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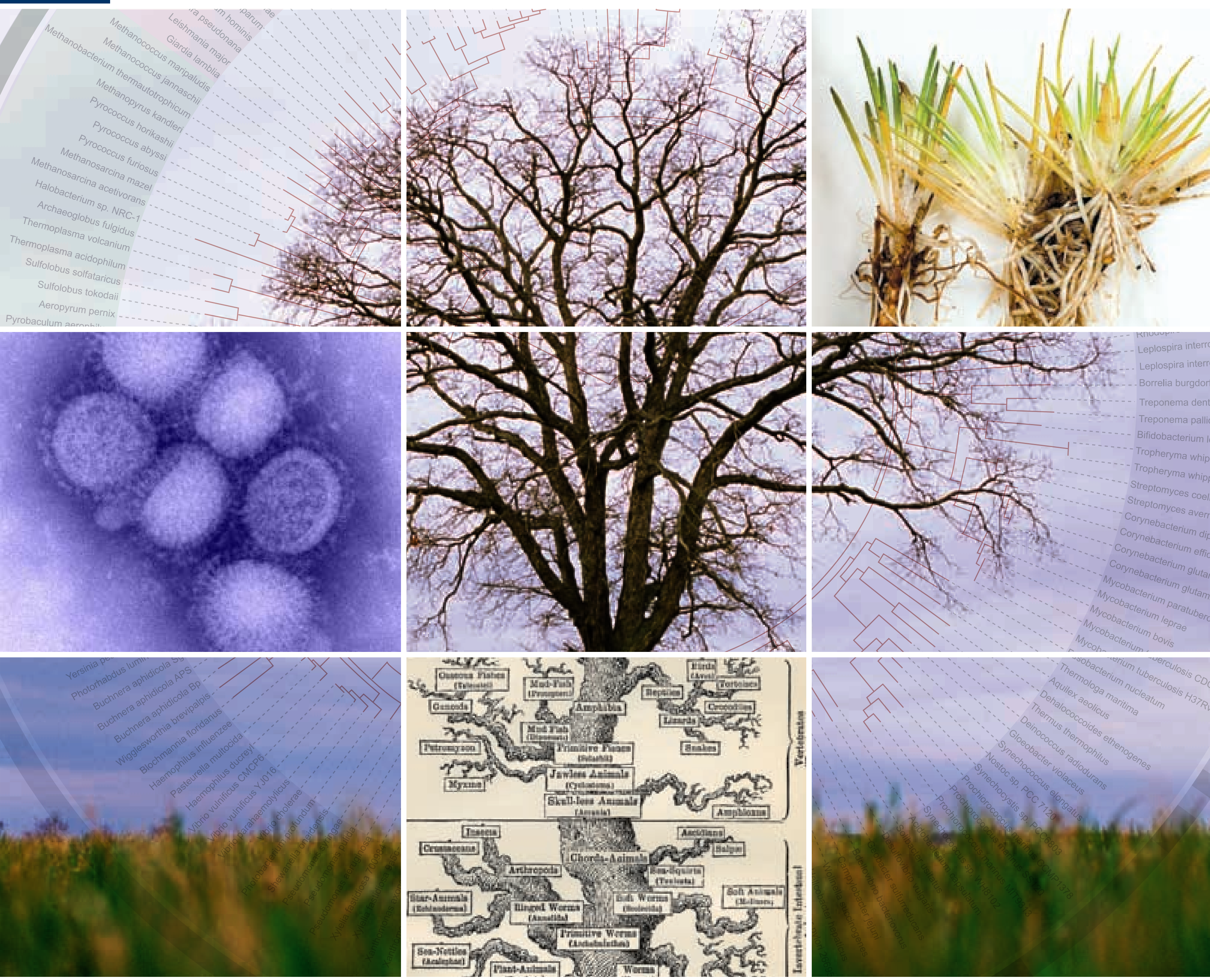
SYNERGY

JOURNAL OF UBC SCIENCE

DARWIN'S TREE BRANCHES OUT

Variation, Heredity and the Enigma of Sex
UBC evolutionary biologists are looking deeper and deeper into how species have evolved. **06**



EVOLUTION IN ACTION

One hundred and fifty years ago, Charles Darwin wrote *On the Origin of Species*, which presented compelling evidence for all species of life having descended from a common ancestor through the process of natural selection. Over the intervening 150 years, Darwin's theory of natural selection and gradual change, combined with Mendel's laws of genetic inheritance, has led to the modern theory of evolution—the unifying theory of the life sciences.

Modern evolutionary biology guides the development of each year's flu vaccine and our response to emerging viral diseases like H1N1. We can learn much about evolution and human diseases like cancer by exploring the genetic connections between humans and other organisms. And by exploring how past generations of plants and animals adapted to an "evolving" environment, we are better equipped to forecast the effects of

NEWS

New Canada Research Chairs: Testament to UBC Science Research Strength

UBC Science strengthens its research excellence this year with the appointment of two investigators in chemical biology and computer science as Canada Research Chairs (CRCs) and with the renewal of eight CRCs in focal research areas of chemistry and physics.

CRC in Chemical Biology Stephen Withers is applying tools of chemistry to understand the roles of carbohydrates. His research is developing new methodologies for the synthesis of carbohydrate-based therapeutics. CRC in Computer Systems and Security Andrew Warfield's work will help make existing software systems more stable and secure and will provide developers with better tools to build new software.

This year's CRC renewals in UBC Science include:

- James Feng, CRC in Complex Fluids and Interfaces
- Jeremy Heyl, CRC in Neutron Stars and Black Holes
- Reinhard Jetter, CRC in Plant Natural Products Chemistry
- Hongbin Li, CRC in Molecular Nanoscience and Protein Engineering
- Scott Oser, CRC in Solar Neutrinos
- Dominik Schötzau, CRC in Numerical Analysis of Multiphysics Problems
- Moshe Shapiro, CRC in Quantum Control of Atoms and Molecules
- Dominique Weis, CRC in Geochemistry of the Earth's Mantle.

"In the current economic climate, it is more important than ever to attract and retain talented investigators whose work can help us confront and manage complex issues," says John Hepburn, UBC vice-president, Research and International. "These world-class researchers are a testament to UBC's international reputation for excellence."

* Evolution: Look for this icon and find out how our researchers and students expand and apply our understanding of evolution.

global and regional climate change on biodiversity and ecosystems.

Today, UBC's science faculty and students conduct evolutionary biology research, using a variety of approaches, to deepen our understanding of evolution. This issue of *Synergy* features several snapshots of evolutionary research contributions our scientists are making to the field—such as explaining the evolutionary benefits of sexual reproduction, discovering the mechanisms of how plants and animals adapt to their environments, and elucidating the phylogenetic roots and branches of the "tree of life." You can also read about the Beaty Biodiversity Museum (see p. 16), which will open in spring 2010 to showcase some of the world's most extensive and unique biological collections—including Canada's first exhibition of a blue whale skeleton.

We at UBC Science are proud of our scientists. They are helping to advance the fundamental understanding necessary to tackle ongoing challenges in our rapidly changing world. They teach and inspire the next generation of scientists, who will continue to expand and apply their knowledge toward a sustainable future.

Simon M. Peacock
Dean, UBC Faculty of Science

BIODIVERSITY

Evolution of Species Changes Ecosystems

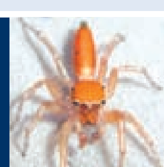
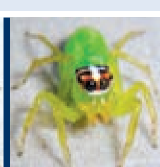
Scientists have come to agree that different environments impact the evolution of new species through natural selection. Recent experiments show—now for the first time—that the reverse is also true: species impact the evolution of their environments. Scientists from the UBC Biodiversity Research Centre created mini-ecosystems in large aquatic tanks using different species of recently diversified three-spine stickleback fish and saw substantial differences in the ecosystems in as little as 11 weeks. CRC in Evolutionary Biology Dolph Schluter is renowned for his work on sticklebacks—a group of fish species that has become a model system for today's evolutionary research. The study involved species—newly discovered in British Columbia lakes—that diverged from their oceanic ancestors to become fresh-water species following the last ice age. As larger organic carbon molecules and bits of decaying plants and animals emerged in their tanks, the sticklebacks effectively changed the light environment of their own ecosystem. "As new species arise from a common ancestor and evolve new ways of exploiting the environment, each inadvertently reshapes the dynamics of the ecosystem around it," says Schluter. "We are just beginning to understand how."

Discovery: Jumping Spiders in Papua Guinea

Beaty Biodiversity Museum director Wayne Maddison discovered dozens of jumping spider species new to science as part of a Conservation International expedition to Papua New Guinea this past spring. "Instead of sitting at the centre of a web, jumping spiders found a new way to make a living by wandering around their habitat and pouncing—like cats—on their prey," says Maddison, a professor in the Depts. of Zoology and Botany. He estimates there may be at least 5,000 more species of unidentified jumping spiders in the world. The newly discovered species will help shed light on how jumping spiders evolved their unique features. Exploring spider biodiversity and evolution could potentially inform fields as diverse as medicine and robotics. "Our finding shows that the great age of discovery isn't over by far."

UBC and Indiana University Botanist Leads Crop and Weed Study

CRC in Plant Evolutionary Genomics Loren Rieseberg will lead an Indiana University Bloomington team that has been awarded an $8 million, four-year National Science Foundation grant to study the genetics of economically important and evolutionarily interesting plant species. The project will investigate the largest family of flowering plants (Asteraceae), which includes sunflowers, safflowers and lettuce. "This project will have a major, lasting impact on both crop and weed science through the production of permanent, publicly available genomics resources," says Rieseberg, who is jointly appointed at IU Bloomington and UBC's Dept. of Botany.


