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Volume XXVIII Number 1 June 2013

Research

magazine

UNIVERSITY
of GUELPH

CHANGING LIVES
IMPROVING LIFE


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In India, Chennai locals flock to a water truck, carrying their colourful, U of G-engineered water storage containers that minimize contamination and disease. Read more on page 21.

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Volume XXVIII Number 1 June 2013

Focus: International Research and Collaborations

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Going beyond traditional boundaries

Guelph researchers are passionately engaged in discovery and knowledge mobilization to further the University's commitment to bettering the lives of people everywhere.

The University of Guelph had the highest overall average in the 2012 International Student Barometer, conducted by the International Graduate Insight Group. It's the largest annual survey of international university students in the world. The University of Guelph was first overall for learning environment and first in research-intensive areas such as laboratories and learning spaces.

At many institutions, research occurs between colleagues down the hall from each other. Or maybe down the highway. Or even across the country.

But the University of Guelph has traditionally gone beyond those boundaries. And with the arrival of increasingly sophisticated communication tools, that outreach has become all-encompassing. Today, about a third of all research publications in the University involve at least one international collaborator.

Regardless of discipline and orientation, research is now inherently collaborative across disciplines and across countries. Networks of collaboration connect Guelph faculty, students and staff with researchers in universities and research centres everywhere.

This issue of *Research* focuses on some of those collaborations. Like the research highlighted on our international collaborations website www.uoguelph.ca/international/info/, the stories here show how international teams of researchers work on leading-edge questions and issues. Their contributions are characterized by their depth of engagement and by the commitment to provide leadership.

I invite you to explore these pages and let me know how you think the University of Guelph can do more to unite with like-minded universities around the globe to support academic and humanitarian objectives, and make a difference.



Prof. Kevin Hall

Kevin Hall, Vice-President (Research and External Partnerships)



University of Guelph researchers collaborators in more than 100 c

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SPARK

www.uoguelph.ca/research/spark

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USA, MEXICO, SCOTLAND, IRELAND

LIGHTING UP RURAL COMMUNITIES

Electricity's arrival in Nicaragua and Colombia is changing lives

BY KATHARINE TUERKE

DESPITE BEING A part of most people's everyday lives, more than 1.6 billion people still don't have access to electricity. But life is changing for the rural communities that are now plugging in.

Prof. Louise Grogan, from the Department of Economics and Finance, is using surveys and census data to examine how the arrival of electricity in rural Nicaragua and Colombia is changing the lives of men and women.

"After sunset, there is little people can do without light," says Grogan. "And alternative sources of light, such as kerosene lamps, are relatively expensive per lumen."

Nicaragua is the poorest country in Central America and has the lowest rate of household electrification. Grogan used national household surveys to investigate how electricity affects men's and women's use of time in Nicaragua.

She found that households with electricity worked more outside of the household. In these households, women were more likely to work outside of the home and earn money. With more money, women switched their cooking fuel from firewood to kerosene.

"Light from electricity extends the working day and changes how households allocate their time and resources," says Grogan.

Traditionally, women spent most of their time gathering firewood but switching cooking fuels may mean more free time to work, less deforestation and less pollution inside the house from fumes. Indoor fuel pollution is a major cause of respiratory disease and death in children.

Rural electrification in Colombia had similar effects. Again, having power lengthened the working day, increased

female employment and changed work time allocation.

Interestingly, women from municipalities with electricity had fewer children and lower fertility rates. This was the direct result of more women working at local markets outside the home.

In both Nicaragua and Colombia, rural electrification did not affect employment for men, because men mainly work full-time and engage less in activities in the household.

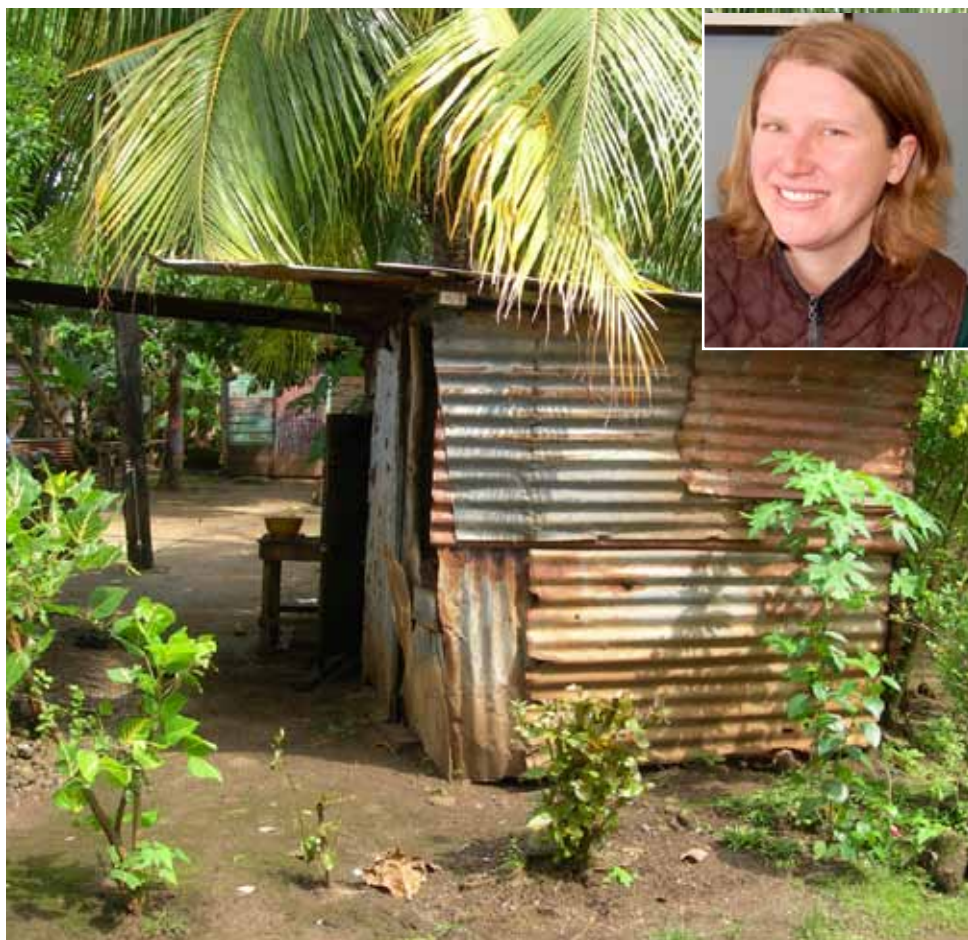
Next, Grogan will examine how electrification of rural areas changes the types of occupations and industries in which people work.

"Cost-benefit analyses of rural electrification generally don't capture other societal benefits like increased earning for women and deforestation reduction," says Grogan.

Bringing electricity to rural areas is considered expensive. But the development of alternative power sources and new technology means more people have access to low-cost electricity. Lighting the home with electricity is much cheaper than other methods, such as batteries or gas.

The results of the Nicaragua study were published in the journal *World Development*. **R**

Prof. Louise Grogan (inset) is investigating how the arrival of electricity to run rural Nicaragua (such as the village below) and Colombia is changing gender roles.





Prof. Khosrow Farahbakhsh and graduate student Rachael Marshall are making recommendations on how to transform waste material into garden beds, such as this one in the community of Todos Santos Cuchumatán.

Community approaches to modern waste problems

Researchers help rural Guatemalans develop their own unique solutions

STORIES BY KATHARINE TUERKE

IN MANY DEVELOPED countries, we have recycling facilities and other services that reprocess some solid waste and help protect people from waste-related health hazards. But not so in rural areas in many developing countries – they don't have access to such facilities and services, so garbage is littered or brought to dump sites that are often located next to vital water bodies or too close to town.

Prof. Khosrow Farahbakhsh and graduate student Rachael Marshall from the School of Engineering are working with the community of Todos Santos Cuchumatán, a small indigenous community in northwestern Guatemala, to develop successful strategies for managing waste and increasing local capacity.

"Poor solid waste management is causing contamination and health issues that are affecting the well-being of the community and surrounding ecosystem," says Marshall.

Historically, most waste was organic and either fed to animals or buried in the ground

where it decomposed. But the change from organic to plastic waste means traditional practices no longer work. Plastic from packaging, tourism and disposable products doesn't break down easily and contaminates soil and water.

Initially, top-down waste management approaches focused on the technical aspects, rather than on the role people play in the cause and solution. Approaches that lacked community input, such as a new wastewater treatment facility that was installed in Todos Santos, also failed.

"It was never used because the people didn't know how to use it. The technology wasn't appropriate for the community," says Farahbakhsh. "Solutions need to use local materials and be culturally sensitive and context specific to be sustainable."

So their study takes a participatory systems approach, working with the community to look at the big-picture, systemic structures that perpetuate waste management challenges. The researchers' fieldwork

involved interviews with community members to include the perspectives of both genders and of youth. Solutions that worked in similar communities and other regions were pooled together to create a bank of ideas. Options that were politically, culturally or economically inappropriate for the area were eliminated.

Four potential future scenarios were developed that range from simple and easy, to an ideal community-developed vision for waste management. Each one builds on the previous solution, so the community can use them as stepping stones to work towards the goals the community sets for itself.

Some of the suggested projects within these scenarios include using pushcarts instead of trucks, introducing a tax to help pay for garbage collection, and converting waste into building material.

Dealing with the waste where it is generated is ideal because it eliminates the cost of transporting it. Building a low-cost incinerator is another possibility because it fits with the traditional practice of burning waste, and electricity could be produced as a by-product.

Next steps include providing the community with all the potential strategies, translated into the local language.

"The solution is more than waste management. It can create employment, build economic capital and improve social conditions," says Farahbakhsh.

This research was partly supported by the Natural Sciences and Engineering Research Council. **R**

CASH FROM TRASH

Recyclers have formal role in Argentina's economic recovery

SCAVENGING THROUGH TRASH to collect recyclable or valuable materials is a common sight around the world. But the 2002 economic crisis in Argentina left thousands of men and women out of work. With limited employment options available, as many as 9,000 people are making their living as informal waste recyclers – called cartoneros.

What's it like to make a living sorting through other people's garbage? That's what Geography professor Kate Parizeau wants to know. Her interest in waste management, environmental health and social justice issues motivate her study of the cartoneros in Buenos Aires, Argentina.

"It's not an easy life but the cartoneros do important work," says Parizeau. "They contribute to the economy, provide material for industry and serve the environment by keeping items out of the landfill."

Cartoneros – derived from the Spanish word for cardboard – earn money by collecting, separating and selling recyclable materials, like plastic, glass, cardboard, paper, metal and wood, which are found in different residential and commercial areas of the city.

Some cartoneros take anything recyclable, whereas others specialise in just one type of material, depending on their route, the size of their cart and how many people are working in their team.

"It is estimated that the cartoneros reduce the amount of waste sent to Buenos Aires' landfills by 11 per cent," says Parizeau.

Her early work discovered that the informal recyclers were part of the low-income class. Searching through garbage did lead to health problems but many of the other jobs available to them also posed health risks. Many of the health issues faced by the cartoneros were related to urban poverty.

Using surveys and interviews, Parizeau examined how male and female informal recyclers view their work. Both men and women view their work as an income-earning opportunity but women expressed more concern for familial and community concerns than men did. Also, women tended to collect clothing and household goods, whereas men were more likely to collect construction materials and have heavier loads of goods.

Recently the municipal government of Buenos Aires has begun to organize the cartoneros by assigning them specific territories and giving them a partial income supplement with the expectation that the recyclers would still sell the materials they found.

