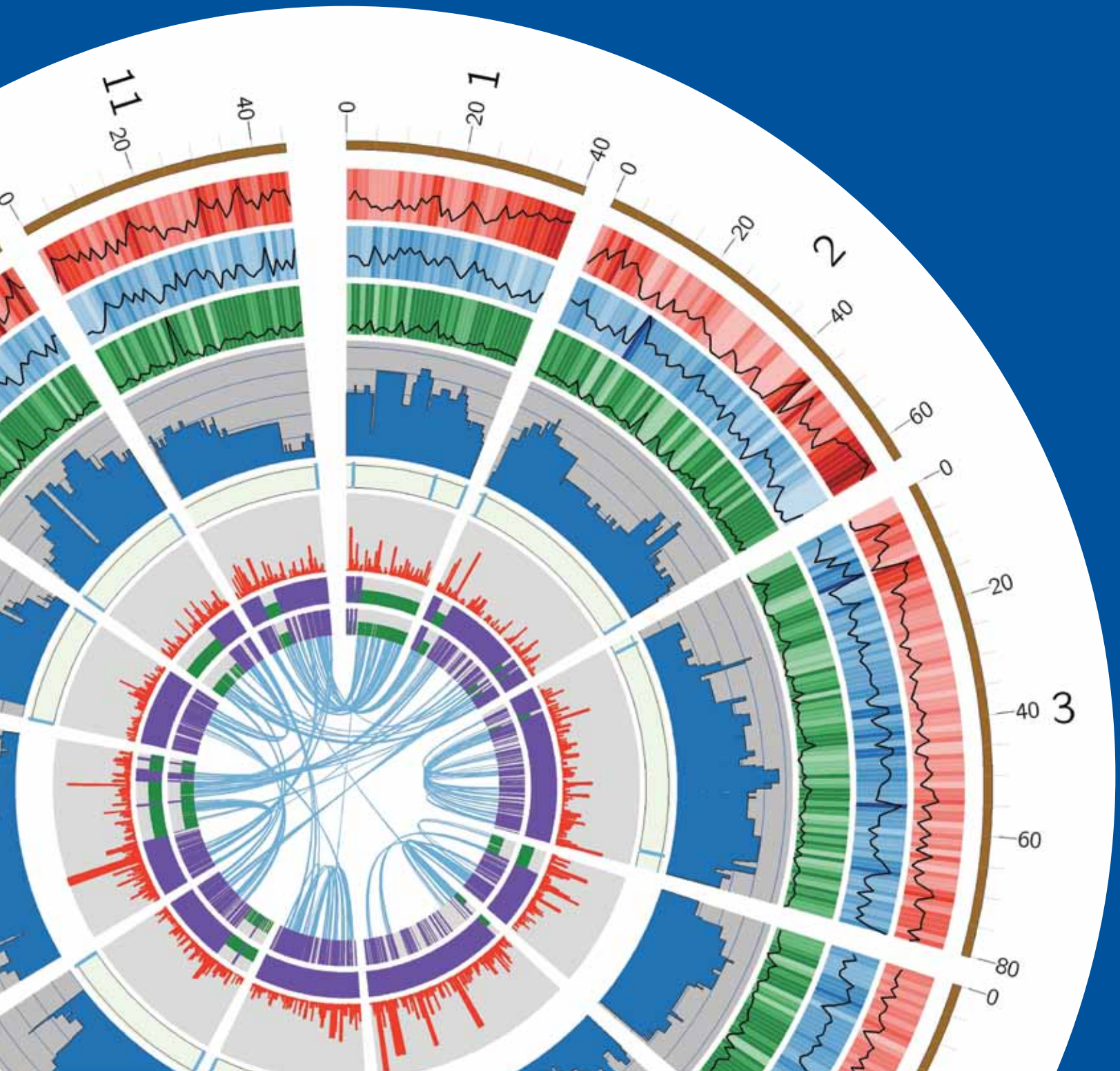
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

University of Pretoria
Research Review
2014

Our vision

To be a leading research-intensive university in Africa, recognised internationally for its quality, relevance and impact, and also for developing people, creating knowledge and making a difference locally and globally.



ISBN: 978-1-77592-120-2

Contents

Image from AA Myburg *et al*. Nature, Vol 510, 19 June 2014.

Message of the Vice-Chancellor and Principal

The University of Pretoria is a research-intensive university where quality, relevance and impact are central to our goals and to the nature of the research that we pursue.

Prof Cheryl de la Rey
Vice-Chancellor and Principal

The major challenges we face in Africa and globally – from the need to expand access to education, food and water security, to the promotion of social justice and sustainable development – all give direction to the research that we conduct. Since it is evident that these challenges are increasing in complexity and that life at the local level is more and more influenced by global trends, at the University of Pretoria there has been a growing emphasis on multidisciplinary, collaborative work across knowledge and geographic boundaries. Rapid advances in communication and technology have enabled faster and more effective flows of information and knowledge dissemination and this is manifesting in a growing number of international collaborations and partnerships. During 2014 the University's existing collaborative partnerships were strengthened with research groups, universities and institutions in Africa, Europe, Asia and North and South America, through our 227 new and renewed agreements. Aligned with our focus on Africa, UP was an active participant in 28 African scientific organisations, networks and consortia.

During 2014 the University paid special attention to research in strategic areas that align with priorities in our national and regional context, while continuing to increase our research productivity and developing the research capacity of the University. Building on the institutional research themes that have been a key component of our UP 2025 institutional strategy, during 2014 we established the Genomics Research Institute (GRI) and, arising from our Institute for Food, Nutrition and Wellbeing, the University was successful in its bid for the DST-NRF Centre of Excellence in Food Security which it co-hosts with the University of the Western Cape. The institutional research theme on Capital Cities has grown to involve researchers in the Humanities, Law, Economics and Management, and in Engineering, Built Environment and Information Technology, and is a key mechanism through which we give tangible meaning to the University's partnership with the City of Tshwane.

Contributing to our goal of building on our research strengths, two new research entities were established in the Health Sciences field: the

Centre for Sustainable Malaria Control is now independently funded by the national Medical Research Centre (MRC), and the Institute for Cellular and Molecular Medicine and the MRC Unit for Stem Cell Research, now an MRC Research Unit, also funded by the Medical Research Council. In the engineering field, we established the industry-funded Chair in Maintenance Engineering and the Sedibeng Chair in Water Utilisation Engineering.

Overall, in 2014 there was pleasing progress in our research productivity and impact, ranging from the work of our emerging researchers to that of our leading scholars. The University strengthened its international position, achieving recognition of our research in an expanded range of fields including: Arts and Humanities, the Life Sciences and Medicine, Social Sciences and Management, Engineering, Environmental Sciences, Agricultural Sciences, and Plant and Animal Sciences – as demonstrated by our position in the top 1% of institutions internationally in these fields, and in the international rankings of universities. Among South African universities, UP was the leader in the 2014 QS field rankings in the field of Agriculture and Forestry, and in the fields of Computer Science, Mathematics, Engineering, Molecular Biology, Genetics and Immunology, the citation impact of our research exceeded international norms.

The University takes pride in the diversity and quality of its research activity. As illustrated in this Review, our research spans a broad spectrum of knowledge fields, from the humanities, social and natural sciences, to the physical, health and veterinary sciences. I wish to express my sincere appreciation to all our researchers who have embraced the goals of UP 2025, the University's long-term strategy. Thank you, too, to the Department of Science and Technology, the National Research Foundation and all our research partners, sponsors and donors who have enabled us to expand and strengthen the University's postgraduate programmes and research activities. It is through the contributions of many that in 2014 we moved closer to our goal to be a leading research-intensive university that makes a difference locally and globally.

The University takes pride in the diversity and quality of its research activity. As illustrated in this Review, our research spans a broad spectrum of knowledge fields, from the humanities, social and natural sciences, to the physical, health and veterinary sciences.

Overview by the Vice-Principal: Research and Postgraduate Education

As the Vice-Principal for Research and Postgraduate Education, it gives me much pleasure to provide this introduction to our research achievements during 2014, a year in which our work advanced our objectives of strengthening and broadening scientific and scholarly knowledge and also offered the best learning opportunities for all our students.

Prof Stephanie Burton, Vice-Principal for Research and Postgraduate Education

Our approach in 2014 was to identify and invest in our existing areas of research strength; to identify new research areas where the University has the potential to make a greater impact in contributing to knowledge and society; and to build research capacity and productivity in these areas. Our commitments to be a leading research institution, increasing the quality and quantity of our research productivity, and contributing effectively to positive social change, were the goals that directed and sustained our research work in 2014.

Our 2014 research record shows that we have made good progress in achieving these aims. We are pleased that in the year under review the number of staff members who hold doctoral degrees increased from 663 in 2013 to 719 in 2014 (a growth of 8,4% in just one year), while the number of staff members who hold National Research Foundation (NRF) ratings increased from 375 to 393 (5%), with 95 scientists holding A and B ratings. Research output also grew in relation to our work in 2013 by close to 4%.

The fact that UP researchers published 1 266 papers with international collaborators from 68 countries in Africa and around the world is an important achievement, as is the active participation of 200 postdoctoral fellows, of whom 145 are from countries other than South Africa.

The numbers of international staff and students have also grown, with UP having 2 622 international postgraduate students in 2014, over 8% of the total contact enrolment.

As a further measure of UP's high standards of research, publication and public engagement, a number of UP staff members received external awards or honours during 2014 across fields as diverse as capacity building,

work as emerging researchers, and Veterinary Science. In addition, 11 members of the UP academic staff were the recipients of institutional recognition, including the first two awards for the Vice-Chancellor's Book Awards launched in 2014.

Supporting and improving the quality and volume of research output requires substantial financial support, and in 2014, externally raised funds grew by 16% over the previous year to over R400 million. Part of this income means that UP was able to acquire advanced research equipment to the value of more than R55 million, following the approval of six funding applications submitted to the NRF. Such grants are made on the basis of the cutting-edge science undertaken at UP and are a crucial investment in UP's research infrastructure. Several of the scientific instruments are the first of their kind in the country. Developments such as these help to create a vibrant and competitive working environment for our researchers.

The University of Pretoria has placed research at the core of its vision and its current strategic plan, UP 2025, and 2014 has demonstrated, once again, the progressive gains that are being made each year as we move towards achieving this vision. This steady pace of growth, however, reminds us that the University's research achievements are in fact those of its academic staff, research and postdoctoral fellows and students – and the staff who support them. It is fitting, therefore, to end this overview with sincere congratulations and thanks to all the researchers, and to members of the Department of Research and Innovation Support, who made UP's 2014 performance as successful as it has been.

The University of Pretoria has placed research at the core of its vision and its current strategic plan, UP 2025.

Director's message

UP, a leading research-intensive university

In partnership with the Executive, Faculties and other support departments, the Department of Research and Innovation Support strives to provide a supportive research environment and programmes at UP.

Dr Carol Nonkwelo, Director: Department of Research and Innovation Support

The 2014 Research Review is structured firstly to provide an overview of UP's research achievements in 2014. Secondly, we have used a number of narratives to illustrate the contributions of UP to science and society. The science stories and summaries in Part 2 give context to the outstanding work produced by researchers during 2014. Part 3 profiles UP's A-rated researchers and awards in 2014, and concludes with faculty profiles that illustrate the diversity of knowledge fields, centres of expertise, and capacity that define UP's research.

We thank all contributors for their dedication and commitment towards enhancing the University's research and innovation profile. We also thank our established and expert researchers for going beyond the call of duty to assist with the training and mentoring of emerging researchers and postgraduate students.

It is important to note that the examples included in this Review do not reflect the full spectrum of the diversity of research endeavour at UP in 2014. Instead, the focus is on using examples of research that illustrate some of the excellence, relevance and impact that were achieved in 2014.

We trust that readers will enjoy this showcase of UP's 2014 research achievements.

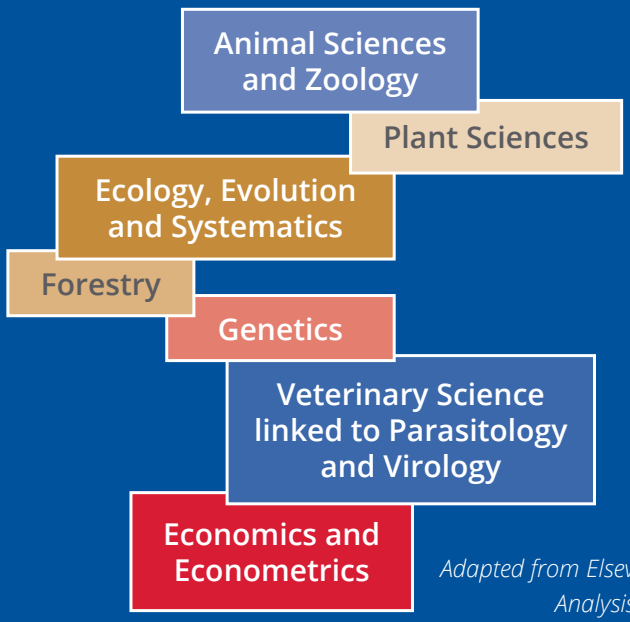
NOTE: The University of Pretoria's research publications in 2014 are available on http://www.up.ac.za/research-innovation as a complete reference.

Research overview

In the course of 2014, research at the University of Pretoria increased in impact, levels of productivity and international collaboration and partnerships.

High impact

Our areas of research strength are wide ranging. In 2014 we had high productivity and impact in the following disciplinary fields:



Adapted from Elsevier Fingerprint Analysis, March 2015.

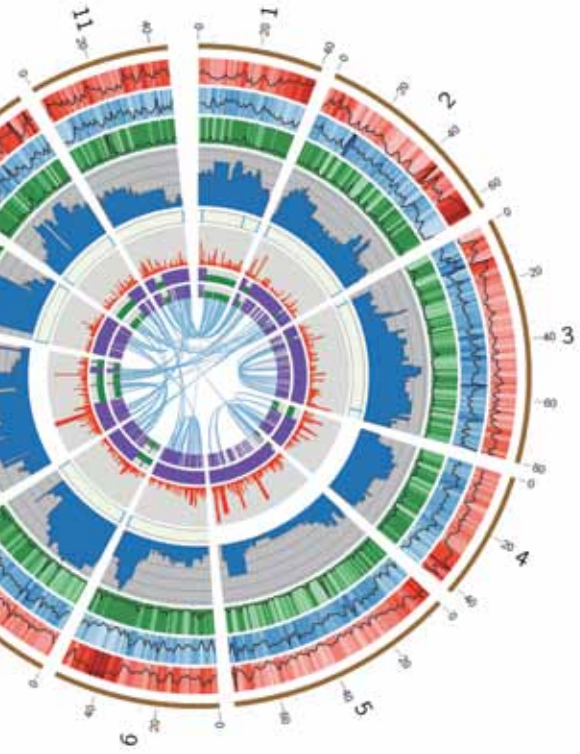
World rankings

The University of Pretoria was ranked 471-480 in the QS World Rankings and 46th out of all BRICS Universities.

Quacquarelli Symonds (QS) subject rankings for 2014 show eight knowledge fields in which UP ranks in the top 200 internationally:

- Agriculture and Forestry . . . . . [101-150]
- Communication and Media Studies . . . . . [151-200]
- Development Studies . . . . . [51-100]
- Education . . . . . [151-200]
- English Language and Literature . . . . . [151-200]
- Geography . . . . . [151-200]
- Law . . . . . [101-150]
- Philosophy . . . . . [151-200]

QS rankings of disciplines are the result of the aggregated opinions of scholars from around the world.



Highly productive and recognised researchers

393
NRF-rated researchers on our staff, reflecting a 19% increase from 2012.

28
Researchers at UP listed in the WoS Essential Science Indicators as authors or co-authors of the global top 1% in their fields in 2014.

1 465
Journal publication units in DHET accredited journals.

16%
Increase in external research funding.

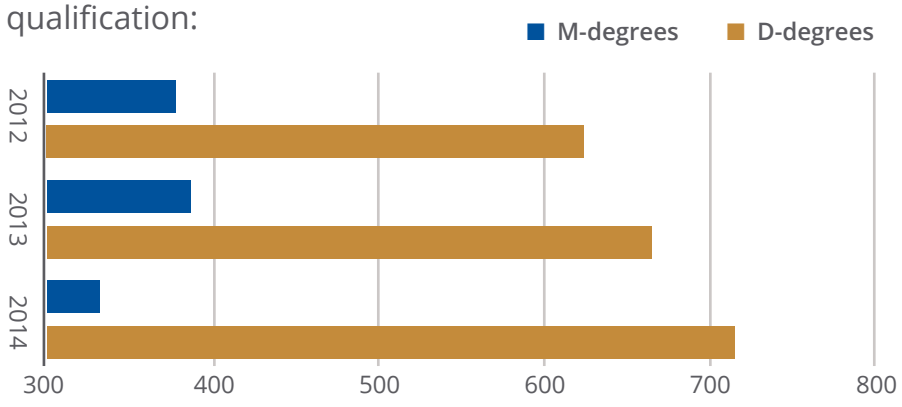
719
Academic staff with PhDs – an increase of 14.6% from 2012.

