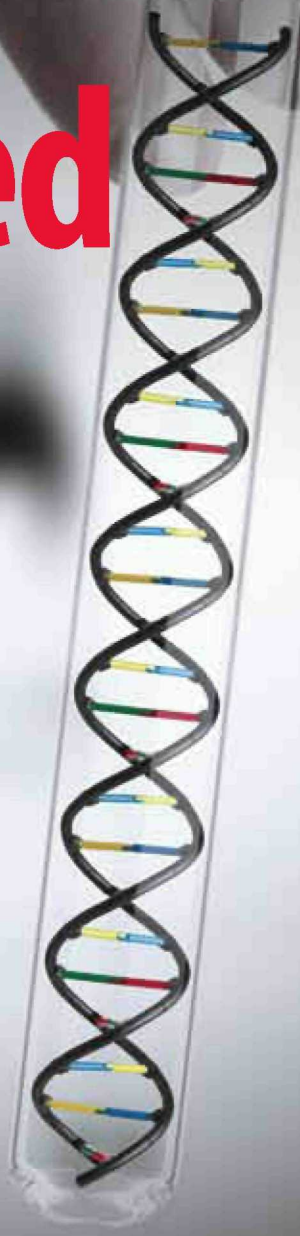
ICICS
CONNECTING KNOWLEDGE

magazine

innovations

Fall/Winter 2012

Towards Personalized Medicine



Also

PEOPLE AND PLANET FRIENDLY HOME

CAPTURING ATTENTION

TOOLS FOR THOUGHT

RECIPES FOR SKILLED MOVEMENT

TARGETED, CONTROLLED DRUG DELIVERY

and more...

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director's desk

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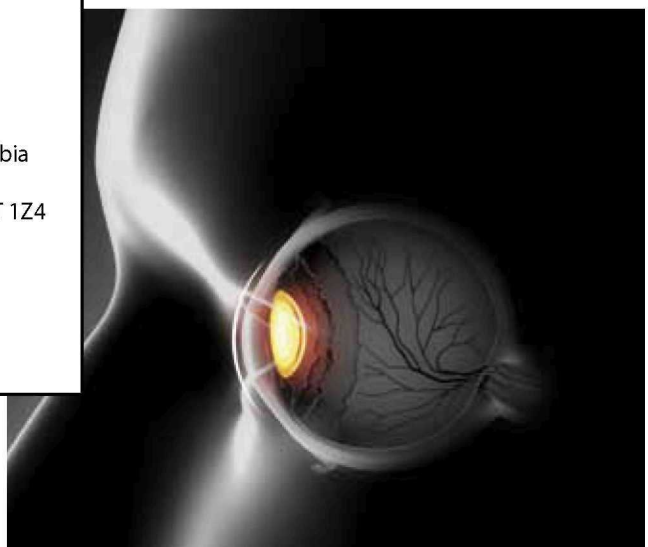

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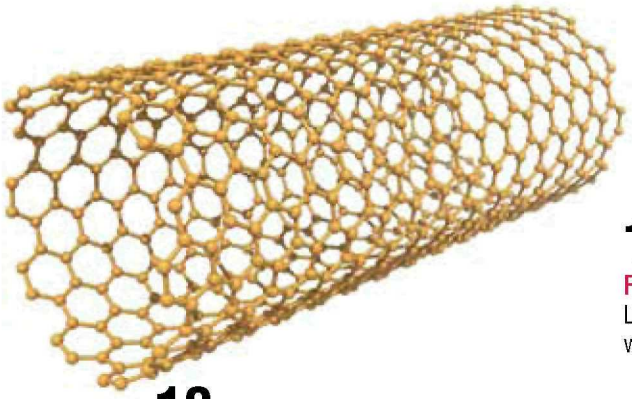

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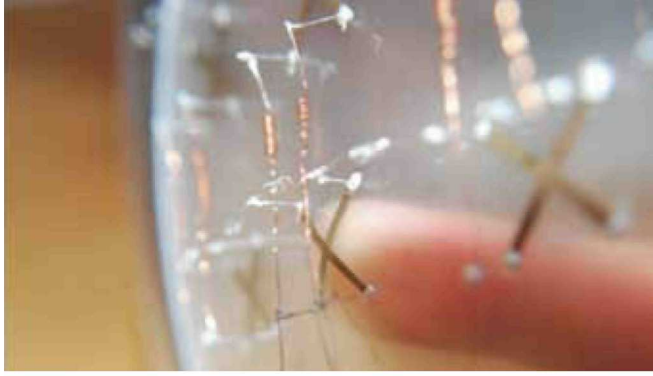

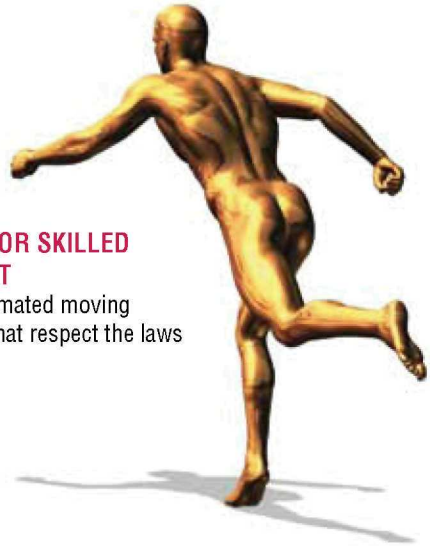

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A former nuclear-missile firing-room is being put to civilian use.

Welcome to a new issue of ICICS Innovations magazine. Over the past two years, I have re-focused the efforts of ICICS toward initiatives that take advantage of our uniqueness as a faculty-spanning entity at UBC. This fortunate position allows us to spearhead wide-ranging research projects like the People and Planet Friendly Home described in these pages. It also enables us to engage industry in a collective way that benefits researchers, companies, and the university.

Few companies can undertake the multidisciplinary research that generates innovative products, and ICICS researchers need the support of industry. ICICS can identify teams of researchers for companies wishing to benefit from UBC expertise, and with the University Industry Liaison Office work out appropriate intellectual property agreements. The People and Planet Friendly Home initiative represents a new way for industry to do business with UBC, as well as a new approach to sustainability.

Also in this issue, we present advances ICICS researchers are making in drug delivery devices, personalized medicine, nanotechnology, visual analytics, attention, and more. I hope you enjoy it.

Panos Nasiopoulos
ICICS Director

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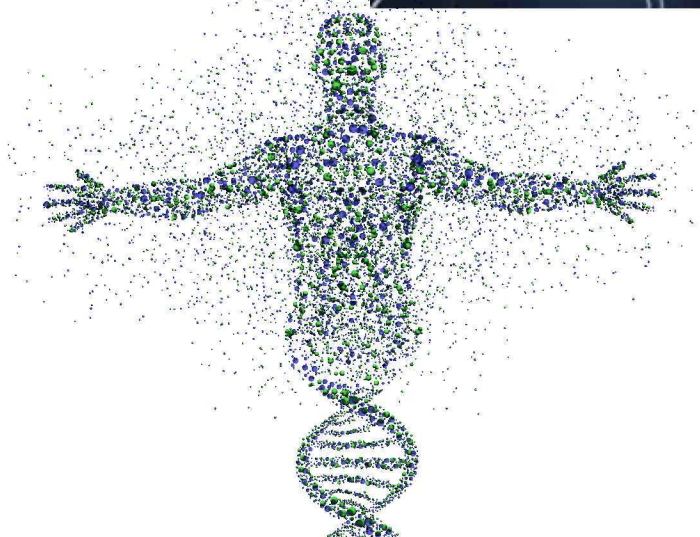
TOOLS FOR THOUGHT
Visual analytics provides insights into the deluge of data.