"Some cartoneros have legitimate reason to distrust the government and don't want to be part of the new system, while others are excited to be recognized as a legitimate worker and wear the uniform," says Parizeau.

Argentinian urban recyclers, cartoneros, sort through curbside trash to make their living.



Prof. Kate Parizeau

Next she'd like to examine the effects of the government's new regulations in Buenos Aires. Parizeau will also investigate how informal recyclers work in other large cities such as Vancouver, where bottle depots accept more than beer and liquor bottles.

This research was funded by the Social Sciences and Humanities Research Council, the International Development Research Centre and the Trudeau Foundation. ■



WEIGHING EDUCATION AHEAD OF HEALTH AND INCOME

The global Human Development Index needs another look, says researcher

STORIES BY SAMANTHA BEATTIE



Prof. Thanasis Stengos is improving the Human Development Index to more accurately measure a country's level of development based on schooling, income and life expectancy.

IT IS DIFFICULT to characterize a country's level of development in a single number, but the Human Development Index (HDI) is a starting point for understanding a country's dynamics.

Governments around the world have used the HDI to inform national development planning, as have development researchers and agencies such as the United Nations, the World Bank, the World Health Organization, the United States Agency for International Development and the International Monetary Fund. But despite the index's widespread use, researchers say there's still room for improvement.

Among these is University of Guelph Economics Prof. Thanasis Stengos, who's working with a team of development experts from the United Kingdom, Italy, Greece, Turkey and Cyprus to improve the way HDI is calculated. Right now, it's determined by equally weighing life expectancy at birth, gross national income per capita and average and expected years of schooling per capita. But the team is developing a formula that will weigh one indicator more than the others.

"One of the main criticisms of HDI is that it is based on an arbitrary weighting scheme, when in fact health, education and income do not necessarily contribute equally to development," says Stengos.

"Development agencies and policy experts need to be able to unpack a country's HDI to see what areas need to be improved upon the most."

The team is working to break down the HDI into two indexes that are more specific. The first will weigh education more heavily than health and income. That's because when a population's educated, it's easier to build a strong health-care system and generate economic growth. There's a larger skill base to draw from than if a population is not educated.

The second index will weigh income more heavily, which Stengos says represents a different view of development because, out of the three indicators, it is the most challenging aspect of development to achieve.

In the future, the indexes can be consulted to see exactly where a country has improved.

Collaborators include Prof. Mehmet Pinar of Edge Hill University in the U.K.; Prof. Elettra Agliardi of the University of Bologna in Italy; Prof. Theo Mamuneas of the University of Cyprus; Prof. Ege Yazgan of Istanbul Bilgi University in Turkey; and Prof. Nikolas Topaloglou from Athens University of Economics and Business in Greece.

Funding is provided by the Social Sciences and Humanities Research Council and the University Research Chairs Program. ■

THE HUMAN DEVELOPMENT Index (HDI) is a statistical system commissioned by the United Nations Development Programme that ranks 187 countries based on their education, health and income indicators.

Development from the bottom up

THE CHRONIC POVERTY that characterizes much of the developing world makes it hard to believe these countries received almost one trillion dollars in foreign aid in 2011. The issue of aid effectiveness is causing many development ethics experts to pause and consider why aid is given, whom it's meant to empower and the negative consequences it may have.

Among these experts is Prof. Monique Deveaux, the Canada Research Chair in Ethics and Global Social Change. She is seeking to debunk global poverty myths and explore better ways to think about poverty reduction by combining philosophical thinking with practical development work.

"Philosophy needs to catch up with the best work done by development practitioners and economists, many of whom recognize that empowerment of the poor is a critical part of poverty reduction," says Deveaux. "At the same time moral philosophy has a lot to offer in terms of understanding complex causes of poverty and the ways in which economically advanced countries contribute to these causes."

Currently, much development aid – which in theory is meant to target those living in poverty – goes through top-down channels. This gives the donor country and national governments a lot of say in where the money goes, often failing to help the poorest of the poor.

"What we usually fail to see is that there is a lot of activity by poor communities that has the potential to create more sustainable change," says Deveaux.

Oftentimes, she says, poor people living in developing countries are not viewed by the developed world as moral agents who have the ability to organize initiatives and pursue development goals.

But leaving them out of development work can have negative consequences.

Deveaux says that in some cases, the most vulnerable groups feel excluded from projects that were originally meant to assist them. As well, top-down work can overlook important cultural factors that


will prevent people from accepting a new technology, or growing a new crop.

To overcome these challenges, she says local people need to be directly consulted and involved in the project to address what their community needs.

One such organization Deveaux supports is Women in Informal Employment: Globalizing and Organizing. It works internationally, supporting and strengthening networks that the working poor can use to increase their voice in policymaking. The organization is also working to legitimize informal employment – such as unregistered or household workers – that are usually impoverished but ignored by many state policies.

"By giving the most vulnerable groups outlets to be heard, they're able to shape the world around them for the better," says Deveaux. "That's why I'm arguing for a reversal in development and philosophical thinking – to empower those who traditionally don't have a voice but need to be heard the most."

To fuel the debate about moral and political understandings of global poverty, Deveaux coordinated the 2012 Toronto Critical Perspectives on Global Justice workshop. There, scholars from across Canada, Britain, the United States, Australia, Italy and Germany grappled with these issues.

Funding for Deveaux's research is provided by the Canada Research Chairs Program, the Dean of the College of Arts and the Social Sciences and Humanities Research Council. 



By combining philosophical thinking with practical development work, Prof. Monique Deveaux is weighing in on global poverty reduction.



What can we learn from Estonia's vodka-based tourist trail industry, rooted in the lush countryside, that can be applied in Canada? That's what Prof. Brent McKenzie (inset) is out to find.



Following the vodka trail

BY MATT MCINTOSH

FIRST CAME THE hallowed whisky trails of Scotland. Closer to home, the wine trails in southern Ontario and British Columbia's Okanagan Valley followed. Now, the small European country of Estonia is eyeing its own claim to fame – a world-renowned vodka trail – thanks to Guelph researchers.

While visiting Estonia, Prof. Brent McKenzie, Department of Marketing and Consumer Studies, observed that Estonians have a strong connection with vodka. That led McKenzie and Mark Samman, an undergraduate student in the College of Management and Economics, to investigate how vodka's historical significance could enhance Estonian tourism.

A spin-off, they thought, might be how their experiences might improve the "trail" literature here at home...or better yet, how to create similar attractions here in Ontario.

"The concept of 'trails' really are good ways to attract tourists, and this province has a lot of assets – such as our craft breweries, for example – that we could better utilize for that purpose," says McKenzie. "But Estonia specifically has a rich, interesting history

that has a lot to do with vodka. Highlighting that history in relation to its production would be a great attraction."

McKenzie is using a form of what's called "participatory action research." That is, he and Samman are directly involving themselves in the project to achieve an end goal, rather than just providing objective analysis. For this project, their first step is recognizing vodka's cultural and historical importance to Estonia.

McKenzie says the name of what we know as vodka today came from the Slavic word "voda," meaning water, and has been part of the Baltic region for centuries.

In Estonia, the industry has steadily grown over the years. But it's had a dark history associated with it, due in part to high rates of alcoholism in some surrounding countries.


Despite these realities, the researchers believe there's room for positive change in how Estonia perceives and capitalizes on vodka tourism. And, although Russia is often celebrated worldwide as the heralded vodka czar, Estonia has a unique,

architectural claim to the spirit's fame, which McKenzie suggests could be the foundation of the vodka trail – that is, the 17th- and 18th-century manor homes that dot the country. In addition to serving as the private residences of local nobility or people of some other significance, these homes served as local distilleries by making vodka for the estate and surrounding community.

Most of these homes no longer produce spirits; however, many have become tourist destinations in the form of hotels or resorts.

"These manor homes could be mapped out just like the historic whisky distilleries in Scotland. Plus, many of them are already tourist destinations, so there's an advantage there," says McKenzie.

McKenzie is currently in Estonia speaking with the owners of these manor houses about vodka making, and the potential benefits of being part of a national tourist attraction such as a vodka trail.

Funding for this project is provided by the Social Sciences and Humanities Research Council. 

LIGHT. CLEAN. DEADLY.



Prof. Tim Dewhirst

Smoking habits die hard in unconventional Korea

BY KATHARINE TUERKE

TIGHT RESTRICTIONS HAVE been placed on how cigarettes can be advertised in Canada. Billboards, like the Marlboro Man, are no longer seen in North America. But how does legislation and marketing strategies impact smoking around the world?

Prof. Tim Dewhirst, Department of Marketing and Consumer Studies, and Wonkyong Beth Lee, from the University of Western Ontario, are studying the cigarette branding and consumption demographics in one of the world's top 10 cigarette markets, the Republic of Korea.

“Unlike most developed countries, smoking rates are still very high in Korea,” says Dewhirst. Indeed, about 40 per cent of Korean men smoke compared to 24 per cent of males in Canada.

To study cigarette branding in Korea, Dewhirst and Lee gathered cigarette packaging and print media publications containing tobacco advertisements. In particular they analyzed the marketing strategies for the popular brand, The One, advertised by its manufacturers as supposedly low in tar, light, clean and prestigious.

This brand used colours and symbols that have culturally specific meanings and associations. For example, “in Korean Buddhism, the round circle (Ilwonsang) is a symbol of Oneness and represents the origin, or perfect and integrated Dharma of the universe,” says Lee.

Generally, menthol cigarettes are considered feminine in Canada, but those by

The One were targeted towards men.

Korea ratified the World Health Organization's Framework Convention on Tobacco Control (WHO FCTC) in May of 2005. The treaty specifies that tobacco advertising and promotion should be banned, terms like ‘low tar’ and ‘ultra-light’ not be used, and health warnings should account for 50 per cent or more of the package's principle display area.

“Although Korea ratified the WHO FCTC, our work has shown that important obligations of the treaty are not being met,” says Dewhirst.

Dewhirst and Lee also investigated Virginia Slims' cigarette advertising in Japan, Korea and the United States. Generally this brand is targeted towards women but not in Korea – there men are the focus.


Interestingly, it is illegal to overtly promote tobacco products to women in Korea and Japan – although companies seem particularly cautious in Korea because of the cultural and social norms against women smoking.

“Comparing the cross-cultural differences between Korea, Japan and the United States



In most markets, Virginia Slims targets women, but in Korea the brand has been marketed to men

highlights the unique marketing techniques used in each country,” says Dewhirst.

Funding for this research was provided by the Ontario Institute for Cancer Research, Canadian Institutes of Health Research and the Canadian Tobacco Control Research Initiative. 

BRANDING: THE USE of a name, symbol, design or logo to identify a product. Typography, colour, taglines, symbols and characters further add meaning and identification of the product and help differentiate it from competitors.

Towards better chemotherapy



Protein studies at the University of Guelph target more efficient chemotherapy drugs

BY MEGAN COWIE

THE ROLE OF one of the human body's proteins, P-glycoprotein, is to protect our cells from toxic chemicals, but unfortunately it also reduces the effectiveness of chemotherapy drugs. Understanding how the protein works could lead to better chemotherapy treatments, researchers say.

P-glycoprotein is a membrane transporter responsible for pumping harmful substances across cell membranes and out of cells. However, it also pumps anti-cancer drugs out of tumour cells, which dramatically reduces the effectiveness of chemotherapy treatments.

After each round of chemotherapy, more P-glycoprotein is expressed in cancer cell membranes, which further increases resistance to chemotherapy drugs.

Currently, cancer patients don't have many treatment options. They can have surgery or radiation therapy, but when those fail, chemotherapy is necessary. And when chemotherapy fails, no more options exist.