36
Industry and internationally funded Chairs.

11
SARChI Chairs funded by the DST-NRF South African Research Chairs Initiative.

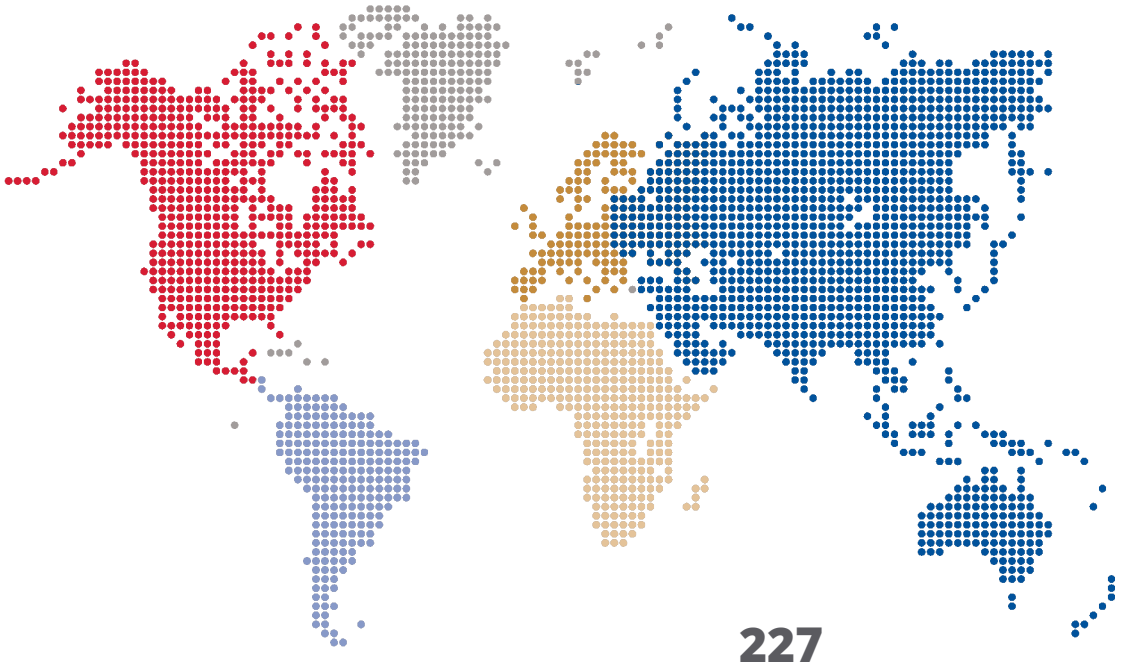
88
Institutes, Centres and Units building capacity in key research areas.

Staff with master's and doctoral degrees as highest qualification:

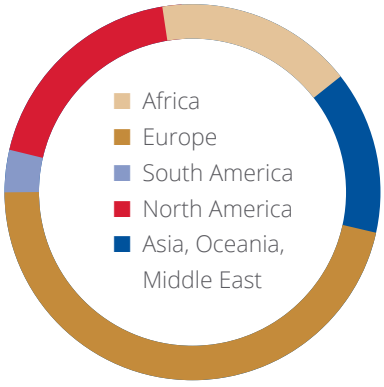


** HEMIS - Higher Education Management Information System*

International collaboration, joint research and publications



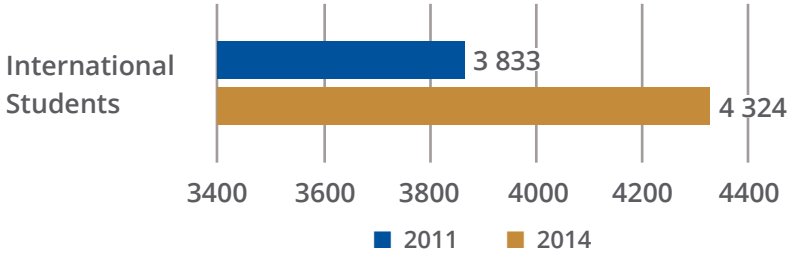
227
Institution-wide international partnerships



UP's international profile rests primarily on four pillars: participation in international university associations; international students studying at UP; active international partnerships; and publications co-authored with scholars from beyond South Africa's borders.

UP is a member of more than 20 international associations and networks.

The overall number of international student studying at UP in 2014 increased by 13% from 2011.



237
Doctoral graduates in 2014

200
Postdoctoral fellows

145
International postdoctoral fellows from more than 45 countries.

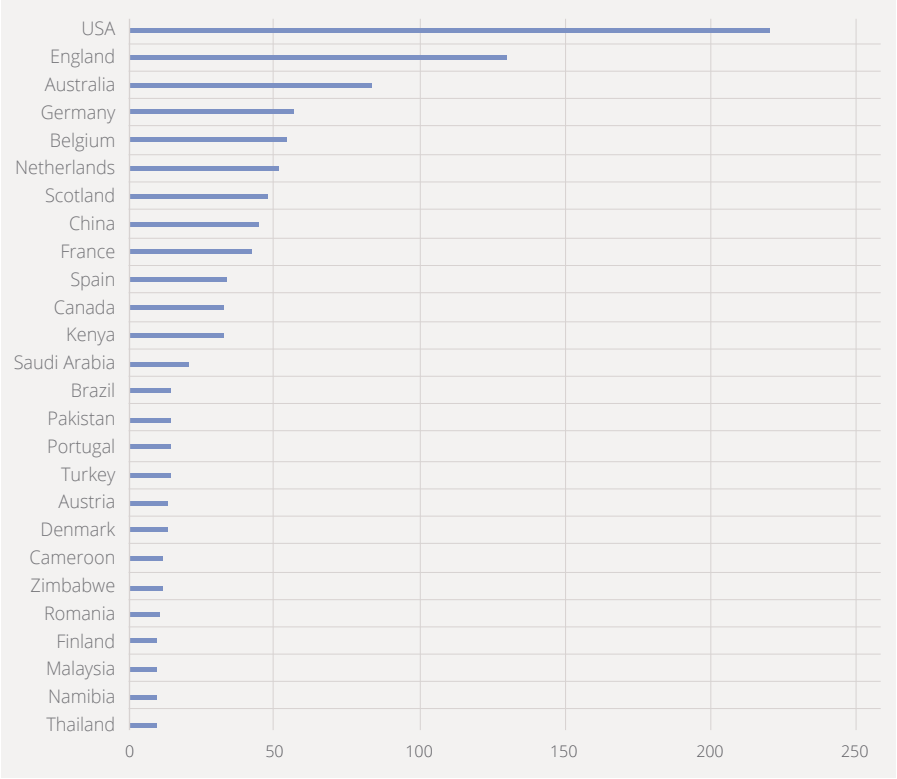
51%
Publications with international collaborators in 2014

140
New agreements with industry and public sector partners.

7
International patents filed in 2014 under the Patent Cooperation Treaty system.

77
Total number of patents in the UP portfolio.

1 226
Staff members published 1 226 collaborative research papers across 68 countries



Frequencies of 10> co-published articles with UP researchers in 2014 shown here, Thomson Reuters InCites™.

PART 2

Driving relevance and impact

The University of Pretoria's research strategy is built on addressing the very real challenges of the contexts of which we are a part – our place in Africa, and our commitment to knowledge production that speaks to a global world.

The science stories, summaries and short features presented in Part 2 follow five broad themes:

1 – Science, society and development

2 – Environment, forestry and agriculture

3 – People, plants and animals

4 – Health

5 – Sustainability and social justice

THEME 1

SCIENCE, SOCIETY AND DEVELOPMENT

Scan of the brain.

Over time the role and place of universities in society and development have been debated, with an increasing emphasis in more recent years on their public good. Our first theme in this Review presents examples of research − ranging from the humanities, to economics and the applied sciences − that illustrate the University of Pretoria's commitment to making a difference.

We start with the University's research project on the African philosophy of Ubuntu, where the focus is on investigating the meaning and value of Ubuntu in human and social development.

Examples of research from different perspectives illustrate the importance of issues related to gender, diversity and identity – in the workplace, at schools and in the broader society. Further, the focus on the assessment of school performance shows the importance of benchmarking children's development, while the early detection of hearing loss demonstrates the potential impact of innovation.

Examples related to socio-economic development illustrate some of the research achievements at UP in 2014. The Human Economy Project examines economic life from the perspective of ordinary people in places that are normally marginal to global discourse and conventional economics. Other examples show the focus on investigating the effects of inequality, financial instability and international patterns of trade on economic growth, and of research related to the energy crisis, economics and climate change. A short summary is also presented on the importance of a resilient mining industry as a source of economic growth and employment opportunity. In this grouping of examples, the Dynamic Market Index – as a comparative global measure of institutional evolution and competitive performance – is an illustration of the outcomes of an in-depth global study.

Summaries of two expert lectures[1] in 2014 are given as commentary: the first, a literary analysis of the great expectations held in Africa for liberation; and the second, reflections on grand strategy and leadership in meeting the aspirations for development.

---

[1] The UP Expert Lecture Series, an initiative of the Vice-Chancellor and Principal, Professor Cheryl de la Rey, provides a public platform for researchers of the University of Pretoria to engage with a general audience on significant developments in their fields of expertise.

Group leaders, presenters and participants in an Ubuntu project workshop.

Ubuntu – an African philosophy with universal resonance

The University's project on the African philosophy of Ubuntu investigates the meaning and value of Ubuntu in human and social development in Africa.

The Ubuntu project at UP is a multidisciplinary project with continental reach, housed in the University's **Centre for the Advancement of Scholarship** (CAS). It has attracted major funding from the Templeton World Charity Foundation in the first phase of research. The emphasis is on the contribution of the humanities and social sciences to deepening our understanding of 'personhood and identity' in Africa – or, phrased differently, self and community, *Ubuntu* or the East African variant *Utu*. At the same time, the focus is on how an indigenous value system such as Ubuntu can be mobilised in reconstituting community and in bringing about reconciliation and healing in post-traumatic contexts in particular.

A significant achievement in 2014 was a comprehensive review of published narratives and documentary films, focusing on personal narratives and testimonies of victims and perpetrators of violence, and of community leaders, in Kenya, Uganda and South Africa.

Scholars at UP and from across the continent are engaged in different stages of research. In order to ensure the integrity and coherence of the overall project, four clusters define the project with researchers meeting frequently to share research outputs and insights:

- Cluster one, headed by **Prof James Ogude**, focuses on unpacking and theorising the concept of Ubuntu;
- Cluster two, headed by **Prof Julian Muller**, deals with Ubuntu in personal narratives and the significance of Ubuntu in African churches;
- Cluster three, headed by **Prof Christof Heyns**, addresses with Ubuntu and unlawful killings in Africa; and
- Cluster four, headed by **Prof Maxi Schoeman**, examines Ubuntu as public policy and its role in inter-state relations.

A significant achievement in 2014 was a comprehensive review of published narratives and documentary films, focusing on personal narratives and testimonies of victims and perpetrators of violence, and of community leaders, in Kenya, Uganda and South Africa. The respective analyses were led by Profs James Ogude, Dominic Dipio and Julian Muller. A number of junior staff members at UP have been involved in the project in ways that have provided them with a platform to extend their ongoing and completed PhD research, working on different research trajectories linked to Ubuntu.

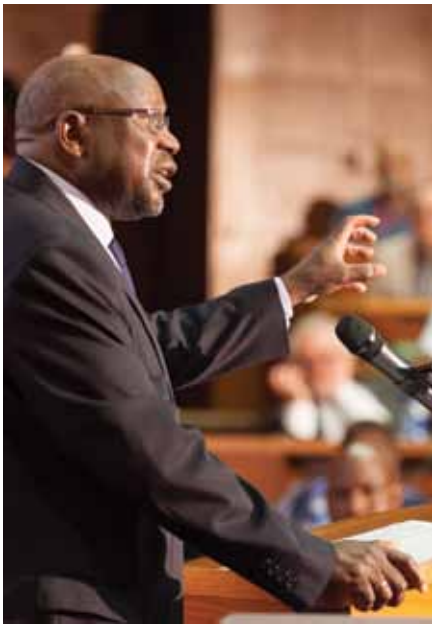
Work also started on developing a database on the protection of the right to life in several African countries, with the aim to classify violations and collate reports from across Africa. An important component of this project includes a qualitative analysis of the data collected explicitly to foreground the role of Ubuntu in fostering accountability for the right to life violations.

This project is appropriate not only for South Africa at the beginning of the third decade of our young democracy, but also in contributing to a collective understanding of identity and accountability in Africa's futures.

EXPERT LECTURE | A SUMMARY

Great expectations and the mourning after

Prof James Ogude explores ways in which post-independence experience in Africa has been represented in African literature, and how African writers have attempted to explain the collapse of the contract between the people and the political elite.



Prof James Ogude is a research fellow and the Deputy Director of the Centre for the Advancement of Scholarship (CAS) at the University of Pretoria. His research is unique in its location at the intersection of culture and human subjectivities. His ultimate aim is to understand what shapes our ordinary experiences and how societies reconstitute themselves as they seek to transform and shape the political and cultural institutions that govern our lives.

Using the Ghanaian writer, Ayi Kwei Armah's novel, *The Beautiful Ones Are Not Yet Born*, James Ogude traces how the African dream and expectation at the moment of independence gradually turns into a post-colonial nightmare – a period of mourning rather than a celebration. Deliberately crafted to capture the weight of Africa's political experience, his lecture title, *Great Expectations and the Mourning After*, signals the bitter irony of what might have been and what now plays itself out in the national drama as exploded dreams – a dark blot on 'African polity'.

Ogude contends that at the heart of this mourning is political betrayal of the ruled by the rulers – a recurring thematic concern of many African writers. After all, the story has always been one of the most powerful vehicles for mapping out the challenges on the continent and its many possible futures, and Ogude insists that if there is one thing that the African novel has done so successfully, it is to try and trace the reasons for this betrayal of the majority of the African people.

He argues that a close reading of the African novels such as Armah's *The Beautiful Ones Are Not Yet Born*, point to political corruption and consumer capitalism whose ethos the ruling elite have taken to in great haste. This, though, is compounded by the fact that the nationalist class that takes over power at independence, as Fanon would have it, lack originality of ideas and are a class of functionaries.

Ogude's analysis shows that the ethic of conspicuous consumption, in particular, is one that many African writers return to every now and again to draw attention to how the trappings of materialism, lust for wealth and power become the hallmark of a neo-colonial mentality driving what Armah calls the 'new men of substance' in Africa – the political elite. Mindless of how their wealth is built on the ordinary people's poverty and squalor, they traverse the land with arrogance and utter contempt for those they rule, but in ways that surpass their former masters.

Ogude also makes the point that the African political elite are not just content with the sheer accumulation of wealth; instead, through display, it must draw attention to itself. In such a context, he argues, integrity, honesty and hard work are replaced by sycophancy and manipulation.

In the end, Ogude concludes, the pervasiveness of consumer capitalism is so real that it also works to draw the ordinary people – the ruled – into its own orbit. In the process, political space within the post-colonial state

The challenge for Africa, and indeed South Africa as a nascent democracy, is to break what appears like some unyielding cyclic mode of political and economic paralysis.

becomes much more than just an ensemble of dominant actors, but also that of the dominated, whose political intervention does not always contradict those of the political elite who oppress them.

Ogude's argument is that when a state fails its people and yet it remains the main institution of economic advancement, this kind of behaviour is expected. It is a culture born out of the instrumentalisation of the state by the ruling elite, and therefore access to the state resources can only be perceived in idioms of consumption.

The challenge for Africa, and indeed South Africa as a nascent democracy, is to break what appears like some unyielding cyclic mode of political and economic paralysis. It is important to remember that nation-building or the building of any human civilisation is never an easy task; it is both protracted and challenging – always calling upon us, as Ben Okri says, "to break the matrix of life as we know it; to create something new simply because the human in us compels us to go beyond ourselves in search of illusive freedom".

Gender, diversity and cross-cultural studies in the workplace

An important research focus in the Faculty of Economics and Management Sciences is on diversity in the workplace. Topics range from identity in the workplace, cross-cultural studies of assessment instruments, to how organisations can become more equitable and inclusive.

Categories of diversity

Prof Deon Meiring and a postdoctoral fellow, **Dr Velichko Valchev**, are part of an international team of scholars working on the development of a South African Personality Instrument (SAPI). The SAPI project aims to develop a single, unified personality inventory for South Africa that takes into consideration both universal and unique personality factors to be found across culture and language groups in South Africa.

Researching the similarities and differences implicit in personality concepts, the researchers found similarities but also substantial differences. The research suggests that social-relational norms, and also norms of tradition, progress and moral integrity, are an important source of variation in concepts of personality. The implication is that a broad spectrum of personality concepts should be included in the development of personality models and measurement tools for South Africa's diverse cultural groups.

A major milestone in 2014 was that the first round of quantitative results indicated a six-factor structure for the SAPI. Once the personality inventory is completed and standardised, it will be submitted for classification to the Psychometrics Committee of the Professional Board for Psychology (Health Professions Council of South Africa, HPCSA).

Prof Saloshna Vandeyar

INTERVIEW

Immigrant student identities

While capturing data at schools for another project a few years ago, Prof Saloshna Vandeyar, in the Department of Humanities Education, became aware of the shifting dynamics and power relations playing out in South African schools. The tense black-and-white and intra-black dynamics in our democracy's early years seemed displaced by a new form of 'othering', namely black immigrant students.

How do these students, commonly labelled as 'makwerekwere', constitute and negotiate their identities? How are their identities represented in an environment that may strive for integration, but is judgemental and confrontational? And what can schools do to create inclusive spaces? These were some of the questions that led to Prof Vandeyar's pioneering research and her first major book, co-authored with Dr Thirusellvan Vandeyar, Senior Lecturer in UP's Department of Science, Maths and Technology Education.

Titled *The construction, negotiation and representation of immigrant student identities in South African schools*, this book contributes fresh South African insights to global immigrant studies. "It also seeks to address diversity and social justice education by interrogating contested spaces: shared places in an attempt to create 'educationscapes' where all can feel a sense of belonging; where students value human dignity and view each other as cosmopolitan citizens of the world," explains Prof Vandeyar.

Using the methodology of portraiture rather than pathology, the text describes how immigrant student identities are framed, challenged, asserted and negotiated within the institutional cultures of schools. It also covers the schooling system's influence on their identity formation, among other aspects. Importantly, critical lessons and 'good practice' that can accelerate racial desegregation and social integration of immigrant students in South African schools are shared.

The content is relevant to all stakeholders in education – from teachers to parents – as well as psychologists, anthropologists and society at large.

It is another addition to this academic, scholar, multi award-winning researcher and author's already considerable body of work. She has been playing a leading role in understanding the implications of teacher and student identities in constructing classrooms inclusive of racial, linguistic, gender and ethnic identities. Her main aim, as always, remains promoting intercultural, cosmopolitanism and social justice education.