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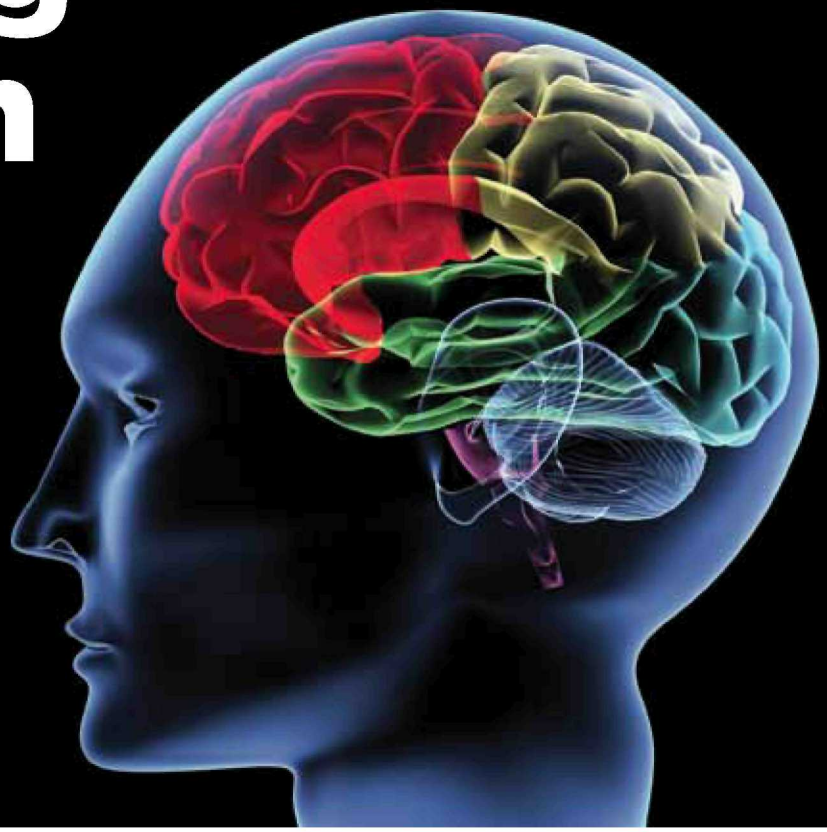
Capturing Attention

Tracking Trains of Thought in Real-Life Environments

by Mari-Lou Rowley



The mechanisms behind "paying attention" are much more complex than watching and listening. Psychology professor and director of UBC's Brain and Attention Research lab, Alan Kingstone, has developed new methods and tools to study attention and apply this knowledge to real-world problems.

We are constantly interacting in and with the environment around us, and that environment is always changing. New technologies and personal devices add a layer of complexity to real-world situations that can make it more difficult to pay attention to the task at hand. Consider the young mother pushing a baby stroller and listening to her iPod, or the businessman talking to a client on a hands-free cell phone. Which one has the best chance of making it across the road safely? These are the kind of questions that UBC psychology professor and department head Alan Kingstone is studying.

"We know that people who use cell phones are less attentive and more dangerous when driving and walking," says Kingstone. In a recent study, he and his team of students monitored people crossing a street. Surprisingly, they found that people listening to a personal music device (PMD) were more attentive than those who weren't.

"When you are listening to music on a PMD, you can still be in control and self-aware of what is happening to you externally," Kingstone explains. Cell phones, however, are another matter entirely, because the user's attention is drawn to and focused on the conversation. And when our attention is focused elsewhere, we are less likely to perceive sudden changes—the brake lights on the car ahead of us, for example. "That's why hands-free cell phones are just as dangerous as hand-held ones," Kingstone says. "People think it's a structural issue, because your hands are not on the wheel, but it is attentional."

Raising the BAR on Research

Traditional lab studies of human attention tend to measure one aspect and response at a time—in an environment stripped of all other stimuli and human interaction. But we are social beings, and we interact in a social environment. Kingstone has shown that attention is a dynamic integrated process that requires all of our senses to keep our train of thought on track. His real-world, multisensory "cognitive ethology" approach acknowledges that our mind is continuously working to match our current goals with the environments we move within throughout the day (i.e., work, commute, home, school, online).

> "We observe what people do naturally and try to take that behaviour into the lab to replicate and study it."

Kingstone and colleague Jim Enns recently received a major award from the Canada Foundation for Innovation, which has helped facilitate the Brain and Attention Research (BAR) lab's study of human cognition and social attention in complex real-world settings. BAR lab researchers use a variety of techniques and technologies, such as natural observation, eye tracking, brain imaging and body motion tracking, to capture the network of physical, physiological and social responses both in the "wild" environs of the real world and in controlled lab settings. The Natural Sciences and Engineering Research Council is another major supporter of Kingstone's research.

"We observe what people do naturally and try to take that behaviour into the lab to replicate and study it," says Kingstone, who was recently elected a Fellow of the Royal Society of Canada for his innovative research and contributions to the field.

A common example of how environment can influence behaviour is in the workplace. A cubicle in a stuffy office with no windows is not likely to induce the same productivity as an office with lots of natural light, space and fresh air. Kingstone notes that his office in the Centre for Interactive Research on Sustainability (CIRS) is enormously conducive to research and creativity. Recent data from the BAR lab also indicates that CIRS has a subtle but profound influence on how people make sustainable decisions.

"CIRS is an incredibly inspiring structure. Every component—from paint, energy and water systems, to food delivery—is part of the CIRS research program. We are just beginning to understand the relationship between CIRS and its inhabitants, and how this relationship can influence people's performance and decisions."

For more information, contact Alan Kingstone at alan.kingstone@ubc.ca

CLAS HELPS STUDENTS MAKE THE GRADE

With so much information and so many new technologies vying for our attention, an important application of Kingstone's research uses technology to filter information and help focus attention. The Collaborative Lecture Annotation System (CLAS), developed by Kingstone and former UBC postdoctoral fellows Tom Foulsham and Evan Risko, provides students with a software application that allows them to "click" on key moments in videotaped, as well as live, lectures. While writing notes can take attention away from the lecture, digital note taking allows students to be more engaged in listening, learning and thinking. At the end of the lecture, they can compare and share notes with their peers to see if they missed any important points. And instructors can see what portion of the lecture students are clicking on, which aids in evaluating teaching and presentation skills.

People & Planet Friendly Home

Sustainable Housing You Can Live With

A SUITE OF NEW TECHNOLOGIES BEING DEVELOPED IN AN ICICS-LED PROJECT WILL MAKE OUR HOMES BETTER PLACES TO LIVE AND EASIER ON THE ENVIRONMENT. NO MANUAL REQUIRED.

Smart homes intended to make our lives easier through technology have been around for over 30 years. In these early incarnations, appliances and other devices were networked through the home's electrical wires, and controlled by a keypad. Although you could turn the eight-track player off and dim the rec-room lighting without leaving the couch, "noise" in the wires often caused interference—the system might not respond to commands, or could turn the TV on in the middle of the night.

Today's smart home technology aimed at convenience is much more sophisticated and reliable, using robust wireless networks to communicate. Lighting, temperature, smart appliances, and security and entertainment systems can be controlled locally, or remotely through a smart phone or web page on a computer. Differing levels of automation versus user control can be set.

Another variant of the modern smart home has reduced environmental impact as its main goal. Prominently displayed information systems help residents track and manage their energy use, and can be accessed remotely using a smart phone or other mobile device. Lights might turn themselves off when a person leaves a room, and rooms can be heated or cooled depending on whether they are occupied, and by whom. Improved insulation, smaller living spaces, and solar, wind, and thermal electrical generation also help reduce the home's carbon footprint. These "green" homes, however, either directly restrict their occupants' lifestyles, or try modifying their behaviour to realize environmental gains. They also use mostly off-the-shelf technologies.

The People and Planet Friendly Home

ICICS Director Panos Nasiopoulos offers a third option. His brainchild, the People and Planet Friendly Home, is a department-spanning, multi-year research project at UBC whose goal is to create smart living spaces with reduced environmental impact, that also improve

the lives of their occupants. The key to realizing such an ambitious project, Nasiopoulos believes, lies in developing new technologies that incorporate this two-pronged design principle from the start.