Worldwide, scientists are trying to get to the bottom of this problem. But P-glycoprotein has a complex structure that's difficult to understand using conventional techniques.

That's why Dr. Frances Sharom, Department of Molecular and Cellular Biology, is using a reductionist approach to study how the protein works on a molecular level. This means that she is looking at the protein's components separately to understand how it works as a whole. Sharom hopes that this research will lead to more effective cancer treatments.

"It's a really big problem. About half of all cancer deaths occur because chemotherapy fails," she says.

Sharom's laboratory was the first to successfully purify the protein and put it into artificial membrane systems, which has allowed her to study the protein in isolation from the highly complex whole cell.

Sharom and her team also developed a new approach to studying the protein using a light emission technique called fluorescence spectroscopy, which has enabled her to examine how the protein transports drugs in real time.

A better understanding of the structure and mechanism of P-glycoprotein will help pharmaceutical companies develop drugs called modulators that will improve the success of chemotherapy treatments.

"If we can find out how this drug pump


Prof. Emeritus Frances Sharom (inset) is using fluorescence spectroscopy to study how proteins transfer chemotherapy drugs out of tumour cells, such as the one above.

actually works, then hopefully we can block it with modulators. And then we can administer a modulator to cancer patients at the same time as chemotherapy drugs, so they will be more effective," says Sharom.

An alternate approach involves developing new chemotherapy drugs that P-glycoprotein cannot pump out effectively. To achieve this, Sharom is collaborating with Dr. Weishuo Fang from the Institute of Materia Medica in Beijing. They are working to identify new variants of taxol, a chemotherapy drug used to treat breast and ovarian cancers.

P-glycoprotein is a member of the ABC protein family, one of the largest protein families known to scientists. ABC proteins are present in bacteria, fungi, plant, and animal species, and they are characterized by their use of ATP – the cellular energy currency – to pump substances across cell membranes.

Proteins in the ABC protein family have similar structures, and Sharom believes that they all work in a similar way. So if researchers are able to figure out how P-glycoprotein works, the same principles will apply to the other family members.

Sharom's work is funded by the Canadian Cancer Society. 

HELPING CANCER PATIENTS COPE WITH NAUSEA

BY ANDREA SECCAFIEN



Prof. Linda Parker

NAUSEA IS A common and distressing side effect of many drugs and medical treatments, such as chemotherapy. The neurobiology of nausea is not well understood, but recent developments are changing that.

University of Guelph behavioural neuroscientist Prof. Linda Parker is investigating the anti-nausea effects of different compounds found in the cannabis plant, which might help relieve the nauseating side effects of chemotherapy.

“Millions of people have been touched by the debilitating side effects of nausea and vomiting produced by chemotherapy treatment of cancer,” says Parker, who holds the Canada Research Chair in Behavioural Neuroscience.

Vomiting can be controlled by current medications in approximately 80 per cent of patients. But nausea is more difficult to control, especially anticipatory nausea.

Anticipatory nausea is experienced when patients return to the clinic where they received chemotherapy. The clinical setting becomes associated with nausea produced by the chemotherapy treatment due to Pavlovian conditioning. No current treatments to control nausea and vomiting are effective in reducing anticipatory nausea in cancer patients.

Traditionally, the problem has been the lack of a reliable animal model to test new treatments. But Parker and her students have now developed such a model using laboratory rats, called conditioned gaping. Although rats can't vomit, they display a disgust reaction called gaping when re-exposed to a taste or to a context that was previously paired with a drug that made them feel nauseous. This finding provides a new animal model of anticipatory nausea, remarkably similar to that

seen in chemotherapy patients.


Using the rat model of anticipatory nausea, Parker and postdoctoral fellow Erin Rock have investigated the ability of compounds found in the cannabis plant to mitigate anticipatory nausea. She looked at Delta-9-tetrahydrocannabinol (THC), cannabidiol (CBD) and cannabidiolic acid (CBDA), which is the precursor to CBD and is found in the plant before it is heated. The compound THC was effective, but is undesirable for some patients because of its psychoactive, or intoxicating, side effects.

On the other hand, neither CBD nor CBDA are psychoactive. What Parker found is that both CBD and CBDA also suppressed gaping caused by the nausea paired context. In fact, CBDA was about 1,000 times more potent than CBDA, meaning the dose needed to control nausea can be decreased.

These findings hold promise for new treatments using CBDA. Parker's lab is at the centre of an international collaboration that includes medicinal chemist Rapheal Mechoulam at the Hebrew University of Jerusalem. Mechoulam's group discovered THC, the principal psychoactive constituent, or cannabinoid, of the cannabis plant as well as the endogenous chemicals produced in our brains that act like THC (anandamide and 2-AG).

The team is also working with world-renowned pharmacologists Roger Pertwee from University of Aberdeen and Aron Lichtman at Virginia Commonwealth University. Another collaborator, one of the most prominent cannabinoid chemists, Alexandros Makriyannis, provides Parker's group with new compounds to test in her nausea models.

Much of Parker's current work is in collaboration with GW Pharmaceuticals, United Kingdom, which provides the compounds found in the cannabis plant to test for anti-nausea potential.

This research is funded by the Natural Sciences and Engineering Research Council, Canada Research Chairs Program and GW Pharmaceuticals. 

Security at the cellular level

Researchers study the structure and assembly of bacterial cell surfaces

STORIES BY KATHARINE TUERKE



Prof. Chris Whitfield

BACTERIA ARE PROTECTED from harmful factors in their environment by a multi-layered cell envelope made from proteins, lipids and sugar-containing molecules. These components are essential for cell survival and the ability to cause disease. A better understanding of the processes involved in building the cell envelope will help to identify potential targets for new antibacterial drugs.

Prof. Chris Whitfield holds a Tier I Canada Research Chair in Molecular Microbiology. He's teamed up with Profs. James Naismith, University

of St. Andrews, and Robert Ford, University of Manchester, to use a multidisciplinary approach to understand the structure and function of systems that assemble bacterial cell surfaces.

"Identifying the cellular machinery guarding what crosses the membrane requires multiple experimental approaches, ideas and expertise," says Whitfield.

For bacteria to grow and divide, nutrients must enter through the cell envelope while large molecules exit to form critical structures on the bacterial surface. All of this activity must be achieved without breaching the vital barrier of the cell envelope, or the bacterium dies.

Bacteria, like *E. coli*, have a protective coating surrounding the outside of their cell envelope, called the capsule. It's made of large polymers composed of complex sugars and helps protect bacteria from host (immune) defenses. It also contributes to the formation of

resilient biofilms that allow bacteria to colonize surfaces. After they are assembled, these capsule polymers must pass through the cell envelope in an organized fashion to reach the surface of the bacteria.

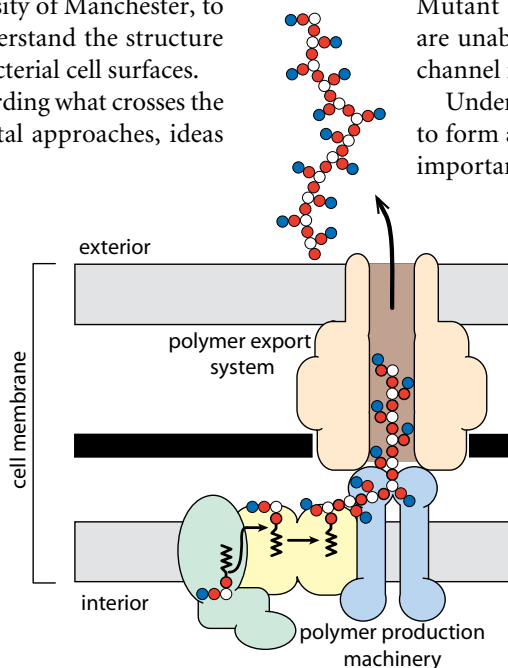
By combining molecular, biochemical and advanced structural biology techniques, like electron microscopy and X-ray crystallography, the team is trying to identify the mechanism that exports the polymers forming the capsule.

"With the ever-advancing sophistication of experimental methods, we are now able to address key scientific questions at an unprecedented level of molecular detail," says Whitfield.

Together they have described the structures of several of the components of a molecular machine that assembles the capsule. After synthesis, the polymers enter a channel, made from multiple copies of a protein called Wza. The channel spans the cell envelope and allows the polymers to transit to the cell surface. Mutant bacteria, which don't have the Wza protein, are unable to form the capsule, indicating that the Wza channel is essential for the export process.

Understanding how many cellular components interact to form a fully active assembly and export machine is an important first step towards identifying targets for new antimicrobial drugs. Next, Whitfield and the team hope to identify inhibitors that will disrupt some of the critical machinery.

This research was supported by funding from the Canadian Institutes of Health Research, Natural Sciences and Engineering Research Council, Canada Foundation for Innovation, Canada Research Chairs Program, and Wellcome Trust. 



Multiple copies of the Wza protein form a channel that helps polymers move to the cell surface.

Teaming up to fight malaria



Shutting down specific enzymes is the key to more efficient anti-malaria drugs

ONE BITE FROM an infected mosquito is all it takes to get malaria. This devastating disease occurs in about 100 countries worldwide, affecting more than 200 million people. With no vaccine available, more effective treatments are needed. Understanding how specific enzymes work may be the key.

That's where University of Guelph professor and Canada Research Chair Rickey Yada and research associate Huogen Xiao come in. They're teaming up with international scientists from Singapore, Japan and the United States to investigate the structure and function of what's called plasmepsin enzymes. The plasmepsin enzymes are a group of enzymes involved in malaria and belong to the aspartic protease family of enzymes. Other enzymes in this family are involved in various food processes including fermentation and in the coagulation of milk when making cheese.

The researchers hope to be able to shut off these enzymes and help reduce the incidence of malaria.

"The best approach to solving problems is to work with others that have complementary expertise and not do it alone," says Yada.

The plasmepsin link to malaria is direct. Malaria parasites use red blood cells to multiply. So shutting down these enzymes stops the breakdown of blood proteins, which the malaria parasite needs to mature and reproduce.

Figuring out the shape or structure of these enzymes is the first step, using X-ray crystallography. It involves firing X-ray beams at the group of enzymes that diffract in specific directions. By measuring the angle and intensity of these diffracted beams the researchers were able to find out the atomic arrangement (or structure) of these enzymes.


Yada and Xiao teamed up with X-ray crystallographers Prasenjit Bhaumik (now at the Indian

Institute of Technology) and Alexander Wlodawer and Alla Gustchina from the Center for Cancer Research, National Cancer Institute, in the United States. Yada says now that they know what the plasmepsin enzymes look like, they can figure out how they work.