How do students, commonly labelled as 'makwerekwere', constitute and negotiate their identities?

Negotiating identities

Dr Nasima Carrim has initiated one of the first studies in South Africa that is focused on a study of the challenges Indian managers encounter in managerial career advancement, and how they negotiate their identities in the process. Her research builds on her early work on South African Indian women's struggle for identity in the corporate world. The observation that Indian males are invariably treated as a sub-set of black male managers has motivated the current study.

Narratives of self

In a related, yet different paradigm to the predominantly psychometric approach pursued by researchers in Economics and Management Sciences, a novel approach to narrative career counselling in the Faculty of Education has reaped rewards.

Prof Kobus Maree from the Department of Educational Psychology is locally and internationally recognised for his work on narrative or storied career counselling, with much of his research focused on marginalised communities. His approach is in keeping with the notion of career as a story and consistent with leading theories of life design, including career and self-construction.

In 2014 Prof Maree was awarded the Stals Prize of the South African Academy of Science and Arts for exceptional research and contributions to education, and the Psychological Society of South Africa's Award for Excellence in Science.

Biracial heritage and identity

In a landmark study, **Dr Wendy Carvalho-Malekane's** PhD thesis focused on how young adults with a biracial heritage construct identities in post-apartheid South Africa.

With the number of interracial marriages rising post-1994, Dr Carvalho-Malekane mentions that there is an increased need to understand the unique perspectives of people with such a heritage. Until now, research in this field has been lacking in South Africa, possibly because interracial marriages were illegal in the apartheid past, and interracial families may have been reluctant to discuss the subject.

This lecturer in the Department of Humanities Education's interest in this topic was ignited by her own heritage. Her mother is white and Spanish and her father black and Tswana.

Dr Carvalho-Malekane's study involved young women and men between ages 18 and 25 with biracial heritages in Gauteng. A key finding was that participants identified with both heritages, classifying themselves as members of two racial groups.

In addition to serving as the foundation for further research, the study has a bigger aim. "As South Africans, it is important to acknowledge and respect the various racial, ethnic and cultural identities within our multiracial and multicultural country. One of my research goals is to help individuals understand and support diverse identities and backgrounds, as well as to respect and celebrate differences within South African communities."

Benchmarking performance in schools

The Progress in International Reading Literacy Study (PIRLS) is an international comparative study of reading literacy. **The Centre for Evaluation and Assessment** (CEA), headed by **Prof Sarah Howie**, in the Faculty of Education served as the National Research Centre for the assessments in 2006 and 2011. It is also the National Centre for PIRLS 2016.

The assessment was initiated by the International Association for the Evaluation of Educational Achievement (IEA) and has been conducted in more than 40 countries internationally at five-year intervals. For South African learners there was no difference in the overall achievement in 2011 compared to 2006.

For the CEA, 2014 was a productive year with more than 15 papers presented by researchers at national and international conferences. Four master's students completed their dissertations based on the PIRLS data, and a further seven doctoral students completed their theses in Assessment and Quality Assurance.

In summary, the prePIRLS assessment results (an easier assessment compared to the PIRLS), showed that 71% of Grade 4 learners in South Africa were able to reach only a rudimentary level of reading, and 6% were able to read at an advanced level. While the performance of Grade 5 learners compared well with learners in other developing countries, 43% did not reach the lowest international benchmark. It is clear that much remains to be done in basic education.

PIRLS is but one of the CEA's activities. The Centre also launched its participation in the International Performance Indicators in Primary Schools project, which includes Australia, China, England, Hong Kong SAR, Russian Federation and South Africa.

Another multiyear and multimillion rand (R3,6 million) project undertaken in 2014 involved the monitoring and evaluation of the special project schools for the Michael and Susan Dell Foundation. This project seeks to help accelerate the progress of underprivileged children in mathematics and science.

Photo by Thomas Barry

Hearing screening innovation

The World Health Organisation estimates that 6,8 million children (under 15 years) and 30 million adults in sub-Saharan Africa alone suffer from permanent disabling hearing loss. The impact on individuals and society is immense. For children early detection means the possibility of optimal development; for adults, this results in the appropriate interventions to minimise the impact.

Prof DeWet Swanepoel with colleague, Faheema Mahomed, testing the smartphone hearing device.

The significance of UP's hearScreen™ smartphone innovation, with **Prof DeWet Swanepoel** as the lead inventor and audiology expert, is enormous. The hearScreen innovation uses patented software, developed by **Dr Herman Myburgh**, to transform a smartphone into a calibrated device that detects disabling hearing loss.

The innovation, made possible by the revolution in technology, cuts costs by more than 80% compared to that of traditional screening devices, and significantly improves and alters current models of school and community-based prevention for hearing loss. Traditional screening and diagnostic devices are often not available in remote or resource-constrained environments and require trained personnel to operate. In contrast, by making it possible for non-specialists to conduct screening, the innovation – a light and mobile smartphone and app – can be used by teachers, and by community and primary health care workers, as the first contact point for early detection of disabling hearing loss. A great benefit of this new technology is that the data of every screening can be uploaded to a central, secure database.

The research team received the 2013/2014 National Science and Technology Forum (NSTF)-BHP Billiton Award for an outstanding contribution to science, engineering and technology through research leading to innovation. Prof Swanepoel also received the 2014 AU-TWAS Young Scientist National Award in the category of Basic Sciences, Technology and Innovation.

An important application is in school-based screening, which has been a priority for the national Departments of Health and Basic Education since the introduction in 2012 of the Integrated School Health Policy.

Photo by Liezl Rees

The Human Economy Project

"The human economy is being made and remade from the bottom up. It is above all a strategy that seeks to combine economic democracy at the local level with the interests of humanity as a whole." This statement encapsulates in some part the focus of the project on 'the ordinary business of life' and human concerns so as to expand economic democracy, particularly in Africa and the global South.

The Human Economy Project is co-directed by **John Sharp**, the South African Director and Professor of Social Anthropology at the University of Pretoria, and **Keith Hart**, International Director and Centennial Professor of Economic Anthropology at the London School of Economics.

While interdisciplinary in scope, the project relies extensively on ethnographic methods as an appropriate counter to the methods adopted in mainstream economics.

Now in its third year, the project continues to be highly productive. Its core members comprise eight postdoctoral fellows from around the world (Angola, France, Germany, the UK, the Netherlands, the United States, Spain, and Zimbabwe) and eight doctoral students (from Cameroon, Lesotho, Nigeria, South Africa and Zimbabwe) whose research is dedicated to addressing the theme of economic democracy in different ways. Together with the Directors, this team produced three books and more than 25 chapters in books and articles in refereed, accredited journals in 2014. It also hosted two conferences.

The key publication of 2014 was an edited collection of case studies – *People, Money and Power in the Economic Crisis: Perspectives from the Global South* – written by core members and associates of the project, and published by Berghahn Books of Oxford and New York. This is Volume 1 in the project's Human Economy series and presents nine case studies, from southern Africa, South Asia, Brazil and Atlantic Africa.

The authors examine economic life from the perspective of ordinary people in places that are normally marginal to global discourse and the narrow vision of conventional economics.

John Comaroff, Harvard University, comments as follows in his review of this seminal text:

"This series is more an agenda-setting enterprise than a mere book series. It promises to be the most important scholarly initiative to come from the global South in a very long time; one that is sure to change how we think about the world at large, about economy and humanity."

Environmental economics and energy

Recent research has increasingly focused on the effect of inequality, financial instability, democracy and other institutions on economic growth, as well as international patterns of trade, in Africa and other emerging regions. Questions of the environment and economy and effective energy policy have become an important research focus, particularly for South Africa.

Research undertaken at UP in 2014 focused on policy. The scholars leading this research theme include the team of **Profs Jan van Heerden** and **James Blignaut**, and **Dr Heinrich Bohlman** who specialises in econometric and computable general equilibrium (CGE) models; and **Prof Roula Inglesi-Lotz** who focuses on energy policy and its effects.

CGE modelling is used to calculate the impacts of energy policy in South Africa, the impacts of increased electricity tariffs on the economy at large and the different role players in it, and the impact of the implementation of carbon taxes on the environment and economy. A major project was completed for Eskom, using a CGE model of South Africa, to estimate the effects that different possible electricity tariff increases would have on the economy and on the role players in the economy (households, industries and the government). This project is ongoing and an improved model will result in more accurate simulations in future.

The team also received sponsorship from the World Bank to simulate the effects of a new carbon tax on the South African economy and all its stakeholders. The research, which was undertaken in 2014 at the request of the National Treasury of South Africa, used a dynamic CGE model. The results showed that a carbon tax, together with appropriate recycling options, would give double dividends to South Africa: it would lead to much cleaner air and environment in the long run, while it would not be harmful to economic efficiency if the tax revenue is used correctly.

Research Chair in Advanced Sensor Networks

The field of Advanced Sensor Networks (ASN) has vast and diverse application potential. In 2014 the ASN research group in the Department of Electrical, Electronic and Computer Engineering was awarded a Research Chair in ASN under the South African Research Chairs Initiative (SARChI).

In the first phase, the research programme will involve the development of mathematical modelling to enhance the efficiency and effectiveness of wireless sensor networks (WSN). The focus will be on four key components – placements, routing and throughput, quality of service, and security – and through partnerships, and research and training, a strong team of researchers will be developed.

While WSN has emerged as one of the dominant network technologies, there are several challenges associated with implementation. Research into what future sensor devices standards should be as important, as well as the configurations needed for optimal WSN efficiency.

The application focus will include areas pertinent for South Africa, such as health care monitoring, smart-power grid, in-situ soil moisture content, wildlife movement, industrial automation and disaster monitoring. The SARChI Chair will work closely with the Meraka Institute at the CSIR so as to carry research and new technologies to the technology transfer stage for completeness.

The Research Chair in ASN, Prof Attahiru Alfa, in the Department of Electrical and Computer Engineering.

Roula Inglesi-Lotz, Associate Professor in the Department of Economics.

INTERVIEW

Linking economics to energy, the environment and climate change

"We didn't inherit this earth from our parents. We borrow it from our children." A firm believer in this quote, Prof Roula Inglesi-Lotz, Associate Professor in the Department of Economics, is a leading researcher in energy and environment economics.

"Problems related to energy, the environment and climate change affect economies. By looking for solutions, we can make a difference and improve the economic growth of countries, and inform future policies and strategies. We can even change the everyday lives of people in South Africa, sub-Saharan Africa and the world," she says.

In 2014 her contributions in this field earned her Junior Researcher of the Year awards from the Faculty of Economic and Management Sciences, and the University's Exceptional Young Researchers Award.

Collaboration with students, local and international colleagues, such as Prof Tsangyao Chang from Feng Chia University, Taiwan and Prof Mehmet Balcilar from the Eastern Mediterranean University, North Cyprus, are key to her work. 2014 saw this lecturer and postgraduate supervisor write and contribute to nine papers, published in international and local journals.

Her research investigates the influence of prices on industrial electricity consumption in South Africa, as well as several broader macroeconomic and development issues. Together with Prof James Blignaut and Dr Reyno Seymore, both from UP's Department of Economics, she also constructed a greenhouse gas emissions inventory for South Africa – the first of its kind in such detail and according to international standards.

However, she believes that a study proposing a benchmark-and-trade system to improve energy efficiency – and not emissions – was her most important work in 2014. "It is the first study aimed at targeting the actual source of emissions, which is the way in which economies consume energy to produce goods and services. This paper comes as a proposed solution stemming from two years' research during my PhD work," she notes.

Prof Inglesi-Lotz has already identified several future research projects. "The scarcity of energy sources and concerns make these kinds of studies more critical than ever before," she notes. "With research about energy and environmental issues still in a 'developmental' stage, there are exciting opportunities at every step forward."

Commenting on UP as a research institution, Prof Inglesi-Lotz says: "Efforts from the faculty and management are coordinated to help researchers produce not only quantity of outputs, but most importantly high-quality and meaningful research. This is also obvious in the everyday research and interaction of staff members with their students."

"By looking for solutions, we can make a difference and improve the economic growth of countries, and inform future policies and strategies."

Prof Roula Inglesi-Lotz

Energy, mining and swarm intelligence

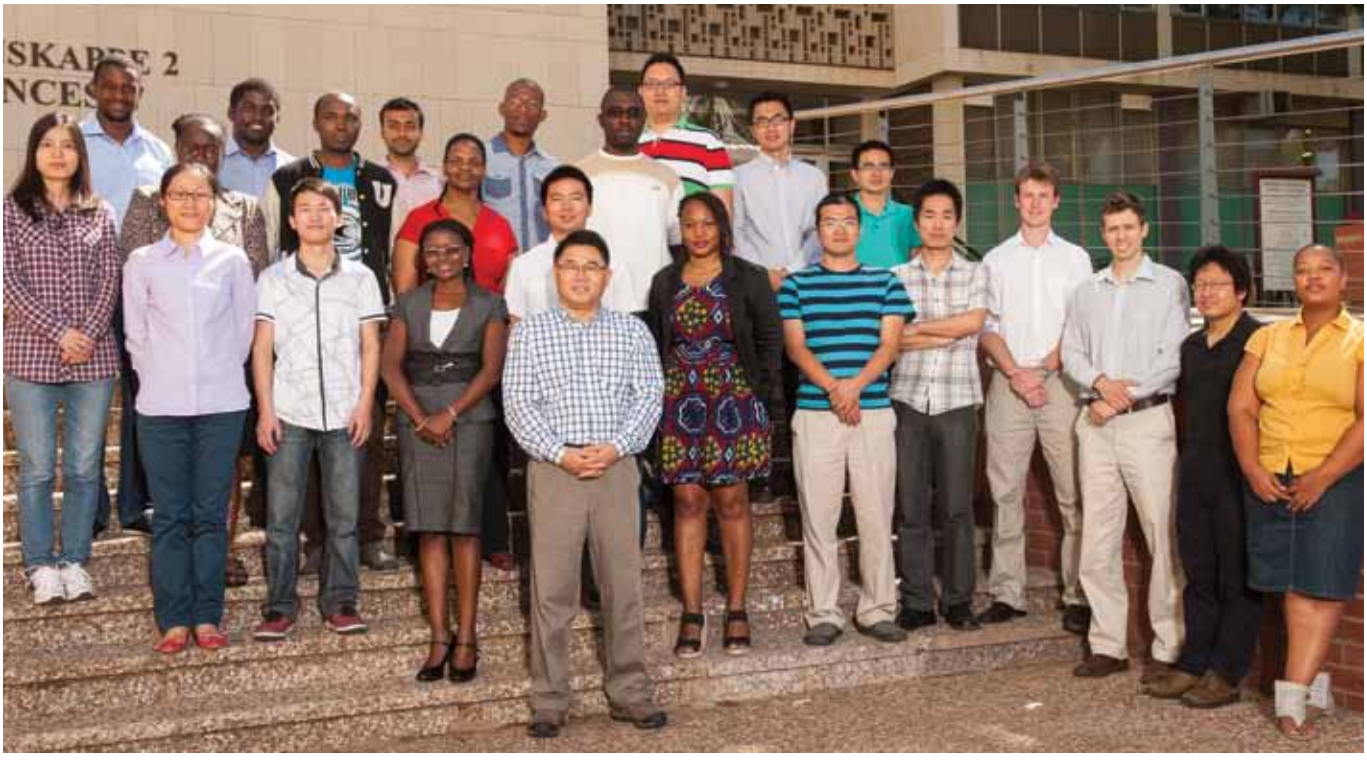
Many examples showcase research achievement in 2014 across the knowledge fields and research clusters in the Faculty of Engineering, Built Environment and Information Technology. Three are selected to illustrate the relevance and impact of the research in 2014.

Exploring energy solutions

Several research initiatives address the energy crisis that South Africa faces.

The South African National Energy Development Institute (SANEDI) National Hub for Energy Efficiency and Demand-side Management (EEDSM) focuses on producing high-quality master's and doctoral graduates to meet the needs of an expanding and sustainable energy industry.

Linked to the Energy Systems Group, an active research group in the Centre of New Energy Systems (CNES), there are always a number of postdoctoral fellows and postgraduate students working on various energy projects with researcher members. In 2014 a total of 18 papers were published, and 20 doctoral, 11 master's and 40 part-time honours students worked with researchers in the CNES and the National Hub (EEDSM).



Prof Xiaohua Xia, Director of the Centre of New Energy Systems and the SANEDI National Hub for Energy Efficiency and Demand-side Management, with postgraduate students and colleagues.

Key questions relate to the demand and supply side of energy, with publications addressing a range of issues. Examples include:

- Mathematical modelling for the social impact of energy-efficiency savings;
- Analysis of the economic benefit of electricity price forecast in industrial load scheduling;
- Optimal energy management for a jaw crushing process in deep mines;
- Energy dispatch strategy for a photovoltaic-wind-diesel-battery hybrid power system; and
- A multi-objective optimisation model for the life-cycle cost analysis and retrofitting planning of buildings.

Contributing to a resilient mining industry

A resilient mining industry is of particular relevance to Africa, which has an estimated 40% of the world supply of mineral resources. It is anticipated that over the next decades the mining sector will be a major source of economic growth and employment opportunities.

The mining sector is complex, and research requires a multi-disciplinary and collaborative approach to effect change. It is also an industry that lends itself to the use of virtual reality and visual realisation to gain experience in hazardous environments and to embed understanding of complex concepts and interrelationships, both physical and social.

The Mining Resilience Research Institute (MRRI) and the **Virtual Reality Design Centre** (VRDC) at UP make important contributions to mining in Africa. Construction of the VRDC started in 2014. The interfaculty research projects in the MRRI are contributing to practical implementable solutions to increasing the resilience of the mining industry, and to addressing complex mining industry problems. Research disciplinary fields range from the humanities, economics and urban and regional planning, to law and engineering.