"We have ICICS researchers from engineering, computer science, psychology, and medicine working on the home," Nasiopoulos says, "and will soon bring in people from architecture, landscape architecture, sociology, nursing, and business. This range of expertise, which ICICS can uniquely provide, will produce the innovation we're after." For example, psychologists will conduct subjective assessments of the new technologies to ensure their multi-generational appeal. Experts from the Sauder School of Business will keep the project on track for commercial relevance.

A New Way of Doing Business with the University

This wide-ranging approach to research has won the support of an industrial consortium backing the project. Led by TELUS, the companies involved acknowledge that they lack the in-house resources to conduct multidisciplinary research of this scope. To remain competitive, however, they know they must innovate, which increasingly requires a multidisciplinary approach—they need to form partnerships with university research centres like ICICS. Likewise, university researchers need industry sponsorship, especially in these days of government fiscal restraint.

The People and Planet Friendly Home project represents a new way for industry to do business with UBC. ICICS can identify teams of researchers for companies wishing to benefit from UBC expertise. Working with the University-Industry Liaison Office, ICICS can negotiate intellectual property agreements among companies, researchers, and UBC to make these collaborations more attractive for all involved.

Initial Research

Research is now underway to establish the home's communications and sensing backbone. Applications are being developed to monitor the health of occupants using mobile phones, and provide recommendations. Advanced wayfinding techniques for smart powered wheelchairs will enable the elderly and disabled to comfortably live in the home. New architectures for integrating different home energy systems and electrical/electronic devices will reduce energy consumption. Innovative methods for capturing and displaying 3D high dynamic range content are being developed to create an immersive, intuitive experience for users interacting with the home's visual displays.

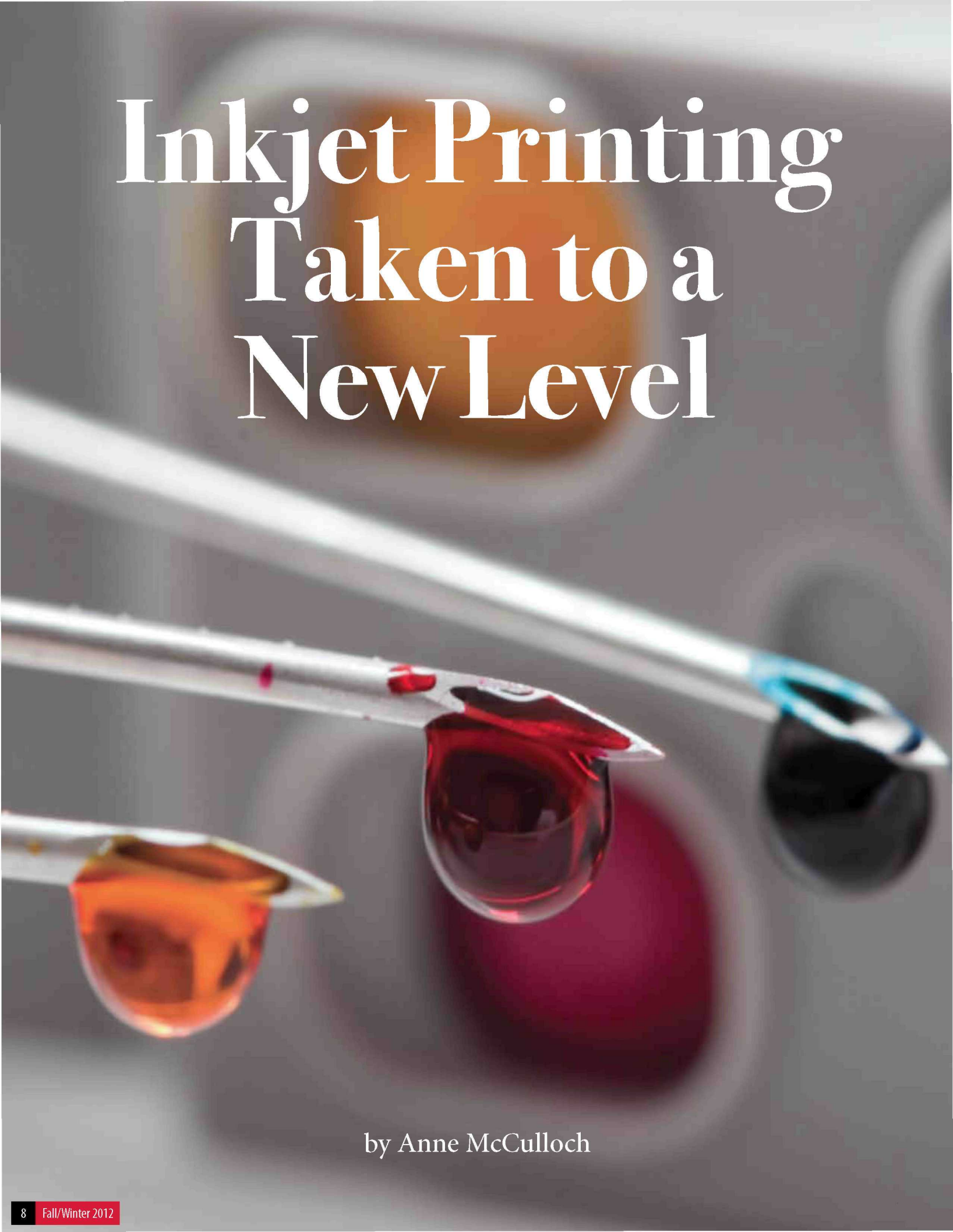
The prototype technologies will be tested and integrated in a mock living environment in the ICICS building. The project complements UBC's "Campus as a Living Lab" sustainability initiative, and discussions are underway into building a full-scale home on the UBC Point Grey campus. The People and Planet Friendly Home's "no-manual required" technologies will be affordable and enable seamless transitions to new technologies as they evolve. They will also be transferable to existing houses, apartments, and business environments.

For more information, contact info@icics.ubc.ca

"TELUS is excited to be part of this unique approach to sustainability at UBC."

Jim Slevinsky, Director, Technology Strategy, TELUS

Inkjet Printing Taken to a New Level



by Anne McCulloch

Nanostructures are objects whose size falls between the molecular and the microscopic. They include nanowires, nanotubes, and quantum dots, and offer unique electronic and optical features. These features, however, are only useful when the nanostructures are integrated and patterned into some sort of device. The challenge is to develop a fabrication technique that can handle many of the nanostructured materials that are currently available.

Electrical and Computer Engineering (ECE) professor Konrad Walus' innovative solution is to apply inkjet printing as a fabrication platform. Instead of printing lines of ink on paper, Walus prints working devices with the potential to solve important problems facing government and industry. For example, Walus and colleagues are working with the engineering firm Weir-Jones Group to develop inkjet-printed strain sensors based on carbon nanotubes. The company plans to test the sensors for use in the monitoring technology it deploys on offshore oil wells and gas pipelines. Similar strain sensors can be used to quickly assess which parts of an earthquake-damaged building are livable, and which bridges should be closed and repaired to avoid devastating collapses, potentially saving lives and money.

> More representative screening tests would lower the cost of drug testing and be a first step toward eliminating the need for animal and human testing.

The inkjet printers in Walus' lab aren't sold at the office supply store, but the technology and underlying concepts are identical to those that are. He and his team are refining the parameters of inkjet printing for novel applications and developing custom printers that can handle inks embedded with nanostructures. Patterning the inks at the micro-scale is precise enough to access the unique features of nanocomposites, but the performance of the devices varies widely depending on how they are printed and the materials used. "Conceptually it's very simple to understand, but the devil is in the details," says Walus.