(L-R) Discovery in Papua Guinea: A sample of the vibrant colours found in salticid spiders. Photos: Wayne Maddison • Weed and crop study: Sunflowers are ideal model plants for Loren Rieseberg's genetics studies of economically important and evolutionarily interesting plant species. Photo: Jason Rick

Couple's Legacy Takes Flight at UBC Science

A lifelong love of birding and conservation: Hildegard and Werner Hesse on Mandarte Island, BC. Photo: Peter Arcese

Passion for birding drew Hildegard and Werner Hesse to UBC for over half a century and created a legacy that will benefit avian research for years to come.

It all started during a summer road trip through British Columbia's Cariboo region in 1956. Across the Cariboo's rolling grasslands and lush valleys, Hildegard and Werner Hesse spotted bird after bird they did not recognize. When they returned home to Vancouver, the Hesses decided to improve their birding skills by taking a three-year UBC night course on the birds of BC. The course nurtured their love of birding and eventually drew the couple into avian research at UBC and beyond, helping them cement a large network of like-minded friends across North America. It also led to a lasting relationship between the couple and the university.

The Hesses, who both passed away in 2008, left UBC an estate gift that will bolster avian research for years to come. The endowments—which will total as much as $1,150,000—will support avian research in the faculties of Science and Forestry, and provide ongoing summer grants to UBC Science undergraduates conducting ornithological research.

"It's a privilege, and quite humbling, to be able to honour the Hesses' lifelong commitment and passion with these endowments," says UBC's dean of Science Simon Peacock. "Their foresight will benefit research and conservation efforts, and enrich the learning experience for Zoology students for years to come."

The ornithology research endowments follow a long history of support to the university, which included funding for research on Mandarte Island (a bird sanctuary south of Vancouver Island, BC) and for UBC's Beaty Biodiversity Museum.

SUSTAINABILITY

BioRenew: Investment in "Green" Infrastructure

Research infrastructure and sustainability at UBC Science received a $65 million boost from the federal and provincial governments earlier this year. Research facilities and classrooms of the Biological Sciences west and south wings, originally built more than 50 years ago, will be renovated incorporating the Leadership in Energy and Environmental Design Silver standard. "This remarkable investment will fuel much-needed short-term economic development while strengthening the research platform that has made BC and Canada international leaders in research and education," says UBC president Stephen Toope. "The BioSciences complex serves as a hub for research, involving more than 400 researchers, and contains classroom and lab space serving more than 14,000 students a year," says UBC's dean of Science Simon Peacock. "The new funding will enable much-needed upgrades and will help attract the brightest minds from around the world." The BioSciences renewal project is expected to be completed in 2011.

BIOTECHNOLOGY

Genomic Research Helps Fight Mountain Pine Beetle Epidemic

This past summer, Canadian researchers decoded the genome of *Grosmannia clavigera*, a fungus found in the mouth of the mountain pine beetles (*Dendroctonus ponderosae*) that pose a major threat to North American forests. "We are approaching a systems-level understanding of the mountain pine beetle epidemic," says UBC Michael Smith Laboratories' Jörg Bohlmann, who co-authored the study and co-leads UBC's Tria Project: Mountain Pine Beetle System Genomics and the TREENOMIX: Conifer Forest Health Project. "What happens in nature is not confined to one species, but involves the interaction of various species." Through further gene sequence studies of the beetle and pine tree species, Bohlmann expects to gain more insights into the molecular-level mechanisms of the beetles' attack and the trees' defence strategies.

* Evolution: Look for this icon and find out how our researchers and students expand and apply our understanding of evolution.

HEALTH RESEARCH

Early Stage of Tuberculosis Pathogenesis Illuminated

An international research team led by UBC microbiologist Lindsay Eltis has identified and successfully inactivated the binding mechanism of an enzyme that the tuberculosis agent *Mycobacterium tuberculosis* uses to grow on the human body's cholesterol. The bacterium can survive for years inside white blood cells that normally attack and destroy harmful microbes. "While cholesterol metabolism by the bacterium appears to be most important during the chronic stage of infection, it begins much earlier and may contribute to the pathogen's dissemination within the host," says Eltis. "We hope that this research will lead to new chemotherapeutics to fight a disease that is increasingly resistant to available antibiotics."

ASTRONOMY

First-time Observation of "Recycled" Neutron Star

UBC astronomer Ingrid Stairs is part of the first international team to observe the transformation of an ordinary, slow-rotating pulsar into a super-fast millisecond pulsar—a reborn neutron star. The discovery was made during a large radio sky survey by an international team of astrophysicists at McGill University, UBC, West Virginia University, the US National Radio Astronomy Observatory and other institutions in the US, the Netherlands and Australia. "For the first time, we have caught a glimpse of an actual cosmic recycling factory in action," says Stairs. "This system gives us an unparalleled cosmic laboratory for studying how millisecond pulsars evolve and get reborn."

EDUCATION

UBC Science PhD Students Named Vanier Scholars

Four UBC Science doctoral students are among 17 UBC recipients of the inaugural Vanier Canada Scholarships, the Canadian equivalent of the Rhodes scholarships in the UK and the Fulbright scholarships in the US. The four winners—Cindy Blois (Canada), Stephan Ettenauer (Austria), Richard Fitzjohn (New Zealand), Ryan Morin (Canada)—will each receive $50,000 a year for up to three years to support their graduate research in mathematical sciences, nuclear physics, biodiversity and gene expression studies. "Graduate students play a vital role in the research enterprise here at UBC and around the world," says UBC president Stephen Toope. "Their contribution to the generation of new knowledge—both driven by innate curiosity and real-world applications—helps us better understand our world while providing important economic and social benefits."

* Evolution Reaching Out: Celebrating Darwin's 200th Birthday

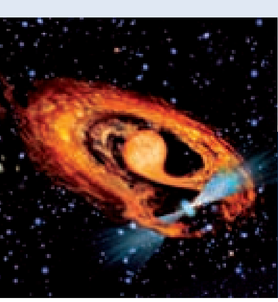
UBC and Simon Fraser University put on a lecture series, Darwin and You, at the Harbour Centre as part of this year's Vancouver Evolution Festival marking Darwin's 200th birthday and the 150th publication anniversary of his book *On the Origin of Species*. Contributions from UBC Science included biology instructor Greg Bole, who has portrayed young Charles Darwin, presenting a monologue on the evolution theorist's life—his accomplishments and frustrations, hopes and predictions. You can find a video of Greg Bole as Charles Darwin and more information about evolution and biodiversity at www.beatymuseum.ubc.ca.

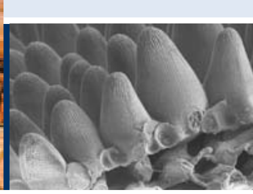
ANALYTICAL TOOLS/NEW MATERIALS

UBC Science Projects Receive Research Infrastructure Boost

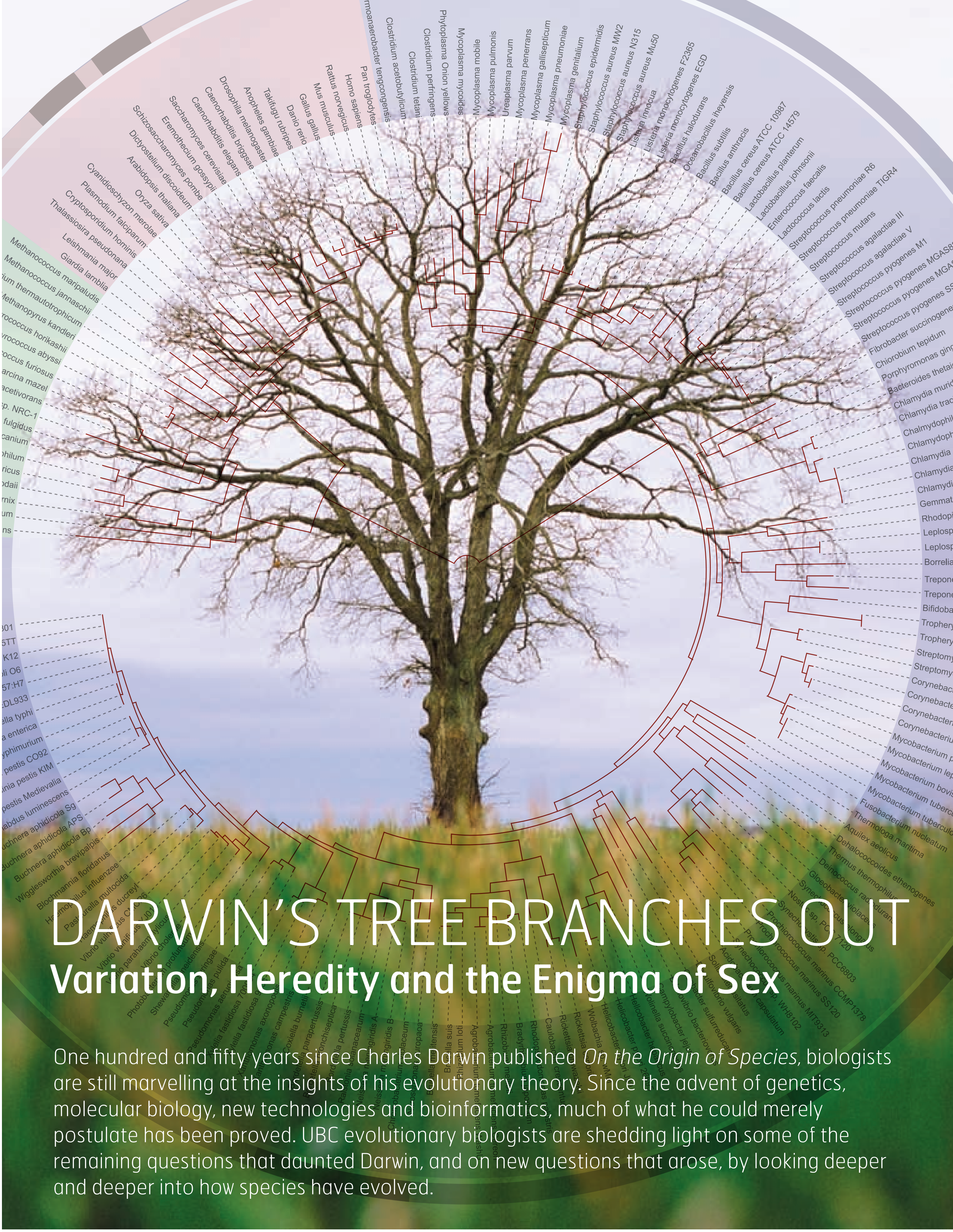
World-class research into ultra-cold materials, geochemical analysis, infectious disease and the chemistry of biological surfaces has garnered UBC Science $13 million in funding from the Canadian Foundation for Innovation this year. This research infrastructure support is part of a $666 million investment for a total of 133 projects at 41 institutions across Canada. UBC ranked second, with 12 projects funded. UBC Science projects include:

- Low-Temperature Picometer Spatial Resolution Spectroscopic Scanning-Tunneling Microscope ($1 million), led by Douglas Bonn, Dept. of Physics & Astronomy
- Centre for BioInterface Characterization: From Molecular to Cellular and Macroscopic Properties ($2.5 million), led by Reinhard Jetter, CRC in Plant Natural Products Chemistry, Depts. of Chemistry and Botany
- Advanced Structural Biology for Re-emerging Infectious Diseases ($4 million), led by Lawrence McIntosh, Depts. of Chemistry and Biochemistry and Michael Smith Laboratories
- Centre for Research on Ultra-Cold Systems ($2.6 million), led by Takamasa Momose, Depts. of Chemistry and Physics & Astronomy
- Pacific Centre for Isotopic and Geochemical Research ($3 million), led by Dominique Weis, CRC in Geochemistry of the Earth's Mantle, Dept. of Earth & Ocean Sciences.





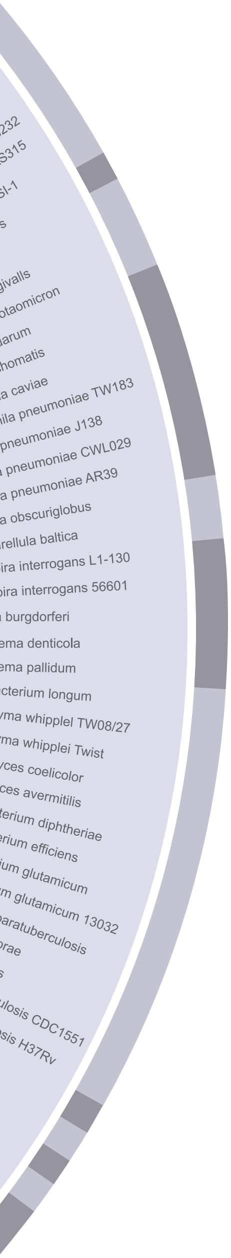
(L-R) The mountain pine beetle epidemic poses a major threat to North American forests. • An artist's rendition of a "recycled" neutron star. Image: ESA/Francesco Ferraro (Bologna Astronomical Observatory) • Charles Robert Darwin in 1840. Drawing: George Richmond • Characterizing biointerfaces at a molecular to microscopic level is the scope of one of the newly granted research centres at UBC. Photo: Christopher Buschhaus



DARWIN'S TREE BRANCHES OUT

Variation, Heredity and the Enigma of Sex

One hundred and fifty years since Charles Darwin published *On the Origin of Species*, biologists are still marvelling at the insights of his evolutionary theory. Since the advent of genetics, molecular biology, new technologies and bioinformatics, much of what he could merely postulate has been proved. UBC evolutionary biologists are shedding light on some of the remaining questions that daunted Darwin, and on new questions that arose, by looking deeper and deeper into how species have evolved.



> "Let it be borne in mind how infinitely complex and close-fitting are the mutual relations of all organic beings to each other and to their physical conditions of life."
> — Charles Darwin, *ON THE ORIGIN OF SPECIES*

Charles Darwin's theory of evolution and the interrelatedness of all living things has become the cornerstone of modern biology, and it has revolutionized thinking about humanity's place in the natural world. "Survival of the fittest" is now a common catchphrase—but what does it mean, and how are researchers testing and applying Darwin's theories today?

Fitness, in the evolutionary sense, doesn't refer to the "biggest, fastest or strongest," but to the capacity to survive and reproduce by passing on a set of genetic variants in a gene pool. Two major forces—natural selection and genetic drift—separately drive which variants will prevail or diminish. Selection is not an intentional "seeking out," but a mechanism favouring traits that increase "fitness." On the other hand, genetic drift is the random changing of allele frequencies (genetic variants) from one generation to the next, which may or may not have immediate effects on the fitness of organisms.

"While the existence of genes and molecular mechanisms that underlie biological evolution were unknown to Darwin and his peers, he provided the first plausible and causal explanation of the fossil evidence that suggested changing species over time," says Sally Otto, professor in the Dept. of Zoology and director of UBC's Biodiversity Research Centre. "Darwin discovered the principles of evolution—variable and heritable traits and natural selection. Based on these principles, he concluded the common ancestry of all known species."

Variation Is the Spice of Life

Darwin knew that natural selection—and evolution—required variation. Over the past few decades, researchers have found that variation arises by genetic mutation and by the transfer of genes between populations of bacteria and other micro-organisms. In species that reproduce sexually, new combinations of genes are produced by DNA exchange—or recombination—where two genes on chromosomes inherited from different parents come together on the same chromosome.

"Mutations are always occurring; sometimes they are lethal and sometimes they are favourable," says Otto. But a positive mutation will not necessarily prevail if it disrupts other functions of the gene or if, by genetic drift, it is lost by chance. Otto combines biological and mathematical tools to study how populations change over time and to identify how and when certain evolutionary traits and transitions might occur.

Sex and the Single Genome

Why do most animals, plants and fungi reproduce sexually? The pleasure principle aside, why don't we just bud and clone ourselves and get on with life? Sex, after all, is a risky business, and it consumes an inordinate amount of time and energy. Individuals have to find a mate, attract it, risk contracting sexually transmitted diseases, avoid hazards and predation during mating (sometimes by the mate itself), and are distracted from livelihoods such as gathering food. If Darwin's theory of survival of the fittest is correct, then why would we want to mix perfectly good genes with unknown genes and undo the favourable combinations of past selection?

One of the oldest explanations for the paradox of sex is that it has evolved to generate the variation needed for selection. "I think the latest views on the enigma of sex do come back to Darwin, and the need for variation—but for slightly different reasons," Otto says. "What sex and recombination can do is allow evolution to proceed beyond the point that can be reached based on the initial genotypes present, by allowing beneficial alleles carried by different individuals to be brought together."

Otto and UBC colleagues are exploring how and why rates of sex vary among species—for example, how stress affects the tendency to reproduce sexually or asexually. While stress may decrease the sex drive in humans, it seems to motivate sex in other organisms. Otto's students are exploring how stress influences the production of flowers (sexual reproduction) versus basal stems (asexual reproduction) in the monkey flower. "The prediction is that if plants are under stress and doing poorly, they should invest more in flowering because their genes then have a chance to escape a genome that functions poorly in the current environment. If the plants are doing well, they should expand clonally as much as possible."

Other models developed by Otto show that sexual reproduction emerges most readily when populations need to adapt or to eliminate deleterious mutations from their genome but there are only a finite number of

(L-R) Sally Otto is professor in the Dept. of Zoology and director of the UBC Biodiversity Research Centre • Jeannette Whitton is associate professor in the Dept. of Botany and director of the UBC Herbarium • Rosie Redfield is professor in the Dept. of Zoology • Sean Graham is associate professor in the Dept. of Botany and research director of the UBC Botanical Garden • Brett Finlay is professor in UBC Michael Smith Laboratories.

"The time will come I believe, though I shall not live to see it, when we shall have very fairly true genealogical trees of each great kingdom of nature." – Charles Darwin, IN A LETTER TO T.H. HUXLEY (SEPT 26, 1857)

DNA: Bacterial Energy Bar

Bacteria reproduce asexually, through simple cell division, yet they can take up DNA from their surroundings—a phenomenon called natural competence. Rosie Redfield, professor in the Dept. of Zoology, has spent a good part of her career asking how, when and why? Although all these questions are interrelated, perhaps Redfield's most surprising finding pertains to "why." Her lab discovered the sequence of genes responsible for DNA uptake in *Haemophilus influenzae*, a human pathogen as well as model system. They have also found this group of genes in many related pathogens, including *Escherichio coli* and *Vibrio cholerae.*

The commonly accepted explanation for competence is that bacteria shuffle genes around in order to provide the variation needed for selection. "In other words, DNA uptake does for bacteria what sex does for us," Redfield says.

However, her lab has identified molecular changes (similar to the signals that make us hungry) that suggest *H. influenzae* and other bacteria take up DNA for food. "Bacteria take up DNA when they are hungry for nucleotides and when they don't have enough energy to make these molecules from scratch," she explains.