So, for example, a **Chair in Natural Resource Legislation** has been established in the Faculty of Law, and the MRRI forms part of the Sasol Chair: Safety, Health and Environment initiative.

Important further developments in 2014 included a Memorandum of Understanding with the Mine Health and Safety Council for UP to serve as a Centre of Excellence; and the revitalisation of collaboration with the CSIR on mining.

The MRRI also facilitated a workshop in November 2014 attended by over 60 senior industry leaders. Research topics were presented, including papers by postgraduate students, on the role of virtual reality in changing the safety behaviour on mines. Industry stakeholders expressed overwhelmingly positive support for the research at the MRRI and the virtual reality training facility, and for sustaining the partnership between the mining industry and UP.

Photo by Christian Pirk

Swarm intelligence

In the field of swarm robotics, developing approaches to control a swarm of simple stimulus-response robots to perform a complex task are based on the foraging behaviour of honeybees and desert ants.

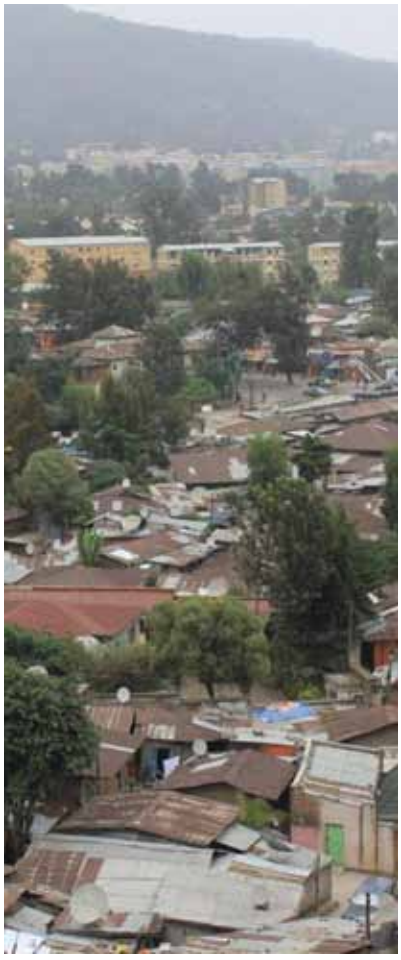
This research focus falls under the **SARChI Chair in Artificial Intelligence at UP**. Algorithmic models of such phenomena in nature are applied to solve complex optimisation problems, including problems where the search landscape is dynamic and changes over time, where multiple conflicting objectives have to be optimised simultaneously, and where multiple solutions have to be found and tracked.

Prof Andries Engelbrecht, Head of Computer Science, is the current Chair. His research focus is on computational intelligence, and the particular interest of his research group is in computational swarm intelligence, evolutionary computation, artificial neural networks, artificial immune systems, and learning from zero-knowledge using competitive co-evolution.

Prof Andries Engelbrecht holds the SARChI Chair in Artificial Intelligence.

His work on particle swarm optimisation (PSO), which was based on models of bird-flocking behaviour, has received international recognition. His work also provides some of the first theoretical analyses of PSO and its convergence properties.

Photo by Liezl Rees



The Centre for Dynamic Markets is a subscription-based project that serves the business and state sectors, and multinational corporations. Comprising a small team based at GIBS in Johannesburg and in Nairobi, Kenya, the Centre is dedicated to generating and disseminating insights into and information about doing business in dynamic markets. In addition to research publications, the service takes the form of high-level monthly discussions led by recognised experts, regional briefings, a bi-weekly bulletin of news and summaries from dynamic markets, and the writing and presentation of case studies.

The Centre for Dynamic Markets

The GIBS Dynamic Market Index is a comparative global measure of institutional evolution and competitive performance that is the result of research undertaken by the Centre for Dynamic Markets.

Launched in 2014, the Dynamic Market Index (DMI) is based on an in-depth global study of six enabling pillars of market dynamism that provides insight into the key attributes of an evolving political economy and of true economic potential. The study in 2014 was across 133 countries over a seven-year period (2006–2012), with the six pillars relating to:

- Open and connected
- Red tape
- Socio-political stability
- Justice system
- Macroeconomic management, and
- Human capital.

Results will be released bi-annually to identify how countries are performing and the conditions that serve as catalysts for economic growth, wealth creation, innovation and overall socio-economic development.

The 2014 global study notes that the period 2006-2012 was a particularly turbulent time, with significant change in the global economy. The second report released in 2014 narrows the results to the 33 African countries that were part of the sample. The conclusions and recommendations point to several factors that enable and constrain economic growth in dynamic markets.

Photo by Liezl Rees

EXPERT LECTURE | A SUMMARY

Grand strategy and leadership

In **Prof Nick Binedell's** expert lecture delivered in August 2014, he reflected on the 20 years of South African democracy and, building on this, provided comments on current and future challenges.

Prof Nick Binedell, Dean of The Gordon Institute of Business Science (GIBS).

Prof Binedell used three critical structures of a modern nation state – politics and government, business and the economy, and civil society. Drawing on the work of French historian, Fernand Braudel, he made the important distinction between contemporary or surface level events, which frequently dominate news and commentary, and the deeper structures and processes that are long lasting in effect.

Binedell noted that it was important to recognise achievements over the past 20 years and, at the same time, that South Africa will remain significantly influenced by both the positive and negative features of our past. Survey data and the media, for example, show an increasing level of concern about South Africa's broad direction and performance.

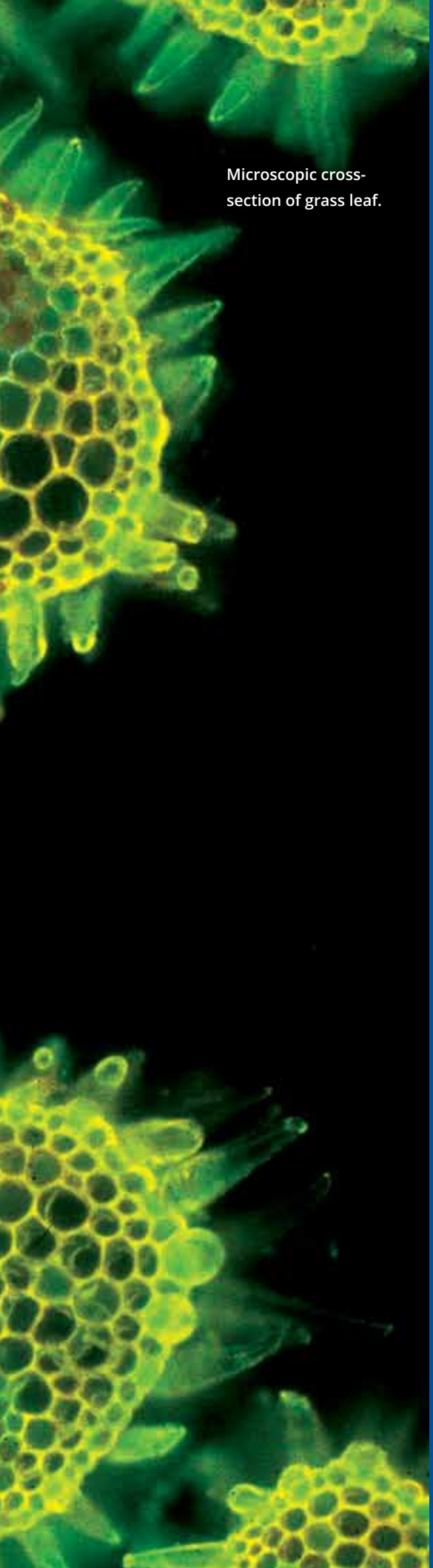
His lecture focused on the strategic strengths of South Africa – or what he referred to as 'killer apps'.

These include the fact that we are in a constitutional democracy; have a good (if uneven) infrastructure for an emerging economy and are in many aspects significantly ahead of emerging markets; have a strong private sector that has shown the ability to operate globally; are in a well-located time zone; and are a resilient and adaptive people.

He concluded by focusing on the centrality of the performance of the economy. South Africa has a distinctive set of private sector capabilities that are now being exploited globally. The critical point made was that sufficient domestic investment by South African business is vital, as well as foreign investment by multinationals to ensure a growth rate that leads to a sustainable political economy. Unless this growth rate is achieved, the South African political economy will come under significant pressure given its demography and the level of inequality that characterise society.

THEME 2

ENVIRONMENT, FORESTRY AND AGRICULTURE



Microscopic cross-section of grass leaf.

The term 'environment' has many implications and dimensions. It encompasses virtually all aspects of the world around us – from the diversity of macro- and microorganisms with which we interact, to the habitats in which they live and the physical factors that affect their (and our) lives.

Over the past decade, environmental research has become a major focus worldwide. The prominence of research on environments and environmental issues, and the rapid growth of this research focus in South Africa, is driven by a variety of factors:

- The growing appreciation of the future impacts of climate change on fundamentally important issues such as food security and human livelihoods;
- The realisation that South African biodiversity, which includes organisms of all sizes – from viruses to the 'Big 5' – is a national resource with enormous potential economic value; and
- The recent development of new and extremely powerful genomic and metagenomic research tools.

South Africa has the privileged position of being one of the major biodiversity hot spots of the world (the Cape fynbos biome has over 6 000 endemic plant species, for example), and of encompassing an enormously wide range of environments, from sub-tropical coastal forests to desert dune-scapes, and some of the richest marine waters on the globe. Conversely, large parts of our nation are water limited, and our agricultural economy must continue to support a growing population.

In consequence, environmental research has a new imperative, whether to understand the nature of pathogenic microorganisms, which reduce crop productivity, to engineer important economic crops to enhance their value, or to investigate the 'unexplored' microbial diversity in unique South African marine and terrestrial environments.

University of Pretoria researchers play leading national and international roles in all these areas. Research groups in the biological sciences, most of whom are already exploiting the latest cutting-edge 'omics' technologies, have demonstrated true research excellence in 2014.

The summaries of research have been chosen to illustrate the relevance and impact of some of these research achievements.

Prof Zander Myburg holds the Chair in Forest Genomics and Biotechnology in the Forestry and Agricultural Biotechnology Institute (FABI), and is also a research team member in the Genomics Research Institute (GRI).

Forest genomics – a world leader

A notable highlight in 2014 was the publication in *Nature* of the complete genome sequence of the economically important tree species *Eucalyptus grandis*. **Prof Zander Myburg** in Genetics at the University of Pretoria, was the lead investigator of an international consortium of over 80 researchers who completed the decoding and analysis.

E. grandis is a representative of a large genus of woody plants endemic to Australia and islands to the north of the continent. Fast-growing Eucalyptus tree species and hybrids in South Africa constitute the most widely cultivated hardwood crop globally (20 million ha) and are an important wood fibre feedstock for the pulp, paper and timber industries.

The large-scale international project to sequence the *E. grandis* genome was funded by the United States Department of Energy. Along with the entire genome sequence, the research team deciphered many important aspects of the unique biology of these large woody perennials, such as genome evolution, woody biomass production, reproductive diversification and the biosynthesis of secondary metabolites, including those in Eucalyptus oil, another well-known product from these trees.

An important outcome of the research is that it has opened the door to the use of Eucalyptus trees in bio-refineries, for the renewable production of bio-based materials, chemicals and energy.

Prof Myburg's research programme focuses on the genetic control of wood development in fast-growing forest trees and the genetic regulation of cellulose biosynthesis in wood fibre cells. The programme is supported by South African forestry industry partners, the Technology and Human Resources for Industry Programme (THRIP), the National Research Foundation (NRF) and the Department of Science and Technology (DST).

FABI
a critical mass of researchers

Among the many research highlights of the past year, as well as exceptional publication output, several members of the **Forestry and Agricultural Biotechnology Institute** (FABI) have received prestigious awards.

FABI's founding director, **Prof Mike Wingfield**, is also President of the International Union of Forestry Research Organisations (IUFRO), one of the oldest and largest research networks in the world.

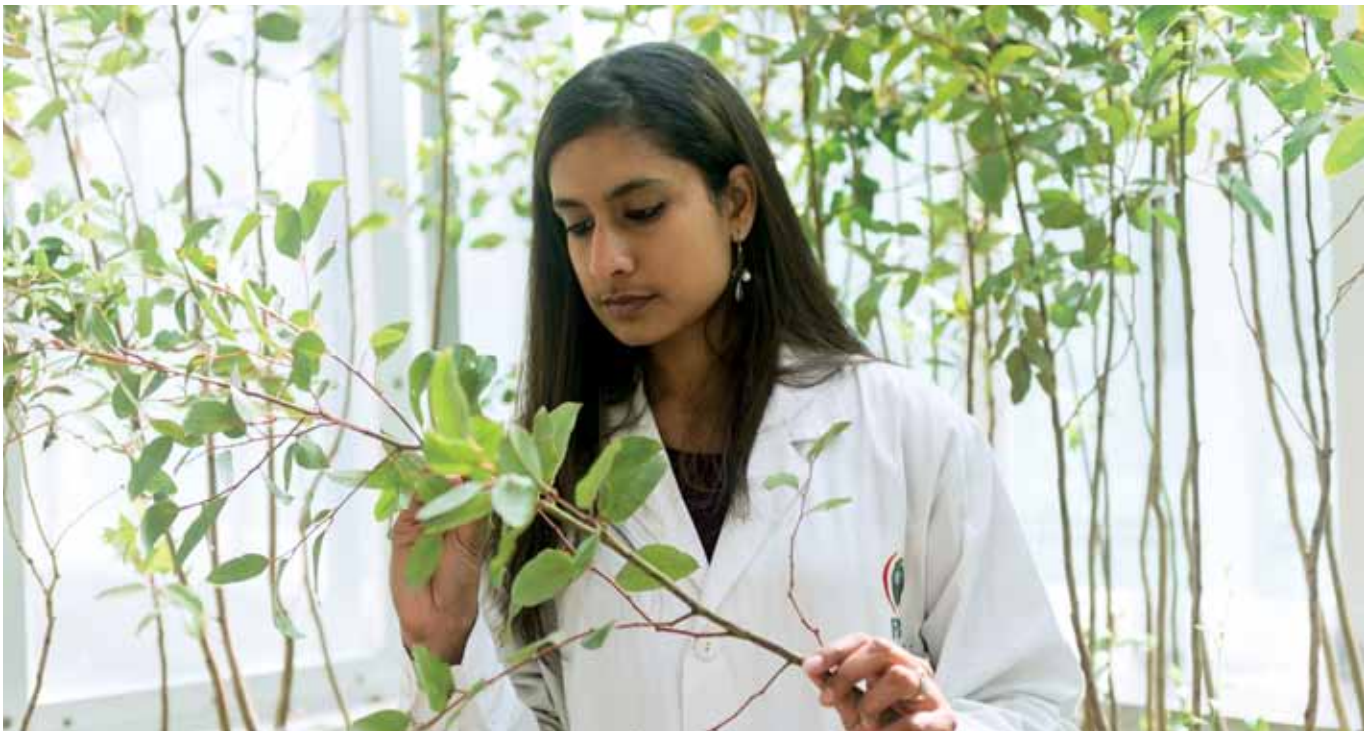
The Institute has established a substantial international footprint in just 18 years and reached a point where 20 FABI academic staff had NRF ratings – two being A-rated scientists and five with B-ratings, two of its members received the NSTF award for researchers for an outstanding contribution to SET through research capacity development over the last 5-10 years, and one researcher being awarded the Christiaan Hendrik Persoon Medal of the Southern African Society for Plant Pathology.

In 2014, FABI provided a research home for approximately 140 MSc and PhD students and included major international research programmes such as the Tree Protection Co-operative Programme (TPCP), the Forest Molecular Genetics (FMG) group and the DST-NRF Centre of Excellence in Tree Health Biotechnology (CTHB), among others.

Today FABI is very different from the institute it was in 1998. While in the first years research conducted in the Institute was almost all in the field of tree health, this now covers a wide range of topics relevant to agriculture and forestry.

Prof Wingfield suggests that the greatest strengths of FABI are that its focus lies at the intersections of numerous disciplines, allowing students and academics to capture the power of different approaches and techniques, as well as in its international flavour with students coming from many different parts of the world. The goal is to promote inter-disciplinary research in the broad plant sciences, to drive research excellence and to engage positively with stakeholders, including the industry and funding agencies that support FABI research.

Funding for research comes from a wide variety of sources including state, government, international research initiatives and, importantly, the South African forestry and agricultural industries.



Plant-pathogen interactions

Pests and pathogens threaten the productivity of various crops worldwide. Eucalyptus species, considered a wood and fibre crop by forestry industries, is also subjected to these biotic stress challenges.

Dr Sanushka Naidoo, programme leader of the Eucalyptus and Pine Pathogen Interactions (EPPI) group at FABI, describes their research as dedicated to uncovering the defence arsenal of Eucaluptus, based on the study of the host 'defensome' (or defence transcriptome).

The group studies the interaction between Eucalyptus with insect pests and pathogens. These pathosystems provide the biological platform to address key questions such as the molecular basis of tolerance and susceptibility, the signature defence responses to different types of pests and pathogens, the convergent defence responses in the host, and which regulatory sequences and defence genes could be targeted to enhance defence in Eucalyptus.

The genome sequence of *Eucalyptus grandis* described in the first example under this theme has been an exciting development. Coupled with data from high-throughput transcriptomic studies, the research group has been able to elucidate plant-pathogen interactions, especially the defence response of *E. grandis* to the gall wasp.

Research will continue to build on these important interactions to develop a model for resistance mechanisms in *E. grandis*.

The Centre of Excellence in Tree Health Biotechnology

The DST-NRF **Centre of Excellence in Tree Health Biotechnology** (CTHB) focuses its research efforts on the health of trees (trees in native woody ecosystems, plantation forests, amenity trees and fruit trees), particularly through the application of biotechnology tools.

The CTHB is one of the core research teams in FABI and was established in 2004 as one of the first seven Centres of Excellence funded by the DST and the NRF.

The central node of the network of researchers is run by 13 PhD-level scientists and their postgraduate students, postdoctoral fellows and research fellows.