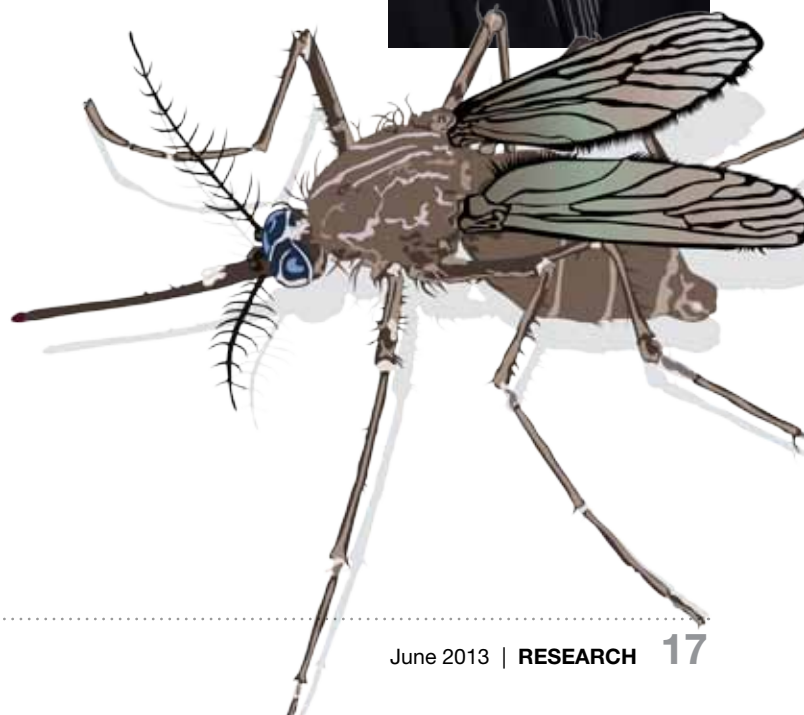
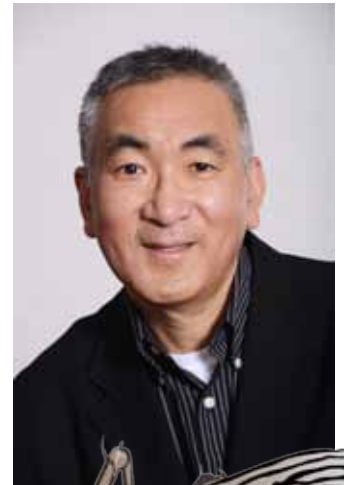
Shao Yao, a chemist from the National University of Singapore, and Yoshiaki Kiso from Kyoto Pharmaceutical University in Japan, also joined the team. Their knowledge and development of enzyme blockers, called inhibitors, is used to figure out how to stop plasmepsins from functioning.

They will test a series of inhibitors to see which one(s) stops these enzymes.

"A better understanding of the structure and function of aspartic protease enzyme family will lead to better treatments for tropical diseases, such as malaria, and to novel uses, including those in the food industry," says Yada.

Funding for this research project is provided by Natural Sciences and Engineering Research Council and the Canada Research Chairs program. 

Prof.
Rickey
Yada



Cambodia's

University of Guelph innovation addresses iron deficiency in rural Cambodia

BY KATHARINE TUERKE

Iron deficiency is a curable, nutrient-deficient disorder affecting 3.5-billion people worldwide. Although it's often considered a serious clinical problem for women and children, men are also affected. For rural areas of Cambodia with limited access to health care and treatment options, the health, social and economic impacts of iron deficiency are exacerbated. But the University of Guelph has found a simple, cost-effective solution that involves a smiling iron fish.

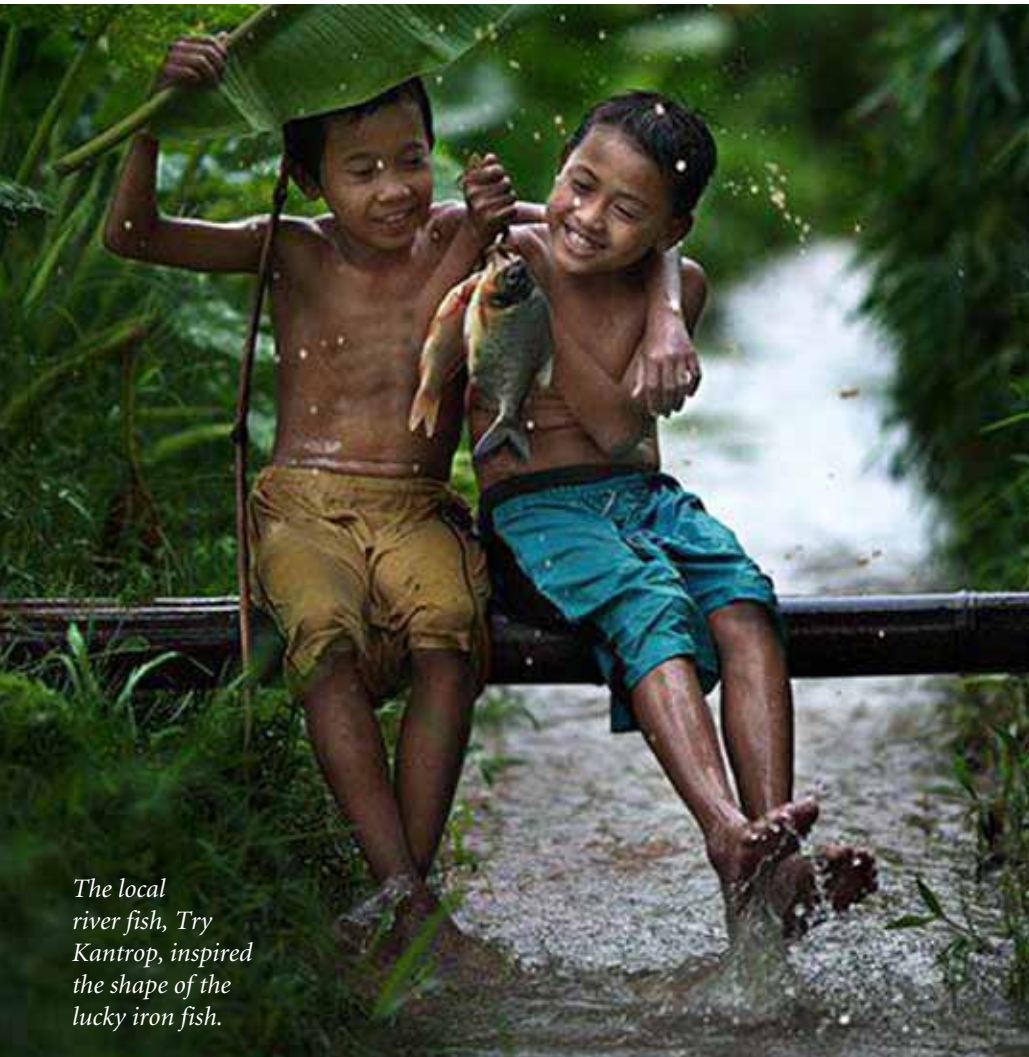
University of Guelph President Alastair Summerlee, Prof. Cate Dewey, Department of Population Medicine, Guelph graduate Chris Charles and doctoral student Gavin Armstrong have teamed up with local NGOs working on the ground in Cambodia (such as Resource Development International and Helen Keller International), to eliminate iron deficiency in rural Cambodia.

"We knew that whatever we came up with had to be low-cost, effective and, above all else, something that people would use," says Charles. "We knew that our big challenge would be getting the community to accept our solution."

Standard treatments for iron deficiency and anemia just weren't feasible in Cambodia, due to cultural and financial restrictions. Most Cambodians eat very little meat and don't get a lot of iron from their diet. Regular use of iron supplements will correct iron deficiency,

President Alastair Summerlee with the lucky iron fish that alleviates iron deficiency in Cambodia.

“lucky” cure



The local river fish, Try Kantrop, inspired the shape of the lucky iron fish.



considered lucky according to village folklore.


And the results have been positive. Women report feeling better three months later, and blood tests showed significant increases in their iron level.

One year later, 90 per cent of women were still using the lucky iron fish in their cooking pots. Moreover, iron from the fish improved iron levels for the whole family.

“Cooking everyday with the lucky iron fish has almost eliminated anemia from children in the rural areas where we have tested the fish,” says Dewey.

The fish was made locally from recycled metal. That benefits local metal workers and iron recyclers. Now, the team is trying to help Cambodians build and sell their own lucky iron fish.

“We are working with Resource Development International to create TV ads to advertise the lucky iron fish, but word of mouth has been the most effective form of advertising,” says Armstrong.

Support for this research was provided by the Students for Development Award, Association of Universities and Colleges of Canada, Ontario Graduate Scholarship, International Development Research Centre, Canadian Institutes of Health Research, Guelph Commercialization Fellowship and the University of Guelph. 

but in regions where the daily income is \$1 a day, pills are unaffordable.

Elsewhere in the world it has been shown that iron deficiency anemia can be treated with regular use of cast iron pots or pans. However, women in rural Cambodia prefer to use aluminum pots because they are lighter and less expensive. So the only other solution the team had was placing a small piece of iron in the women’s cooking pots. Iron leaches from the iron fish and into the water and food during cooking.

At \$1.25 US, the idea was inexpensive, easy and meshed with their culture and daily routine: villagers boil water every day, and cook a great deal of rice and soup.

“Boiling one litre of water for 10 minutes will provide 75 per cent of your daily iron requirements,” says Summerlee. “The other 25 per cent can come from food.”

After trying several shapes, including a disk and lotus flower, the Cambodian women chose the fish design. The iron fish is based on the local river fish, Try Kantrop,

Clay pots for safe water

Novel tools that are affordable for Cambodians

BY SAMANTHA BEATTIE

A SIMPLE ONE-FOOT-TALL clay pot – similar to a common flowerpot – has the potential to provide clean water to millions of people in developing countries, says a University of Guelph researcher.

The pot originated in a Honduras development project headed by the non-governmental organization, Potters for Peace. Over the past nine years, Prof. Ed McBean, the Canada Research Chair in Water Supply Security and Engineering, has been working on improved designs.

He says the pots made out of clay, rice husk, iron and silver nitrate have pores large enough for water to drip through, but small enough to block 99.9 per cent of harmful waterborne pathogens. The iron and silver nitrate also work to destroy harmful organisms, forming a film on the inside of the pot that is removed by periodically scraping the sides.

Now, he's working to make these cleansing pots more accessible, affordable and applicable for impoverished people in Asia, as well as Latin America and Africa.

"Water is vital to human life, but when it's contaminated by bacteria such as cholera, it can act like a poison, causing long-term illnesses and oftentimes death," says McBean. "My goal is to give people control over their own water supply in a way that makes sense to them."

Indeed, contaminated water is a plague on developing countries. The diarrheal diseases associated with it are among the top three causes of death in children less than five years old. That equates to as many as two million deaths a year.

What's more, says McBean, is that water-related diseases amplify poverty. They cause children in the developing world to miss an estimated 443 million school days a year, hindering their education and future.

That's where the clean-water clay pot comes in. Unlike boiling water, the pot filters water in a relatively short amount of

time – one to three litres an hour. As well, the cleansing procedure is simpler because users don't have to be concerned about getting the water to the most effective robust boil needed for removal of the pathogens. Instead, they just have to pour water into the pot and wait one to three hours for gravity to do its job.

Better yet, this water filtration system does not rely upon expensive infrastructure. The pot is made from local material. And in African countries where rice isn't grown, sawdust can be used instead.

Currently, there's one catch. The pot costs about \$6, which is steep for people who make only a dollar a day. But McBean remains optimistic.

"Other filtration methods have been tried but aren't used by the local people after the initial introduction," says McBean. "However, perhaps purchasing the pot for the sole purpose of filtering water will create a greater incentive for these families to keep using it long after implementation."

Next on McBean's agenda is to educate local people about how to properly take care of and clean their clay pots.

Collaborating on this and related research are the non-governmental organizations Society for People's Action in Change in Equity and Resource Development International Cambodia (RDIC), as well as graduate students Joseph Brunsting, Emily Nickerson, Ryan Brennan, Ingrid Sorenson, Laura Robertson, Heather Murphy, Kim Thomas, Joel Gretton, Cameron Farrow, Hamid Salsali and Diana Nicholson.

Funding is provided by RDIC, the Natural Sciences and Engineering Research Council's Discovery Grant, and the Canada Research Chairs program. ■

Prof. Ed McBean (left), along with undergraduate student Emily Nickerson, is developing a clay pot that has the potential to filter and provide clean water to millions in Asia, Africa and Latin America.