"I think Darwin would be very interested to see that researchers are still struggling to understand something that he himself found puzzling—why we have sex," says Redfield.

individuals (and genotypes) in the current population. And yet there are circumstances where avoiding sex is not only convenient, but downright safer, as shown by the work of UBC researcher Jeannette Whitton (see next column).

The Problem of Ploidy

In evolutionary biology, sex and ploidy are related attributes. Ploidy refers to the number of complete sets of chromosomes in a biological cell. For example, human sperm and egg cells are haploid, each having only one set of chromosomes. Human body cells (somatic cells) are diploid because they contain two sets of chromosomes, one set from each parent. Thus, sex involves the alternation between a reduced ploidy level (in eggs and sperm) and a doubled ploidy level (after fertilization). Most animals (including humans) and plants, spend much of their life as diploids. Yet other organisms such as mosses and many moulds spend the majority of their days as haploids.

But why is this the case? Does having a doubled set of chromosomes improve the odds of survival? Otto notes that, on the one hand, diploids have one more gene copy, which can mask deleterious mutations and thus aid survival. But on the other hand, diploids can pass on this harmful DNA to their offspring. Since haploids have only one set of chromosomes, selection is efficient at weeding out such genes. "This double-edged sword helps explain why ploidy levels vary among organisms. In particular, we tend to find diploidy among larger organisms because of the advantages of masking deleterious mutations (including cancerous mutations) in the large number of somatic cells of a long-lived organism," she says.

Sex and Ploidy in Plants

Some plants do remarkably well without sexual reproduction. Take the dandelion, for instance. It reproduces through the asexual formation of seeds (apomixis), so that each plant is a genetically identical clone of the mother plant. Dandelions, like most plants, are polyploid, having more than two sets of paired chromosomes. This high incidence of polyploidy suggests that having multiple sets of genetic material provides an evolutionary advantage.

Jeannette Whitton, associate professor in the Dept. of Botany and director of the UBC Herbarium, is studying how ploidy and breeding systems lead to recurrent patterns of evolution in *Townsendia*, a diverse Rocky Mountain genus of Easter daisy. The questions Whitton wants to answer are: What does polyploidy really do? Does it have a role of its own or does most of its role come about indirectly?

In field studies of 40 populations of *Townsendia*, she and colleagues in UBC's Biodiversity Research Centre found that a transition from diploid to polyploid plants occurred repeatedly in four different locations, from northern Colorado to the Yukon. In all cases, this transition occurred in previously glaciated areas and happened concurrently with a transition to asexual reproduction and loss of the faculty for sexual reproduction.

Whitton noted that the polyploid plants appear to have a colonization advantage in deglaciated areas because of their ability to clone. Whitton's studies of the Easter daisy are also a good example of evolutionary convergence, where each colony

(L-R) Based on its morphological characteristics, the tiny inconspicuous water plant *Hydatella* was formerly thought to be related to grasses and rushes. Photo: Simone Cottrell • Modern phylogenetic analyses, however, revealed its close relationship to the spectacular water lily (*Nymphaea*)—an early line of flowering plants. Photo: jmbc Source

independently acquires similar characteristics—in similar ecosystems but separate geographical areas.

"Anything that happens repeatedly over evolutionary time is evidence of an underlying common theme," says Whitton. "The way animals and plants adapt to environments tend to involve the same genes again and again." She notes the work of UBC colleagues Dolph Schluter on sticklebacks (*Synergy 5.2*) and Loren Rieseberg on sunflowers (*Synergy 2|2007*). "I think Darwin would be very excited to see how we have been able to demonstrate this on both a broad scale and at the molecular level."

From Genealogy to Genetics: Mapping the "Tree of Life"

Darwin thought that a common genealogy probably linked all organisms. The first edition of *On the Origin of Species* contained only one illustration, Darwin's sketch of "The Tree of Life." Today, biodiversity researchers such as Sean Graham use phylogenetic trees to infer how organisms are related to each other (phylogeny) and how species evolve.

Graham, associate professor in the Dept. of Botany and research director of UBC Botanical Gardens, is a self-described "archaeologist of genomes." He studies the relationship of organisms by looking at traces of their history left in genomes. Phylogenetic trees combine visual tools with mathematical models to help deduce the stepwise process by which complex organisms evolved.

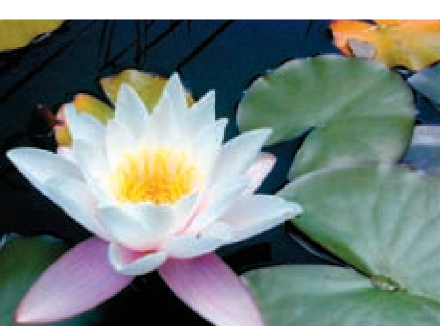
"Darwin considered the origin of angiosperms, or flowering plants, 'an abominable mystery,'" says Graham. "He spent 40 years thinking about plant sex and wrote three books on that alone." Most plants on Earth are angiosperms, yet, in a geological time frame, flowering plants evolved only recently, first appearing around 135 million years ago. "The mystery is, how did flowering plants appear so suddenly in the fossil record, and why did they diversify so quickly and rise to ecological dominance?"

Shaking Up Genetic Trees

Graham and former PhD students Hardeep Rai and Jeffery Saarela (now at the Canadian Museum of Nature) uncovered one of the biggest misconceptions in botanical history. The tiny and obscure aquatic plant family Hydatellaceae, formerly thought to be related to grasses and rushes, is really a close relative of the water lily, a very early line of flowering plants. DNA sequencing and a re-examination of anatomy led to the plant's reclassification.

Based on their thin, grass-like leaf structure, these tiny plants were traditionally lumped in with monocots (a large and diverse group of angiosperm plants that have a single-leaf initial sprout). The diminutive Hydatellaceae have minute petal-less flowers that are pollinated by wind. Why the water lily, with enormous insect-pollinated flowers, is their closest relative, and how they split off from the main evolutionary branch of angiosperms so early on in their evolution are intriguing puzzles. UBC research has intensified interest in the basic biology of these dramatically different but closely related plants.

"Darwin called evolution 'descent with modification,' and we tend to focus on modification," Graham says. "But for Darwin, the idea of descent through common ancestry—or phylogeny—was equally important."



H1N1 Virus: Evolution in Action

Viruses like H1N1 are parasites that exploit host organisms in order to spread and multiply. Their ability to swiftly mutate and proliferate allows them to find and adapt to new "niches." UBC microbiologist Brett Finlay has spent most of his career studying the evolution of host-pathogen interactions. "H1N1 is a combination of human flu virus, bird virus and swine virus. It is these new variants we are concerned about, because no one is immune and because of the virus's enhanced ability to spread," he says.

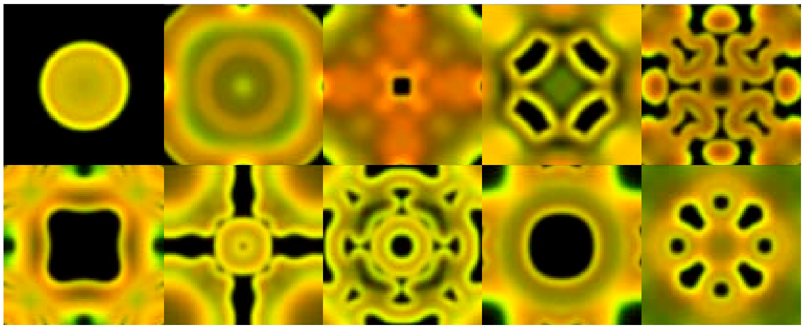
With normal flu, usually the very young or very old people—those with undeveloped or compromised immune systems—are most vulnerable. Scientists don't know why H1N1 is more lethal in younger healthy people, but this was also the case with the 1918 Spanish flu pandemic, which was also an H1-type virus.

Canada has an alarming rate of H1N1 infections among Aboriginal populations, notes Finlay. "The numbers are disproportionately high, and we don't know how much is due to environmental factors such as poor diet and living conditions, or how much might be due to genetic propensity."

Viruses, like humans, evolve in and with their environment. Human society has "evolved" from small groups of isolated hunter-gatherers to global commuters living in large industrialized urban centres where viruses can wreak most havoc. Yet we encounter millions of mutating microbes every day—and humans have evolved in such a way that most of us manage to survive the onslaught.

"Darwin didn't even know about viruses, yet they illustrate his whole evolutionary concept, and that we are biological organisms that have to live within the confines of evolution," Finlay says.

Game Theory: Modelling the Emergence of Co-operation



Evolutionary theory hinges on survival of the fittest, yet entities from micro-organisms to human and animal societies co-operate for the common good. UBC mathematician Christoph Hauert is developing new models to discover the factors that lead to co-operation.

Darwinian selection—a key aspect of evolutionary dynamics—acts on individuals to change characteristics of entire populations. Co-operation is a driving force behind selection. Without co-operation, there would be no evolution or ecological communities. Genes would not be arranged into chromosomes, cells would not build complex organisms, and individuals would not form societies. Yet survival of the fittest implies that individuals look out for themselves in order to reproduce successfully.

One of the greatest conundrums for biologists and mathematicians alike is the emergence of co-operative behaviour. In theory, co-operators make a sacrifice to benefit others at some cost to themselves, while selfish individuals (exploiters or defectors) reap the benefits without the costs. Yet altruism persists. “Co-operation can thrive only if it makes individuals better competitors, yet often it is not clear how this is achieved,” says UBC assistant professor Christoph Hauert. “In the short term, it would seem better not to co-operate, because an individual doesn’t have to pay the costs, but that would lead to the disappearance of co-operation within a few generations.”