Low-cost Sensors Collect Real-Time Data

Air quality in Vancouver is currently measured using manually collected samples. Technicians collect air in canisters, which are brought to a central lab every six days for analysis with highly advanced equipment. Walus and ECE/Mechanical Engineering professor Boris Stoeber are working on an alternative solution. In collaboration with Environment Canada and Metro Vancouver, they are developing polymer chemical sensors that can be printed on an inkjet printer and are inexpensive enough to be integrated into Metro Vancouver's air-quality monitoring network. The wealth of data these sensors could provide, delivered real-time to an analyst's computer, would enable Environment Canada and Metro Vancouver to develop evidence-based policies for improving the quality of our air.

Printing 3D Tissue for Drug Development

Once a biochemical target for a disease is discovered, the drug development process involves high-throughput screening to identify biochemical compounds that may be effective in treating the disease. Plates with row after row of wells containing cells are bombarded with a wide variety of compounds by a liquid-handling robot.

But this kind of test does not represent the complexity of a living organism, since cells behave differently in different environments. For example, studies have shown that liver cells arranged in a particular way and surrounded by other cells behave like liver cells, whereas liver cells simply placed in a well do not. Pattern is important.

Walus has assembled a team, including Stoeber and ECE professors Karen Cheung and Edmond Cretu, to develop a printing system that produces a model better representing human physiology. "What's in the well matters," says Walus. "We're trying to print three-dimensional tissues in each well so the predictive capacity of the well is substantially improved. A large number of drugs fail because the early stages of testing were not predictive."

Walus and his team are collaborating with the Vancouver-based Centre for Drug Research and Development to integrate the new printing system into the centre's workflow. More representative screening tests would lower the cost of drug testing and be a first step toward eliminating the need for animal and human testing.

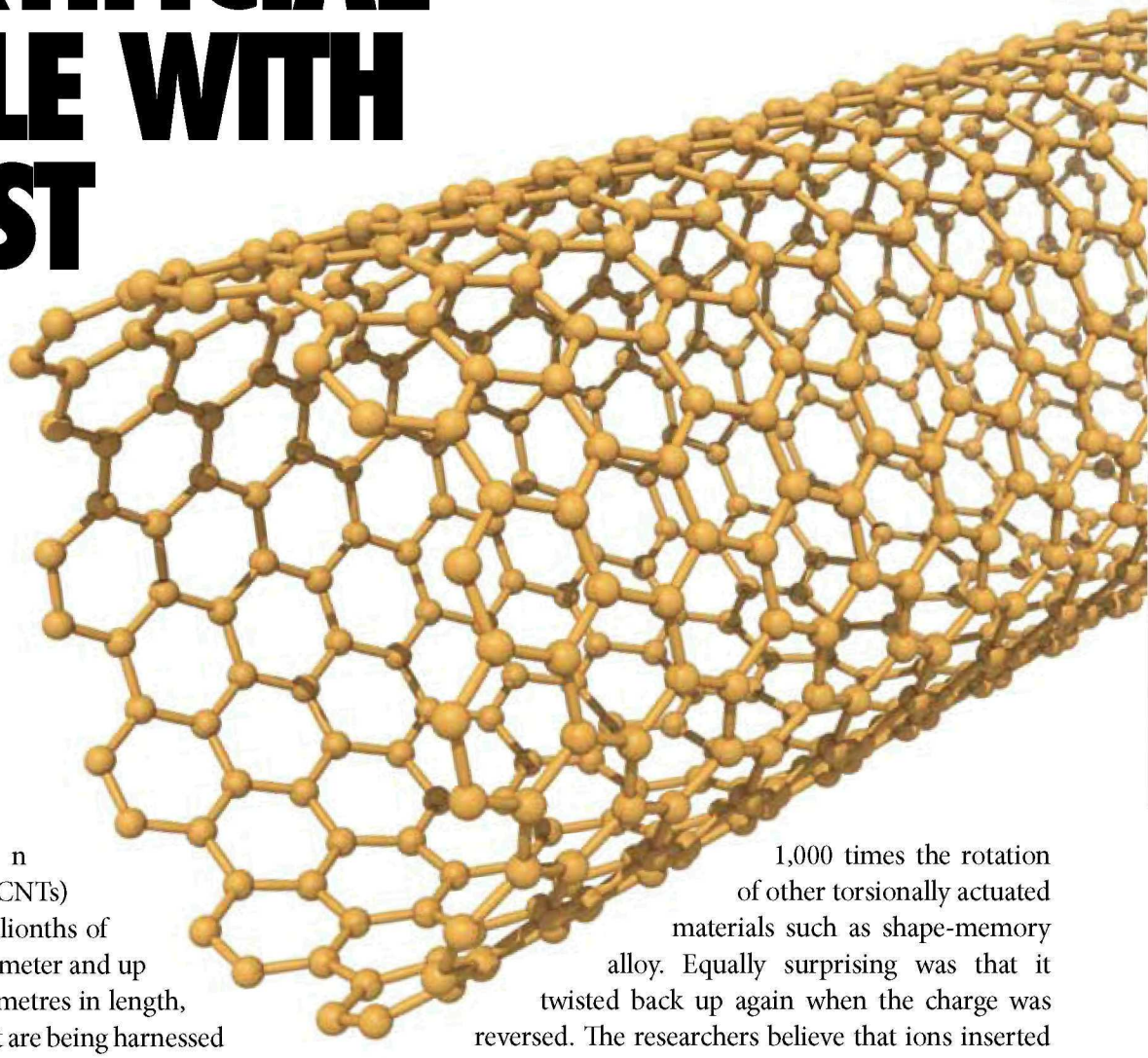
Opening Up the Engineering Design Space

Walus is refining functional inkjet printing to make devices that cannot be made with other technologies. He also hopes, eventually, to make custom microdevices more accessible to the wider population. "We have spent years working out the processes in the lab," he says, "but we want people to be able to just buy a functional inkjet printer and do it themselves at home." Right now, anyone with $1,000 and an idea for a mechanical part can buy a 3D printer and make a prototype. If they could also print a functional circuit, they could make a complete electromechanical device.

"The engineering design space is so big that we'll never cover it all if only a very small number of people contribute," Walus adds. "If everyone can chip in, a lot more innovation will result."

For more information, contact Konrad Walus at konradw@ece.ubc.ca

AN ARTIFICIAL MUSCLE WITH A TWIST



Electrical engineering professor John Madden and colleagues have developed a simple, tiny artificial muscle made of carbon nanotubes that mimics real muscle by responding to an electrostatic stimulus.