THESE FILTERS IMPROVE HEALTH

University of Guelph engineers develop economical solutions for cleaner water

BY KATHARINE TUERKE

Globally, diarrheal remains the leading cause of death among infants and young children. The main culprit is a lack of safe water and inadequate sanitation. At 1.7 million deaths each year, India alone accounts for nearly a quarter of child deaths worldwide. Improving water quality would reduce diarrheal episodes by nearly half.

That's why Kevin Hall, the University of Guelph's Vice-President (Research and External Partnerships), and doctoral student Morgan MacDonald teamed up with Prof. Ligy Philip from the Indian Institute of Technology Madras to develop an economical way to improve water quality for the 10,000 people living in the urban slum of Chennai, India.

Their solution: A storage container with a small (11.5 cm), narrow opening to avoid recontamination from cooking utensils or unclean hands.

"A successful system has to be cheap, adaptable and designed with input and materials from the community," says Hall. Indeed, their system costs \$25 to make and less than \$6 to maintain per year.

Currently, local people gather drinking water from a water truck that visits every three to four weeks, or from water taps that draw water from a nearby lake that houses garbage, raw sewage and debris.



Graduate students Syed Imran Ali (left) and Morgan MacDonald with Prof. Ligy Philip (centre-right) held workshops to teach Chennai women how to build their own water filter.

Once collected, the water sits stagnant in open containers, becoming a breeding ground for bacteria, parasites, disease-carrying mosquitoes and other kinds of contamination.

So Hall and his research team developed a point-of-use gravity filter and water storage container. Collected "dirty" water is put through the gravity filter and then the cleaner water is stored.

The filter is made up of multiple layers of sand, gravel and charcoal. As gravity pushes the water through each layer, particles, bacteria and parasites are removed.

Monthly samples comparing filtered water from the storage containers to the original source show that the filters effectively removed bacteria such as *E. coli*. Surveys revealed that users were very satisfied with the technology. In fact, they had an 80 per cent compliance rate a year later.


"These point-of-use filters are also empowering women by providing them an

opportunity to develop a small business and gain financial stability," says Hall.

Indeed, through workshops, these women are taught how to collect and prepare the materials to make their own filters. The income earned from selling the filters helps give them financial independence and security.

Local people are also receiving instruction on the importance of washing, sanitation and hygiene through a series of events, including workshops and street theatre.

And it isn't only India that needs help – access to clean, sustainable water is a global concern. So Hall and his team are also creating point-of-use gravity filters for marginalized communities in Indonesia and Eastern Africa – including Kenya, Rwanda, Tanzania and Uganda.

This research was supported by a grant from the International Development Research Centre, the Natural Sciences and Engineering Research Council and the Indian Institute of Technology Madras. 

BIODIVERSITY GETS A BARCODE

Guelph researchers initiate a worldwide campaign to catalogue every species

BY KATHARINE TUERKE



Prof. Paul Hebert

HAVE YOU EVER seen a bird, insect or tree you didn't recognize and wonder what it was? Historically, trained taxonomists could only reliably identify around 1,000 species. But a new technique developed at the University of Guelph is accelerating the pace of species identification and discovery.

Canada Research Chair and Integrative Biology Prof. Paul Hebert introduced a system that uses DNA barcodes to identify species instead of the traditional approach that's based on morphological characteristics.

To speed progress, Hebert has teamed up with researchers in 28 countries to establish the

International Barcode of Life Project. Together, their goal is to barcode five million specimens across 500,000 different species by 2015. So far they're on target.

"Developed countries have the sequencing infrastructure, but developing nations are home to 90 per cent of the world's biodiversity so it's a natural collaboration," says Hebert.

DNA barcodes are analogous to the UPC barcodes seen on store products. Visually similar, both types of barcodes are tools that are used to organize, catalogue and identify things – animate in one case, inanimate in the other.

Here's how it works. DNA barcoding targets the analysis of standardized gene region(s) that's very similar among members of a species, but clearly different between species. For animals, it's a segment of the mitochondrial cytochrome c oxidase 1 gene, or CO1, while for plants, it's the matK and rbcL genes.

Hebert and others employ these gene regions as species-specific sequences to identify global biodiversity.

These gene regions are short – making sequencing quick and cheap – yet long enough to identify variation among species. A fragment of a specimen, such as an insect leg, a feather, or piece of fur, has enough DNA to generate a barcode.

"Preserving biodiversity is a global priority that demands international collaboration," says Hebert.

But DNA barcoding is more than a species identification and classification tool. It's also helpful in exposing market fraud, protecting endangered species, monitoring the environment and fighting disease.


For example, the U.S. Food and Drug Administration teamed up with Guelph researchers to use DNA barcoding to identify mislabelled food and health products. It's common for seafood to be fraudulently labelled as a more expensive species. The technique

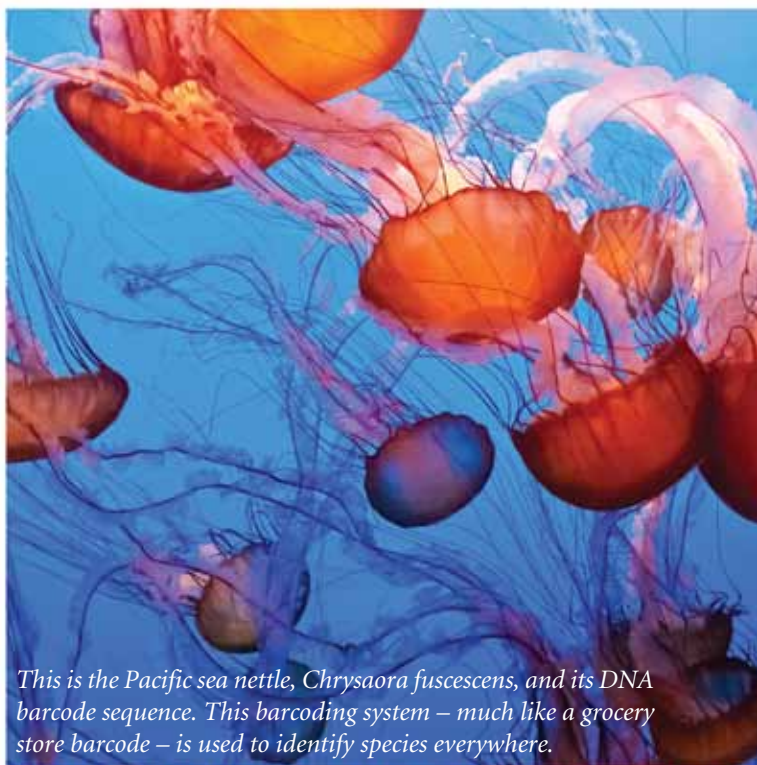
has also been found to probe for substitution in herbal medicines such as Korean ginseng.

In the future, Hebert hopes to see the development of a handheld barcoding instrument that would allow users to identify any organism anywhere.

This research was supported by the Canada Foundation for Innovation, the Ontario Ministry of Research and Innovation, Genome Canada, the Ontario Genomics Institute, the Natural Sciences and Engineering Research Council, the International Development Research Centre, the Gordon and Betty Moore Foundation and the McCain-Evans Foundation.

Want to identify an organism you've seen? Then visit the barcode reference library at, www.boldsystems.org.

To get your own specimen sequenced, visit biodiversity.ca/services.html. 



This is the Pacific sea nettle, *Chrysaora fuscescens*, and its DNA barcode sequence. This barcoding system – much like a grocery store barcode – is used to identify species everywhere.



Adapting to captivity

International survey looks to parrot owners for insight

BY KATY JONKER

FROM THE VERY smallest parrots, such as lovebirds and parakeets, to the grandiose macaws and cockatoos, parrots are commonly caged as pets all over the world. However, little is known about how their biology affects their behaviour while being confined. That's where Prof. Georgia Mason and PhD candidate Heather McDonald Kinkaid from the Department of Animal and Poultry Science come in.

They're working with collaborators in the Netherlands to assemble the largest and most comprehensive set of epidemiological data ever collected on the demographics, housing conditions and behaviour of parrot species kept in people's homes. Their survey is designed to reveal prevalence rates of feather-plucking and other behavioural problems across species, as well as detailed information about the housing conditions in which these problems arise or disappear in individual birds.

Their hope is to provide a concrete resource – not just for parrot owners – but also for zoos, research institutions and conservation breeders around the globe. They can use this research to better understand which species are biologically predisposed to developing behavioural problems in captivity, such as feather-plucking, or stereotypic movements and why.

“International input is crucial for this project, not only because our results will be directly applicable worldwide, but also because the popularity of the different species varies across countries and we'd like our data set to be as representative as possible,” says McDonald Kinkaid.

The survey is being offered online in eight languages, each bearing more than 100 questions specific to different taxonomic parrot groups. To date, respondents in 24 countries on six continents have submitted thousands of questionnaires.

Once the results are gathered and analyzed, McDonald Kinkaid will combine information about the prevalence of behaviour problems across species with species-typical data she has gathered on their natural lifestyles. She will then determine whether differences among species are related to variations in the species' wild biology.

Identifying biological risk factors will help the researchers determine the most effective ways to improve how parrots are kept, says Mason. For example, how their wild counterparts forage or how often they socialize may influence their behaviour in captivity. Other risk factors may include flock size, or intelligence.

Integrating these findings will allow the team to confidently identify which species are naturally prone to developing problems in captivity, which aspects of natural biology



Prof. Georgia Mason

put them at risk, and which aspects of housing or care affect the chance that high-risk individuals and species will develop these problems.


“Up until now, people have been making mostly observation-based ‘judgement calls’ about how parrots are doing in captivity, saying, for example, that certain species seem to be at high risk for behavioural problems, or appear to do well in specific environments. We hope to be able to provide scientific evidence to support some of these common assumptions, as well as some new insights,” says McDonald Kinkaid.

Mason says their next job is to analyse a database on parrots held around the globe. This database goes back decades and has information on 87,000 individual birds.

In the future, Mason and McDonald Kinkaid will look at other indicators of welfare in captive parrots, such as breeding success and longevity, and parrots kept in different environments, such as zoos.

Collaborators include Profs. Johannes Thomas Lumeij and Nico Schoemaker, and graduate student Yvonne van Zeeland of the Faculty of Veterinary Medicine at Utrecht University, in the Netherlands.

This research is supported by the Natural Sciences and Engineering Research Council Discovery Grant, Canada Research Chairs Program and the Canada Graduate Scholarship.

You can participate in the survey at www.parrotsurvey.com. 

AGROFORESTRY ENHANCES FARMING IN GHANA

BY KATY JONKER

ONE OF THE University of Guelph's longest-standing international collaborators is the Republic of Ghana, and institutes therein. Since the 1970s, a large contingent of Ghanaian exchange students have studied in many disciplines at Guelph. Although

They're working in six Ghanaian communities – Ayakomaso, Dumasua, Fiapre, Adoe, Kobedi and Kwamekrakrom in the Brong Ahafo region – to implement sustainable agroforestry technologies for food production. Income generation activities will



Prof. Naresh Thevathasan is helping Ghanaian farmers enhance sustainable agricultural production by integrating trees - such as mango - alongside other crops.

several students have remained in Canada, the vast majority of Ghanaian alumni returned to this sub-Saharan nation, and research interests have blossomed.

Now, Profs. Andy Gordon and Naresh Thevathasan, School of Environmental Sciences, Prof. Helen Hambly-Odame, School of Environmental Design and Rural Planning, and Environment Program Coordinator Rick Gary of Ridgeway Campus, are continuing to answer the call for help.

improve food accessibility and educational activities will aid the country's capacity in sustainable food production.