In 2014, the network also included researchers and their students at the South African Agricultural Research Council, Rhodes University and universities of Stellenbosch, Cape Town, Witwatersrand, Free State and Venda. During 2014, 57 PhD, 42 MSc and 10 BSc Honours students participated directly in the research of the CTHB and its sister programme, the Tree Protection Co-operative Programme (TPCP). In the same period, seven PhD, 15 MSc and 10 BSc Honours students from the joint CTHB-TPCP programmes completed their degrees.

At least 67 articles authored and co-authored by the staff and students of the CTHB were published in internationally recognised peer review journals in 2014. In addition, three book chapters and one book was authored and co-authored by the staff and students of the CTHB. Most of these publications describe research that addressed issues pertaining to the health of both native trees and plantation forestry species, and issues that potentially threaten the health of these plants.

The Tree Protection Co-operative Programme

The **Tree Protection Co-operative Programme** (TPCP) celebrated its 26th year in 2014. This unique programme is a joint venture between all the major forestry companies in South Africa, the South African government and the University of Pretoria. It is now widely recognised as the strongest single programme dealing with tree health issues in the world.

The programme provides the South African forest industry with a robust, sustainable and cost-effective base of support to deal with pest and disease problems in plantations and nurseries. It also conducts research and training for companies, research organisations and governments globally.

The success of the programme lies in its ability to combine basic research and training of postgraduate students, with practical solutions to problems the industry faces. The group is a leader in genomics, population genetics, phylogenetics, ecology and evolution of fungus and insects on trees and, in the past year, published in all the leading journals in those fields to advance basic understanding of these organisms.

At the same time, the group has developed and released two new biological control agents for pests on *Eucalyptus*, passed the 14 billion mark in biocontrol nematodes

produced to control an invasive wasp in pine trees, and launched a number of new programmes to deal with newly arrived invasive pest and pathogen problems.

Prof Don Cowan, Director: Genomics Research Institute, and of the Centre for Microbial Ecology and Genomics, received the NSTF 2014/2015 award for his outstanding contribution to SET through research capacity development over the last 5-10 years. He received the UP Chancellor's Award in recognition of exceptional achievement in research in 2014.

The Genomics Research Institute

The Genomics Research Institute (GRI), established in 2011 as one of the first four institutional research themes at the University of Pretoria, has in a short space of time become one of the largest and strongest research entities in the University.

Led by **Prof Don Cowan**, the GRI – a virtual institute – has a membership of 70 academic staff and over 200 researchers across the faculties of Natural and Agricultural Sciences, Veterinary Sciences and Health Sciences. There are four A-rated researchers in the team with 96% of its academic staff members holding PhD degrees. The team includes some of the leading researchers in the University, and a good number of developing researchers.

The Institute's research activities are divided into three sectors: environmental genomics, human and health genomics, and plant and animal (agricultural) genomics – fields that reflect the importance and impact of the genomics revolution. At the heart of the revolution is DNA sequencing, made possible with new sequencing technology that impacts on virtually every field of the biological sciences.

The 2014 performance of the GRI provides clear evidence that the University of Pretoria is the leading centre of genomics research in South Africa (and in sub-Saharan Africa). Institute members reported a catalogue of over 120 publication outputs, and combined external research grant funding of over R35 million.

Several examples can be used to illustrate research achievements in 2014, with a few chosen here that relate, in particular, to agriculture and – through the research of the Centre for Microbial Ecology and Genomics (CMEG) – to research conducted in extreme environments and using metagenomics.

The Centre for Microbial Ecology and Genomics

The Centre for Microbial Ecology and Genomics (CMEG), led by A-rated scientist, **Prof Don Cowan**, is a core research group within the GRI. The 30-strong research group includes four research fellows and 10 postdoctoral researchers and has an extensive network of national and international collaborators.

CMEG researchers, with their collaborators, published 28 research articles, reviews and book chapters in 2014. The examples that follow illustrate some of the research undertaken.

The Centre drove several major research projects on aspects of environmental microbial ecology in interesting and relevant soil and aquatic systems as diverse as the Antarctic Dry Valleys, 'fairy circles' in the Namib Desert, commercial sorghum cropping in Limpopo and Argentinian sub-Antarctic peat-bogs.

Metagenomics of hot deserts

The application of modern genomic, metagenomic and bioinformatics technologies to understand the form and function of microbial populations in desert soils is one of the major research themes in the CMEG laboratory.

Over a dozen CMEG researchers are involved in this programme, with Research Fellow **Dr Jean-Baptiste Ramond** taking a major role. Researchers have investigated the importance of water bioavailability on microbial community structure and function and have been the first to probe the diversity of viruses in these desert soils. They have reconstructed the complete genomes of several novel microorganisms and inferred the physiological characteristics that allow them to survive in this extreme environment. The group has recently expanded their biodiversity research to include largely unstudied taxa such as archaea and microinvertebrates.

This 'flagship' programme, which has a large collaborative dimension with multiple national and international participants, produced nine international publications in 2014.

Photo by CMEG

Dr Thulani Makhalanyane, a member of the Centre for Microbial Ecology and Genomics, and lecturer in Genetics, joined an international team in the Antarctic Dry Valleys in January 2014 to expand the Centre's research on Antarctic soil microbiology.

INTERVIEW

Answers to global climate change may lie in the soil

The McMurdo Dry Valleys of the Antarctic are harsh and extreme ecosystems. There are no plants or higher organisms and no rainfall, yet microorganisms are surviving, even thriving. Studying how these microbial communities live and adapt offers clues to understanding our world, especially how climate change may affect it, says Dr Thulani Makhalanyane, a member of the Centre for Microbial Ecology and Genomics (CMEG) and lecturer in the Department of Genetics.

At the cutting-edge of this evolving field, Dr Makhalanyane received a TW Kambule-NSTF award for his contributions as an emerging researcher in 2014.

He has been researching the microbial ecology of cold and hot desert soil habitats, such as the Antarctic and the Namib Desert, under the mentorship of Prof Don Cowan, CMEG Director, since 2008. Using state-of-the-art 'meta-omic' approaches, Dr Makhalanyane aims to understand the role of active microbial populations in shaping the soil environment and how environmental factors drive the structure and function of microbial communities.

The research forms part of South Africa's responsibility as a member of the Antarctic Treaty. "The CMEG's work in the Antarctic represents some of the leading outputs in this field globally, and I have been fortunate enough to be part of that," says Dr Makhalanyane.

One of their most exciting Antarctic hypolith studies, according to him, was published in *ISME J*, the leading journal in microbial ecology in 2013. "Our results showed that some of these communities may be at greater risk due to climate change," he notes.

2014 was a busy year for Dr Makhalanyane. He joined a sampling expedition to the Antarctic Dry Valleys, where he met leading scientists in his field and collected an impressive sample set, which the team is still using. "I also visited the Pacific North West National Laboratory in Richland, US where I had the opportunity to apply some of the most sophisticated molecular approaches in the field," he says.

This was also the year in which he presented work at the International Society for Microbial Ecology (ISME) Symposium in Seoul, South Korea and joined the ISME board as a young ambassador. Dr Makhalanyane co-authored a total of six research papers in 2014, including a book chapter.

He and the CMEG team have recently started marine molecular ecology research, specifically focusing on oceans surrounding our country. Dr Makhalanyane notes that it's a massive undertaking, but one that will reveal even more answers to issues related to global climate change.

"As a young researcher, my drive towards self-improvement and advancement are closely aligned to the University's Vision 2025. There is an incredible amount of institutional support for young researchers."

Dr Thulani Makhalanyane

Metagenomics of sub-Antarctic peat bogs

Photo by CMEG

Research at the Centre for Microbial Ecology and Genomics (CMEG) in extreme environments is enhanced by international collaboration. A collaborative project on peat bogs in the Ushuaia region of southern Argentina provides evidence of environmental adaptations.

Collaborator, Dr Gabriela Mataloni, from Universidad Nacional de San Martín in Argentina, has extensively studied the eukaryotic diversity and trophic structure of water bodies (pools) in peat bogs.

The metagenomic surveys, performed by CMEG Research Fellow **Dr Angel Valverde**, have expanded the research to include bacterial communities.

These studies reveal highly diverse and specific bacterial communities within the different pools, suggesting a dominant role of deterministic processes (habitat filtering) on bacterial community composition. Peat bog–associated bacteria show strong habitat associations that have likely emerged through their adaptation to these particular habitats. To what extent these bacterial populations can adapt to the changing environmental conditions remains to be elucidated in future.

Dr Pieter De Maayer, Research Fellow at the Centre for Microbial Ecology and Genomics (CMEG).

INTERVIEW

Microscopic organisms with big 'green' potential

With dwindling fossil fuel reserves and increasing greenhouse gas emissions, developing alternative energies has become a global imperative. Enter *Geobacillus*, a group of heat-resistant microorganisms, and Dr Pieter De Maayer, Research Fellow at the Centre for Microbial Ecology and Genomics (CMEG).

Geobacilli live in environments where temperatures exceed 65˚C, such as hot springs, the edges of volcanoes and compost. Dr De Maayer's research involves the use of cutting-edge omics technologies to unlock this microorganism's potential for the biological production of alternative energy sources. His principal approach is the use of comparative genomics, where alignments of full genome sequences from multiple organisms can reveal the unique genetic elements responsible for adaptation and performance.

Over the course of his academic career, Dr De Maayer has worked on different aspects of microbiology, biocontrol, microbial systematics and taxonomy, and plant pathogenic bacteria, but it's in the field of microbial biotechnology where he feels most at home. "Using microorganisms to finding sustainable, environmentally-friendly and often cheaper methods to produce almost anything is highly attractive, so their biology and functioning need to be researched," he says.

Supported by Prof Don Cowan at CMEG, he has been studying how *Geobacilli* can effectively degrade hemicellulose (a plant cell wall polymer) into simple sugars, which in turn can be converted into ethanol – and ethanol can be used as a sustainable biofuel. "The discovery led me to the idea to genetically engineer a hemicellulose superdegrader *Geobacillus* strain. It will be able to convert multiple types of hemicellulose found in mixed sources, such as municipal and agro-forestry waste," explains Dr De Maayer. This strain is currently being developed.

He is also studying *Geobacillus thermoglucosidans* which can efficiently turn waste gases containing carbon monoxide into hydrogen gas. "As hydrogen is tipped as the alternative fuel for the future, I am collaborating with Prof Christoph Syldatk from the Technical Biology Group, Karlsruhe Institute of Technology (KIT), Germany on the hydrogen production work," he notes. Dr De Maayer's ultimate goal is to patent or commercialise hydrogen-producing Geobacillus strains.

In 2014, this emerging researcher published 10 papers in peer-reviewed journals and two book chapters. One of these was a major review article, which he co-authored on the adaptation mechanisms used by microorganisms living in cold environments. He also obtained an NRF Research Career Advancement Fellowship.

"I have studied at a number of different institutions. However, nowhere have I felt as at home as at UP. UP is fully embracing novel, cutting-edge technologies, which means it will rise to the top as an academic and research institution," he concludes.

"I have studied at a number of different institutions. However, nowhere have I felt as at home as at UP."

Dr Pieter De Maayer

Grey leaf spot disease in maize production

Research led by **Prof Dave Berger** in the Department of Plant Science and member of the GRI, addresses the grey leaf spot disease in maize that affects both commercial large-scale farmers and small-holder farmers.

Cercospora zeae-maydis and *Cercospora zeina* are two distinct fungal species known to cause the matchstick-like grey leaf spot (GLS) lesions on maize leaves. Commercial farmers control GLS to some extent with fungicide sprays, a solution not readily available to small-holder farmers. Increasingly alternatives to chemical control are sought.

The development of maize varieties with resistance to GLS is therefore an attractive goal.

Prof Berger was awarded a US Department of Agriculture Norman E Borlaug International Agricultural Science and Technology Fellowship. Hosted by Dr Burt Bluhm, a leading international researcher in the genetics of fungal pathogens of crops at the University of Arkansas, the fellowship has enabled Prof Berger and his Molecular Plant-Pathogen Interactions group to focus on the fungus *C. zeina*, the causal agent of this disease in Africa.

The genome sequencing of an African isolate started in 2014. Genome assembly and annotation have been carried out in collaboration with **Yves van der Peer**, Professor in Bio-informatics and Genome Biology, and Group Leader of Bio-informatics and Systems Biology, Ghent University, Belgium, who also holds a joint appointment at UP.

This collaborative research, in which **Dr Bridget Crampton** of the Department of Plant Science and FABI is also involved, investigates the pathogenicity mechanisms and population genetics of *C. zeina*. The long-term aim is to find weaknesses in the armoury of the fungus that can be exploited to develop novel control strategies.

The results of this study have also been implemented in the maize breeding programmes of PANNAR Seed. A feature of this project is that postgraduate students not only work in the laboratory, but are also exposed to field work in the context of the maize industry. One PhD (Bioinformatics) and three MSc (Biotechnology) students recently graduated from the programme. Two of the MSc students are now working at patent law firms, and the third is special projects manager at a local biotechnology company.

Bacterial genomics

Prof Lucy Moleleki is in the Department of Microbiology and Plant Pathology.

Prof Lucy Moleleki in the Department of Microbiology and Plant Pathology, is the research group leader of bacterial genomics and host pathogen interactions in FABI.

Her research addresses important pathogens of potatoes specifically the root knot nematodes (*Meloidogyne spp*) and soft rot/blackleg-causing bacteria (*Pectobacterium spp*). There are two major components: to understand virulence mechanisms of soft rot pathogens and how these bacteria interact within their major host potato; and also to study host defences in potato plants elicited by the soft rot pathogens. The second focus is on root knot nematodes of potatoes, work that is undertaken in collaboration with various research teams internationally.

Research findings are regularly communicated to potato growers in South Africa to help them manage these important diseases. Furthermore, by publishing results in high-impact journals the researchers are able to reach the wider scientific community.

The Plant Pathology Programme

Soil- and seed-borne diseases are one of the most limiting factors in the production of potatoes and hence the importance of the Potato Pathology Programme @ UP. The programme conducts research into potato diseases and also houses a diagnostic clinic for plant diseases, specifically potato diseases.

Prof Jacquie van der Waals, her research team and postgraduate students focus on the epidemiology, diagnosis and control of pathogens in order to improve management in the field. Various techniques are combined to better understand disease spread and the interaction of host and pathogen. Research findings are ultimately used to provide growers with a risk assessment.

Prof van der Waals has strong collaborations with researchers in Scotland, The Netherlands, Israel, Poland and Zimbabwe and also works closely with several colleagues at UP and at the Agricultural Research Council.

Adapted from: http://www.up.ac.za/en/plant-science/article/2133331/prof-jacquie-van-der-waals

Sorghum fields in Limpopo

In collaboration with **Prof Jacquie van der Waals** in the Department of Microbiology and Plant Pathology, CMEG researchers aim to identify the core microbiota associated with some of the most important crops produced in South Africa – sorghum, maize and potatoes.

Root-associated microbes influence the fitness of their host plants, either negatively, by acting as pathogens, or positively, by increasing the stress tolerance of the plant, assisting with the uptake of phosphorus and nitrogen, producing phytohormones, or reducing the infection of plant tissues by pathogens.

A comprehensive understanding of the 'root microbiome' and its activity has the potential to provide new insights into the biodiversity of agricultural ecosystems, as well as opportunities for increasing crop production.

Photo by CMEG

Fairy circles – the debate continues

How can the phenomenon of fairy circles be explained? Three groups of researchers at the University of Pretoria have evidence for different mechanisms that might be the cause of the mysterious fairy circles of Namibia.

In the Namibian desert along the coast from southern Angola to just across the border into South Africa is a phenomenon of barren patches – now commonly named 'fairy circles'. Several diverse hypotheses for these strange barren patches have been put forward, but none have universally been accepted.

Prof Marion Meyer and **Drs Senejoux** and **Heyman** from the Department of Plant Science have investigated a possible link between the fairy circles of the Garub region (between Aus and Luderitz) and a poisonous succulent plant, *Euphorbia gummifera*. They collected soil samples to look for the 'footprints' of this plant possibly left behind inside the fairy circles. With the use of GCMS trace analysis they could identify euphol, a characteristic triterpenoid of the *Euphorbia* genus, in all soil samples from inside the fairy circles. Only trace amounts of euphol could be found in a few samples from outside the fairy circles, implying that this plant was present where there are now fairy circles.

Conversely, **Prof Egmont Rohwer** and his colleagues in the Department of Chemistry have evidence that subterranean gas seeps may be implicated in fairy circle formation. Highly sensitive spectroscopic analyses of gasses collected from fairy circle soils, and from control soils outside the circles, have shown the presence of hydrocarbons unique to the fairy circle sites.

Prof Don Cowan and his CMEG research team have entered the debate with another theory. They argue that the behaviour of fairy circles (which are 'born', 'grow' and eventually 'die') is reminiscent of inhibition circles around toxin-producing microbial cultures. CMEG honours student Annelize Pienaar and Research Fellow **Dr Jean-Baptiste Ramond** used modern phylogenetic methods to investigate the bacterial and fungal diversity of fairy circles and control soils. While there are clear differences (published in *PLoS One* in 2014), the authors have yet to confirm 'cause and effect'.

THEME 3

PEOPLE, PLANTS AND ANIMALS

Killer whales and penguins being studied as part of the Marion Island Marine Mammal Programme.

Photo by Nico de Bruyn

The widely used term, the Anthropocene, refers to the current age during which humans profoundly influence dominant geological conditions and processes. By definition this denotes a period in the history of the Earth where humans have a more dominant average impact on the earth than any other force of nature. There is a wide recognition that the pace of change is increasing, that we face novel, unpredictable futures both ecologically and socially, and that these are interconnected. It is thus urgent to overcome the prevalent division of Nature and Society that impacts our thinking, our research and our policies.

The coming of the Anthropocene has depended deeply on the domestication of animals and plants. A relatively small number of these domesticated organisms have been the foundation that provided the nutrition, energy and other products and services that sustained the global development of the civilisations we know today. Societal development has also depended heavily on non-domesticated animals and plants for various indirect, yet critical, products and services.