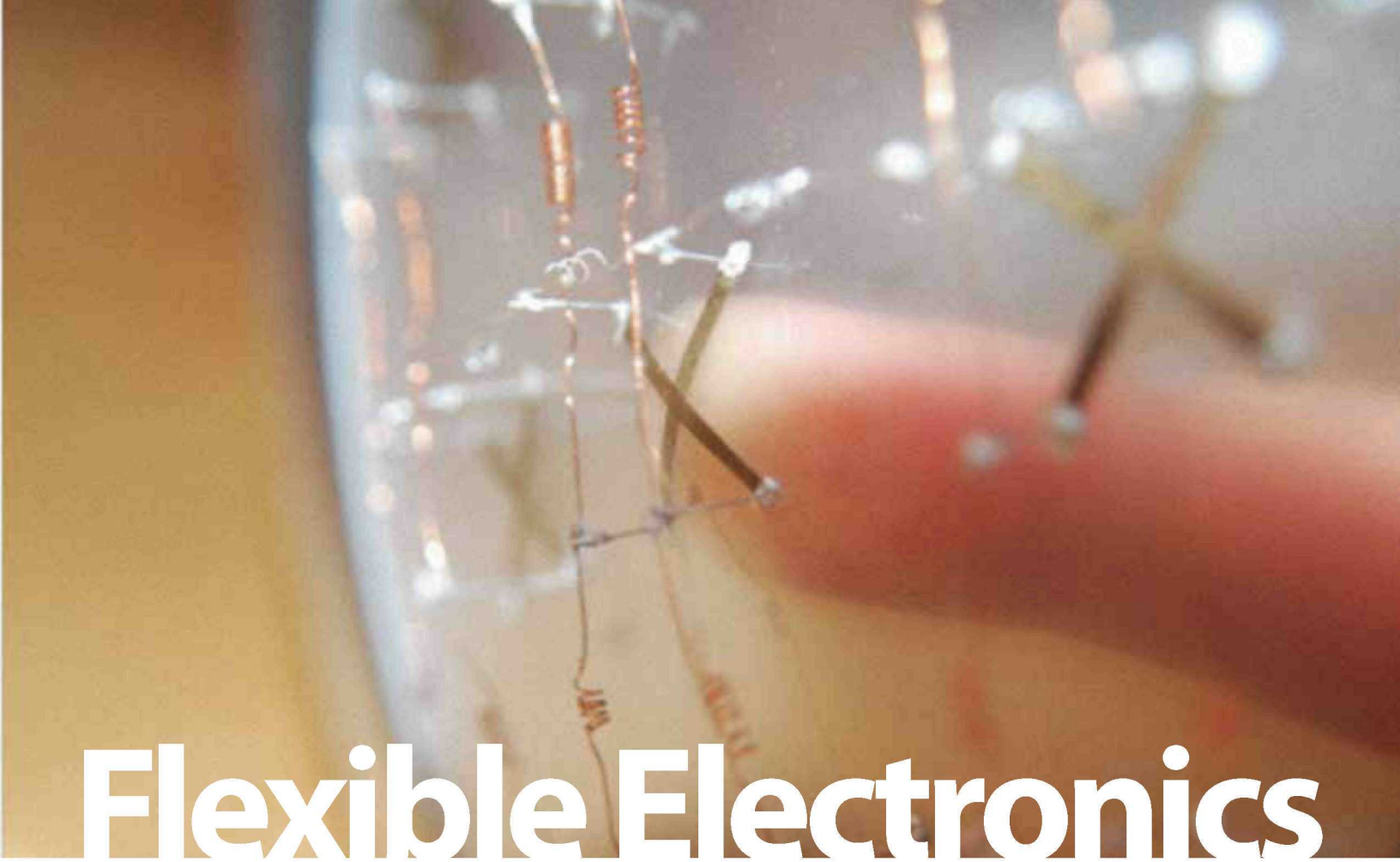
Carbon nanotubes (CNTs) are several billionths of a metre in diameter and up to a few centimetres in length, and have unique properties that are being harnessed by researchers for a growing number of applications (see preceding article). John Madden and an international team of researchers have exploited their ability to function as actuators in devising a torsional artificial muscle that shows great potential.

Madden's collaborators at the University of Texas, led by Ray Baughman, began by spinning together forests of CNTs to create a twisted "yarn", varying in length from six to ten centimetres and roughly one-tenth the diameter of a human hair. Tissaphern Mirfakhrai, a PhD student in Madden's lab, immersed the yarn in a salt solution and applied a low voltage. The yarn contracted lengthwise by nearly one percent, even under loads 1,000 times higher than those sustainable by similar diameter human muscle. "When you consider the forces it's contracting against," Madden says, "it's as powerful as an internal combustion engine." His collaborators in Australia and Texas were surprised to find that, given the yarn had an equivalent of 20,000 twists per metre, charging also led to a rotation in the opposite direction of 40 turns, 1,000 times the rotation of other torsionally actuated materials such as shape-memory alloy. Equally surprising was that it twisted back up again when the charge was reversed. The researchers believe that ions inserted between the nanotubes when the charge was applied caused the yarn to swell and untwist.

By attaching a tiny paddle to the yarn, the team found that the muscle had a high rotation rate and that, for its weight, was as powerful as human muscle; since the initial experiment, Madden and his team have boosted its rotational power by at least ten times. The paddle also enabled the team to conduct fluid mixing experiments.

With its low voltage requirement, ability to be miniaturized, and fast, extensive, torsional rotation, Madden believes the muscle could one day be used to power in vivo devices, such as microfluidic pumps and valves. It could also be used in drug discovery to mix minute quantities of fluids. An electric motor shrunk down to a similar size would be too weak to be useful.

For more information, contact John Madden at jmadden@ece.ubc.ca



Flexible Electronics

Most of the integrated circuits that run our electronic devices are based on silicon semiconductors. They are compact and powerful, replacing rooms full of vacuum tubes and scientists in lab coats, but they are also expensive to manufacture over large areas and limited by their rigidity. Electrical and Computer Engineering professor Peyman Servati is looking at ways to produce low-cost, flexible electronics for applications ranging from flexible displays to "intelligent skin".

The key is to go small—very small—using nano-materials as the basis for electronics deposited on thin, flexible materials such as fabrics or plastics. In one project, researchers in Servati's Flexible Electronics and Energy Lab (FEEL) in collaboration with Frank Ko (Materials Engineering) have used conducting nanotubes and nanowires to create a composite fibre mesh resembling the veins of a leaf. Like the metallic electrodes used in conventional solar panels, the nanofibres collect electrons generated under sunlight, which can be stored in batteries for later use. Unlike conventional systems, however, panels based on Servati's fibres would be relatively inexpensive to manufacture, and flexible—or even stretchable—depending on the substrate used.

In another project, Servati and doctoral student Mahshid Karimi are developing novel synthesis methods for nanowires that are excited by both sunlight and heat. After "slow cooking" the source material, nanowires with the desired properties are deposited, at a fraction of the cost of conventional production techniques. The particles can then be incorporated into fabric tape and used to generate energy from heat sources in the home, such as the back of a refrigerator. A translucent window blind incorporating the particles can double as a solar/thermal panel.

Servati and his FEEL colleagues are also exploring applications of new nanomaterials and microfabrication techniques for large-area transparent "electronic skin" capable of monitoring mechanical deformation. The "skin" would have applications in wearable electronics, structural health monitoring, tactile and vibrational monitoring, and disposable electrical sensors. Together, FEEL researchers are helping to lay the groundwork for the post-silicon era.

For more information, contact
Peyman Servati at peymans@ece.ubc.ca

Recipes for Skilled Movement

An approach to animated motion where characters learn from their experiences

The ability to move and act are fundamental abilities of both humans and animals, but our best models for simulating them, or replicating them with a robot, are still only pale imitations of the real thing. Motion-capture technology makes it possible to capture the nuances of even the fastest motions, but it is simply impossible to capture the entire range of motions of every living being. Also, creating new motions by reassembling captured segments is very limiting, akin to using pieces of existing photographs to create new ones.

Computer scientist Michiel van de Panne has developed techniques for what might be called "skill capture" rather than "motion capture": modelling the physics and muscle actuations that generate motions, rather than the motions themselves. "Simulating the physics of an articulated body is well understood," van de Panne notes, "but the challenge is to develop the control algorithms that can produce a given motion." One example might be the algorithm (or recipe) for computing the control forces at the joints of a human walking uphill while carrying a crate, or of a dog cantering downhill. The solutions he has developed rely on tools drawn from control, numerical optimization, and machine learning.

Van de Panne's work is distinguished by its developmental approach–his simulated humans need to know how to walk on flat terrain before being able to walk up hills; a detailed 3D dog simulation needs to master cantering at slow speeds before learning how to gallop. Since the simulations can be carried out in real-time, the characters in a game or simulation scenario can physically interact with each other and their environment in realistic ways that were not possible before.

Over the years, van de Panne has simplified his techniques to the extent that an artist with no previous animation experience can create highly varied characters with a range of convincing motion in a matter of minutes. Aside from its computer animation applications, van de Panne's work should help lead the way to legged robots with significantly better locomotion skills and dexterous hand manipulation, and multi-skilled full-body biomechanical simulations.