“By utilizing the U of G - Ghana relationship and our expertise in agroforestry technology we can increase community and household income generation capacity while providing enormous opportunities for Ghanaians,” says Thevathasan.

Their project, entitled Agroforestry Practices to Enhance Resource-Poor Livelihoods (APERL), aims to specifically

increase food harvests and production, provide clean water sources, extend forest cover and decrease forest fires, enhance biodiversity and alleviate famine.

The researchers have supplied interested households with more than 35,000 mango and citrus fruit tree seedlings, fodder and timber trees and initial breeding livestock such as pigs, goats and sheep. Education in utilizing these resources is provided through hands-on training workshops and focus groups on topics such as managing farm animals, livelihood planning, record keeping and budgeting.

Thevathasan and the APERL team are also offering workshops on the establishment of short-rotation woodlots (plots covered with tree species that have the ability to grow back, once cut) to meet the energy demands in homes, and to protect the natural forest reserves.

Plus they're broadcasting agroforestry technology education through local radio stations, an activity headed by Hambly-Odame.

To enhance sustainable agricultural production, they have been implementing tree-based intercropping technology – that is, purposeful tree integration into agriculture landscapes.

And finally, the researchers are constructing tree nurseries, charcoal kilns, household mushroom production units and boreholes to encourage continuous income generation while providing clean water sources for selected community members. The project has created more than 600 jobs in farming and academia.

Protecting these valuable investments from wild fire damage is of paramount importance. To that end, the project has reduced fire frequency and damage by 90 per cent through education, and by creating fire belts around the farming communities.

The researchers are also identifying high-risk fire areas and creating a volunteer fire squad. They're implementing bushfire management workshops centered on fire education and management, awareness creation and law enforcement to allow for long-term impact.

Prof. William Oduro and his support team in Ghana have been instrumental in helping this project succeed. It is supported by the Department of Foreign Affairs, Trade and Development, formerly known as the Canadian International Development Agency. ■

Protecting fish in the Mekong Basin

BY SAMANTHA BEATTIE

AS THOUSANDS OF Cambodian fisherman stand steadily on their hand-hewn boats half the size of a conventional canoe, dipping their mile-long nets into the Tonlé Sap waterbody, it's hard to imagine this way of life disappearing. And yet, researchers say its demise could be inevitable, if something isn't done to mitigate the effects of climate change, population growth and power dams.

The inland fishery associated with the Tonlé Sap and surrounding Mekong River basin provides the majority of the protein consumed by 50 million people in the Mekong region. To better understand and preserve this ecosystem, Prof. Kevin McCann, a University of Guelph

ecologist and Canada Research Chair, and Prof. Neil Rooney, an environmental scientist, have partnered with the non-governmental organization Conservation International to model the fishery's dynamics.

"The problem is that even though this incredibly complex ecosystem is relied upon by millions of people, we don't even have the basic information needed to explain what changes are currently happening, and how the system is likely to be impacted in the future," says McCann. "That's what we're figuring out, with the hope that this information will be used to inform new conservation approaches."

The lake plays such a major role because of

the flooding that occurs during the monsoon season. When that happens, it swells to about 15,000 square kilometres, about four times its normal size. This draws in and supports more than 150 fish species from the adjoining Mekong River. The lake's flooding waters cover resource-rich land, providing a robust, highly productive ecosystem.

McCann says Cambodians have developed ways to capitalize on this resource. Mile-long nets are a common and non-discriminatory practice, enabling fishermen to catch massive amounts of fish of different sizes and values. But the consequences of indiscriminate fishing can be devastating. McCann says larger fish species are facing extinction; they're caught so young they don't have time to reproduce. This has already happened to some of the lake's largest species, including fresh water dolphins and the Mekong giant catfish.


As a result, fishermen are now mainly catching smaller and less valuable fish.

"Paired with the fact that the country will be experiencing more floods and droughts due to climate change, a growing number of mouths to feed, as well as impending power dam construction along the Mekong River, it's apparent that fishing practices are going to have to change," says McCann.

The team has been working with Cambodia's Ministry of Agriculture, Forestry and Fisheries to figure out some obtainable fishing solutions. One idea has been to introduce nets with larger mesh so that juvenile fish are not caught and have time to mature and reproduce.

The next phase of the project will be to convey their findings to the local people and to encourage them to take up more sustainable practices.

Collaborators include Conservation International's Dr. Lee Hannah, Prof. Les Kaufman of Boston University and University of Washington professor Gordon Holtgrieve.

Funding is provided by Conservation International and a Natural Sciences and Engineering Research Council Discovery Grant. 



Prof. Kevin McCann

Hundreds of thousands of Cambodians rely on the Tonlé Sap for food and income, but environmental change and degradation has meant the near-extinction of large fish species.





Small industries hold promise for ‘greener’ international development



STORIES BY SAMANTHA BEATTIE

THINKING SMALL – MICRO, in fact – may be the key to more sustainable international development, University of Guelph researchers say.

That’s because it’s micro industries in developing countries that provide the majority of employment and are better suited to simpler innovations to increase productivity, rather than complex technologies.

In an upcoming research project, Rural Planning and Development Prof. Nonita Yap, along with Indian business leaders and non-governmental organizations, will be looking at small dairies, brickyards, iron foundries, tanneries and cashew processing facilities in the Indian states of Orissa and West Bengal.

“Simple innovations can really make a big difference without a lot of added costs. In this way they’re like low hanging fruit – too good to be true and yet they are true,” says Yap. “However, these innovative strategies aren’t spreading beyond the few industries that they’re introduced to, so we need to figure out why.”

They’ll be studying whether or not changes to improve worker health, environmental conservation and productivity have spread throughout these industries. For example, in

past research Yap found that buffalo dairy producers do a lot of the work by hand. But instead of introducing an entirely new robotic system to improve productivity, other more practical and simple innovations – from a better milk delivery schedule or an improved method for sealing milk bags – were just as effective and cheaper to implement.

Yap says that major donors, such as the World Bank, the United States Agency for International Development and the Canadian International Development Agency, have spent millions of dollars trying to introduce cleaner production innovations in developing countries to reconcile the development challenges of unemployment, low productivity and pollution.

But many of these projects have been met with varying degrees of success, hinting at deeper, structural issues that may go beyond producers simply sharing new ideas and knowledge.

Yap says that existing research suggests that the government policy environment tends to favour large-scale industries, making it difficult for small business owners to obtain critical resources such as bank loans and other financial assistance.


Another barrier may be that the small and simple innovations that Yap champions are under-appreciated because there is bias

Prof. Nonita Yap (inset) says making small changes to micro industries can help towns such as this one in Orissa, India become more environmentally sustainable.

for what she calls “the big and modern.” The problem is that small industries rarely have the financial capital to access these complicated technologies, she says. Even when technologies are made available through donors, producers don’t have the internal technical resources or skills to absorb and adjust them to suit their own needs.

With this research, Yap and her co-investigators hope to influence business organizations, non-governmental organizations and policy makers to more effectively introduce and disseminate these worker and environmentally friendly innovations.

Her research partners include the Xavier Institute of Management in Bhubaneswar, India, CTxGreen Canada and various Indian organizations, including the Centre for Community and Development, the Foundation for MSME Clusters, Gram Vikas, and The Energy and Resources Institute.

Funding is provided by the Social Sciences and Humanities Research Council and Canada’s National Economic Action Plan. 

UNDERSTANDING THE SOCIAL DIMENSIONS OF CLIMATE CHANGE

TUKTOYAKTUK, A COMMUNITY of 870 people in the Northwest Territories, is slowly melting into the Beaufort Sea as permafrost thaws and flooding increases. Meanwhile in Krasnoe, Russia, reindeer herds are feeling the brunt of longer, hotter summers. And in Qeqertarsuaq, Greenland, traditional hunting practices that were once central to the community's culture and economy are becoming less significant, as animal migration patterns change and accessible game dwindles.

These are but a few of the situations a group of researchers working across the Arctic Circle are finding as they examine the social and economic impacts of climate change facing northern communities.

Canada Research Chair and University of Guelph Geography Prof. Barry Smit is part of this research project, known as Community Adaptation and Vulnerability in Arctic Regions (CAVIAR). It comprises applied and social scientists from Canada, the United States, Greenland, Iceland, Norway, Sweden, Finland and Russia. In these countries, they're researching 21 sites affected by climate change and collecting information from community members, archives and organizations that will eventually be used to better understand the social adaptation that accompanies climate change.

"The problem is that there are gaps in our climate change knowledge because the research in this field has mostly been conducted by scientists focusing on individual physical processes," says Smit. "That's why CAVIAR is working to figure out the human response to a myriad of environmental changes and create a powerful policy foundation that can help improve community response."

CAVIAR researchers are uncovering current environmental risks faced by communities, as well as their coping strategies. From there, they'll have a better idea of what to do to avoid future problems.

For example, in Tuktoyaktuk, village leaders have implemented shoreline protection measures to slow erosion. However, CAVIAR's study has revealed that despite such efforts, the community will likely need to be relocated as the erosion and flooding intensifies.

And in Krasnoe, where reindeer herds are the most significant source of community income, climate change is promoting disease and dehydration, as well as meat spoilage. In response, producers are searching for breezy pastures to provide insect and heat relief for their herds. They're also investing in better slaughter and storage facilities to improve meat preservation.

CAVIAR team members say Krasnoe reindeer producers will also benefit from new transportation and radio communication services; they'll be able to speed up the slaughter and marketing of their meat, and have better access to veterinary services and advice.

The researchers say that people in Qeqertarsuaq are transitioning from relying on traditional food sources, such as hunting, to more expensive store-bought food, so it's important for the government to continue providing financial support for the unemployed, elderly and disabled, as well as promoting community food sharing and trading.

"By systematically documenting ways that communities, organizations and institutions are adapting to change, we're able to figure out what's missing and what can be further improved upon," says Smit. "We're looking to help inform future decisions that could help maintain livelihoods for thousands of people."

Funding is provided by the Research Council of Norway, the ArcticNet program in Canada, Canada Research Chairs Program, the Finnish and Swedish research councils and the International Polar Year 2007-2008 Joint Committee. **R**

CAVIAR IS PART of the International Polar Year (IPY) program. Collaborators include Profs. Ben Bradshaw, University of Guelph; Trevor Bell, Memorial University; Derek Armitage, University of Waterloo; Frank Duerden, Ryerson University; Ralph Matthews, University of British Columbia; Wayne Pollard and James Ford, McGill University; Monica Tennberg, University of Lapland; Elena Androva, State Russian Herzen Pedagogical University; Carina Keskitalo, Umea University; Gary Kofinas, University of Alaska Fairbanks; and Dr. Niels Einarsson of Stefansson Arctic Institute and Dr. Grete Hovelsrud of Arctic Centre.

Near Ulukhaktok, Northwest Territories, University of Guelph graduate Dr. Tristan Pearce is part of a research team examining climate change impact on Arctic communities.

A SWEET DEAL

Pollinator project in Vietnam helps farmers, communities and the environment

BY MATT MCINTOSH

FOR CENTURIES, VIETNAMESE people have used honey as a medicine for ailments such as digestive problems and minor wounds, as gifts for neighbors and friends, and, of course, as food. However, a lack of manageable hives and a poor understanding of bee management have hampered native honeybee beekeeping in most parts of the country.

Now, thanks to the collaborative efforts of researchers from the University of Guelph and the Vietnamese Bee Research and Development Center (BRDC), beekeeping in rural Vietnam is becoming a fast-growing industry that's bringing much needed revenue and a higher social status to local residents.