Two popular game theory models used to study the evolution of co-operation among unrelated individuals are the prisoner’s dilemma (for interaction among pairs) and the public goods game (for group interactions). Both of these early models illustrate that in unstructured populations—where individuals move about randomly, interact and move on—co-operators quickly vanish. How, then, does co-operation evolve?

The Importance of Nearest Neighbours

Anyone who has lived in a remote area of Canada in the wintertime knows that co-operation with one’s neighbours is essential for survival. “Most of the time we don’t randomly interact with other individuals,” explains Hauert. “Usually, interactions occur more frequently among individuals who are geographically closer.” He has developed a game theory model that takes into account the proximity of neighbours. When modelled on a spatial grid, each individual occupies a square on a chess board and interacts only with its immediate neighbours. Such local interactions promote the formation of clusters where co-operators can survive.

Modelling Ecological Public Goods

Public goods models—based on the production, consumption and exploitation of common resources—are used to study problems as diverse as antibiotic-resistant bacteria, habitat diversification and global issues of climate change. In collaboration with Joe Yuichiro Wakano at the Meiji Institute for Advanced Study of Mathematical Sciences in Japan, and Martin A. Nowak at Harvard University, Hauert developed an ecological public goods model that links ecological dynamics, variable population size and evolutionary dynamics.

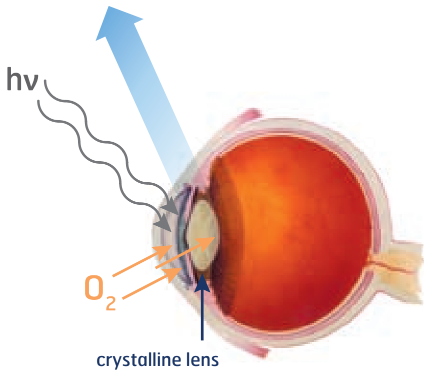
Graphic simulations of the researchers’ model illustrate the dynamics of co-operation. In a spatial structure, co-operators form clusters that tend to migrate slowly, in order to take advantage of positive interaction with neighbours and the locally sustained common resource. In contrast, defectors tend to migrate more quickly away from each other in order to locate clusters of co-operators to exploit.

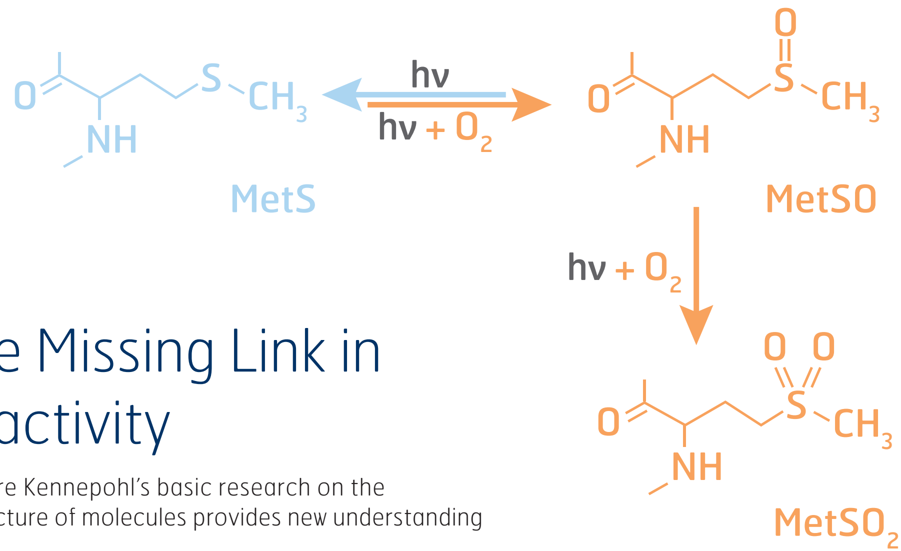
The group’s findings are particularly relevant in the context of microbial populations, where migration rates of microbes are driven by public goods interactions. His team’s ecological public goods model illustrates that antibiotic-resistant bacteria tend to stick together as co-operators. And, freewheeling strains of antibiotic-susceptible bacteria with high motility (defectors) may actually increase the density and survival rate of the antibiotic-resistant strains. “Whenever bacteria release into their environment enzymes that deactivate an antibiotic, that is a form of co-operation, and a public goods game for the bacteria,” Hauert explains.

> *continued on page 13*

For further information on this research please visit www.math.ubc.ca/~hauert

This research was funded in part by grants from the National Institutes of Health (US) and Natural Sciences and Engineering Research Council (Canada). Christoph Hauert holds a 2009 Peter Wall Early Career Scholarship (UBC).





Revealing the Missing Link in Chemical Reactivity

UBC chemistry professor Pierre Kennepohl's basic research on the electronic and geometric structure of molecules provides new understanding of chemical reactivity.

How atoms fit together and how chemical bonds are formed and broken is the foundation of all chemical reactions. While basic principles that govern these reactions are well understood, many aspects are still unknown. In their spectroscopic studies of reactive species, UBC chemist Pierre Kennepohl and his group have found missing molecular clues.

"Reactive intermediates are the crucial links between the starting point and endpoint of a reaction, and chemists try to predict what they are because we often can't see them," says Kennepohl. Since intermediates can exist for very short periods of time—in the order of nanoseconds—they are often difficult to study. Kennepohl and his group use X-ray absorption spectroscopy (XAS) and X-ray emission spectroscopy (XES), which require high-energy radiation sources, to shed light on these elusive molecules.

Redox Reactions: The Body's Rust Mechanism

Oxidation-reduction (redox) reactions involve the transfer of electrons, often in concert with the movement of oxygen atoms. Oxidation refers to the loss of electrons, and reduction to the gain of electrons. Free radicals are highly reactive atoms or molecules with unpaired electrons, and they are responsible for cell damage, aging and many diseases. "In a similar way to an old pickup truck rusting in the driveway, the body undergoes a continuous battle with the elements," explains Kennepohl.

There are a plethora of antioxidant products on the market to counteract the effects of free radical damage. Yet—like rust inhibitors—do these products really work, or do they just postpone the inevitable? "We understand the big picture of the changes in oxidative levels and how those impact cellular function, but in terms of the details of how this happens, we understand very little," Kennepohl says. However, fundamental discoveries made by his group are advancing knowledge that has an array of applications, particularly in the health sciences.

Let There Be Light

Cataracts are a typical example of age-related effects of oxidation. The most abundant protein in the eye lens, α-crystallin, becomes less transparent and more permeable to oxygen with age. Increased levels of oxygen in the cornea, as well as exposure to UV light, have long been thought to damage the eye and contribute to cataract formation.

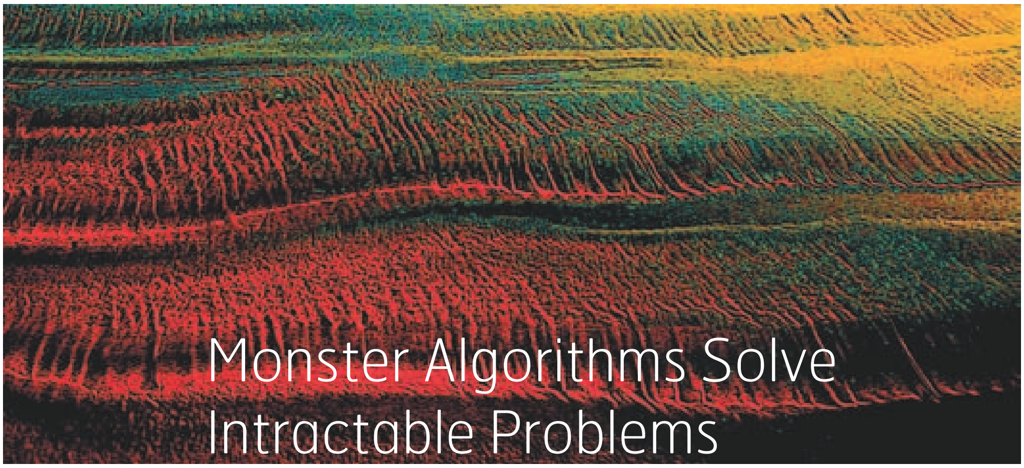
Kennepohl and PhD student Anusha Karunakaran-Datt have been studying the amino acid methionine (MetS), a particularly susceptible component of α-crystallin. It is generally believed that when MetS oxidizes to the sulfoxide form (MetSO) it plays a role in cataract formation by causing protein misfolding. MetSO can be readily switched back to MetS by enzymes. However, if this redox cycle is interrupted, further oxidation can lead to the formation of even more damaging sulphone ($MetSO_2$), which cannot be reduced back to the normal MetS state. In XAS studies of single sulphur atoms in MetS, the researchers confirmed that UV radiation exposure increases oxidation by forming MetSO and $MetSO_2$. However, they were surprised to discover that UV exposure can also transform the harmful MetSO back to unharmful MetS.

"The assumption has always been that sunlight is the enemy," says Kennepohl. "But this seems to be the case only when oxygen is present in the cornea. These studies suggest that controlling the permeability of the eye's lens to oxygen might be important in preventing age-related cataracts."

> *continued on page 13*

For further information on this research please visit www.chem.ubc.ca/personnel/faculty/kennepohl

This research was funded in part by grants from the British Columbia Knowledge Development Fund, Canada Foundation for Innovation, Natural Sciences and Engineering Research Council (Canada) and Stanford Synchrotron Radiation Lightsource (US).