For more information, contact Michiel van de Panne at van@cs.ubc.ca

Exploring Neuron Firing in the Firing Room

The former firing room for France's land-based nuclear missile arsenal is now being put to civilian use.

For many years, epilepsy researchers believed that grand mal seizures were caused by a low-frequency brain wave recruiting neurons and causing them to fire. This theory, however, has not significantly improved understanding of the mechanism generating seizures, nor the ability to predict them, in five decades.

Electroencephalography (EEG) records the brain's electrical activity as expressed along the scalp. Epilepsy can be detected in an abnormal EEG pattern. However, fluorescent lights and other sources of electromagnetic (EM) radiation in a clinical setting interfere with EEG readings, and need to be filtered out. This process masks higher frequency bands that may be significant in diagnosing and treating epilepsy and other neurological conditions.

During a sabbatical in 2006–07, Electrical and Computer Engineering (ECE) professor Matt Yedlin was working at the Sophia Antipolis campus of the University of Nice, in southern France. Nearby is the underground complex that formerly housed France's land-based nuclear missiles. Knowing that the complex's firing room had been reconfigured as a low-EM noise lab for civilian experiments, it dawned on Yedlin that the Laboratoire Souterrain à Bas Bruit (LSBB) would be a good place to conduct unfiltered EEG studies. He approached ECE colleague and signal processing expert Guy Dumont with the idea, and the two subsequently tested subjects both in a hospital and in the underground shielded "capsule," 500 metres below the surface. It was the first biomedical experiment conducted in the LSBB.

The results showed that clean, unfiltered signals can be obtained in the capsule, revealing brain activity in frequency bands of interest to researchers—particularly the gamma band, from 30–70 Hz—that are normally filtered out. This builds the case for testing epilepsy patients in the capsule, with the appropriate medical protocols in place should they experience a seizure, to improve understanding of the epileptic brain. It also creates the possibility of using the LSBB to establish benchmark recordings for testing new EEG equipment.

The LSBB has recently been granted full national laboratory status in France, with the funding that goes with it. Thanks to Yedlin and Dumont, UBC is the only university in North America to have signed a Memorandum of Understanding with the lab, opening the door to further collaborations, half a kilometer down.

For more information, contact Matt Yedlin at matty@ece.ubc.ca or Guy Dumont at guyd@ece.ubc.ca

TOWARDS PERSONALIZED MEDICINE

Biomarker panels based on genetic and other information could usher in a new era of sophisticated medical diagnoses and treatments tailored to the patient.

Heart transplant patients must endure 14 needle biopsies in the year following their transplant operation to determine whether their body is accepting or rejecting the new organ. Immunosuppressant drugs are administered accordingly. The procedure is highly invasive, traumatic for the patient, and expensive. Since 2004, a multidisciplinary team based at St. Paul's Hospital in Vancouver has been developing blood tests to detect organ rejection in transplant patients. They hope to eliminate the need for biopsies, or at least limit their frequency. In their current incarnation as the PROOF (Prevention of Organ Failure) Centre of Excellence, the team is building on these results to develop non-invasive predictive, diagnostic, and prognostic tests for heart, lung, and kidney health. The goal is to be able to detect problems well ahead of their appearance as symptoms.

Signatures of Health

UBC computer scientist Raymond Ng is PROOF's Chief Informatics Officer. A data mining pioneer, Ng's job is to sift through the entire set of genes, proteins, and metabolites from the blood of organ-transplant patients and locate telling patterns. He and his team of statisticians, physicists, biologists, and clinicians look for features of these data that show significant differences pre- and post-transplant, in patients whose transplant was successful. This enables them to pinpoint "biomarkers" such as a certain gene that may be indicators of organ health. They also consider clinical data such as cholesterol levels, and imaging data in the case of chronic obstructive pulmonary disease (COPD) patients.

Relationships among these different types of data are then explored to form "combinatorial" biomarker panels, whose statistical strength for diagnostic purposes far outweighs that of individual markers. Ng uses semantic search techniques to learn more about the biomarkers from the Internet and medical databases, so that biological hypotheses can be formed about the panels.

"In current practice," Ng says, "clinical symptoms are very crude, and are detected late in the progress of organ disease. Our hope is to develop sophisticated monitoring tools that can be used for early detection and intervention." The goal is to arrive at a single scoring function, or "signature of health," specific to the patient that can be interpreted in the clinic.

Deepening the Pool

Since organ transplant operations are so expensive and relatively few compared to other procedures, the PROOF team is collaborating with a kidney transplant team at Scripps Health - San Diego to increase the size and diversity of the sample patient pool. St. Paul's treats mostly Caucasian and Asian patients with acute kidney failure, while Scripps treats many Hispanic and African-American patients with chronic kidney disease. Bringing the data from the two centres together will strengthen the biomarker panels and help get them approved by Health Canada and the U.S. Food and Drug Administration.

Realizing Personalized Medicine

"Implementing personalized medicine," Ng points out, "is a long journey. Moving it from very sophisticated genetic arrays to regulatory approval to the bedside is far from trivial. But our centre is determined to do it." The PROOF team has patents on its biomarker panels from Canada, the U.S., and Europe, and is conducting an international trial at hospitals in Canada, the U.S., and India. If successful, the panels could significantly change medical practice, for the better.

For more information, visit the PROOF website at www.proofcentre.ca or contact Raymond Ng at rng@cs.ubc.ca

FROGS AS ENVIRONMENTAL SENTINELS

The antimicrobial properties of silver have been known for centuries. Before antibiotics came into use, wound dressings were often impregnated with ionic silver particles to ward off infection. Today, nano-sized silver particles ("nanosilver") are being used in antimicrobial coatings in consumer products ranging from socks to refrigerators. However, since nanoparticles are small enough to enter our lungs and bloodstream, there are concerns about their potential health effects.

Raymond Ng is lending his expertise in developing biomarker panels (see adjoining article) to a team of University of Victoria researchers who are investigating the effects of nanosilver on frogs. Frogs are good environmental sentinels because their metamorphosis from tadpoles to frogs depends on proper thyroid function, which is highly sensitive to environmental toxins. In humans, thyroid dysfunction can affect foetal brain development, and cause other problems.

Ng is comparing the genes, proteins, metabolites, and clinical data of tadpoles exposed to nanosilver versus controls. He uses the results to develop biomarker panels as indicators of safe levels of nanosilver exposure. Environment Canada is highly interested in the results, as Ng's panels would be a much more sensitive means of assessing the environmental impact of chemicals than currently used techniques.

TOOLS FOR THOUGHT

USING VISUAL ANALYTICS TO GAIN INSIGHT INTO THE DELUGE OF DATA

by Mari-Lou Rowley

Technology is driving such an exponential increase in the amount and complexity of data that the challenge is how to make sense of it all. ICICS researchers are working with industry to develop tools that use human visual and cognitive abilities to explore—and gain insight from—massive data sets.

Aiding Disaster Response

Imagine the worst. A major earthquake hits Vancouver, cracking bridges and buildings, hurtling debris, downing power lines, and setting fires raging across the Lower Mainland. Emergency response centres are bombarded with incoming information—much of it conflicting.