Understanding the trends in how humans interact with nature, how we can alter the course of our usage patterns, improve efficiency of production, yet reduce our impact on Nature and preserve the remaining biodiversity, is more urgent today than ever before.

The University of Pretoria has a particularly strong research focus on interactions between humans and animals, domesticated and non-domesticated. Not only do these studies open worlds of wonder, but they contain the insights to avoid human disaster as well as to conserve these natural treasures. These studies cover a broad base, from bees with sophisticated societies to elephant seals and their intricate family structures, from protecting whales and rhinos to horses, from understanding the evolution of animal societies to managing the threat of human disease epidemics linked to bats or birds, and more.

Photo by Christian Pirk

The Social Insect Research Group

Honeybees are major pollinators of both native flora and agriculturally important crops and there has been a growing appreciation for the dependence of people on the food provided by the fruits and crops pollinated by bees. The results of research at UP will provide an answer to the question of declining honeybee populations, at least on the African continent, and more.

In addressing concerns about the welfare of honeybee populations, the **Social Insect Research Group** (SIRG) at UP is studying the epidemiology of bee diseases and parasites, and monitoring the population densities of honeybee colonies in undisturbed habitats to establish what fluctuations are occurring in the wild population of colonies. The wild population of colonies is the crucial resource required for crop pollination in agriculture and for providing livelihoods for beekeepers.

The bee colonies have recently been threatened by several parasites and diseases that are affecting the colonies of commercial beekeepers, and whose effect on the wild population is poorly understood. Bees are also threatened by climate change and land transformation.

The work undertaken by the SIRG ranges widely – from investigating bee diseases and parasites and exploring the chemical ecology of relationships between queens and workers through the use of pheromones in populations of honeybees throughout the African continent; to analysing genes responsible for the expression of a variety of social behaviours; assessing population densities and distribution within South Africa; and focusing on honeybee nutritional physiology to understand their ability to withstand pesticides and toxins in the agricultural environment.

Research also focuses on the socially parasitic Cape honeybee workers that are unique to South Africa. They have invaded and destroyed colonies of their neighbouring subspecies and have significantly disrupted the local beekeeping industry. The knowledge gained from studying these parasitic workers has helped inform beekeepers of the methods to avoid spreading these parasitic worker bees to host colonies. Also, this example of social parasitism has allowed researchers to gain insight into the evolution of social parasites and the regulation of worker reproduction in honeybee colonies that allows for a richer understanding of the evolution of social behaviour in insects.

Members of the SIRG include **Profs Robin Crewe**, **Sue Nicolson**, **Christian Pirk**, and **Drs Fabien Démares**, **Hannelie Human** and **Abdullahi Yusuf**, close on 20 postgraduate students, and several international visitors and students. In 2014, the group published more than 16 publications, including in **Nature Genetics**, a monograph on honeybee nests published by Springer, joined a global network on pollinator losses, and participated in the first Chinese-South African workshop on honeybee reproduction.

Dr Abdullahi Yusuf, Research Fellow at the Department of Zoology and Entomology.

INTERVIEW

Conserving African honeybees

Essential in solving environmental challenges is a deeper awareness of the behaviour and chemistry of living organisms. This allows for biological control agents to be developed that provide sustainable environmental solutions without having to resort to synthetic compounds. For Dr Abdullahi Yusuf, Research Fellow at the Department of Zoology and Entomology, this is the ultimate aim.

Dr Yusuf's work focuses on the behaviour and chemical ecology of social insects, as well as improving bee health and conserving African honeybees. His areas of interest include pheromone communication and reproductive dominance in honeybees, ants and termites.

In 2014, Dr Yusuf published work on olfactory detection of prey by the Matebele ants, as well as details of its prey choice and raiding behaviour. These ants are potential candidates in the search for alternative, environmentally-friendly termite control methods, he explains.

His research on the pheromones of the West African honeybees was also published. "The message is that although honeybees appear similar, they are indeed different. Hence, moving or replacing native sub-species with non-native ones could pose a threat to biodiversity and conservation."

Dr Yusuf first came to UP in 2007 as a PhD student under the International Centre of Insect Physiology and Ecology African Regional Postgraduate Programme in Insect Science. He is part of the dynamic multidisciplinary Social Insects Research Group (SIRG) and comments as follows on UP's research environment:

"UP provides an ideal research environment where one can interact, share ideas and learn from experts from various fields. Within our department you have the opportunity to work with physiologists, ecologists and conservation biologists. There are geographers/ Geographical Information System (GIS) experts next door, and chemists and mathematicians just across the road. This is quite unique," he says.

"UP provides an ideal research environment where one can interact, share ideas and learn from experts in various fields."

Dr Abdullahi Yusuf

The Mammal Research Institute

The Mammal Research Institute (MRI) at UP is approaching its 50th anniversary at UP and has distinguished itself as the 'go to' African mammal institute for consultancy, training and research with an output of over a 100 peer-reviewed publications in 2014.

The MRI is directed by **Prof Robert Millar** who has published over 400 articles in international journals. The MRI is pan-African in its research and training, with activities extending across Southern and Central Africa to West Africa, Ethiopia and the Southern Ocean. International collaborations exist in all continents, and postgraduate students and research fellows reflect this diversity, making the MRI a truly international training ground.

The MRI currently has 18 postdoctoral fellows, 37 PhD students and 48 master's students enrolled, as well as several externally enrolled students under MRI co-supervision. The number of MRI associates and members varies between 30 and 50.

The impact and relevance of MRI research is reflected in four overarching themes:

- Systems ecology and conservation management;
- Marine mammals as bio-indicators of ocean health;
- Social and physiological adaptation to environmental impact; and
- Infectious diseases at the wildlife-livestock-human interface.

Four examples are chosen as illustrations of research conducted under these themes.

MammalMap

MammalMap is a joint initiative of the Mammal Research Institute at the University of Pretoria, and the Animal Demography Unit at the University of Cape Town. Through collaboration with scientists, conservation organisations, wildlife authorities and citizen scientists across Africa, all reliable evidence of current mammal occurrence is consolidated into a single open-access database.

The project has been enormously productive with its significance evident at multiple levels. Some of the highlights for 2014 are the increase in the number of mammal distribution records from less than 7 000 in late 2012 to over 45 000 by April 2014, and the partnership with the Endangered Wildlife Trust and the South African National Biodiversity Institute that has led to the South African Red Data List for Mammals being revised.

MammalMap has made impressive inroads into quantifying mammalian specific distribution and numbers, with the project directly contributing to the IUCN red list of endangered species.

Photo by Ryan Reisenger

The Marion Island Marine Mammal Programme

The **Marion Island Marine Mammal Programme** (MIMMP) – one of the flagship programmes of the Mammal Research Institute – has been the focus of an unprecedented research endeavour for more than three decades. The focus is on species ecology and species responses to natural and human-induced stressors in a changing environment.

Since 1983 researchers have studied killer whales, the Southern elephant seals, and Antarctic and sub-Antarctic fur seals on the remote Marion and Prince Edward Islands.

"This is the only long-term project of its kind where intensive research is conducted year-round on multiple top predators from one sub-Antarctic site – and by one comparatively small team," says **Dr Nico de Bruyn**, the principal investigator. "I foresee an exponential increase in our ability to address internationally-relevant ecological, global change and other environmental questions."

In this relatively uninterrupted marine habitat, indicators of negative change in this eco-system act as an early warning system for ecological and environmental change in more complex systems.

"We know, for example, that elephant seal numbers declined dramatically probably due to food limitation. They are now slowly recovering. However, with new information that the youngsters consume large amounts of krill, they may be under threat again with increasingly large krill fisheries in the Southern Ocean.

"This, together with our other findings provides information about how mammals respond to changes in the environment. It can be translated directly to how other populations, including humans and their primary food

2014 highlights for MIMMP

- It is now the most intensive and longest running of its kind in the world;
- Continuing with satellite-linked tracking on elephant seals, fur seals and killer whales to assess their movements and interactions with the oceanscape;
- Appointing field personnel for the 73rd South African expedition in 2015 – as part of their commitment to capacity building (83 individuals have participated in these expeditions over the past 32 years); and
- Continuing to collaborate with five leading Antarctic research nations (UK, Australia, Germany, the US and France).

Equally important, by training field personnel and students, the programme prepares the next generation of decision-makers and builds capacity for a growing science sector in South Africa.

stocks, respond to changes."

One of the articles published in 2014 was on the bizarre coercive mating behaviour of fur seals with king penguins. This aberrant behaviour has captured the imagination of the popular media and the scientific press, with several international interviews and media reports exploring the possible and plausible reasons for such wayward behaviour. What could be the possible advantage to the seals?

This mating across different classes of vertebrates is completely new to science.

The tentative conclusions are that this emergent behaviour may be learned behaviour, associated with some reward, or it may be an extreme case of reproductive interference, which could be explained by the 'mate deprivation hypothesis', given an increase in fur seals.

Photo by Nico de Bruyn

Marion Island's geographical position is vital in driving global climate patterns.

Photo by Nico de Bruyn

"How to weigh an elephant seal with one finger"

A single photographer with a measuring stick and ordinary digital photographic equipment can determine the mass of an elephant seal anywhere in the field with the push of a button.

This is how **Dr Nico de Bruyn**, lead researcher in the MIMMP, and fellow researchers capture the benefit of photogrammetry as a means of determining the mass of animals in the wild. The size and weight of animals are important variables in determining population processes, ecosystem changes such as food availability, and survival and reproduction.

While several studies have developed photogrammetric techniques for indirect mass estimation, many require sophisticated, custom-designed equipment or analytical tools, which limit their applicability in a variety of field scenarios. The new method centres on animal volume estimation in relation to the three-dimensional area around it, rather than features of the animal itself. It means that weight can be calculated, using measurements taken from photographs.

This powerful technique is increasingly used by MRI researchers to study the body mass of marine and terrestrial mammals non-invasively in field studies.

The southern right whale survey

For the past 37 years, the Mammal Research Institute's Whale Unit, led by **Dr Ken Findlay**, has conducted an annual survey of the southern right whale population. This is one of several research programmes centred on conservation research and the status of the coastal marine mammal populations in relation to current anthropogenic impacts.

The survey is carried out by helicopter along the South African southern Cape coastline between Muizenberg and Nature's Valley in October each year, and all encountered mother and calf groups are photographed from above. The distinctive colouration or pigmentation markings on their backs and pattern of wart-like callosities on their heads make it possible to identify individuals and to track their reproductive history, movement and migration patterns through repeat photography across years. The survey data consequently provide a suite of information on the vital parameters of the population, including abundance, population growth rate, survival, calving intervals and the age when a female calf first returns with her calf. Each survey's collected identification photographs are added to the Mammal Research Institute's catalogue of identification photographs, now numbering about 1 700 recognisable adult whales.

The ongoing dataset emphasises the good news that the SA population has steadily increased by just under 7% per annum from an all-time low of a few hundred when whaling on right whales stopped in 1935. This population is now in the region of 5 000–6 000 individual southern right whales, of a total global population of about 15 000.

The surveys have over the last three years been sponsored by member companies of the Offshore Petroleum Association of South Africa (OPASA).

Dr Ken Findlay photographs southern right whales from the open rear starboard door of a helicopter.

A group of two adult southern right whales with a white calf photographed off Pearly Beach in October 2014. Approximately 4% of calves each year are born with such white colouration to mothers with grey markings on their backs.

Nigel Bennett, an A-rated scientist, is Professor of Zoology at the University of Pretoria, holds the DST-NRF SARChI Chair in the field of Mammalian Behavioural Ecology and Physiology and the UP Austin Roberts Chair of African Mammalogy. He annually visits the mountain gorillas in Rwanda and Uganda and uses these visits to enjoy the wonderful fauna that Africa has to offer. In his opinion Africa has the most interesting and unusual mammals and he believes there are numerous world-class research projects that can be conducted on Africa's amazing fauna.

Small mammals – solitary and social

Some African mole-rats are solitary and others are social, occurring in colonies where reproduction is restricted to a single female and two male consorts. **Prof Nigel Bennett** and his co-workers have been trying to unravel why some species are solitary and others social. They have also pursued how the breeding female suppresses reproduction in non-breeding females.

Nigel Bennett's research focus is ecology, animal physiology and behaviour and he uses the African mole-rat as his model animal. Through this work, Bennett has come to understand that it could be the food resource distribution and the pattern of rainfall that dictate whether the mole-rat is solitary or social. Furthermore, in the social species, the breeding female somehow appears to bring about reproductive suppression by a physiological mechanism in the most social of mole-rats.

Unlike other researchers investigating co-operative breeding in mammals, Bennett has undertaken a multifaceted approach that has led to an integrated understanding of reproductive suppression in mole-rats. His work has set the benchmark in understanding the phylogenetic and ecological constraints regulating reproductive success and social evolution in mammalian species and his research record ranks him among the best researchers studying social regulation of reproduction in any group of mammals in the world.

Ultimately, it is the environment in which the mole-rats occur that has shaped the pattern of sociality exhibited by the various species. Africa has a diversity of underground storage channels throughout much of the continent south of the Sahel, and it is this food resource, its distribution, and the size of the food resource that have shaped social evolution in this subterranean endemic family of rodent moles.

Oxidative stress (OS) also can have a dramatic effect on reproduction. Increased reproductive effort is linked to a reduction in survival and it is proposed that OS may influence this relationship. A number of markers of OS were analysed in the breeding females and non-breeding females and it was found that breeding females had reduced oxidative damage compared to non-breeding females. This in turn may promote the longer lifespans of breeding females.

Sex allocation theory suggests that mothers benefit from adjusting the sex ratio of their offspring. In cooperative breeders mothers are expected to bias the sex ratio in relation to their current needs. This as group size increases, sex ratio are predicted to be biased towards the

Photo by Dr Maria Oosthuizen

sex more likely to disperse. "We found, from an extensive study straddling two decades from pups born and reared in the laboratory, that the number of male pups born increased with the number of female helpers, but decreased with the number of male helpers."

Ecosystem engineers – shaping vegetation and soils

Ecosystem engineers are organisms that create new habitats through their activities, often increasing the heterogeneity of environmental conditions and the diversity of the associated fauna and flora.

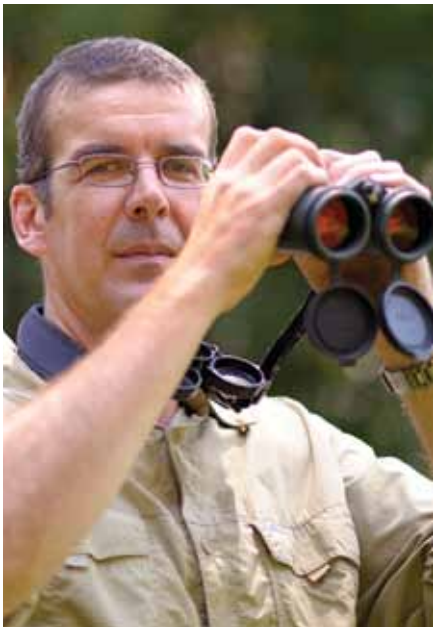
Burrowing mammals such as aardvark, meerkats and mole-rats may be particularly effective ecosystem engineers, and form the basis of a collaborative project between **Dr Natalie Haussmann** in the Department of Geography, Geoinformatics and Meteorology, and **Dr Peter le Roux** in the Department of Plant Science.

Examining the impact of animal burrows on micro-climate, soil characteristics, plant abundance and vegetation composition gives an understanding of how large an ecological impact just one species can have – and highlights the conservation value of ecosystem engineers. For example, aardvark burrowing is important for the occurrence of several grassland plant species, and the loss of this ecosystem engineer could therefore have negative impacts on environmental diversity and on other organisms.

A preliminary investigation into the ecological impacts of aardvark burrowing in savanna, suggested that burrowing negatively affects vegetation cover and plant species richness. This research is now being expanded to consider how environmental conditions may alter the impacts of burrowing mammals, comparing sites from the Karoo, the Kalahari and the Highveld grasslands.

Currently six postgraduate students are involved with the project, working on topics ranging from the impact of burrowing mammals on the success of invasive plants, to farmers' perceptions of burrowing in an agricultural context. Undergraduate students are purposefully involved in this project to expose them to research in action and to foster an interest in environmental studies.

Photo by Peter le Roux



Prof Andrew McKechnie is in the Department of Zoology and Entomology at UP, and a core member of the DST-NRF Centre of Excellence at the Percy FitzPatrick Institute.

Photo by Adam Riley

Birds and climate change

The question of whether birds have the physiological potential to cope with warmer temperatures is one of the focal points of the Hot Birds Programme that involves researchers from the University of Pretoria, collaborating with national and international institutions.

Prof Andrew McKechnie points out that this is not a trivial question to answer, with his research team's work focussing on how birds are likely to respond to a warming world. Professor McKechnie is a core member of the DST-NRF Centre of Excellence at the Percy FitzPatrick Institute, and of the Department of Zoology and Entomology in the Faculty of Natural and Agricultural Sciences at UP.

The focal species for the research into the effects of climate change is the White-browed Sparrow-weaver *Plocepasser mahali*. He notes that besides being abundant in habitats ranging from the hot, arid Kalahari Desert to mesic savannas and woodlands, the sparrow-weaver's habit of roosting communally in distinctive and conspicuous nests makes it a highly tractable study subject.

The starting point has been to ask just how much physiological variation there is within bird species that occupy a wide range of habitats and climates. In order to quantify this variation, the researchers have worked at three sites that differ considerably in seasonal temperature extremes: the Kalahari Desert and two sites with comparatively mild summer maximum temperatures.

Heat tolerance and evaporative cooling capacity is measured by progressively exposing sparrow-weavers to higher air temperatures while measuring their body temperature and the rates at which they dissipated heat via evaporation, without exposing them to potentially dangerous levels of heat stress.

