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SYNERGY

JOURNAL OF UBC SCIENCE

CREATING KNOWLEDGE OUT OF DATA

UBC researchers are working at the forefront of bioinformatics, information visualization and security to help science deal with a deluge of data. **06**

a place of mind

THE UNIVERSITY OF BRITISH COLUMBIA

CREATING KNOWLEDGE OUT OF DATA

We've entered a new era of leveraging computers to accelerate scientific discovery. Increases in computational power and the emergence of high through-put science have led to an almost unimaginable amount of data being generated, stored and shared, much of it online. These leaps forward offer great potential, but also bring with them a host of challenges—particularly in data mining, analysis, visualization and security.

This issue of Synergy offers a glimpse into the wide range of work being done at UBC Science at the forefront of some of these fields, and the very real impact the work is having on health, systems management, business, privacy and online security.

As one would expect, the research is highly interdisciplinary. It links computer scientists who are advancing data visualization tools with colleagues in microbiology,

NEWS

MICROBIOLOGY

World's Largest, Most Complex Marine Virus is Major Player in Ocean Ecosystems

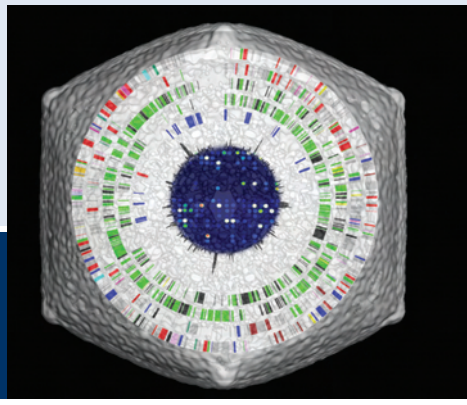
UBC microbiologists have identified the world's largest marine virus—an unusually complex 'mimi-like virus' that infects an ecologically important and widespread planktonic predator.

Cafeteria roenbergensis virus has a genome larger than those found in some cellular organisms, and boasts genetic complexity that blurs the distinction between 'non-living' and 'living' entities.

"Virus are classically thought of small, simple organisms in terms of the number of genes they carry," says Prof. Curtis Suttle, an expert in marine microbiology and environmental virology and lead author of the study. "Much of the genetic machinery we found in this virus you would only expect to find in living, cellular organisms, including many genes required to produce DNA, RNA, proteins and sugars."

The findings are reported in an October issue of the Proceedings of the National Academy of Sciences. Viruses can't replicate outside of living host cells and they depend on proteins provided by the cell, a boundary that is often used to delineate 'non-living' from 'living' organisms. Giant viruses challenge this definition, as they still need a cell to replicate, but encode in their own genome most of the proteins required for replication.

Curtis and his team where able to determine that the pathogen—discovered in Texas coastal waters in the early 1990s—has a genome that contains approximately 730,000 base pairs. That makes Cafeteria roenbergensis virus the largest known marine virus, and the second largest known virus, after the fresh water-



Creating Knowledge Out of Data: Look for the theme colour throughout this issue to find out about our scientists' and students' work in bioinformatics, infovis and data security.

psychology, medicine and, of course, the pure computational sciences. The work also draws our researchers into collaborations with partners in health research like Genome Canada, and with business partners like Google, Yahoo!, AT&T and Microsoft.

On another note, I'd like to thank the many friends of the Faculty who took time over the summer and fall to visit our new Beaty Biodiversity Museum. Public previews of the Beaty's Blue Whale Skeleton Exhibit over the summer and the museum's opening in October have already attracted thousands of visitors.

We value your support for the ongoing outreach and research missions inherent in the museum's mandate. I invite our Science alumni to schedule some holiday time this winter to explore—or further explore—the wealth and wonder of UBC's natural history collections.

I also invite our alumni to comment on UBC Science's draft strategic plan, posted at **science.ubc.ca**. Your input will be crucial in helping us articulate our commitments and goals, particularly regarding undergraduate education and community involvement, over the next several years.

Simon M. Peacock
Dean, UBC Science

borne Acanthamoeba polyphaga mimivirus, which weighs in at 1.2 million base pairs.

Cafeteria roenbergensis virus also infects a major marine zooplankter which occupies a key position in marine food webs.
Read more at: science.ubc.ca/news/478

CHEMISTRY

$1.6-Million Boost for Atmospheric Aerosol Research, Graduate Training

UBC Science researchers have received $1.6 million in federal funding to establish a graduate training and research program in atmospheric aerosols, based out of the Department of Chemistry. The interdisciplinary program, led by associate professor Allan Bertram, will focus on mixtures of very fine solid and liquid particles suspended in the air, which have important impacts on human health, weather and climate change.

"This research funding highlights the quality of UBC graduate students and our strong track record in multidisciplinary collaborations aimed at solving real problems in the world," said UBC president Stephen Toope in announcing the funding. "We're grateful to the Government of Canada for its vision and ongoing support of leading-edge research and graduate education." The funding is part of a Natural Sciences and Engineering Research Council of Canada initiative designed to help graduates expand their professional and personal skills.

SCIENCE EDUCATION

UBC Science Education Guru Confirmed to White House Post

The United States Senate confirmed UBC professor and Nobel laureate Carl Wieman to the position of Associate Director for Science in the White House Office of Science and Technology Policy this fall.

Wieman joined UBC Science in 2007 as professor of Physics and director of the Carl Wieman Science Education Initiative, designed to transform science teaching and learning at UBC and beyond. "The CWSEI has made an indelible impact on thousands of UBC students, and we have no doubt Carl will affect wider change in science education in American schools through his new role," says UBC president Prof. Stephen Toope. "We wish him the best in Washington, and look forward to him rejoining us."

Over the past three years, more than 18,000 UBC students have been affected by the CWSEI through the transformation of courses. More than 40 courses in seven science departments are undergoing or have finished transformation. The work has attracted international attention and support, including a $2-million gift from Google's founding investor and UBC Science alumnus David Cheriton earlier this year. Sarah Gilbert, CWSEI associate director, will serve as acting director during Wieman's tenure with the Obama administration.