Monster Algorithms Solve Intractable Problems

Computer scientist Holger Hoos combines artificial intelligence (AI) and human ingenuity to build new algorithms for solving difficult computational problems.

Algorithms for solving computationally difficult problems are the heart of many software systems driving technology that supports or influences all aspects of daily life. These systems are used in diverse application areas, including communications, transportation, commerce, manufacturing and health.

Together with students and colleagues, UBC associate professor in Computer Science Holger Hoos has developed novel methods to boost the performance and efficiency of such algorithms. "These methods allow the human experts to focus on high-level issues, while the machine does all the dreary and tedious work that humans tend not to be very good at," he says.

Designing algorithms for so-called hard combinatorial problems requires a great amount of experience, intuition and creativity—a combination that is difficult to teach at a scientific or engineering level. "By building computational procedures that do part of the work, we not only improve the algorithms, but also make the design process much more principled and specified, therefore easier to learn," Hoos says.

Curiously, the algorithms that tend to run faster and produce better results are the ones that cannot be proven theoretically to be effective. Hoos is a member of UBC's Bioinformatics, Empirical & Theoretical Algorithmics Laboratory (β-Lab), one of the few computational labs in the world that brings theoreticians and empiricists together to try to bridge this theory–practice gap.

SATzilla Crushes Competition

In mathematical logic and computing theory, satisfiability (SAT) refers to a prototypical problem with far-reaching applications, from auto manufacturing and "bug" fixing in computer hardware and software, to satellite control and scheduling. Even problems in biology, such as phylogenetic analysis (see article on p. 6), can be encoded and solved using SAT methods.

Together with UBC colleague Kevin Leyton-Brown and graduate students, Hoos developed SATzilla, a meta-algorithmic technique that uses AI, or machine learning, to analyze a set of high-performance SAT algorithms and then automatically match the most efficient algorithm to the problem at hand.

In the recent 2009 International SAT Competition—the world championship in solving SAT problems—Hoos and his group swept up three first prizes in widely different categories, showing that SATzilla performed well across the board.

Clearly, Hoos and his team find inspiration in film and literary classics. Like Mary Shelley's famous monster, their most recent SAT solver uses a Frankensteinian patchwork of parts from different algorithms. SATenstein, which solves SAT problems based on a sophisticated optimization procedure, is itself constructed by other higher-level optimization techniques. "Taking optimization to the second or meta level is extremely important, because that is where seemingly small decisions can have huge consequences in terms of solving the problem at hand," explains Hoos.

Bioinformatics: Predicting the Unknown

The field of bioinformatics involves modelling biological phenomena of a system where information at the most detailed level is unknown. Bioinformatics has become increasingly important in many areas of biology and medicine, including molecular diagnosis and treatment of disease. Predicting the structure of proteins and ribonucleic acids (RNA) is a hard combinatorial problem. RNA is an essential part of genetic machinery, responsible for many biological processes such as protein synthesis and regulation of gene expression in all living organisms.

A common problem for molecular biologists and health researchers is defining RNA secondary structures, which to a large extent determine the shape and function of many types of RNA molecules. Such molecules are involved in processes associated with diseases such as hepatitis, dementia and Parkinson's disease. A key component of this research involves developing energy models that capture the driving forces behind RNA secondary structure formation. In collaboration with computer science professor Anne Condon and PhD

> continued on page 13

For further information on this research please visit http://people.cs.ubc.ca/~hoos

This research was funded in part by grants from the Natural Sciences and Engineering Research Council (Canada), Mathematics of Information Technology and Complex Systems (MITACS, Canada) and the Actenum Corporation.

Game Theory: Modelling the Emergence of Cooperation – *continued*

Co-operation and Punishment

Most game theory models used to study human interaction and behaviour assume that all individuals participate; they can choose to co-operate or not, but they have to "play the game." But what if no one wants to play? "If we turn these interactions into voluntary interactions, then they lead to co-operation," says Hauert. "Voluntary interactions can also promote other mechanisms."

Throughout history, co-operative or compliant behaviour—whether to a state law or religious doctrine—has often been enforced through institutions by sanctions or punishment. In recent work, Hauert and colleagues have shown that freedom to participate can have a surprising—and paradoxical—effect on co-operation. "If participation is voluntary, our model shows that co-operation-enforcing behaviour, such as punishment, emerges," he says. "If participation is obligatory, then the defectors are more likely to win." Dictators take note!

Image (p.10): Ecological public goods games in spatial settings can exhibit dynamics that range from extinction to periodic oscillations to stable co-existence. Their simulation produces fascinating ever-changing patterns. More at www.math.ubc.ca/~hauert (follow link to Visual Labs).

Revealing the Missing Link in Chemical Reactivity – *continued*

Sulphur Radicals and Anti-Cancer Agents

Recent research in organometallic complexes has shown that some of these complexes may target and kill certain types of cancer, and much interest is focused on the mechanisms that increase their selectivity and reactivity in cancer cells. In collaboration with bioinorganic chemist Peter Sadler of the University of Warwick (UK), Kennepohl and student Thamayanthy Sriskandakumar are studying ruthenium(II)-based anti-cancer agents. Initially, researchers assumed that the sulphur atom in the ruthenium complex had to be oxidized in order for it to make room for DNA binding and thus kill cancer cells. Kennepohl's group found that to be only part of the requirement.

In order to allow for DNA binding, they found that it was necessary for the sulphur to be both oxidized and protonated (adding a positive hydrogen ion), which can only occur under acidic conditions (i.e., at low pH). Cancer cells tend to have a lower pH than normal cells. "Although sulphur is just below oxygen on the periodic table and exhibits similar chemical behaviour in terms of chemical reactivity, very little is known about the role of sulphur radicals and how they interact with metals in the body," says Kennepohl. His group is the first to investigate the electronic effect of oxidation at a single-sulphur atom on the chemistry of such metal complexes.

Image (p.11): Oxidation of methionine (MetS) to methionine sulfoxide (MetSO) and sulphone (MetSO$_2$) in the eye's crystalline lens plays a role in cataract formation through causing protein misfolding. Eye graphic: Courtesy of National Eye Institute, National Institutes of Health.

Monster Algorithms Solve Intractable Problems – *continued*

student Mirela Andronescu, Hoos has developed techniques for automatically improving these energy models, thereby substantially improving the accuracy of secondary structure predictions. In another area of research, Hoos is working with industry partners in the resource sector, such as the BC company Actenum Corporation, to improve operational efficiency and reduce environmental impact.

"An algorithm is like a factory. Once you've built it, you run the process it was designed for over and over again. That's why it is worth putting a lot of thought into building the most efficient algorithms possible."

Evolutionary Algorithms Build Better Cars

Evolutionary algorithms take inspiration from Darwinian evolution to solve computationally challenging problems. In these algorithms, a population of possible solutions is subject to mutation, recombination and selection, and evolutionary fitness refers to the quality of a potential solution. Automotive companies such as BMW, Volkswagen and Audi are using evolutionary algorithms to improve car body design. "Crash scenarios studied by colleagues in Germany demonstrate that these cars—although lighter than current cars—are just as safe, if not safer," says Hoos.

Image (p.12): Complexity is the underlying theme for both Hoos' AI research as well as this artwork *Granular Synthesis*. Visit http://people.cs.ubc.ca/~hoos/art.html to enjoy more of Holger Hoos' digital paintings.

Students Collaborate Across Disciplines, Train to Become Biodiversity Experts

We are losing species and ecosystems at an accelerating pace. Global climate change, habitat loss and associated rise of extinction rates have made it increasingly important to identify the factors that generate and maintain biological diversity. UBC's new program Biodiversity Research: Integrative Training and Education (BRITE) is designed to produce a generation of scientists able to understand the evolution and interconnectedness of the Earth's biosphere, and to help safeguard its diversity.

The need for experts who improve our understanding of what sustains biodiversity—the variety of, and relationships among, all living things in the world—and who harness this knowledge for concrete action has never been more pressing. Enter BRITE. This program, led by evolutionary biologist Sally Otto, has been initiated to create an enhanced learning and training environment for biodiversity researchers at all levels—from undergraduate to graduate students to post-doctoral fellows.

Housed at UBC's Biodiversity Research Centre, the program will integrate international collaboration and internships with concrete scientific research work. "Much of our training in the past has been aimed at the career goal of an academic position," notes Otto. "However, many of our students have private or public sector careers in mind." BRITE's internship program provides the opportunity for graduate students to spend four months in industry, government agencies or non-governmental organizations. This will allow students to translate their research expertise into practical skills, while gaining a new perspective on ways that their biodiversity expertise can be applied outside of the academic realm.

Internship opportunities range from conservation projects with Parks Canada to bioinformatics programming at the Genome Sciences Centre to policy development with local MPs and First Nation groups. This type of experience will also be helpful for students who have an academic career in mind. "Professors often find themselves involved with activities that fall outside of traditional academic training, such as serving on the boards of non-profit and for-profit agencies, developing educational programs for the public, and contributing to the development of public policy," explains Otto.