The distinction between genetic adaptation and phenotypic plasticity (resilience to environmental change) has important implications, with this work providing new insights into how birds' physiologies are shaped by their environments, and how they are likely to respond to a warming world. The results of the work in 2014 showed that, during summer, Kalahari sparrow-weavers can handle temperatures of up to four degrees higher than the populations in the milder regions, thus providing the first evidence of seasonal acclimatisation in avian heat tolerance.

Adapted from an article written by PhD student Matthew Noakes and Professor McKechnie, published in African Birdlife.

Plants – species diversity and function

The field of ecology and conservation relies heavily on measuring diversity based on the identity of species – which species and how many. However, there is a strong push also to consider the function of species.

Dr Michelle Greve and postgraduate students in the Department of Plant Sciences are running a number of research projects that use plant functional traits to assess conservation threats. A project in the highly fragmented Limpopo grasslands is studying the effects of extensive landscape transformation on species diversity and on the number of functions that are being carried out. The research shows that fragmentation of the natural habitat not only results in the loss of species, but also in the reduction of functions that are being carried out in the system.

In another project, Dr Greve and her team are assessing whether plant invasiveness can be predicted by functional traits in a cold environment. This study has shown that weedy fast-growing species are particularly successful invaders. It appears that the adaptations that have allowed the native species to establish and survive in these cold environments are becoming redundant; under warmer conditions weedy species are starting to dominate.

The animal-human-environment interface

On average, the emergence of new diseases occurs every eight months, of which more than 70 per cent originate as animal diseases. Animal hosts often act as reservoirs for pathogens, or transmit the disease to other species. Over 60 per cent of all known pathogens affecting humans are zoonotic.

This overlap in veterinary, human and ecological health sciences is at the heart of the 'One Health' concept. Research in this area draws on the strengths of the faculties of Veterinary Science, Health Sciences and Natural and Agricultural Sciences. Illustrative examples give some indication of the advances made at UP in the focus on disease control.

Rabies-related research

Rabies remains an important disease in South Africa and in many other regions of the world, and especially so in rural areas where there is limited control of the dog population.

The recent rabies outbreak in the KwaZulu-Natal region in South Africa illustrates that key to rabies-related research is the active surveillance of endemic rabies infection cycles, coupled to a dog rabies elimination programme.

The programme is directed by **Prof Louis Nel** from the Microbiology Department in the Faculty of Natural and Agricultural Sciences. His longstanding international involvement in this research has secured him a high level of international standing and support, including support from the Bill and Melinda Gates Foundation (BMGF).

The objective of the research is to control the disease by exploring the feasibility of eliminating dog rabies. The research has important social, scientific and economic impact. Earlier outbreaks of rabies in KwaZulu-Natal have triggered a range of government-associated initiatives that are now closely linked to the UP rabies programme, illustrating the impact of this research.

The rabies control programme of Prof Nel has now also evolved to include the development of new recombinant rabies vaccines that will not only protect against infection with rabies virus but will also provide an immuno-contraceptive effect.

The epidemiology of viruses associated with bats

The recent outbreaks of the Ebola virus and other viruses that are transmitted to humans via bats have highlighted the importance of the molecular characterisation and surveillance of zoonotic pathogens associated with bats. Researchers at the University of Pretoria have made great progress in this important area of study.

The research of **Prof Wanda Markotter** in the Department of Microbiology in the Faculty of Natural and Agricultural Sciences is focused on the epidemiology and pathogenicity of rabies and rabies-related lyssaviruses unique to the African continent. With all the emerging zoonotic diseases that may affect humans, it has become an important research topic of large international interest.

Several important zoonotic viruses were found in South African bat species, including viruses related to rabies and Marburg viruses. These findings have important public and veterinary health implications as some of the viruses were thought to occur only in tropical regions whereas others have never previously been associated with this bat species in southern Africa. This research also demonstrated the seasonal fluctuation of these viruses within this population. This observation can help identify the high risk period for spill-over to other animals and humans.

INTERVIEW

Bats, viruses and understanding illnesses

"Almost three-quarters of emerging infectious diseases in humans come from animals (zoonotic) and the origin of several of these is unknown. Therefore, it's becoming increasingly important to learn more about viruses and other pathogens to protect human health," says Wanda Markotter, Associate Professor in the Department of Microbiology and Plant Pathology, who has been doing just that.

In 2014 Prof Markotter was one of the recipients of UP's Exceptional Young Researchers award, as well as the TW Kambule-NSTF Award for an emerging researcher for her work in the field of zoonotic viruses

Committed to building capacity in her field, Prof Markotter shares her passion through postgraduate student training. In 2014, two of her PhD students joined the South African Ebola Mobile Laboratory team deployed to Sierra Leone during the Ebola outbreak. This opportunity arose through collaboration between her Viral Zoonoses Group (VZG) and Prof Janusz Paweska from the Centre for Emerging Zoonotic Diseases (CEZD) at the National Institute for Communicable Diseases.

"Our students' participation in Sierra Leone is an example of how UP is involved in capacity building and making a difference," says Prof Markotter. "The students were chosen because they have been trained in working in high biosafety environments, a chance few receive." In 2014, the NRF awarded Prof Markotter and Prof Paweska a capacity building grant to continue this kind of training.

"Looking ahead, my research will focus on the complete ecosystem instead of just pathogens. This will enable us to make more informed decisions about control and prevention," she concludes.

Ticks and tick-borne diseases

Ticks and tick-borne diseases place a major constraint on livestock production in South Africa. A provisional estimate of revenue lost due to cattle deaths ranges between R1,3 billion and R3,7 billion per year.

Prof Christine Maritz-Olivier and student.

The research team directed by **Prof Christine Maritz-Olivier** in the Faculty of Natural and Agricultural Sciences has made substantial progress with research that will pave the way for the development of a vaccine for use in most cattle breeds of southern Africa. The development of immune-biomarkers for pre-screening recombinant antigens has enabled the group to circumvent costly animal vaccine trials by prioritising the best vaccine candidates. This programme is supported by the Tshwane Animal Health Biocluster.

In addition to the anti-tick vaccine programme, research has focused on a vector control programme, as well as on evaluating various components that play a role in disease control.

For example, the research of **Prof Marinda Oosthuizen** on a vector-borne diseases programme involves the molecular characterisation of parasites, mostly through the 18S ribosomal RNA gene. Significant improvements in molecular diagnostic assays promise to make an important contribution in detecting parasites and in infections that play a role in the spread of disease.

Photo by Thomas Barry

African horse sickness

The University of Pretoria has had a longstanding research focus on the molecular biology of African horse sickness virus (AHSV) and other orbiviruses. All of these research activities are focused on trying to understand how the virus replicates and developing diagnostic and vaccine strategies for disease control, as well as other methods to prevent the spread of the disease.

The following examples illustrate some of the progress made in 2014 with respect to research on African horse sickness.

One of the major aims of the research group, directed by **Prof Jacques Theron** in the Department of Microbiology in the Faculty of Natural and Agricultural Sciences, has been the development of technology that enables researchers to fully construct a genetically modified version of the virus.

This technology is the key to developing safe effective vaccines and studying the highly pathogenic characteristics of the virus.

Excellent progress has been made with a programme, first supported by the Animal and Zoonotic Diseases institutional research theme, and subsequently by the Tshwane Animal Health Cluster. The group has also made progress in applying this technology in vaccine development relevant to bluetongue virus.

A bioinformatics modelling approach

Research on AHSV has been further expanded by the research carried out by **Dr Vida van Staden** in the Department of Genetics in the Faculty of Natural and Agricultural Sciences. Her research group has combined a bioinformatics modelling approach with experimental verification to address a longstanding question on African horse sickness virus, and its pathogenicity.

The group also identified and published the characterisation of a new non-structural protein of AHSV that may play an important role in the way horses protect themselves against viral infection.

Horses in transit

On a much more applied level **Dr Patrick Page**, and his team at the **Equine Research Centre**, have conducted research on the possibility of ensuring that horses in transit are kept isolated from the *Culicoides* biting midges that are responsible for transmitting the virus to horses. Two papers addressing such a midge-proof strategy have been published: on insecticide-treated high-density polyethylene mesh to protect against biting midges; and the treated mesh applied to jet stalls housing horses.

The World Organisation for Animal Health (OIE) has now included recommendations that this mesh, impregnated with an approved insecticide, be placed over containers during transport of horses through regions not free of AHSV.

Transfrontier Conservation Areas

Transfrontier Conservation Areas (TFCAs) are large protected areas that straddle frontiers between neighbouring countries, allowing wildlife to move freely between protected areas on either side of the border.

The Faculty of Veterinary Science is involved in multiple TFCAs – in South Africa, Mozambique and Namibia and Botswana – exploring the impact of TFCA development on impoverished people, livestock management and development, and wildlife as an economic resource.

Some species of wildlife, particularly the African buffalo, are reservoirs of pathogens such as foot and mouth disease (FMD) that may infect cattle. To reduce the risk of FMD in livestock, countries that export beef to Europe and elsewhere maintain zones around these wildlife areas and prevent the trade of susceptible livestock out of these regions. The result of this policy is economic deprivation for farmers living in these TFCAs as their market access is severely constrained and their livestock value is markedly reduced.

Recently, as a result of extensive research and lobbying by **Prof Gavin Thomson** and colleagues, the World Organisation for Animal Health (OIE) amended its regulations to allow alternatives to zones as FMD risk mitigation measures and, consequently, less punitive measures for farmers in TFCAs.

The Mnisi Community Programme

Research in several transfrontier conservation areas informed the development of the Mnisi Community Programme, a One Health initiative and research platform in a poverty node alongside the Kruger National Park in South Africa. The platform is investigating a wide range of conditions that affect people, livestock, wildlife and the environment. Research projects range from investigating febrile conditions in people to dog ownership practices and management of rangeland, all with the ultimate view of improving the livelihoods of people in the area.

The Mnisi Community Programme now hosts over 60 projects and is attracting growing international interest.

Conservation research and wildlife management

The Game Ranger Association of Africa (GRAA) honoured two of our veterinarians, Drs Gerhard Steenkamp and Johan Marais (photograph above), for their efforts in protecting endangered species at the annual Rhino Conservation Awards Ceremony.

DNA typing

The Veterinary Genetics Laboratory (VGL) at UP is the world's leading laboratory in DNA typing of rhinoceros. Samples are taken for DNA analysis from live rhinoceros whenever they are tranquillised, or from animal carcases following poaching incidents. These are stored at the VGL and used to link rhino horn with animal carcases.

In 2014, an airline passenger in Singapore was found to have 22kg of horn from eight black rhinos. The VGL was able to show that one of the horns came from a rhino poached six days before in the Kruger National Park, illustrating not only the perverse efficiency of the poaching and smuggling operation but also the immense value of the VGL in linking rhino horn to crime scenes.

Saving the survivors

Two veterinary researchers, **Drs Gerhard Steenkamp** and **Johan Marais**, are the founders and drivers of Saving the Survivors. The project is directed at saving rhinos that survive poaching incidents, often with horrific facial injuries.

The treatment of large traumatic maxillofacial wounds in the white rhinoceros is challenging but the dedication of a team of veterinary doctors has led to the successful closure of the wounds with the possibility of rhino carrying on to live normal lives.

Of great pride to the researchers is that one of the rhino cows has subsequently fallen pregnant and given birth to a normal, healthy calf – a testimony to the skill, dedication and hard work of the vets aiding the survival of these endangered megaherbivores. Both veterinarians have won multiple national awards and their work has attracted international recognition and accolades.

Conservation of Vultures

Researchers in the Faculty of Veterinary Science have been deeply involved in the conservation of vultures. In the 1990s, vulture species endemic to Asia were reduced to near-extinction. The reasons for an extraordinary drop in numbers were at first unknown.

A series of investigations into possible causes led to the discovery that non-steroid anti-inflammatory drugs (NSAIDs) present in the meat of cattle carcasses were responsible. To relieve aged cattle from any physical pain, cattle owners were treating them with the NSAID diclofenac. The contaminated meat consumed by the vultures was causing renal failure and subsequent death. With the value of cattle far outweighing the perceived status of vultures, a suitable alternative had to be found for diclofenac.

As part of an international team, **Prof Vinny Naidoo**, Director of UP's Biomedical Research Centre, has led the way to finding suitable NSAID alternatives.

In 2014, Prof Naidoo co-authored a paper published in Science that highlighted where diclofenac is still licensed. The authors argued strongly for a One Health approach in addressing the problem, calling for stewardship that promotes environmental responsibility, involves all sectors of society and considers environmental effects during production, use and disposal of veterinary pharmaceuticals.

Making rhino horn in a dish

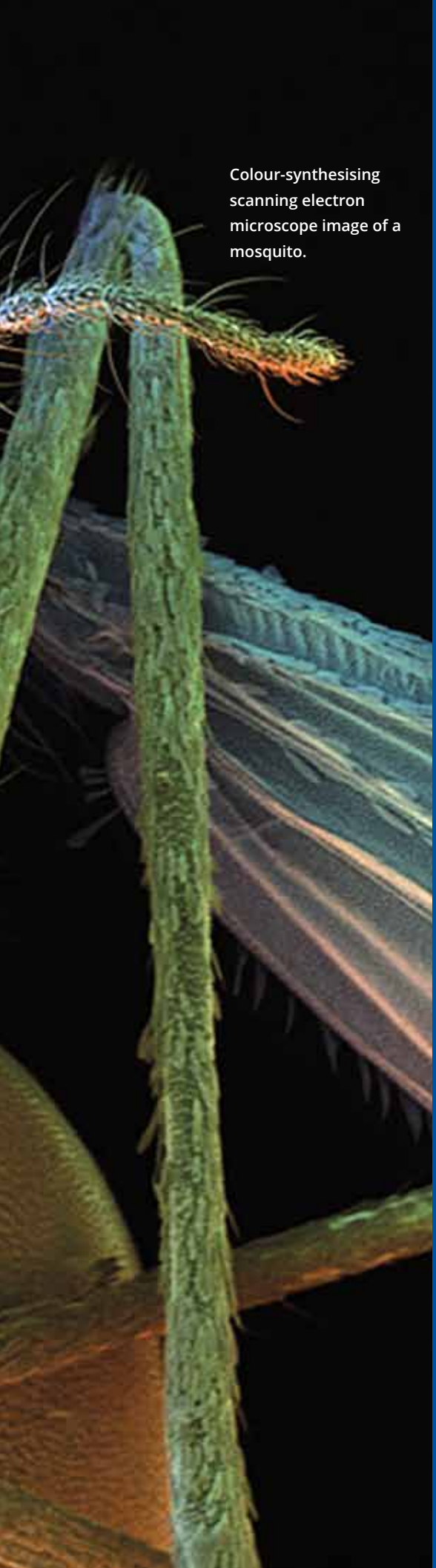
Prof Robert Millar at the Mammal Research Institute and collaborators have produced stem cells from southern white rhino skin cells, as well as from skin cells from the near-extinct northern white rhino in frozen storage for 25 years – an example of the 'frozen ark'.

The research team is currently differentiating the stem cells to melanocytes and keratinocytes to produce rhino horn in culture – a possible means to flooding the market and decreasing poaching.

They are also differentiating the stem cells from the northern white rhino into spermatogoa and oocytes (eggs) with the aim of transferring embryos to surrogate southern white rhino mothers – and thereby to re-establish the northern white rhino population.

THEME 4

HEALTH



Colour-synthesising scanning electron microscope image of a mosquito.

South Africa is unique in many ways and perhaps one of the less obvious is the opportunities it presents for high-quality, high-impact biomedical research. One of the factors that contribute to this opportunity is the great genetic diversity of our people. In addition, South Africa is faced with a heavy burden of disease, which includes diseases that are both communicable and non-communicable in nature. The former includes (but is not limited to) HIV, TB and malaria. Non-communicable diseases include obesity, diabetes, heart disease, hypertension and cancer. Research in the Health Sciences at the University of Pretoria is directed at addressing the national disease burden. Much of the high-impact research also has repercussions which go well beyond our shores.

The strategy during 2014 has been to move towards multidisciplinary research. This has yielded niche areas that contribute to UP being recognised internationally for its quality, relevance and impact, and also for developing people. In addition to investigator-driven research, several research entities embody highly relevant focus areas and a critical mass of researchers essential to the success of biomedical research.

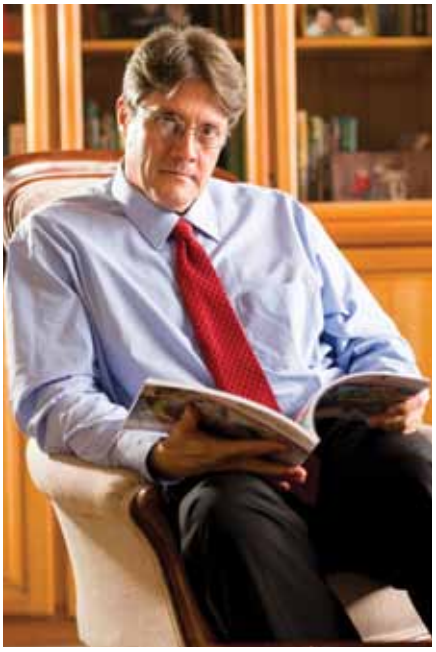
The Institute for Cellular and Molecular Medicine has four streams of research: stem cells, genomics, the neurosciences and infectious diseases.

The Molecular Imaging Research Centre at UP has strategically placed the University at the forefront of the continued global growth of new strategies to improve targeted molecular imaging and therapy in TB, HIV and cancer.

Lead entities in infectious diseases include the Zoonosis and Arbovirus Research Centre and the UP Centre for Sustainable Malaria Control (UP CSMC) designated in 2014 as one of the South African MRC Collaborating Centres for Malaria Research.

Environmental research initiatives study the effects of endocrine-disrupting chemicals that people are exposed to, most commonly through air, food and water, on the endocrine system. Complementary thereto is research conducted on bioprospecting; UP is involved in the discovery of natural products that can be developed as pharmaceuticals, herbal medicines, cosmetics and veterinary products based on South Africa's biodiversity and indigenous knowledge.