BOTANY

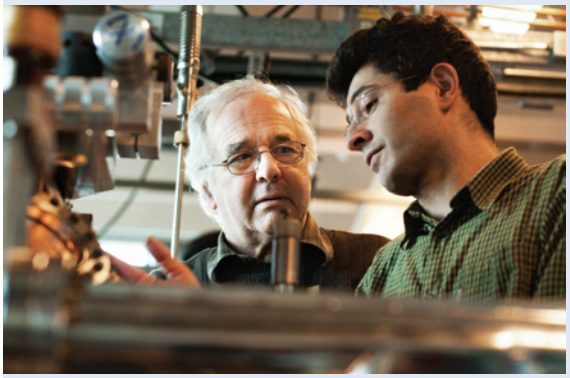
Royal Society Honours for Botany, Chemistry and Physics

Canada's Royal Society welcomed UBC medicinal inorganic chemist Chris Orvig to its ranks this September, and UBC theoretical physicist Ian Affleck was elected to the United Kingdom's Royal Society in May. Not to be outdone, UBC evolutionary biologist Loren Rieseberg was elected to both royal societies. A professor with Botany and Canada Research Chair in Plant Evolutionary Genomics, Rieseberg was cited for "fundamental contributions to society's understanding of speciation mechanisms and the evolution of local adaptation."

(L-R) Genomic map of Cafeteria roenbergensis virus, a giant ocean virus infecting a common microzooplankton. Credit: Chuan Xiao (University of Texas at El Paso) and Matthias Fischer (UBC).
• UBC professor and Nobel laureate Carl Wieman.

Max Planck Partnership Cements UBC's Reputation in Quantum Physics

UBC has forged a formal partnership with the Max Planck Society, Germany's foremost basic research institution and home to 32 Nobel prize winners.



Prof. George Sawatzky, Canada Research Chair in Physics and Chemistry of Nano-structured Materials leads the UBC contingent of the new Max Planck-UBC Centre.

The establishment of the Max Planck-UBC Centre for Quantum Materials will commit both institutions to joint research projects in Canada and Germany, and to increased scholarly exchanges.

"The partnership with Max Planck is a testament to the calibre of research conducted here, and to the fact that our researchers enjoy reputations as some of the most internationally collaborative in the world," said John Hepburn, UBC vice-president, Research and International. "Our interdisciplinary research strengths are further complemented by state-of-the-art facilities such as UBC's Advanced Materials and Process Engineering Laboratory, Canada's National Laboratory for Particle and Nuclear Physics, and priority access to the Canadian Light Source synchrotron."

Principal investigators to lead research groups in the new centre include four Canada Research Chairs (CRCs) and two fellows of Royal Society of London. Three of the researchers are among the 100 most cited physicists in the world. They will be led by Prof. George Sawatzky, CRC in Physics and Chemistry of Nano-structured Materials. UBC is world renowned for research excellence in quantum materials—to date, four CRCs in the area of condensed matter physics have been awarded to researchers at UBC, more than any other university in the country.

Watch more at: science.ubc.ca/news/464

EARTH & OCEAN SCIENCES

Government, Industry Support to Help 'De-Noise' Seismic Data

A new five-year, $5-million government- and industry-funded project at UBC will see researchers in the departments of Earth & Ocean Sciences, Computer Science and Mathematics designing the next generation of seismic imaging technology.

The Dynamic Nonlinear Optimization for Imaging in Seismic Exploration (DNOISE II) project received funding from the Natural Sciences and Engineering Research Council of Canada this October, and matching support from industry partners that include BG Group, BP, Chevron, ConocoPhillips, Petrobras, Total SA and WesternGeco.

"This work will address fundamental issues related to the quality and cost of seismic data acquisition, and to the ability to mine exceedingly large data volumes," says Felix Herrmann, director of the UBC's Seismic Laboratory for Imaging and Modeling and principal investigator on the project.

"These investments will help keep UBC and Canada at the forefront of advancing seismic imaging technology by adapting transformational developments in applied and computational harmonic analysis, convex optimization and geophysical inversion."

The interdisciplinary project involves researchers from across UBC Science, including Michael Friedlander (Computer Science), Ozgur Yilmaz (Mathematics) and Herrmann (Earth & Ocean Sciences). Much of the funding will provide research support for graduate students and post-doctoral fellows.

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MATHEMATICAL SCIENCES

Stacking Boxes Earns Doctoral Research National Honour

Benjamin Young has been awarded the Canadian Mathematical Society (CMS) Doctoral Prize for research conducted while a student at UBC. In his thesis work, Young proved several outstanding conjectures concerning "box counting"—he was able to count the number of ways in which coloured boxes can be piled in a corner with various predetermined colour schemes.

"These whimsical-sounding problems in fact have deep connections to statistical mechanics, representation theory, algebraic geometry and mathematical physics," noted David Brydges, chair of the CMS Research Committee, in making the announcement. "The conjectures which Young solved arose from the interactions of these subjects."

Currently with the Mathematical Sciences Research Institute in Berkeley, California, Young conducted his thesis work under the supervision of UBC mathematicians Jim Bryan and Richard Kenyon. Young will receive the award and present a plenary lecture at the 2010 CMS Winter Meeting in Vancouver this December.

Adding Research Muscle in Math, Evolutionary Biology

UBC Science welcomed two new Canada Research Chairs (CRC) this year, with the appointment of Sujatha Ramdorai as CRC in Mathematics, and Zoology professor and Biodiversity Research Centre director Sarah Otto as CRC in Theoretical and Experimental Evolution. Ramdorai—recently recruited to UBC from India's Tata Institute of Fundamental Research—focuses her work on the algebraic theory of quadratic forms, and more recently, non-commutative Iwasawa theory.