Other key elements of BRITE include lab rotations (allowing students to work with different established biodiversity scientists), workshops (bringing together local and international experts for intensive, hands-on training) and new graduate courses. "We'll give our students the opportunity to explore the various aspects of biodiversity research and sub-disciplines, and to draw from the depth and breadth of expertise we have to offer," explains BRITE's associate director Mark Vellend, an assistant professor in the Depts. of Botany and Zoology. Together with

"I'm intrigued by the dynamic character of the BRITE program. It gives me the opportunity to experience different sectors in a way other graduate studies programs in biology typically don't offer. Also, I feel strongly encouraged to bring science to the people—a concept that we as scientists may have avoided for far too long. I'm sure the holistic approach of the program will definitely aid in making it a huge success. I feel honoured to be part of it."
– Marli Vlok
PhD student Marli Vlok, who describes herself as a molecular virologist, came all the way from South Africa to UBC to broaden her horizons from purely molecular studies to the ecological dimensions of virology.
Photo: Javier Landaeta

"The BRITE program will give me the opportunity to gain a variety of skills and knowledge. I'm interested in becoming proficient at using computational tools to investigate phenomena at the level of the whole genome and, through this approach, advance our understanding of complex biological processes. I think that collaborations within and across disciplines—as encouraged by the program—will profoundly help me with reaching my learning goals. I'm also very much looking forward to learning how this knowledge can be applied outside the academic world." – Gregory Baute
Fascinated by UBC's world-class research reputation, MSc student Gregory Baute came from Tilbury, Ontario, to Vancouver to begin his research career.

colleagues in Zoology, Vellend teaches Community Ecology, one of the five new courses that tackle current topics in ecology, biodiversity and evolution, give insight into statistical methods and experiment design, and explore societal impacts and issues related to biodiversity research.

"We want this next generation of biodiversity scientists to be able to integrate diverse research tools and questions to understand the evolution and ecology of life on earth," says Otto. "They will be better equipped to translate this understanding into tangible action—effecting policy, assessing species and ecosystems at risk, and developing recovery plans. We want to train our students to help guide Canadians toward effective measures to protect our environment and the incredible diversity of life."

* Biodiversity Research Centre

Biodiversity researchers at UBC explore the spectrum of biological diversity, how it evolved and how it is maintained. They investigate the web of life at all levels—from genes to ecosystems through to interactions with society. Prof. Sally Otto is leading a network of distinguished evolutionary biologists such as professors Patrick Keeling (molecular evolution of protists), Wayne Maddison (spider diversity and behaviour), Loren Rieseberg (plant speciation) and Dolph Schluter (fish speciation), and a wide range of experts in biodiversity research such as Chris Harley (ecological change in the sea), Diane Srivastava (biodiversity in miniature ecosystems), Curtis Suttle (marine virus diversity) and Mark Vellend (landscape ecology and conservation). The Biodiversity Research Centre comprises more than 50 professors and associated students and post-doctoral fellows. www.biodiversity.ubc.ca

Learning in Action: Physics Professor Sheds Light on Student Lab Education

For the past two years, physicist Doug Bonn, a renowned expert in superconductor research and newly appointed head of UBC's Dept. of Physics & Astronomy, has overhauled first-year physics lab curricula with an aim to deliver quantifiable results in learning.

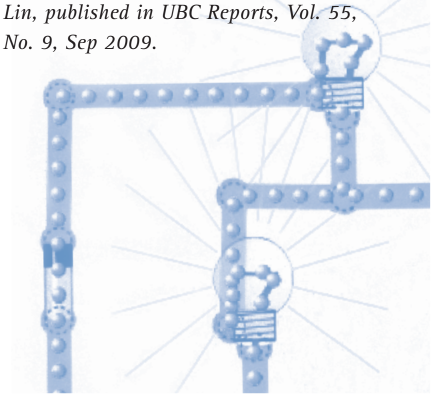
Lab experiments can be designed to teach students how to operate equipment, collect and interpret data, perfect technical skills and establish scientific concepts. "But too often these goals go unexplained and unevaluated," states Bonn. "And how do we know the students have actually learned these skills at the end of the day?" That question appealed to Bonn's research instincts so much that he decided to undertake something that has been little studied—scientifically measuring what students are gaining from labs.

Working with UBC's Carl Wieman Science Education Initiative, Bonn's first task was to identify the unspoken learning goals—and to assess how realistic these expectations are. "In the laboratory environment, there are so many distractors that could obscure the concept," says Bonn. What makes a lab imperfect for learning concepts, however, may provide the ideal training ground for some core science skills. "One of the key roles the laboratory plays is bridging a theory to the real world, where there are distractions and complications," notes Bonn. "To that end, lab exercises should be designed to teach what can't be taught anywhere else: to help students get comfortable with uncertainty, to derive trends from numbers and, ultimately, to interpret real-world phenomena. These are the skills that help aspiring scientists as well as engaged citizens decide how to interpret data presented to them, such as those reported in the media."

With the help of STLF James Day (see text box below), Bonn began developing a "laboratory diagnostic" to see what undergraduates are currently learning and retaining from lab sessions. Hundreds of physics students at UBC and the University of Edinburgh (UK) participated in a study to identify typical misconceptions, which Bonn and Day then tested through specifically designed multiple-choice questions. They found that, regardless of the year of study, students at both universities "tripped over" the same key concepts.

"We now use these diagnostics before and after lab courses and analyze the results to fine-tune the curriculum, including how students are tested after a lab session," says Bonn. New teaching labs designed with these focused learning goals started this fall semester. "It's all about ensuring students are actively thinking, rather than passively absorbing, or even failing to absorb, the information," explains Bonn.

Source: Adapted from an article by Brian Lin, published in UBC Reports, Vol. 55, No. 9, Sep 2009.



The Carl Wieman Science Education Initiative funds and advises UBC science departments to scientifically measure and systematically improve undergraduate education. Combining their expertise in a scientific discipline with knowledge on how people learn, Science Teaching and Learning Fellows (STLFs) assist faculty members to adopt proven best practices in science education.

Of Wings, Tails and Claws, and Other Stories:

Biodiversity Museum Creates Excitement Around Ecology and Evolution

Seeing, smelling and touching whale bones and other animal specimens. Hearing about the thievery, conspiracy, co-operation and other dramas that unfold daily in ecosystems. Conducting experiments and developing theories about the interconnectedness of all living things. These are the kind of rich, hands-on experience students can have at UBC's Beaty Biodiversity Museum, scheduled to open in spring 2010.

In preparation for the museum's opening, members of the outreach team have been developing and piloting educational programs. The museum will offer school programs, teacher training workshops, lecture series and fun science-related events for the whole family. Already, visiting students have had an opportunity to sneak a behind-the-scenes peek, explore some of the two million natural history specimens, interact with researchers associated with the museum—and picture themselves as future scientists if so inspired.

Piloting Future Scientists, Discovering Beauty in Biodiversity

This spring, four grade six and seven classes visited campus to find out what plasticine and coloured pencils have to do with biology. In collaboration with UBC Michael Smith Laboratories' education arm, museum staff designed a program to get students thinking across disciplines. Graduate students in biology and visual arts paired up to develop field trips where students explored the interconnectedness of the biological world and the beauty in biodiversity by creating nature-inspired art projects. The school kids interacted with young scientists, while the grad students—currently working in either the studio or the field—were able to hone their teaching skills.

The pilot biology–visual arts program tested various ways in which students could discover their creative and analytical sides. One variation challenged students to think about how organisms can adapt to diverse environments over the course of evolutionary time. Students were encouraged to ask questions like: "How might wings evolve? What purpose could a big beak serve? Why slither when you can walk?" Beginning with a drawing of a fictitious simple organism that has no visible adaptations, and using photos and descriptions of four kinds of habitat, students then added (on tracing paper) their own adaptations—wings, claws, tails, fangs—creating fantastical superorganisms.

In another variation, students interlinked a range of species (drawn on cards) into a food web—asking themselves: "Where do these organisms live and what do they eat?" With a new awareness of ecological interactions, the students then walked to nearby woods and collected specimens of flowers, tree bark, pine cones and lichens. Back in the lab, each student created biodiversity artwork inspired by—and including—some of their collected "museum specimens."

In another pilot program, students toured the Beaty Museum's Fish Collection. This collection is one of UBC's largest and oldest, with over half a million specimens, many of them older than the students' grandmothers. Walking the narrow aisles between

Students got excited and involved at UBC's Beaty Biodiversity Museum and at the Blue Whale Project Workshop in Victoria, BC. Photos: Derek Tan

shelves stacked with jars of fish specimens floating in preservative can be a little spooky. But the students were thrilled to see deep-sea fish, hear how flatfishes' eyes migrate from one side of the head to the other during adolescence, and hold their noses while peering into a five-foot-long container that stores a giant sturgeon head.

In Victoria, hundreds of students visited the Blue Whale Project Workshop, where whale bones from Prince Edward Island are being prepared for museum display (see *Synergy* 1|2009). The students walked between the whale's two 1,500-pound jawbones, stood inside the reconstructed ribcage (in the belly of the beast!), tried their hand at reconstructing the whale's flipper by placing cleaned flipper bones on the life-sized print of the flipper X-ray, and participated in a hands-on demonstration of how toothed whale feeding differs from baleen whale feeding. And more than a thousand children and adults attended summer open houses to smell the whale for themselves.

Expanding Possibilities: Field Trips, Nature Clubs, Science Workshops

Once the museum opens its doors to the public, the new physical space will allow for an even wider selection of school and outreach programs to help young people and community members understand what biodiversity is, how it emerged and why it matters. A whole slate of field trips, nature clubs and family events is planned.

Field trips will give students a deeper understanding of the richness and complexity of the natural world. A wide variety of school programs will be linked to the provincial integrated resource packages, which prescribe curriculum learning outcomes, and they will be tailored to the grade level, interests and needs of the visiting class. Camp groups, after-school clubs, home schoolers and preschool groups are also welcome. The programs will feature the 80-foot blue whale skeleton, and the arts will continue to be integral, as a way to encourage careful observation and examination of the natural world.