In 2005, University of Guelph Environmental Science Prof. Gard Otis began an official partnership with the BRDC to better share experiences and develop more effective beekeeping methods.

Recognizing the potential for honeybees to spur positive social and economic change, Otis and the BRDC researchers set up a training program designed to teach beekeeping techniques more effectively.

"We have in beekeeping a perfect storm of characteristics, and in Vietnam it builds on a strong cultural tradition," says Otis. "Selling hives, queens, and of course honey, can be a great side activity for income generation."

With guidance from the BRDC, Otis and his colleagues focused their efforts on villages scattered through Vietnam's Ha Tinh province. With annual household incomes of around \$1,500 to \$1,800, villages in Ha Tinh are home to some of the most disadvantaged rural poor.



Vietnamese honey producers are improving beekeeping and upping harvests, thanks to Prof. Gard Otis's work

With support from social scientist Leo Smits of the University of Guelph-Humber, they created a five-day, hands-on training curriculum, with follow-up visits to address problems that may have developed since the initial training.

The curriculum focuses on participatory training methodology provided by Smits, coupled with the beekeeping techniques familiar to the bee scientists from Guelph and the BRDC. This allows the training program more flexibility, making it easier to incorporate novel, locally appropriate solutions to individual problems.


"It's important for us to have a sound knowledge of the bees and beekeeping methods used at the local level," says Otis. "Missing that can make a well-intended project ineffective. We have a lot of good information on what generally works and what doesn't, but it's not a one-size-fits-all thing. We can certainly learn from the solutions and experiences of each beekeeper."

Over the years, this beekeeping project has yielded positive results. By 2011 it was bringing in an average of \$300 for each program participant, even though more than one-fifth of the honey produced is given away as gifts, in keeping with Vietnamese tradition.

And along with economic benefits, the program is also bringing positive social changes to the impoverished countryside. For example, more than one-third of the 200 beekeepers trained through the program are women who now own and operate their own hives.

Many of the beekeepers say that beekeeping has improved their relationships with family, friends and neighbors by contributing to their status in the community.

Otis and his partners at the BRDC hope the industry continues to grow and positively affect the lives of an increasing number of villagers.

Funding for this project was provided by the Department of Foreign Affairs, Trade and Development, formally known as the Canadian International Development Agency, through its University Partnerships in Cooperation and Development program. 



Editors' note: SPARK participant Joey Sabljic accompanied Prof. Gard Otis to Vietnam to document this research program's success. Watch the video here: <http://goo.gl/30iPH>

HAVE A JAVA, HOLD THE RUST

BY ANDREA SECCAFIEN

COFFEE IS EVERYWHERE in modern society; we've wrapped parts of our entire culture around it. So given that prevalence, it's surprising to find that up to 25 per cent of a harvest in any given year can be wiped out by a destructive disease called *Hemileia vastatrix*, or coffee leaf rust. The first results of the attack are impaired photosynthesis, then defoliation, followed by decreased yield and ultimately the death of the coffee tree.

Outbreaks occur everywhere. For example, a severe problem was recently reported in Mexico and Central America, affecting coffee in Colombia, Costa Rica, El Salvador and Nicaragua. The Institute of Coffee of Costa Rica estimates this outbreak may halve the 2013 and 2014 harvests. Governments of these nations are stepping in to help coffee farmers by increasing support to fight the fungus, and increasing the emphasis on coffee rust research.

At the University of Guelph, historian Stuart McCook is liaising with coffee producers around the world to develop a global ecological and economic perspective on the disease's effects, and how coffee producers respond to outbreaks.

"I'm gathering stories of farmers struggling with coffee leaf rust around the globe to better understand the epidemic," says McCook.

With the growth of coffee popularity after 1500, the integration of the global market triggered a major east-west exchange of plants, people, diseases and markets between the world's coffee regions. Demand for coffee began to outstrip the original supply from eastern Africa, allowing other countries to enter the market.

Then came coffee leaf rust. It first appeared as an epidemic in Ceylon and southern India in 1869. Over the next century, it spread around the world from the Indian Ocean Basin to West Africa then to the Atlantic Ocean and the Americas, destroying high quality Arabica coffee plants in its path.

"When more plants and people started travelling and trading around the world, there was an increase in the movement of undesirable things such as spores carrying diseases," says McCook.

To preserve their Arabica coffee, many farmers choose to, in McCook's words, "technify" their coffee farms – that is, invest in modern crop protection products such as fungicides, pesticides and chemical fertilizers.

Under ideal conditions, technified coffee plantations can yield as much as 300 per cent more coffee than traditional coffee farms.

However, this meant a greater investment in labor and input costs.

In the 1980s, new rust-resistant hybrid coffees were introduced as another solution to ward off the rust. Europeans searched for rust-resistant coffee, importing and acclimatizing new varieties and species from around the globe.

Another interesting observation was that Robusta coffee was found to be highly resistant to the rust. However, taste-wise, it's generally regarded as inferior to Arabica beans.

To create a rust-resistant hybrid, traditional Arabica varieties were crossbred with rust-resistant hybrid coffees, with the goal of combining Arabica's taste with the rust resistance of Robusta. McCook says such an approach has drawbacks, such as higher coffee production costs and increasing the use of fungicides and pesticides. Also, replanting a coffee plant will take up to four years to produce coffee beans.

This research is funded by the Social Sciences and Humanities Research Council. ■

Prof. Stuart McCook is investigating how coffee leaf rust is affecting production.

WEIGHING IN ON PROFITABILITY

In Kenya, a healthy pig can lead to better education and medical treatment

BY SAMANTHA BEATTIE



Prof. Cate Dewey

FOR A KENYAN farmer living on less than a dollar a day, owning a healthy pig may make the difference between hunger and nourishment... and even life and death. That's because a pig acts as a safety net that a family can sell for cash to cover essential expenses such as food, education and medical treatment.

However, these farmers are facing a multitude of swine management and public health challenges that prevent them from getting the

most out of their investment. A major concern is that most pigs are left roaming free, where they pick up lice and tapeworm eggs that can be transmitted to humans (see sidebar).

Additionally, none of these farmers have scales to weigh their pigs, and many end up selling them for less than market value.

That's where Population Medicine Prof. Cate Dewey comes in. Along with University of Guelph graduate students Mike Levy and Natalie Carter, University of Nairobi graduate student Florence Mutua and the International Livestock Research Institute, she's collaborating with 28 government extension workers, 800 farmers and 34 butchers to introduce new management strategies, and help improve various levels of Kenyan swine production.

"This collaboration is meant to not only provide swine producers with valuable information, but also to facilitate local extension workers in continuing the learning process long after we've gone," says Dewey.

It all began in 2006 when the team visited 287 smallholder farmers. Here, they weighed and measured hundreds of pigs, injected them against lice, and learned about pig-keeping challenges. Then, they used the data collected to develop a chart for farmers that estimates a pig's weight based on length and girth measurements.

Later, they held workshops for extension workers, teaching them how to optimize production and pig health, as well as how to prevent and control tapeworm. To convey what they learned, the extension workers were paid to hold workshops for farmers, where the team distributed tape measures, weight charts and instructional picture booklets.

The workshops also included information about how to tell if a sow is in heat, as well as how to successfully breed pigs and the importance of keeping piglets warm and dry.

Throughout the study, the farmers were

visited three times at five-month intervals. A second set of workshops presented the research results to all participants.

Remarkably, says Dewey, many farmers thought that veterinarians couldn't treat pigs. But after confirming that the opposite is true, and conveying the importance of lice treatment, the team has found that many farmers have regularly taken up the practice.

The butchers received training too. They attended workshops about keeping records, maintaining food safety and best business practices.

"Although the immediate response from the local people was positive, we wanted to ensure that the new practices were here to stay," says Dewey. "That's why we've focused so strongly on outcome mapping – to identify what's worked and what hasn't, as well as to figure out other challenges we may not have realized initially."

The team returned two years after the study's end to find that the results are positive. The majority of those who went to workshops or participated in the research are cooking pork longer, housing or tethering pigs to prevent tapeworm, and feeding and watering them more. Butchers and farmers are estimating pigs' weight to ensure a fair price for everyone. Plus, butchers are keeping pork behind fly screens, getting government inspections, and not selling meat that shows signs of tapeworm infection.


In some cases, Dewey says, farmers are going above and beyond – sharing what they learned with other farmers and beginning farmer groups. These groups are particularly important because they involve farmers pooling their money to buy more pigs than they could buy individually. Then, the money earned is dispersed throughout the entire group, supporting the education of more children.

Next, the team is working to develop a nutritious pig feed made from readily available



Tethering pigs helps prevent them from contracting tapeworm, a potentially deadly parasite that's transmitted between pigs and humans.

foodstuffs, such as sweet potato leaves, avocados and beans, so that farmers can advance sustainable swine production.

Funding for this project was provided by Veterinarians without Borders and the Ontario Veterinary College Graduate Scholarship Program. 

WITHOUT TREATMENT, SOME tapeworm infections can result in epilepsy. What's more, outbreaks are difficult to mitigate because tapeworms thrive in animals and humans alike. In Kenya, pigs are major perpetrators of the tapeworm lifecycle – about 15 per cent are said to carry tapeworm larvae. When left untethered, pigs come into contact with tapeworm eggs in human feces. From there, the eggs are ingested and migrate to the pig's muscle where they mature to the larvae stage. If humans undercook and consume this pork, then they too become infected. When the eggs migrate to the brain and mature, epilepsy occurs. Dewey urges Kenyan farmers to help stop the spread of tapeworm infections by tethering their pigs.



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NEW TOOLS FOR OLD CROPS



Prof. Manish Raizada cups a handful of millet, a hardy grain he's improving for subsistence farmers in India, Sri Lanka and Nepal

STORIES BY SAMANTHA BEATTIE

SOME CONSIDER MILLETS the golden grains of the crop world. Their hardy seeds, which are no bigger than the head of a pin, have proven their ability to thrive in dry, parched regions of the world. As well, millets are more nutritious than rice. That makes them potentially important crops for subsistence farmers in Asia and Africa. Indeed, in South Asia alone, seven million farmers produce varieties known as minor millets.

But University of Guelph researchers say there's still room for improvement. Simple and cost-effective technological innovations – such as simple seed planters – and micronutrient intervention with metals such as zinc will go a long way to improve production and sustainability, they say.

So with support from the International Development Research Centre and the Canadian International Development Agency, Plant Agriculture Prof. Manish Raizada is introducing what he calls “agricultural tool kits” to more than 2,000 marginalized farmers in Nepal, Sri Lanka and India.

“We’re making this project as all-encompassing as possible,” says Raizada. “We’re ensuring that local knowledge and technology is at the same level, sustainability is considered and indigenous knowledge is valued.”


To target the farmers most in need, the team approached non-governmental organizations (NGOs) that had already established relationships with impoverished local people in the countries’ most isolated regions. The team is working with these NGOs to extensively survey farmers and uncover their individual needs in order to create truly effective tool kits.

“Our goal is to prove that our approach works, and can be scaled-up to large aid agencies,” says Raizada.

The tool kit (see sidebar for contents) helps farmers conduct simple field trials to independently improve productivity long after the project is over.

But the learning process doesn't end there. Improved millet production may render farmers an extra \$100 to \$500 a year. The researchers are encouraging farmers to use that money to send their children to school. Anthropology and Sociology Prof. Sally Humphries, the gender advisor for this project, says special encouragement is being directed towards schooling girls, because, for cultural reasons, they are seldom chosen to go on to school.