ANALYTICAL TOOLS AND HEALTH

Charting a More Detailed Family Tree for Blood Cells

Researchers with UBC's Centre for High-Throughput Biology and Michael Smith Laboratories have mapped what is likely the most comprehensive profile of microRNA (miRNA) expression across the hematopoietic hierarchy—the collection of primitive and differentiated cell types that develop from a common blood-forming stem cell.

Hematopoietic stem cells—found in bone marrow—have the ability to differentiate into all of the different mature blood cell types through a series of intermediate progenitor cell types. MicroRNAs play a critical role in orchestrating this "family tree" of cellular development.

"How miRNA expression is controlled at each stage of the hierarchy is an important biological question for understanding this element of control," says Carl Hansen, assistant professor with Physics & Astronomy and lead author on a Proceedings of the National Academy of Sciences paper. "It's becoming clear that miRNA play a role, not only in blood cell type differentiation, but also in blood cancers. We really wanted to see the big picture of how the microRNA expression is changing at each stage of differentiation, and this study provides the first unified and comprehensive data set."

The study used newly available microfluidic technology capable of cycling 2,300 samples at a time. "This really would have been—at best—a painstaking and expensive process without the benefit of high-throughput technology," notes Hansen.

MOLECULAR EVOLUTION

A Chromosome 'Haircut' for the World's Tiniest Genome

The world's tiniest nuclear genome has snipped off the ends of its chromosomes and evolved into a much leaner genomic machine that infects human cells, according to research published by UBC Botany professor Patrick Keeling this September.

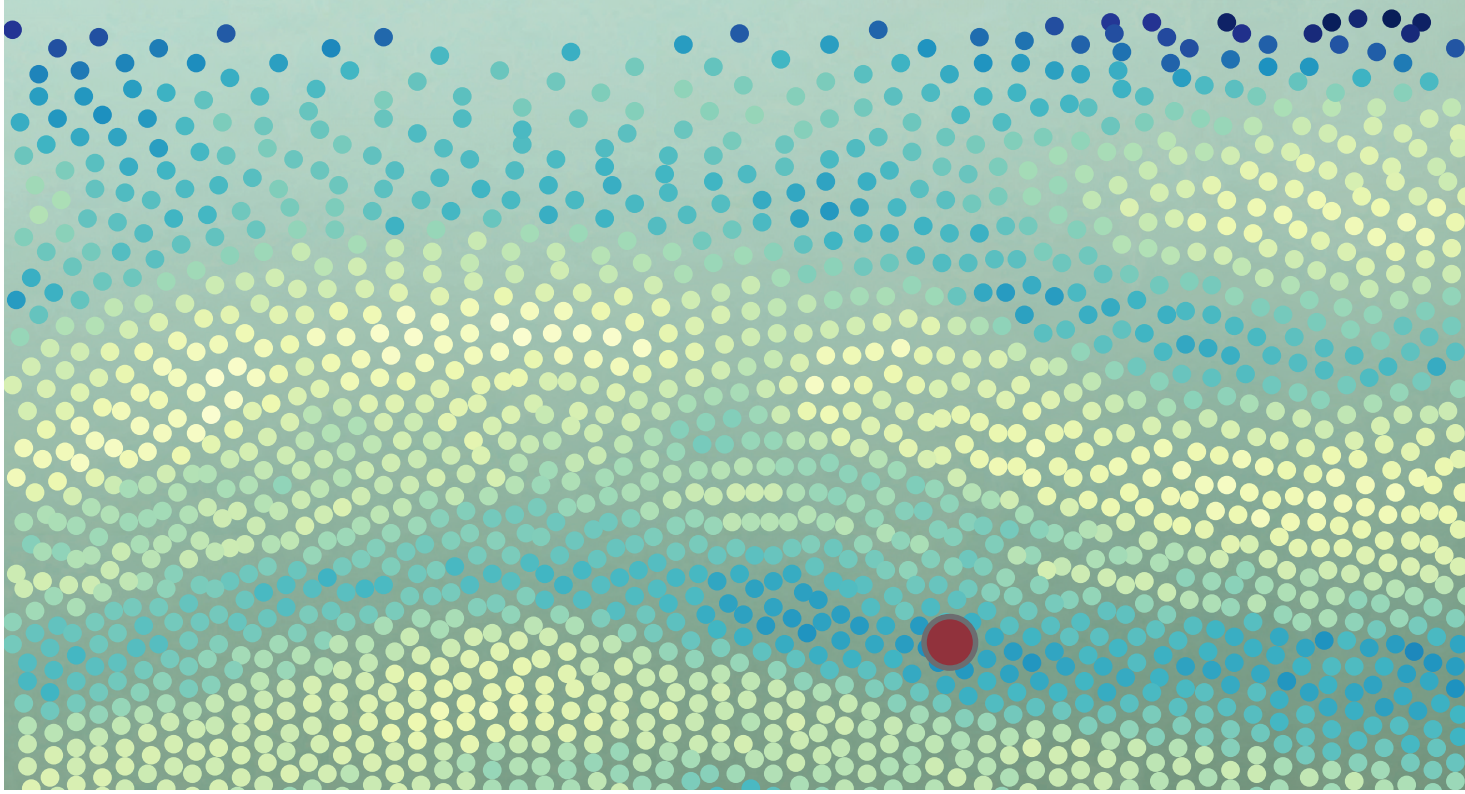
Until recently, E. cuniculi, a parasitic fungus commonly found in rabbits that can be fatal to immunocompromised humans, has been widely regarded as having the smallest known nuclear genome at 2.9 million base pairs. But now, UBC researchers have sequenced the genome of a closely related parasite that makes the E. cuniculi genome seem king-sized. The genome of E. intestinalis, a sister species of E. cuniculi, is 20 percent smaller, at only 2.3 million base pairs.

"On one end of the spectrum, genomes can get larger almost without limit, but there is a limit to how small they can get," says Keeling, whose work was published in Nature Communications. "And the question that fascinated us was, 'In an already tiny genome, what else can be lost?'"

Prof. Sujatha Ramdorai, Canada Research Chair, Mathematics.