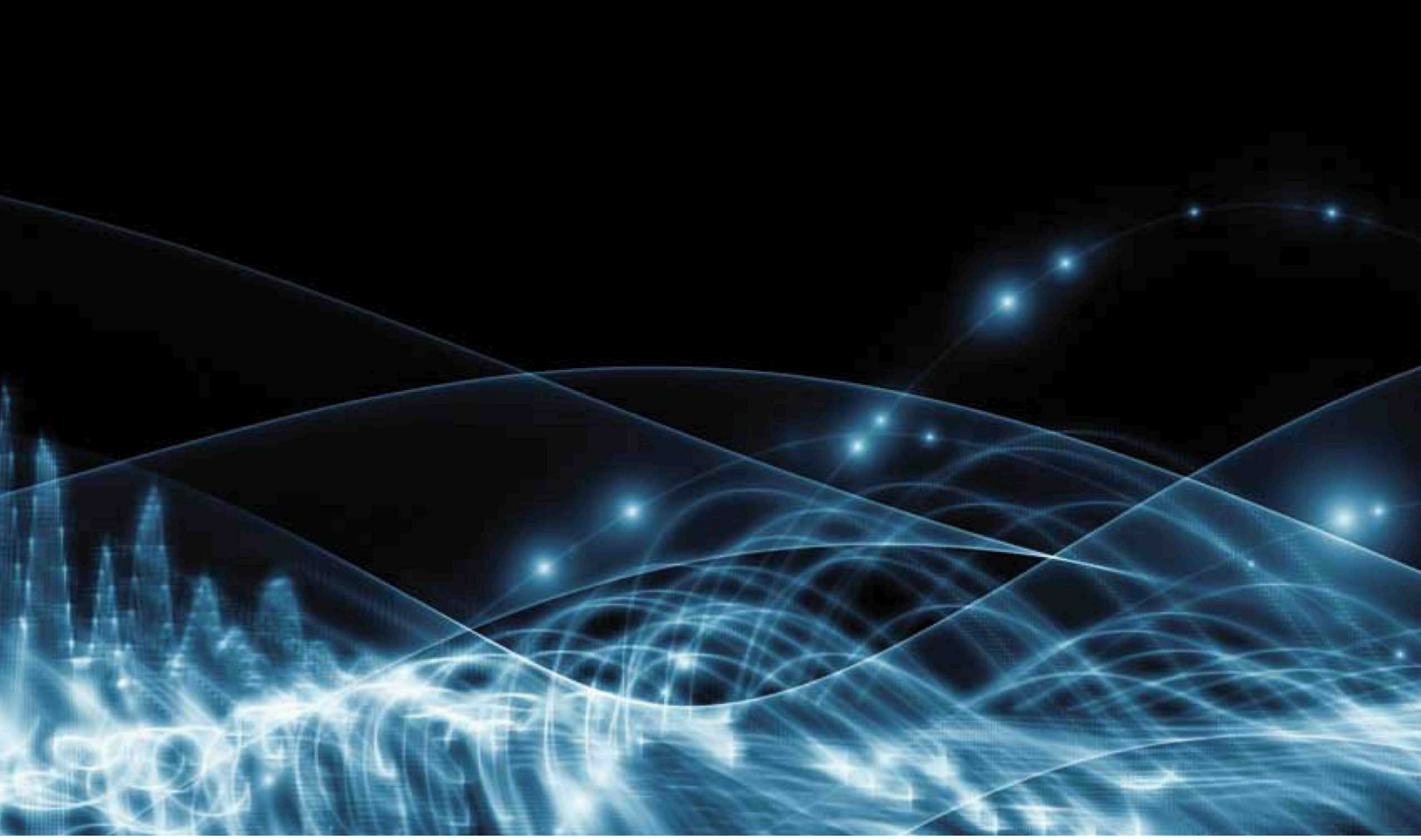
"First responders are under a lot of stress and they have to make real-time decisions under very adverse conditions," says Brian Fisher, an ICICS member and professor at Simon Fraser University's School of Interactive Arts and Technology. Crisis management is one application of visual analytics (VA), which combines information and scientific visualization methods with interactive interfaces to augment analytical reasoning. As associate director of ICICS' Media And Graphics Interdisciplinary Centre (MAGIC), Fisher notes that MAGIC, under former director Sid Fels, was a catalyst to VA research in Vancouver.

With funding from NSERC and Boeing, Fisher, SFU colleague John Dill and UBC postdoctoral student Hélène Gauchou are developing visual analytics tools to aid emergency management and response. They are all members of the Vancouver Institute for Visual Analytics (VIVA), established in 2010 with $1.25 million from Boeing to develop VA expertise and collaboration among industry, university and government. Emergency management is a good example of how VA combines fundamental research, such as Gauchou's work on stress and visualization, with application-focused research in the field.

"VIVA's mandate fosters inter-university collaboration to help students, companies and the broader community solve real-world problems," according to director and SFU computer scientist Fred Popowich. Along with introductory courses in VA, SFU has launched a new certificate program for graduate students, including courses in business, education, interactive arts and technology, communications and computing science. MAGIC is also building a companion program at UBC. "Education, training and increasing awareness of the field of VA are major goals of VIVA," Popowich asserts.

Averting Financial Crisis

Records and information management expert Victoria Lemieux agrees. "I think increasingly we have to come together in interdisciplinary teams working across fields to gain new insights from the edges of our discipline." Lemieux is director



of the Centre for the Investigation of Financial Electronic Records based at UBC, MAGIC acting director, and a professor at UBC's iSchool. As former VP of Credit Suisse in charge of global records, she led the bank's European infrastructure client services technology risk team. Data deluge and lack of transparency worked in tandem with other factors, such as banking deregulation, to trigger the recent global banking crisis.

Lemieux has been involved in shaping new policies and cyber-infrastructures to increase data transparency and security, as a member of the International Standards Organization's Technical Committee 68 on financial services. She notes that, going forward, financial institutions will be required to provide much more data in raw transactional form and regulators will apply their own analytics to diagnose the health of a financial system. This means even larger and more complex data sets, which can't be analyzed using traditional methods. VA can provide both an overview of the big picture and also help analysts to spot trends, patterns and outliers in data to gain an overall awareness of the current market status.

"Visual analytics leverages the human visual system and cognition so that we are able to process data many times faster than we can using other modes," Lemieux points out. "In many cases, we can do this pre-attentively."

"Visual analytics leverages the human visual system and cognition so that we are able to process data many times faster than we can using other modes."

Interacting with Data

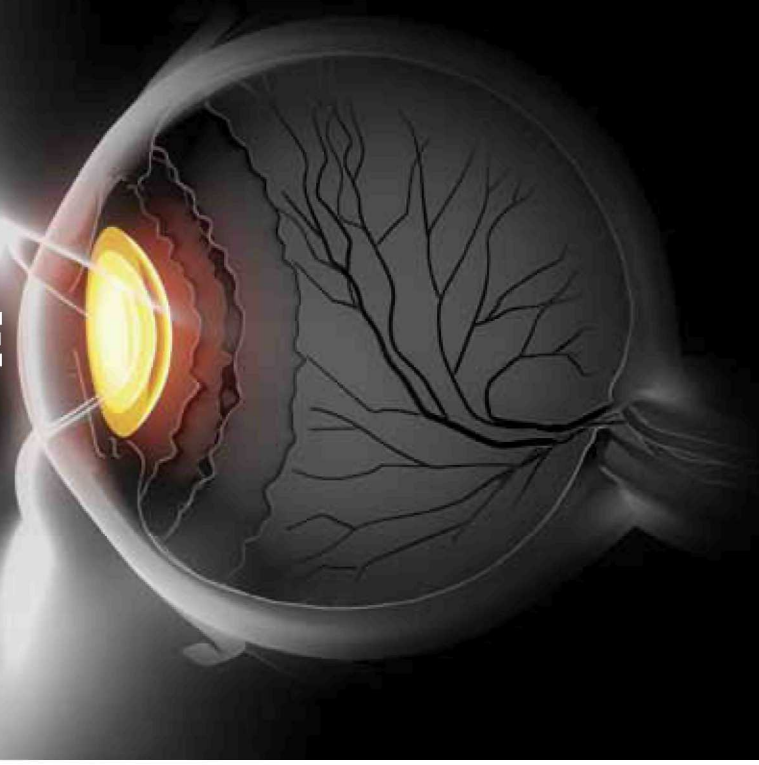
"Interactivity and visualization are a natural fit, and the visual system is much more intelligent than we thought," says Ron Rensink, a professor of computer science and psychology at UBC. He discovered that the ability to see correlation in scatter plots could be described by two related functions, precision and accuracy. "This means that some simple underlying property—similar to perceiving brightness or loudness—supports our visual perception of correlation," Rensink adds. This basic research will help scientists build and measure interactive VA tools.