“We determined early on that targeting women is key to the success of this project,” she says. “They usually take on the brunt of the labour and yet remain the most marginalized, indicating that something needs to change.”

Project collaborators include Integrative Biology Prof. Steven Newmaster, Food Science Prof. Koushik Seetharaman and graduate student Vijay Bhosekar. 

The University of Guelph-developed tool kit may look like a plain, three-foot-tall grain storage bag, but inside it's full of technologies to boost millet production.

Its contents include everything from seed packages to low-cost technologies to instructional picture books, as well as micronutrients, such as zinc, magnesium and iron.

Depending on the local need, the technologies can vary from reusable storage bags that prevent fungus and insects from spoiling harvested millet to two sticks joined by a string that serve as seed planters. Seed planters allow producers to plant in straight rows, which helps to boost productivity because plants have more equal access to sunlight and women can pick weeds faster than in traditional seed-scattering methods.

The instructional picture books explain how to use the tool-kit contents and how to do a field study; for example, by applying micronutrients to one site and leaving the other untreated. Once the millet has grown, the farmer can determine which strategy produced the highest yield.

Making millet easier to swallow

DESPITE MILLET'S MANY virtues, Asian farmers have avoided it in recent years. The small seeds have a tightly bound outer layer that requires laborious pounding to remove. And then, once the seeds are processed, many young people don't like them anyway. Even though millet is part of their culture, it's not part of their cuisine.

University of Guelph Food Science Prof. Koushik Seetharaman is trying to help. He's working to improve the taste. And he's also developing a small-scale processor called a decorticator that will remove the problematic outer layer more easily.

The goal of the project is to complement plant agriculture Prof. Manish Raizada's work, so that once farmers increase millet production, they'll have the means to turn the seeds into food products...and have markets to sell it to.

“Whether it's growing, processing or selling millets, our team is working on enhancing all stages of production and consequently the quality of life for thousands of South Asian millet farmers,” says Seetharaman.

Seetharaman says few millet-processing machines are available to small-scale producers. Millet seeds vary in size and shape, making it difficult to design an affordable machine that can effectively process them all. Instead, producers – most often women – must pound the millet on the ground for hours, which is exhausting.

But with a hand or foot-pedal grinder, processing time could be cut in half and require much less effort. So far, the team members have developed a machine for the large-sized proso and pearl millets, and they're working to better



Although full of promise, millet is tightly bound and bitter, making it difficult to process and sell – something Prof. Koushik Seetharaman is working to change.


adapt it for village-level use.

But taste is another matter. Seetharaman says millet lost favour with younger Indians because government rice subsidies made rice cheap and boosted consumption (even though rice is bland compared to millet).

However, he says, millet is healthier. By comparison, rice is starchy. And it's believed to be a possible culprit in the rising incidence of diabetes and obesity in India.

“That makes it worth re-introducing millet into the Indian diet,” says Seetharaman.

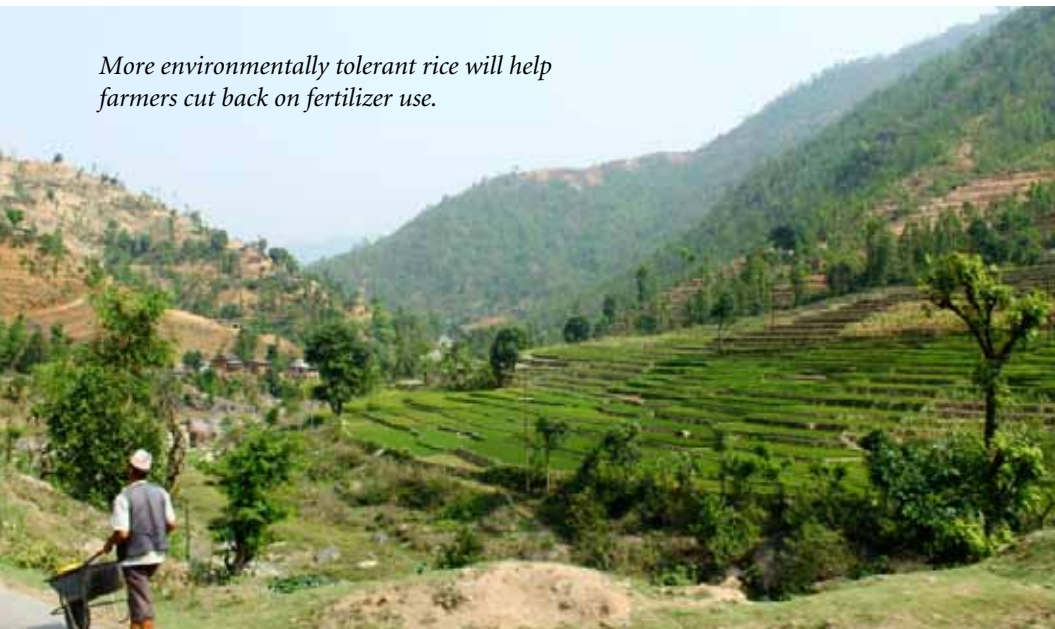
Collaborators on this project include Integrative Biology Prof. Steve Newmaster, graduate students Warren Dodd and Matthew Little, and Prof. Kirit Patel of Canadian Mennonite University.

Funding is provided by the Canadian International Food Security Research Fund through the International Development Research Centre and the Department of Foreign Affairs, Trade and Development, formally known as the Canadian International Development Agency. 

Better yields, less fertilizer

Working to reduce the environmental impact of producing China's largest crops

More environmentally tolerant rice will help farmers cut back on fertilizer use.



BY SAMANTHA BEATTIE

CHINA IS COMMONLY thought of as an industrial giant, but agriculture continues to be the country's largest employer. It's no wonder then that China, facing significant environmental degradation and population pressures, is striving to improve agricultural production efficiency of its two largest crops, rice and corn.

That's where University of Guelph researchers are involved. Molecular and Cellular Biology Prof. Steven Rothstein is leading a collaboration with the Chinese Academy of Agricultural Sciences, to find particular genes that make rice and corn plants more tolerant to lower-nutrient conditions.

Rothstein says better adapted lines would continue to deliver good yields while using less nitrogen and phosphorous fertilizers.

"The scientists from the Chinese Academy of Agricultural Sciences are valuable partners because they have considerable expertise in fields ranging from large-scale DNA

sequencing to field assessment of different crop lines, as well as access to regions with multiple growing seasons," says Rothstein. "And the researchers at the University of Guelph have much to offer in terms of its longstanding plant genetics and genomics programs as well as helping in English fluency, which is the language of scientific communication."

The partners are focusing on rice and corn because they are among the most important crops in China that can be analyzed with genetic tools. Also, because rice is usually produced in paddies, over-use of fertilizer can easily lead to water contamination. That means excess fertilizer directly pollutes nearby streams, rivers and lakes.


To cut back on fertilizer application, the team is working on numerous research projects geared towards gaining a better understanding of rice and corn genomics.

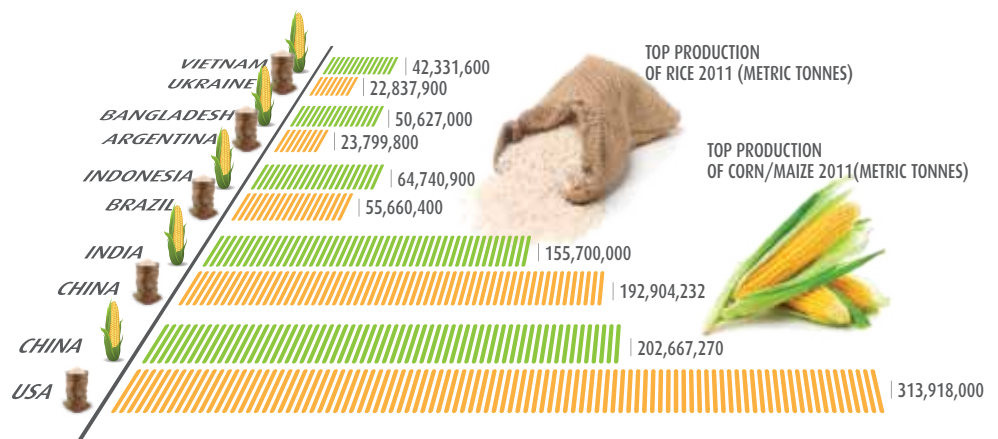
One project is looking at how corn plants' microRNAs respond to varying nitrogen levels. MicroRNAs are molecules responsible for regulating the amount of protein a cell produces depending on the situation – in this case, the amount of nitrogen available.

Other research is honing in on gene expression in rice, by comparing changes to microRNAs when they come into contact with bacterial pathogens versus when the cells experience different levels of nitrogen application.

Rothstein says these projects will help the team understand why some corn or rice lines are less dependent on fertilizer than others. And ultimately, he says, this collaboration will lead to improved plant genetics to lower fertilizer costs and benefit the environment.

Collaborators are Profs. Chuanxiao Xie and Chengsha He from the Chinese Academy of Agricultural Sciences.

Funding is provided by the Natural Sciences and Engineering Research Council and the Ministry of Research and Innovation's Ontario Research Fund. 



Investing in agricultural technology for small-scale African farmers is part of a four-step plan to prevent a world food crisis.



Prof. Evan Fraser

PUTTING FOOD SECURITY ON THE TABLE

BY ANDREA SECCAFIEN

PACKED GROCERY STORE shelves and lineups at fast food restaurants don't suggest that we're entering into a worrisome time for our food supply. But Canada Research Chair and University of Guelph Geography Prof. Evan Fraser says the danger signs are everywhere. That's why he's piecing together solutions from history to develop a food system template that meets the needs of a rapidly growing world population threatened by a shortage of food.

"With the climate changing, energy costs increasing and the global population demanding more from their diets, we will soon be facing a perfect storm of problems that could lead us into a food crisis," says Fraser.

He knows a singular approach to increasing the food supply won't work. Instead, he suggests using a four-pronged approach that integrates action from individuals, governments, improved food distribution and technological innovations to develop sustainable local and global food systems.

First, he says North Americans need to invest in agricultural technology

to help small-scale farmers in Africa who are vulnerable and less productive than they could be. This means working in partnership with small-scale farmers to identify appropriate technologies to close the yield gap.

But he's also a big proponent of local food systems. He says they act as a buffer between consumers and the unpredictability of global food prices. Although local food is more expensive in the short term than cheap food imports, Fraser says in the long run it's a safety net against high prices and low supply.

"We will never be food secure unless we focus on a local system where producers and consumers are tightly knit together," he says.


On an individual level, Fraser says North Americans need to go back to the lessons of their grandparents on basic food literacy skills such as home cooking, baking, canning and gardening to become self-sufficient and to buffer ourselves against a global crisis.

And in the macro view, he urges governments at the international level to encourage conservation by taxing water and other resources that are used heavily in agriculture. The world's food supply is poorly distributed; people in developed countries overeat and waste food, while people in underdeveloped countries live through famines and have insufficient access to foods. Development organizations need to invest in emergency food programs to address crises, says Fraser.

"We need to think of a portfolio of strategies that recognizes that none of these solutions alone will solve the problem, but there are good things that can come out of every one of them. By spreading these ideas I hope to facilitate change in the way people think about the future of food and agriculture," says Fraser.

Fraser outlines his approach in his book *Empires of Food*.

This research is funded by the Canada Research Chairs Program and the Social Sciences and Humanities Research Council.

Other University of Guelph professors involved in this research are Ralph Martin, Rene Van Acker, John Smithers, Alison Blay Palmer and Karen Landman. 



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