CREATING KNOWLEDGE OUT OF DATA

Information Overload – Mining and Interpreting a Deluge of Data



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Rapid technological advances have created a glut of data that requires innovative techniques to mine, manage and interpret. UBC researchers are working at the forefront of bioinformatics, infovis and data security to help create knowledge out of information overload.

Whenever we use a bank machine, refill a prescription, surf the web or engage in social networking, data is being collected, stored and turned into information. Sifting through those warehouses of data to find the patterns that produce useful information is one of the most conceptually and technically daunting challenges in modern research.

Computer science professor Raymond Ng has worked at the forefront of data mining and engineering at UBC since 1992. His early work focused on commercial data mining and management. Over the past 10 years, however, Ng has shifted his focus to health data and large-scale genomics databases.

"Genomics data sets are a natural application for data mining because they're so huge."

Bioinformatics and the Holy Grail of Personalized Medicine

Advances in high-throughput technologies are used in health research to explore gene and protein expression data. Ng worked with the Heart and Lung Institute at St Paul's Hospital and the BC Cancer Research Centre to discover biomarker panels for early detection, diagnosis and treatment guidance of various medical conditions. The challenge in biomarker development is extracting meaningful information from high-dimensional data, where each sample can have tens of thousands of measurements, often concurrently obtained. In one of his studies, there are well over 200 million numbers to analyze.

"Previous pharmaceutical research has been based on population analysis, which doesn't apply to every individual," says Ng, noting that rapid development in genomics technologies is paving the way to the Holy Grail of medical research—personalized medicine. "We can now use this technology to get deep data at the molecular level, so from an applications point of view, personalized medicine is very exciting."

Ng is Genome Canada's PROOF (Prevention of Organ Failure) Centre of Excellence's chief informatics officer. The objective of the centre is to discover biomarkers to help diagnose, treat and prevent heart, lung and kidney failure, which have become epidemic. One in four Canadians is at risk of organ failure, and current methods of detection are often costly, invasive and generally unsuitable for early diagnosis and intervention.

"The whole premise of PROOF is to develop blood- and urine-based biomarkers, which are much less invasive and less costly than biopsies," says Ng. By detecting certain proteins and genes, clinicians can better diagnose and predict whether a patient has or is predisposed to a certain medical condition.

In certain communities, the term "bioinformatics" is better known than "health informatics," which takes into consideration the entire scope of health care. "Medicine is not just about biology; it's about patients, the chemistry of medications, work flow, privacy and technology," he says. Along with Kendall Ho, former associate dean of UBC's Faculty of Medicine, Bernie Garrett from the School of Nursing, and computer science colleague George Tsiknis, Ng developed a course in health informatics, now in its fifth year at UBC. "PROOF and health-related informatics has a high social value, and that's one of the reasons I was excited to take a deep dive in this direction."

Using Visualization Tools to Interpret Complex Information

Information visualization (infovis) combines our most powerful cognitive tool—visual metaphor—with interactive computer graphics to help make sense out of abstract datasets.

Ten years ago, it was an emerging area. Today infovis is a burgeoning interdisciplinary field that combines interactive computer graphics with cognitive science, psychology, human-computer interaction, cartography—and a good dollop of creativity and intuition."What makes this field so exciting and interesting is that I get to work with people in a number of areas, including microbiology, phylogeny, computer networking and computational linguistics to see what problems they have that might be solved by infovis," says associate professor in Computer Science Tamara Munzner.

As with data mining and bioinformatics, infovis has unique challenges and pitfalls. "If you're solving the wrong problem, it doesn't matter if you've done everything else perfectly, your solution will be useless. Or, at the next level, you might have the right problem but the wrong abstraction. Even if you have the right abstraction, the actual way you create the picture and interact with it—the

(L-R): Laks Lakshmanan, Professor, Computer Science • Tamara Munzner, Associate Professor, Computer Science • Raymond Ng, Professor, Computer Science.

Monitoring and Mapping Our Movements

With location-aware device use on the rise, so is the mining of "moving object" data. Companies and governments are able to monitor and analyze the movement patterns of individuals in real-time and even record the traces they leave behind. In Milan, for example, many citizens equip their cars with GPS devices in exchange for a substantial discount on car insurance. In Hong Kong, a company collects daily trajectory data of residents who use its smart card payment system.

Lakshmanan, along with grad student Roman Yarovoy, Francesco Bonchi from Yahoo! Research in Barcelona, and Wendy Hui Wang, now with the Stevens Institute of Technology in New Jersey, were the first researchers to extend and apply the concept of k-anonymity to moving object databases. In this case, the moving objects are humans who are unconcerned with who maps their whereabouts. The research team's technique protects the privacy of users whenever the moving object data is published and released for the purpose of mining and analysis. Until their method is widely employed, however, Big Brother might not only be watching, he'll be taking notes.

cognitive psychology aspect—may not work. And then, at the level of computer science, you need the right algorithm."

Munzner speaks from experience. Some of her initial work was on a technique that allowed the user to see both the forest (overview) and the trees (detail). However, more recent work on the psychophysics of human vision with UBC computer science colleagues Ron Rensink and Joanne McGrenere led her to realize that it might not be the best method. "I've grown less convinced that you need focused material embedded within context, because this requires a distortion that has fairly high cognitive and interaction costs."

'Seeing' Gene Signalling

Munzner worked with UBC microbiologist and immunologist Robert Hancock (Synergy 1|2004) on InnateDB, a database platform designed to analyze the signalling and interaction pathways between genes and proteins involved in human innate immune response. The database can track roughly 2,600 pathways and 111,000 physical, biochemical and transcriptional interactions. Munzner and former master's student Aaron Barsky developed Cerebral, the visualization tool of InnateDB, which displays the complex cascade of genes and proteins in real time, allowing researchers to observe gene regulation in action.