The museum's offerings for children will not stop at field trips. Also planned is a club for nature and research enthusiasts, a story hour for young children (and the young at heart) and a series of nature walks for families. Many of the museum's events are family friendly, such as FestEVOLVE, an evolution celebration held in September, which included a bug hunt, a build-your-own-microscope workshop and tips on wildlife tracking.

There will also be opportunities for teachers to explore the museum and participate in teacher nights and workshops. UBC scientists will support programming aimed at increasing teacher confidence and renewing—or perhaps instilling—a passion for teaching natural sciences. These programs will connect teachers to current research and innovative teaching techniques.

The Beaty Biodiversity Museum education and outreach program invites you to discover how rich the world around you is and to feel what a thrill discovery can be. Check out the exciting possibilities at www.beatymuseum.ubc.ca.

Opening in Spring 2010: UBC Beaty Biodiversity Museum

You are invited to contact the museum's education and outreach coordinator to discuss participation in teacher focus groups, to volunteer or to receive information about future events sponsored by the museum.

BEATY BIODIVERSITY MUSEUM
University of British Columbia
P (1) 604-822-3320 E programs@beatymuseum.ubc.ca

ALUMNI

Science Alumnus Follows in Darwin's Footsteps, Honoured with Kyoto Prize

Evolutionary biologists win 2009 Kyoto Prize: Peter and Rosemary Grant. Photo: Courtesy of Rosemary and Peter Grant

Renowned evolutionary biologist Peter Grant, who received his PhD in Zoology from UBC in 1964, and his wife Rosemary have won the 2009 Kyoto Prize in the Basic Sciences.

The Grants, both currently professors emeriti at Princeton University, earned the prize for their work documenting rapid evolution caused by natural selection in response to environmental changes. The couple is the first husband and wife team to receive the award, which was presented to them this November.

The Grants met in 1960 at UBC, where Rosemary was a research associate. They have spent decades studying 14 species of Galápagos Island finches—including seminal research demonstrating how the beak size of ground finches evolves as

CLASS NOTES AND EVENTS

'65 Barry James Price | MSc
Economic Geology

Currently president of B.J. Price Geological Consultants, Barry James Price's favourite UBC Science memory involves massive snowball fights against engineering students on Main Mall. After graduation, Price enjoyed fieldwork in the Rocky Mountains, and property inspections in Mexico, Chile, Argentina, Panama, Ecuador and China. "Travelling to other countries and talking with the locals was exciting," notes Price. "Addressing classes of students in a small Chinese village was intimidating, but fun."

'69 Mike Ingledew | PhD
Microbiology

Mike Ingledew earned a doctorate in science from the University of Saskatchewan this May, and has put his degrees to spirited use over a 37-year career. He has studied the biochemistry of yeasts and their use in the production of fuel alcohol, beer and distilled spirits, publishing more than 170 papers with his students, and presenting talks worldwide. Ingledew's research has received government funding and awards from industry, and his lab's discovery of very high gravity fermentation (a cheaper and less wasteful way to make suds) was adopted by industry. Ingledew is now scientific director at Lallemand Ethanol Technology. He and his wife Lynne reside in Parksville, BC.

'74 Nancy Turner | PhD
Ethnobotany

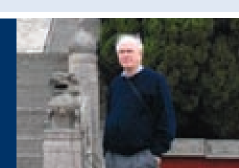
Ethnobotanist and University of Victoria Distinguished Professor Nancy Turner was named to the Order of Canada this July. Her research has demonstrated the pivotal role of plant resources in aboriginal cultures and languages, and has brought about a dramatic reinterpretation of how those resources were used before the arrival of Europeans. Native North Americans were not only hunter-gatherers but also farmers, even if their systems were not recognized by the new arrivals.

'83 Michael Ma | BSc
Computer Science

Michael Ma has spent more than 25 years in the information technology industry, in both North America and Asia. Currently a corporate vice-president with a global wealth management, retirement planning and insurance company, Ma has responsibilities spanning 15 countries and territories in the Asia-Pacific region. As an active industry leader, he is a frequent speaker at industry conferences and seminars.

* Evolution: Look for this icon and find out how our researchers and students expand and apply our understanding of evolution.

ALUMNI
(L-R) Barry James Price, MSc Economic Geology • Ashley Good, BSc Environmental Science



a consequence of the availability of different-sized seeds, which fluctuates with rainfall. Their scientific output includes more than 200 papers, and the couple has shared numerous honours including the Darwin Medal (Royal Society, UK) and the Edward O. Wilson Naturalist Award (American Society of Naturalists).

The Grants took up positions at Princeton University in 1985 after working at the universities of Michigan, Yale and McGill. They returned to UBC in 2007 to deliver that year's Beaty Biodiversity Lecture. The following year they published *How and Why Species Multiply: The Radiation of Darwin's Finches*, a 200-page distillation of the couple's experiences in the field and examination of the speciation process undergone by the finches.

Founded in 1985 by the Inamori Foundation, the Kyoto Prize is Japan's equivalent of the Nobel Prize. The award honours lifetime achievements in basic science, technology and art, and includes a cash prize of approximately US$500,000.

'89 Mia Thomas | BSc
Biology

Mia Thomas took a year of journalism studies at Langara College four years after graduating from UBC and has been working in the newspaper industry ever since. She is currently a reporter with the *Burnaby Now* and *The Record* (New Westminster) papers, both based in Burnaby.

'01 Frances Liang-Ehrlich | BSc
Computer Science

Frances Liang-Ehrlich has pursued her information technology career in North America and Europe and is currently working for IBM France as a project manager for Java-based projects and other business software solutions in the telecommunications sector. Liang-Ehrlich is married, the mother of two young boys, and the organizer of the 600-member-strong Paris Expat Canadian Meetup Group.

'06 Ashley Good | BSc
Environmental Science

Ashley Good works with rural farmers and local governments in northern Ghana to help them harness the business potential of the agriculture industry. In northern Ghana, almost 85 percent of the population relies on agriculture, and as part of an Engineers Without Borders project, Good hopes to empower farmers to use their skills and natural resources to lift themselves out of poverty. She also cites her time at UBC as a huge motivator: "UBC Science gave me the skills to follow my passion for environmental science and the opportunity to blaze my own trail in my field."

'06 Linda Hanson | MSc
Zoology

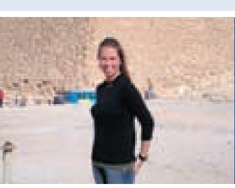
Linda Hanson just cannot seem to pry herself away from UBC. After completing her degree, she became a research assistant with the Faculty of Land and Food Systems' animal physiology lab. She enjoys the variety in the position—including research trips to Brazil and Norway. "Who knew studying fish hearts could be so rewarding?" jokes Hanson. To maintain perspective, she also offers independent scientific consulting, teaches hands-on activities to elementary schools as part of the Vancouver School Board's Scientist in Residence Program, and volunteers with the Burnaby RCMP.

'07 Sylvie Bryant | BSc
Microbiology & Immunology

After graduation, Sylvie Bryant studied Mandarin on scholarship in Taiwan. Then the travel bug really bit and Bryant moved to San Francisco to work as a rotational program analyst for Genentech on a UBC Science Co-op. When Genentech was acquired by Roche, Bryant worked at the company's facility in California. Her rotation wrapped up in August, and she is looking forward to new possibilities and new travel destinations. For now, she is enjoying San Diego, working on a master's in management science and engineering at Stanford, and spending as much time on her boogie board as possible.

* Botany's Evolutionary Best-seller

In 1965, six faculty members in the UBC Department of Botany collaborated to publish *An Evolutionary Survey of the Plant Kingdom*. The work by Robert Scagel, Robert Bandoni, Glenn Rouse, W.B. Schofield, Janet Stein and T.M. Taylor was on the textbook best-seller list for almost a decade.



New Alumni Relations Manager at UBC Science

UBC Science is pleased to introduce Matthew Corker, the Faculty's new alumni relations manager. Matt comes to us from UBC Alumni Affairs, where he worked with other units on campus to deliver events, programs and services to current students and recent graduates. He will be using that experience to help launch a range of new engagement initiatives dedicated to Science alumni. If you would like to become involved or learn more about these opportunities, please contact Matt directly at matthew.corker@ubc.ca.

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Science Alumni—Your Feedback Wanted on *Synergy*!

This issue of *Synergy* launches a fresh look and introduces a theme article on leading-edge research conducted at UBC Science that is relevant to you—our Science alumni. Our new alumni pages include highlights from you and your peers, and will help you stay in touch with Science. Please take a couple of minutes to let us know about your views on the new *Synergy* and for a chance to win a $50 Starbucks gift card and Peter and Rosemary Grant's latest book on Darwin's finches.

www.science.ubc.ca/survey

Celebrate Research Week

March 5–13, 2010, UBC research units and partner institutions will showcase discussion forums, seminars, open houses and symposia on topical issues across a diverse range of research areas. Most events are free and open to the public. Closer to the date, you can find the complete Celebrate Research Week program online, and you can learn more about noteworthy UBC Science contributions at our website.

www.celebrateresearch.ubc.ca
www.science.ubc.ca/news

Help Us Recognize Great Science Teachers

Recent UBC Science graduates are invited to submit nominations for the Killam Teaching Award for Science Instructors. If a professor or lecturer motivated and challenged you or brought innovative approaches to the classroom, now is your chance to thank them. Nominations are due by January 29, 2010.

www.science.ubc.ca/killam

Return undeliverable Canadian addresses to: UBC Science (Synergy)
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