"We need to learn to think and reason with technology," Fisher says. "It's not automatic—especially for anyone over 30—and individual difference must be incorporated into these new tools."

For more information, contact Vicki Lemieux at v.lemieux@ubc.ca

TARGETED, CONTROLLED DRUG DELIVERY

A NEW DRUG-DELIVERY PLATFORM COULD HELP PREVENT DIABETES-RELATED VISION LOSS AND MINIMIZE THE SIDE EFFECTS OF CHEMOTHERAPY.



KEEPING IT SIMPLE is always a sound design principle, but especially when developing implantable biomedical devices. They need to be tiny, long-lasting, preferably battery-less, and biocompatible. A drug-delivery system under development at the University of British Columbia embodies this principle.

In diabetic retinopathy, blood vessels build up behind the eye because of erratic glucose control. These vessels can rupture as the disease progresses, causing blotchy, blurred vision and, if untreated, eventual blindness. The most common treatment is to coagulate the vessels using lasers, but this can cause impaired peripheral, colour, and night vision, as well as laser burns. Both Type I and Type II diabetes patients are at significant risk for this complication.

Mu Chiao is a Canada Research Chair in Microelectromechanical Systems (MEMS) and Nanotechnology for Biomedical Devices at the University of British Columbia. He also has a relative who can no longer drive because of the effects of diabetic retinopathy. So when his colleagues Helen Burt and John Jackson of UBC Pharmaceutical Sciences suggested a MEMS-based drug-delivery approach to treating the disease, he ran with the idea. He set graduate students Fatemeh Nazly Pirmoradi and Kevin Ou to work on the project, and the three eventually developed a device that may one day be placed behind the eye and controlled externally.

The Mechanism

Chiao's device consists of a reservoir sealed by an elastic, magnetic membrane with an aperture in the centre. An external magnet is used to deflect the membrane in toward the reservoir, squeezing the drug out through the aperture. When the magnet is removed, the membrane relaxes and draws physiological fluid in through the aperture to dissolve a

given quantity of solid drug for the next release; no on-board power source is required. The 6 mm x .5 mm prototype device was manufactured at UBC's Advanced Materials and Process Engineering Laboratory (AMPEL).

Testing Using Anti-cancer Drugs

Anti-cancer drugs have been looked at before for treating diabetic retinopathy, since they interfere with cell division and can prevent unwanted blood vessels from accumulating. However, when administered systemically, high dosages are required to have the desired local effect; this damages other tissue and interferes with necessary cell division in bone marrow, hair follicles, and elsewhere. Targeted, controlled release would be the ideal solution, with possible applications in cancer treatment.

The researchers tested their device using the solid form of the anti-cancer drug docetaxel (DTX). They immersed it in a fluid that models human physiological fluid, and found that the drug mixed properly in the reservoir, and released as it should when a magnetic field was applied. The device still worked properly after being immersed for 35 days.

Since only a small portion of the drug dissolves each time the reservoir refills, the researchers speculated that it could remain viable for long periods. Recent tests have shown that DTX remained effective against human epithelial and prostrate cancer cells (both of which divide rapidly, like the blood vessels behind the eye in diabetic retinopathy) for 6 months.

Biocompatibility Issues

"The next step," Chiao says, "is to test the device's biocompatibility. Drug-delivery devices have been placed behind the eye before, so we know it can be done." These devices, however, are based on constant diffusion, so drug release cannot be tailored to the patient's condition. Since Chiao's device is made from the same polymer as contact lenses, the biocompatibility of the material is established. But there are issues specific to the device, such as what might happen if the patient rubs their eye: will this cause the drug to be released, or dislodge the device? If so, the researchers may need to place a buffer between it and the eye. They also don't know whether protein deposition would eventually clog the aperture. As Chiao points out, "developing biomedical devices takes a long time, since there are so many factors to consider. We are still in the very early stages of product development."

Along with Burt and Jackson, the expert team Chiao has assembled includes Jay Kizhakkedathu (UBC Pathology and Laboratory Medicine), who will develop appropriate biocompatible coatings. Frederick Mikelberg, Joanne Matsubara, and David Maberley of UBC's Department of Ophthalmology and Visual Sciences will conduct feasibility studies. Industrial sponsor Intellectual Ventures is supporting the project, and Vancouver-based biomedical company QLT Inc. is providing valuable feedback about device size, the types of drugs to focus on, and other issues. In the long run, Chiao sees the device being implanted behind the eye under local anesthetic in a 15-minute procedure. The patient's family doctor would then actuate it maybe once a month using an external magnet.

Targeted, controlled drug release from an implantable, battery-less device that could remain in the body for months at a time could have far-reaching implications for healthcare. It could dramatically reduce the side effects of chemotherapy, for example, leaving the patient stronger to fight their cancer.

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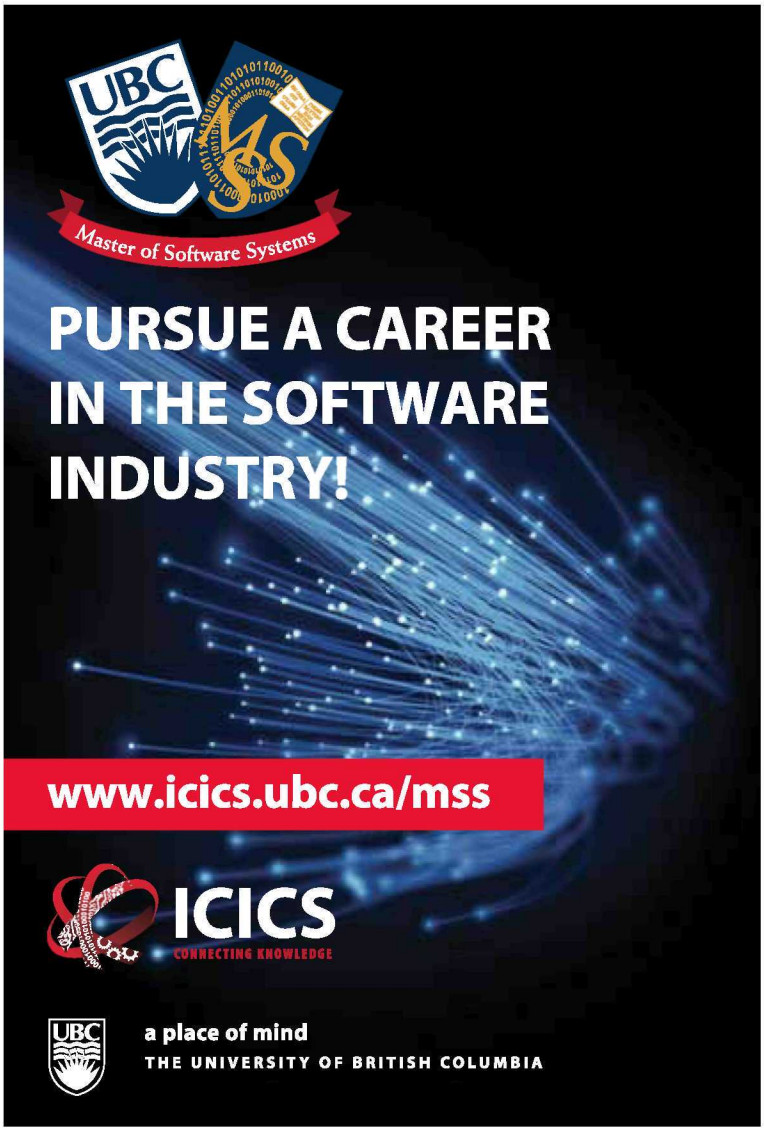

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Our members attract approximately $18 million annually in grants and contracts. Their work strengthens Canada's strategic Science and Technology research priority areas, benefiting all Canadians.

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