The challenge was to create a visualization that would update the system graph (what researchers believe they know about signalling pathways) with real-time data from microarray experiments. "How do you integrate these data? If you just look at the measurements, the data is incredibly noisy, which makes it hard to draw any strong conclusions," Munzner says. The team used a technique called "small multiples," where the large system graph sets the spatial location of nodes and edges, and several colour-coded smaller graphs represent the different measurements, allowing the eye to move quickly between them.

"We realized that humans are much better at side-by-side comparisons, rather than comparing the memory of what you saw to what you see now." Munzner also realized that when it comes to graphical information, biologists aren't merely concerned with topological structure, or what nodes are connected to what edges. They want to know what is happening in the cell, and where the reaction occurred. "We used that information to guide the layout and make pictures that have the intuitive look and feel of hand-drawn illustrations, only the process is totally automatic."

Infovis Solutions for Business

Internet giant Google Inc. wanted to study how people use their search engine and how happy they are with the results. Munzner and former graduate student Heidi Lam worked with Google on Session Viewer, which tracked and logged volunteer user search sessions. The project involved 400 participants and generated roughly 6,000 sessions, which were grouped by search engine type, search domain (such as image or news) and question variant (which defined search tasks). Session Viewer helped spot trends and anomalies while also analyzing individual sessions in the context of a larger population.

Munzner and former student Peter McLachlan also developed LiveRAC, a visualization system for AT&T to support analysis of massive collections of systems management data.

"Imagine huge farms of 10,000 machines generating massive reports every five minutes and you explore all of this time-series data for capacity planning, crash avoidance and forensic

"Medicine is not just about biology; it's about patients, the chemistry of medications, work flow, privacy and technology" – Raymond Ng

analysis," she says. The problem with data summary dashboards on many systems management tools is that they hide the true complexity of what is going on inside the system. A data centre may be at risk even if one critical system is down, but still healthy if many systems are down due to maintenance. LiveRAC allows side-by-side visual comparison at multiple levels of detail.

"Heidi did her field work at Google and is now working for them, and Peter did field work at AT&T," says Munzner. "When I tell biologist colleagues that my students do their field work at Google or AT&T, they find it very amusing, because their students go to jungles and deserts, not air conditioned offices!"

Foiling Data Pirates and Hackers

A company's data is one of its most valuable assets. Yet, the growing need for computational resources, data management and mining expertise, and the costs of having them in-house, has led many companies to outsource. Most data owners recognize that they should not trust service providers with their data, at least not completely. Protecting company data from the servers housing it is the job of UBC computer science professor Laks Lakshmanan, who develops and analyzes data transformation methods to foil hackers.

"Raw data is absolutely deadly if it falls into the wrong hands," notes Lakshmanan, whose advice is don't trust anyone, even a recognized service provider. This applies for all data, but especially relational databases that link demographic and personal information, such as medical, insurance and employee records. "The assumption is that although a server may not be deliberately malicious, they will be curious."

The trick is to disguise or generally transform the data. The most widely used method is anonymization where, for example, word order in names is reversed or names are mapped to numbers. Lakshmanan, Ng and Ganesh Ramesh from Microsoft analyzed the risk of disclosure using anonymized data and designed a method based on risk tolerance, which allows data owners to decide if anonymization is the best protection method for them. However, using statistical methods based on prior knowledge, it is easy to uncover associations among data and personal information, even though the outsourced data may be anonymized.

"As a data owner, I must assume that a service provider has some background knowledge of my business, such as the approximate number of employees, base salary ranges or product lines," Lakshmanan explains.

Protecting data privacy and security in the context of outsourcing is inherently challenging. The server can view not only the data that it is hosting, but also the queries run and the answers it returns. Even when the data is encrypted, with a little background knowledge the server can learn a surprising amount of information from observing these transactions. Along with former PhD student Wendy Hui Wang, Lakshmanan developed encryption techniques that make it extremely difficult for the server to learn any valuable information from the encrypted database it hosts.

K-anonymity generalizes records by replacing street addresses with postal codes, for example, so that even with some prior knowledge, individual records are difficult to identify. "Not only must the original database be indecipherable, even queries and results must be formed so that information can't be gleaned from them," explains Lakshmanan.

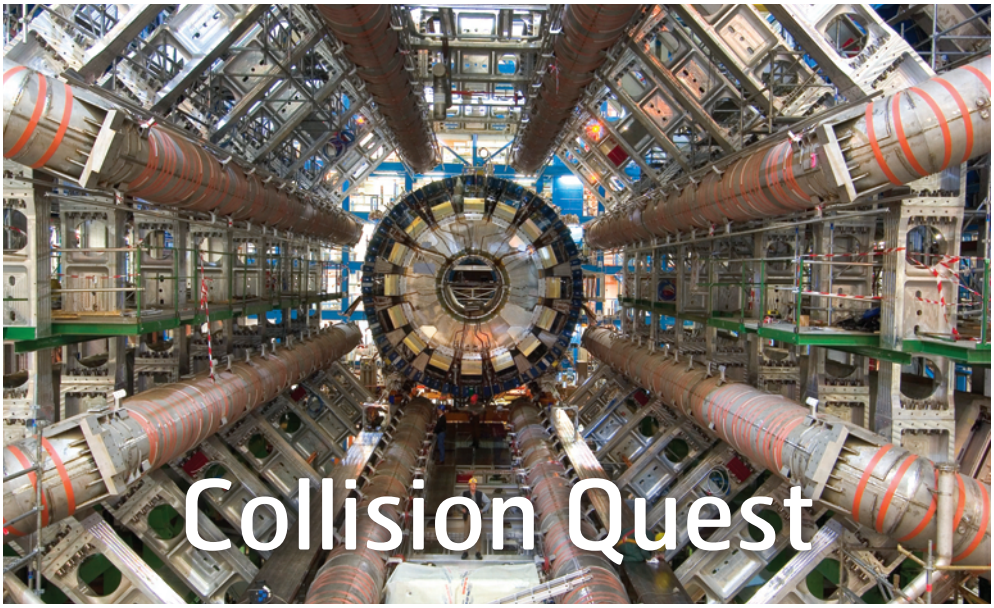
The state of the art in privacy-preserving data mining is to perturb data by adding random noise, or confusing variables, so that the server cannot learn exact values easily. However, patterns mined from the transformed database must be guaranteed to be close to the patterns mined from the original data. In collaboration with Ng and PhD student Shaofeng Bu, Lakshmanan has developed a novel technique for transforming the data so the privacy is protected and the exact mined patterns are preserved.

How Secure Is Your Inbox?

With many services available over the Internet—including social networking, e-mail systems and office suites that store personal data in "the cloud,"—data protection has never been more critical. Yet, data security experts are still determining the extent of risk and what to do about it. One thing is certain: most people are too lax in protecting their online data and identities.

"At a social level, it seems that people who grow up with social networking have no notion of privacy, and the default setting on these networks seems to be changing all the time, so that it's up to the user to keep restoring their personal settings," Lakshmanan says. He is working on several projects in online database management and is about to look into social network privacy and security. "The positive side of this is that once we have a security solution, we will have access to an enormous database of social connections and behaviour that will allow sociological studies, as well as optimization studies such as viral marketing, on a scale we could not have dreamed of 10 years ago."

Perhaps they will be able to answer questions like: Why do we trust virtual spaces and people more than real ones? What drives the desire to blog and tweet? Who has the time?



Collision Quest

Eight torodial magnets can be seen on the huge ATLAS detector.
Credit: The ATLAS Experiment at CERN.

UBC physicists are part of an elite team working on ATLAS—one of six research projects at the Large Hadron Collider at CERN, the European Organization for Nuclear Research in Switzerland. Their quest for subatomic clues to the nature of the universe may open the doors to new physics, and possibly, new dimensions.

What is the universe made of? Answering this age-old question requires more than a child-like sense of wonder, it requires colossal tools capable of making matter out of energy. Based on the principles of Einstein's famous formula E=mc2, these tools—particle accelerators—are not only massive, they are infinitely complex.

"The two things that you want in an accelerator is enough energy to produce new particles, and high luminosity, or beam brightness," says Colin Gay, UBC professor of subatomic physics. Gay is one of the principle researchers in the ATLAS project, which stands for (A) (T)oroidal (L)HC (A)pparatu(S). One of the two largest projects at Large Hadron Collider (LHC)—the ATLAS detector is 25 metres high, 50 metres long and weighs roughly 7,000 tons. The LHC produces the energy required to discover a whole new range of high-energy particles, such as the illusive Higgs boson. The discovery of the hypothetical Higgs boson would solve the question of the origin of mass, and close a loophole in the Standard Model of particles and forces.

"Everything we've measured in previous generations of accelerators has been consistent with the Standard Model. But there are holes in the theory that are all in this new higher energy range," says Gay. He and colleagues are hoping their research will illuminate other perplexing grey areas in physics, such as dark matter, dark energy and the existence of extra dimensions.

What's So Great About Higgs?

According to the Standard Model, everything in the universe is made from 12 fundamental "matter" particles (six quarks and six leptons) governed by four fundamental forces (strong, weak, electromagnetic and gravity) and their carrier particles (gluons, W and Z bosons, and photons). Gravity—which governs macrocosmic bodies like people and planets—just doesn't fit into the microcosm of the Standard Model, and its force carrier particle, the graviton, has yet to be discovered.

Most fundamental matter particles have mass because they interact with one another, and that energy exchange generates mass. Protons have mass because their component quarks and gluons interact. However, an isolated quark still has a small mass, yet physicists don't know where it comes from. To make the Standard Model work, University of Edinburgh physicist Peter Higgs and colleagues hypothesized the Higgs boson.

"That's one of the nasty secrets of the Standard Model," admits Gay. "Without the Higgs particle, you have to set the mass of everything in the universe to zero. The Higgs mathematically rescues that, but we have no idea if it's the right theory."

ATLAS could also lead to new discoveries in super symmetry, dark matter, the expansion of the universe, and cosmic background radiation. "These very different phenomena happen to be in exactly the same range of energy that the LHC will finally enable us to see. The biggest thing to come out of the LHC might not be the Higgs, but an understanding of these other phenomena."

Engineering on the Edge

The UBC ATLAS team was responsible for building part of the inner detector of ATLAS—the transition radiation tracker (TRT)—which bends the charged particles in a helical trajectory allowing for

Colin Gay, Professor,
Particle and Subatomic
and String Theory

For more information on this research please visit atlas.phas.ubc.ca

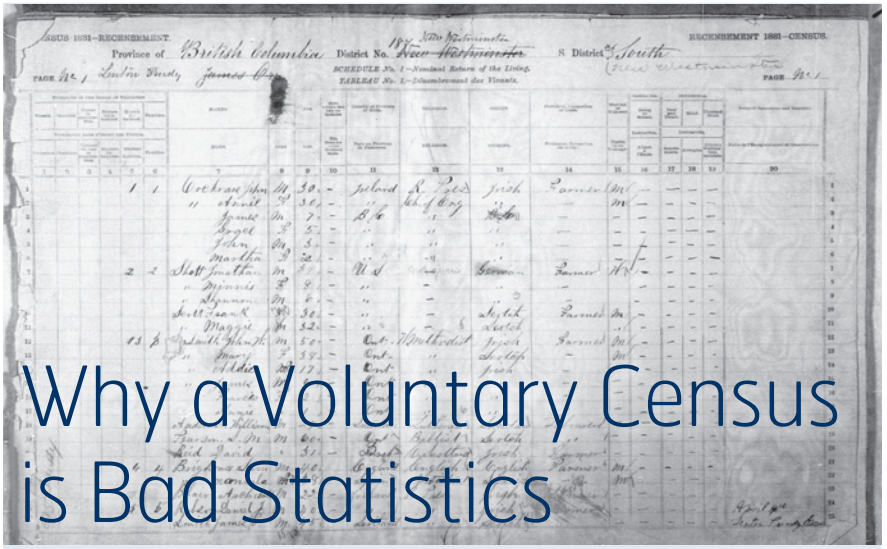
their momentum to be tracked and measured. “The bending is critical, because it tells you the energy of the particle based on momentum,” explains Gay. The detector is so massive that even at the speed of light the particles produced in one collision are still travelling through the detector while the next two collisions occur.

“This poses a huge pattern recognition problem. We need to track roughly 40 points for each particle in order to accurately detect direction and momentum and determine its type. From this, we try to piece together what was produced in a particular collision. If we find the same event type occurred 10 times out of a year’s worth of data, we could have evidence of a new particle.”

Gay was also part of the international team that built the detector’s data acquisition system electronics—another titanic feat, given that ATLAS observes 40 million collisions per second. “Our design must handle approximately 200 gigabytes of data—or an entire hard drive—every second, 24 hours a day, seven days a week for 10 years. And this hard drive full of data has to be acquired, analyzed and checked in real time, every second, without making a mistake.”

The collection, processing and sharing of ATLAS data requires a global distributed network of supercomputers. Canada hosts one of 12 Tier-1 data hubs in the world, located at TRIUMF. Gay works with colleagues from TRIUMF and involves undergrads, graduate students and post-docs in data extraction and analysis.

“In this kind of science, students are a driving force, because I don’t have time to do all of the analysis myself, and that’s where the discoveries happen,” he says. While the analysis can be painstaking, the result could be a whole new way of understanding the universe.



Why a Voluntary Census is Bad Statistics

Portion of 1881 Canada Census.
Credit: Library and Archives Canada.

Rick White, Director of UBC’s Statistical Consulting and Research Laboratory (SCARL), comments on plans to replace Canada’s mandatory long-form census. SCARL offers consulting and collaborative support to researchers and industry clients on experiment design, survey sample development, statistical computing and graphics, and analysis and interpretation.

Why have the rather mundane sounding plans to replace a mandatory long-form census with a voluntary survey caused such an uproar among scientific, business and government commentators? On the surface, increasing Canada’s current census sample size from 20 percent of the population to a voluntary 33 percent might appear like a zero sum game. Even a 40 percent non-response rate on the voluntary version would generate a sample size and information comparable to a mandatory survey. Right?

Canada’s population is 34 million, with roughly 60 percent of that population living in Ontario and Quebec. Imagine that only residents of Quebec and Ontario respond to the proposed voluntary long-form survey. That results in a sample of approximately 20 percent of Canadians, but no representation outside Quebec and Ontario.

To be accurate and representative of the entire population, sampling methods must be unbiased. Voluntary surveys are typically biased, often due to non-response—they allow certain groups within a strata to not respond, and some strata to not respond at all. Canada’s current long form-census uses a stratified, systematic sampling scheme to ensure all large groups in the population are represented in known proportions. If all those sampled respond, unbiased estimates can be calculated for the overall population, as well as for any strata of interest.

A representative sample is not based on size, but rather on who is sampled. The key is getting that representative sample to respond—the most challenging aspect of any survey. A mandatory survey with a proper sampling scheme ensures response. A voluntary survey, however, makes the results unreliable—and often in ways we can’t predict or warn researchers or policy makers about.

For more information on this research please visit www.stat.ubc.ca

PhD student Olga Pena and volunteers (in green T-shirts) facilitate science outreach and education in Colombian high schools.

Cross Border Science

Anyone questioning the impact a single individual can have on the world should meet Olga Pena. The daughter of a housewife and dam builder, Pena led a team of UBC students on a 'field trip' to Colombia this summer, where they inspired more than 1,000 students to take up beakers and microscopes as a means to combat poverty and neglected tropical diseases.

Born and raised in a rural area in the Andean region of Tolima, Pena's elementary school-educated parents encouraged her and her siblings to pursue higher education for hopes of a better life—her brothers are a civil engineer, an agronomist and a soon-to-be lawyer. Pena, the only one in her family fluent in English and the first to pursue post-graduate studies, was admitted to the Pontificia Universidad Javeriana, a top private university in Bogota, at the age of 16. Following her undergraduate degree in Bacteriology and two years of 'adventure' that took her to the University of Southern California, Pena was recruited to UBC last year by world-renowned microbiologist Bob Hancock.

"Olga is a brilliant student," says Hancock, Canada Research Chair in Pathogenomics and Antimicrobials and best known for developing a peptide that fights infections from superbugs and salmonella by boosting the body's own immune system. "I'm extraordinarily pleased to have her in my lab."

It was in Hancock's lab that Pena was exposed to global citizenship. Hancock's involvement with the Bill and Melinda Gates Foundation's Grand Challenges in Global Health, UBC's Neglected Global Diseases Initiative and the campus chapter of Universities Allied for Essential Medicines rubbed off on her and her lab mates, says Pena.

"We have a very multicultural lab, with graduate students, post-docs and technicians from India, Spain, Germany, Serbia, Africa, Australia and Iran," says Pena. "In our discussions we came to the conclusion that developed countries place a lot more emphasis on and investments in science education and it positively affects the socioeconomic status and overall health of their populations. "Whereas in a country like Colombia, where people are struggling on a day-to-day basis, there isn't the culture or infrastructure to support science as an academic or career option."

That's something Pena thought she could do something about. She founded the Accessible Science Initiative (ASI) and in less than a year, assembled a team of UBC undergraduate and graduate students to fundraise their way to bring textbooks, microscopes—and hope—to her home community of Tolima. The team, consisting of students from the faculties of Science, Education, Arts, Applied Science and the Sauder School of Business, partnered with the University of Tolima, where they conducted workshops with 100 school teachers and facilitated interactive science activities with close to 1,000 students. They also developed a science symposium and delivered donations of lab equipment such as microscopes and copies of a Spanish interactive science manual the team produced with 30 hands-on science activities that are sensitive to both the local culture and resources.

"For example, DNA extraction experiments are typically done with kiwi fruits here in North America," says Pena. "But kiwis are expensive and hard to find in Colombia, so we designed the same activity using mangos. Another chapter introduces some of the intestinal parasites commonly affecting the health of the local community to raise awareness among children and teenagers."

"Their approach is extraordinarily innovative," says Hancock, who adds that Pena's enthusiasm is, well, infectious.

"If you ask people whether they care about underprivileged populations, they'll probably say yes, but that's a far cry from actually doing something about it," Hancock says. "Olga knows from personal experience the importance of education in changing the lives of people in an impoverished community, and she's inspired and mobilized her peers to make a tangible difference."

Simon Peacock, Dean of Science, teaching a portion of the First-Year Seminar in Science pilot project.

Curriculum Upgrades Focus on Scientific Literacy and Broadening Students' Horizons

A specialization offering breadth may sound like an oxymoron, but UBC Science students will soon be able to pursue just that through a newly designed Combined Major in Science (CMS) being offered this spring at UBC.

"The CMS allows students to get a broader perspective on science," says Shona Ellis, a senior instructor in the Department of Botany and director of the program. "The diversity and flexibility of course offerings means students can design the focus of their program and really develop a breadth of knowledge across disciplines."

Courses in data interpretation, scientific peer-review, laboratory procedures and communication help ground students in scientific discourse and develop high-level skills to put their knowledge to use.

"For students who aren't going into a specific research area—such as physics or computer science—the CMS lays the groundwork for specializations where broader-based and interdisciplinary knowledge of science is crucial," says Ellis. "It's also a great option for students who are interested in medicine, law, education or journalism after their undergraduate studies."

A new 300-level course, Communicating Science, is being developed specifically for the CMS and focuses on giving students the skills to critically evaluate and communicate scientific issues.

"We want to concentrate on getting students to think about who they are writing for and how best to reach them," says course coordinator Eric Jandciu, a graduate of the UBC School of Journalism who helped run the School's science journalism program. "Science is so entrenched in our daily lives, being able to communicate its implications to the public is an essential skill for scientists."

"Take climate change, for example. We hear about it in the news almost daily, but if the people responsible for communicating the facts about climate change aren't doing it in an accessible way, the public loses its ability to understand the issues and participate meaningfully in the civic discourse required to make changes."

Students will be introduced to the peer review process, an opportunity many don't experience unless they pursue graduate studies. The ability to impartially review scholarly works is considered an essential component of academic quality, but hasn't previously been covered in undergraduate science curriculum.

Small Class, Big Science for First Year Students

Another new course offered this fall will see UBC faculty members, including the Dean of Science, exploring scientific issues—and the very nature of science—alongside first-year undergrads. The First-Year Seminar in Science will challenge students to explore science on a more personal level while building critical thinking and communication skills.

"I'm very excited to be teaching one of our seminars during the fall term and expect to learn as much from our students as they learn from us," says Simon Peacock, Dean of Science and an expert in geotectonics. Peacock will be joined by faculty from Microbiology & Immunology, Botany, Zoology, Computer Science, and the Michael Smith Laboratories.

The seminar, which combines debates, discussions, group activities and a science in society speaker series, will also give students the opportunity to interact with faculty members and peers in a smaller class setting.

The smaller class size is rare in first-year curriculum. It also provides students with an early look into the importance of communicating science, which they otherwise might not encounter until third or fourth year. The course will concentrate on science's role in a larger societal context, by allowing students to explore how knowledge is constructed in a scientific view, and discover how they can use science to make positive contributions on a global scale.

"Science is so entrenched in our daily lives, being able to communicate its implications to the public is an essential skill for scientists." — Eric Jandciu

Science Alum Pitch e-Commerce Venture to Silicon Valley

Two UBC Science entrepreneurs had the opportunity to pitch their business concepts and products directly to Silicon Valley venture capitalists at an August alumni event in Sunnyvale, California.

An online shopping platform company founded by computer science alumni Maryam Mahdaviani and Jan Ulrich was one of six start-ups selected to be part of Accelerating Entrepreneurship: UBC's New Venture. The initiative gives UBC-founded companies the opportunity to present their innovation to a panel of business leaders and investors, including Plug and Play Tech Center president and CEO Saeed Amidi.

Mahdaviani and Ulrich met while doing their master's degree at UBC. Mahdaviani was studying machine learning. Ulrich was focusing on multi-document summarization. Their similar research areas and interest in online marketplaces spawned the start-up Optemo in 2008.

"Jan and I are both online shoppers," says Mahdaviani. "We realized there's a lot of information available online, but it can be hard for people to find what they want."

This realization led them to develop software that allows retailers to better manage their online catalogues and helps customers navigate merchandise more effectively and efficiently. "Besides enhanced keyword and faceted search, the platform also provides example-based navigation. Shoppers can get a feel for available products without having to click through pages upon pages of

Field School Reunion Mines Rich Vein of Memories

Earth & Ocean Sciences classes of 1950 to 1989 shared memories—and a BBQ lunch of hotdogs and burgers at the department's venerable Oliver Field School—at an Okanagan reunion and wine tour this fall. After lunch, many alumni and guests opted for a tour and impromptu lecture at the nearby Gypo mine silica deposits. The reunion's evening was less rustic, with alumni sharing 60 years of geological field school reminiscences over cocktails and dinner at the Spirit Ridge Vineyard Resort in Osoyoos.

IMAGES: UBC's geological field school, past, present and future. The current student training facilities on the site range in age from 35 to 60 years—including the field school's rustic cookhouse. The reunion might just have inspired the next generation of geologists. Credit: Anna Grabowski.

products—they get to search based on look and feel."

As part of the new entrepreneurship@ UBC program, a campus-wide initiative designed to facilitate and encourage new business ventures, an open invitation was extended to companies created by current students and recent alumni to join UBC president Stephen Toope at the California event.

"The number and outstanding quality of the applications is a reflection of the creativity and resourcefulness we've come to expect from UBC students and alumni," commented Toope. "We're delighted to facilitate opportunities where UBC entrepreneurs can advance innovations that impact local and global communities."

Maryam Mahdaviani,
Optemo Technologies

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