Establishing and consolidating a range of initiatives will ensure even greater research productivity in the years ahead, and will contribute to addressing health care challenges in South Africa, Africa and the rest of the world.



Prof Michael Pepper, Director of the Institute for Cellular and Molecular Medicine (ICMM).

Communicable and non-communicable diseases

Both communicable (infectious) and non-communicable diseases contribute to South Africa's disease burden. The University's Institute for Cellular and Molecular Medicine (ICMM) was born out of the realisation that to address the extent of this, a multidisciplinary approach would be necessary.

Prof Michael Pepper, Director of the ICMM, points out that the central philosophy is to begin with the patient and to address directly the issues at hand from a research perspective, the so-called 'bedside-to-bench' approach. This philosophy has worked well as the Institute continues to do groundbreaking research that will impact positively on the quality of life of patients, both locally and internationally.

At present, the ICMM has 22 research groups involving researchers from seven of the nine faculties at the University. This reflects not only the diverse nature of the core theme – molecular and cellular medicine – but also the necessity to address the complex nature of the problems being dealt with from different perspectives.

In addition to creating a culture of cutting-edge, highly competitive and high-impact research, the ICMM has received several high-profile grant applications. In 2014 this included the prestigious award by the Medical Research Council (MRC) of the Extramural Research Unit for Stem Cell Research and Therapy.

A distinguishing feature of the ICMM is the focus on student training and development as a priority. By placing students at the centre of the Institute's research endeavours, several critical needs are being met. These include much-needed capacity development; generating highly competent, autonomous and free-thinking individuals who are destined to take up leadership positions in society; and fostering research as a profession and not merely as a box that needs to be ticked as a requirement for progression up the academic ladder.

Harnessing the creativity and energy of fresh young fertile minds introduces a dynamism that extends the boundaries of the ICMM into previously uncharted waters.

In 2014 there were 169 postgraduate students distributed across the different groups in the ICMM. Outputs in 2014 included 92 original publications and 12 review articles in ISI-accredited journals, 12 book chapters, 10 publications in non-ISI accredited journals and 146 conference outputs.

Prof Michael Pepper is jointly responsible for the Southern African Human Genome Programme, which is a national multi-institutional programme initiated in 2011 funded by the Department of Science and Technology. The project aims to establish sustainable resources for human genomic research in the region, and to translate knowledge and information derived from the sequencing of southern African genomes into improvements in human health. Achievements to date include the sequencing and in-depth analysis of 24 southern African genomes and the initiation of a project that will provide a database of southern African exomes for scientists working in this region.

Addressing major diseases

The ICMM is involved in research into many of the major diseases. Three examples are given here to illustrate the levels of engagement and the international reach of research endeavours.

Human Immunodeficiency Virus – gene therapy trial

Longstanding collaboration with several Swiss and European universities aimed at rendering the immune system resistant to HIV is under way. This involves a gene therapy approach in which one of the HIV co-receptors (CCR5), responsible for HIV entry, is knocked down in hematopoietic stem cells. All of the progeny are therefore resistant to R5-tropic forms of HIV.

Highly promising pre-clinical data have been obtained and the group is now working towards initiating early phase clinical trials.

Obesity – a non-communicable disease with widespread consequences

Work is being conducted to model adipogenesis (the formation and growth of adipocytes or fat cells) to establish a high throughput screening system for identifying novel anti-adipogenic compounds.

Detailed maps of gene expression, as well as changes in the lipid profile of adipocytes during the course of differentiation, have been established.

Cancer – advances in diagnosis and treatment

Projects are under way to address the identification of novel anti-cancer agents, the validation of new diagnostic tools and the identification of the mechanisms of carcinogenesis in some of the more common cancers found in South Africa.

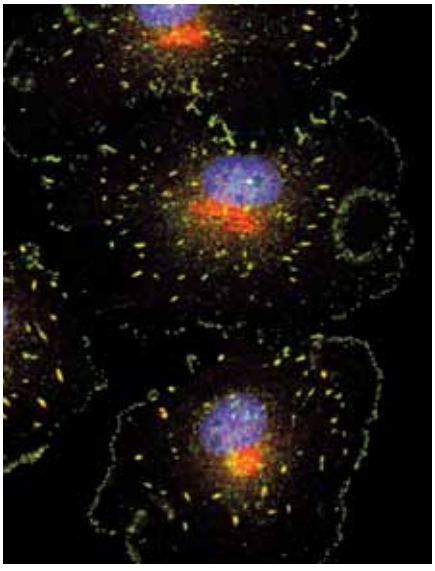
Novel anti-cancer agents and their mechanisms of action have been identified, and a microarray-based diagnostic for leukaemia has been validated on the South African population.

Disseminating research information

In addition to cutting-edge research undertaken by ICMM researchers and those associated with the MRC Extramural Research Unit for Stem Cell Research and Therapy, the ICMM is known for its commitment to information dissemination and partnerships in advancing molecular and cellular medicine. The following are notable:

- The ICMM seminar series, which in 2014 included a visit from leading researchers in plastic and reconstructive surgery from the University of Geneva;
- The 5th consecutive Neuroscience Day (May 2014);
- The 6th consecutive Course in Bioentrepreneurship (October 2014);
- The first Flagship Stem Cell workshop (September 2014); and
- A hands-on bioinformatics workshop (November 2014).

Prof Annie Joubert is in the Department of Physiology.



Cancer cells.

Cancer – potential to attack only cancer cells

A major challenge in cancer research is finding agents that target cancer cells while leaving normal cells unharmed. Key to the development of new pharmaceutically relevant drugs are the dual processes of computational methods to determine how cells would react to various chemical compounds, followed by the development of new compounds and testing their potential anti-cancer efficacy.

Chemotherapy and radiation that are used in the fight against cancer not only attack cancer cells, but also normal cells leading to several side effects for patients receiving treatment. Hence the importance of this study.

The work of **Prof Annie Joubert** in the Department of Physiology, Faculty of Health Sciences, and her multidisciplinary research team is mainly focused on agents that target the proliferation of cancer cells leaving normal cells unharmed. Components actively involved during cell division have to be studied with a view to prevent cancer cells from multiplying.

A key partner in the team is **Prof Fourie Joubert**, Director of the Centre for Bioinformatics and Computational Biology. His research in genomics, and particularly in bioinformatics, became the perfect counterbalance to what was required to identify and develop anti-cancer compounds.

Since 2005 this husband-and-wife team have combined their expertise in biochemistry and bioinformatics in pursuit of developing a new anticancer drug that targets only cancer cells. Together with their postgraduate students, and with national and international collaboration, they have achieved results that hold great promise for anticancer drug development.

Prof Annie Joubert's team has now taken this study further, conducting *in vitro* cellular and molecular studies to assess the potential anticancer efficacy of these newly designed compounds on breast and cervical cancer cells.

The research project has successfully advanced to the assessment of the effect of the drugs on human blood cells. In order further to investigate clinical anticancer drug efficacy, *in vivo* studies using mice as models will be done in collaboration with researchers at Onderstepoort. Different cancer markers will be measured and a possible reduction in tumour size will be assessed to determine the efficacy levels of these drugs.

Brain-body dialogues

In the battle against human disorders, the field of neuroendocrinology is contributing new exciting therapies. The brain receives numerous signals from the body and environment, which it integrates in order to signal appropriately to the entire body. This is accomplished through brain neurotransmitters and hormones that target cell receptors.

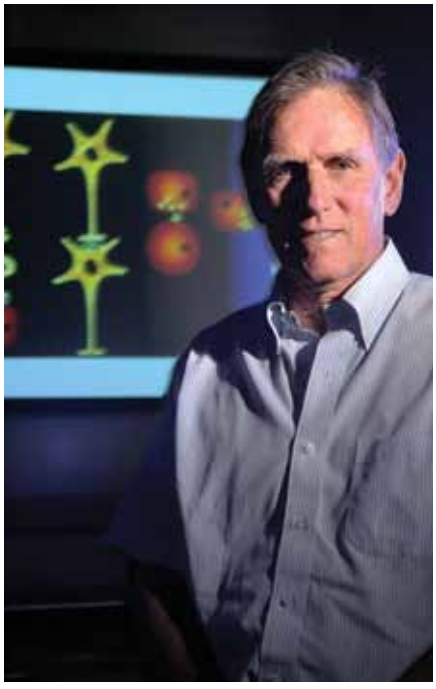
Almost all human disease is impacted by the derangement (or dysfunction) of signalling systems in the body. Therefore modulating the signalling is a major endeavour in treating disease.

Prof Robert Millar explains that neuroendocrinology deals with the way the brain detects external and internal signals in order to regulate most aspects of body and brain function.

Detecting and integrating these diverse environmental inputs (e.g. light, temperature, stress, vision, nutrients, toxins, odorants, pheromones and pathogens) and endogenous signals (e.g. hormones, growth factors, inflammatory and stress mediators, neurotransmitters, metabolites, water, and electrolytes and lipids) is crucial for survival.

The field of neuroendocrinology has yielded important insights into disease and health in vertebrates, and produced a range of therapeutics that are widely used in humans, companion animals and livestock. Indeed, it is fair to say that there is no area of biomedical physiology and pathophysiology that is not impacted by neuroendocrinology.

Some of these, such as obesity, metabolic syndrome and diabetes, are now global pandemics with vast implications for ill-health.



Prof Robert Millar, is Director of the Mammal Research Institute and the Centre for Neuroendocrinology. He is Editor-in-Chief of Neuroendocrinology and was recently elected as President of the International Neuroendocrinology Federation.

An example

An illustrative example is found in the rescuing function of mutant human receptors. Maintaining health in humans and animals is crucially dependent on signalling between cells through receptors. Over 80% of these receptors are G-protein-coupled-receptors (GPCRs), which are therefore the major target of developing therapeutics. Mutations in GPCRs lead to disease.

An example is blindness arising from the mutation of the GPRC, rhodopsin, which is the light receptor in the retina. The mutations result in a failure of rhodopsin to get to the surface of the cell, resulting in blindness.

Prof Millar, **Dr Claire Newton** and **Dr Ross Anderson** have discovered molecules that can enter the cell and stabilise mutant GPCRs so that they can then reach the cell surface. This exciting breakthrough opens up a new dimension of therapies.

Resia Pretorius, Research Professor in the Department of Physiology, and her students published 20 papers in high-impact journals in 2014. Two of these, a study on the biophysical indicators for iron-driven inflammatory diseases in Integrative Biology and a paper in Cardiovascular Diabetology, were among the 10 most read and downloaded in these journals last year.

INTERVIEW

Under the microscope

Most diseases involve inflammatory changes in the body's haematological system (e.g. red blood cells abnormalities and atypical clotting of blood). The Applied Morphology Research Centre (AMRC) takes a closer look, specifically studying blood clotting profiles and blood cell changes in inflammatory conditions in a novel way.

Instead of numerous invasive approaches, they rely on observations using electron, atomic force and confocal microscopes and specially-developed viscoelastic techniques to better understand and treat illnesses, says Prof Resia Pretorius, who started and heads the AMRC. In 2014, she was a TW Kambule-NSTF award finalist for her research in this field over the past 10 years.

Prof Pretorius' image of a fibrin network, which forms when a wound occurs, also took top honours in the Great British Bioscience Image Competition in 2014. The photo resulted from her collaboration with Prof Douglas Kell from University of Manchester on phenotypic diagnostics.

As Research Professor in the Department of Physiology, she guides MSc and PhD students. In 2014, she and her postgraduate students published 20 papers in high-impact journals.

She stresses that the Centre's research would not have been possible without her all-female core team. Challenging stereotypes of women in science, members include Dr Albe Swanepoel, Dr Mia van Rooy, Dr Prashilla Soma and many other female students.

The AMRC is currently investigating the role of bacterial presence in non-communicable and inflammatory illnesses, including Alzheimer's and Parkinson's disease, using its ultrastructural and viscoelastic properties.

This award-winning image was entered in the Great British Bioscience Image Competition in 2014, a competition that showcases bioscience and its importance in everyday life. The image is of a fibrin fibre network of a healthy 63 years old man.

Nuclear medicine and molecular imaging

The **Molecular Imaging Research Centre** at UP is recognised as a centre of excellence for the high-impact research it generates. Imaging researchers associated with the Centre are at the forefront in the continued global growth of new strategies to improve targeted molecular imaging and therapy in TB, HIV and cancer.

Prof Mike Sathekge leads a multidisciplinary and multi-institutional research team committed to translating research from pre-clinical to clinical applications. The purpose is to increase the accuracy of characterisation of disease biology, and to identify new imaging and treatment targets.

Next-generation molecular imaging promises unparalleled opportunities to visualise disease because molecular and cellular alterations occur earlier than structural changes in a disease process. This rapidly developing technology has become an essential tool in the field of oncology, with similar potential for neurology, cardiology and infectious and inflammatory conditions.

It is also anticipated that the increased use of non-invasive imaging technology will unite basic and clinical scientists in developing cutting-edge applications for patient care. It is a powerful clinical tool for early diagnosis, and monitoring various disease processes.

As with disease diagnoses and treatment in humans, imaging biomarkers can also expedite the 'bench-to-bedside' translation of new drugs, vaccines and treatment strategies for animals. Non-invasive imaging biomarkers that make possible the monitoring of disease at several time-points present a major leap forward in targeted analysis and treatment.

Epidemiology, diagnosis and control of vector-borne zoonotic arboviruses

Zoonotic viruses that transmit viruses from animals to humans remain a huge risk that is only controlled by intensive surveillance programmes based on the best available diagnostic tools. The **Zoonoses Research Unit** (ZRU) in the Faculty of Health Sciences is making a major contribution in this respect.

A large research focus on surveillance and the characterisation of zoonotic arboviruses is directed by **Prof Marietjie Venter** with the support of **Profs Robert Swanepoel** and **Leo Braack**. The ZRU is equipped with a BSL-3 laboratory, an essential facility in these surveillance programmes. Monthly surveillance visits are undertaken at various key sites in the Limpopo and Gauteng provinces where fatal cases of such diseases have been recorded.

Excellent progress was also made with research on the molecular epidemiology and pathology of West Nile and viruses such as Shunivirus, the cause of neurological disease in horses. The detection of these zoonotic viruses was greatly enhanced by the validation of a macroarray chip that can detect 29 causes of febrile and neurological disease in humans.

The molecular and serological diagnostic tools developed in the ZRU resulted in more than 12 papers in 2014 with a large number of papers linking vector transmitted viral pathogens to animal diseases with a neurological phenotype. Some also addressed the risk of the spread of these pathogens to health workers and veterinarians.

Conservation medicine

Conservation medicine is an emerging, inter- and multidisciplinary field that studies the relationship between human and animal health, and environmental conditions.

Globally there is an increase in the incidence of many infectious diseases, not only HIV/AIDS, TB and hepatitis C, but also newly-circulating ones such as SARS and Ebola. The increase in communicable diseases possibly reflects the impact of rapid demographic, environmental, social, technological and other changes in our ways of living. Climate change adds a further negative impact on infectious disease transmission patterns, and the consequent environmental change that will affect humans and wildlife.

Several research programmes are focused on the intersection between human and animal diseases in a changing environment.

A further dimension is the focus on assessing maternal, newborn and child health endocrine-related cancers and the epigenomic consequences of environmental chemical pollution, thereby aligning existing research programmes with some of the top global research fronts.

Environmental chemical pollution

People are exposed to a myriad chemicals throughout their lifetime, most commonly through air, food and water – the daily sustenance of our lives. A significant number of such chemicals are considered toxic as they have the potential to disrupt the endocrine system, and are referred to as endocrine-disrupting chemicals (EDCs).

There are sufficient data now to identify EDCs as a public health problem that must be addressed. EDCs are ubiquitous and ultimately land up in the aquatic environment to which people and wildlife are constantly exposed.

Over the past decade, with increasing research worldwide, the list of chemicals with endocrine-disruptive activity has expanded considerably. There is strong evidence that EDCs can compromise the reproductive system as well as the thyroid signalling mechanisms within an organism. EDC exposure can also have an effect on tissues and organs associated with energy metabolism, glucose control, fat cell development and satiety.

The **Environmental Chemical Pollution and Health (ECPH) Research Unit** is a collaborative partnership between the School of Health Systems and Public Health (SHSPH) and Andrology in the Department of Urology in the Faculty of Health Sciences. The research focus is on the occurrence, health effects and projected future impacts of chemicals, especially EDCs, on environmental pollution and health in South Africa and Africa.

The initial screening of the aquatic environment with selected *in vitro* bioassays can be used as a tool to assess the hormonal activity in water mixtures.

The EDC laboratory offers a comprehensive battery of relevant bioassays, while the toxicology laboratory, also located in the Unit, is primarily focusing on the assessment of reproductive health in humans and wildlife.

Maternal and infant health

The MRC Unit for Maternal and Infant Health develops health strategies at primary- and secondary-care levels to reduce mortality and morbidity rates in mothers and infants. The Unit's monitoring systems cover over 350 hospitals and clinics and include all 52 health districts in South Africa.

Areas of intervention and progressive research are focused on integrating best practices into the district health system, and taking effective interventions to scale. The example of kangaroo mother care is a good illustration.

In addition, the Unit investigates new and effective ways of scaling up emergency obstetric and neonatal care.

There is tremendous scope to build on this area of research, as demonstrated by the novel findings and practical, easily replicable strategies that are generated in the process. For example, related areas of research are child health in childhood asthma, urogenital birth defects, and neurodevelopment.

INTERVIEW

SARChI Chair in Sustainable Malaria Control

Prof Lyn-Marie Birkholtz, a leader in the discipline of antimalarial target discovery, heads the South African Research Chair Initiative (SARChI Chair) in Sustainable Malaria Control.

More than half a million lives are lost to malaria each year, according to the World Health Organisation (WHO). In sub-Saharan Africa, this complex, yet preventable disease remains a major public health, socio-economic and developmental challenge.

As part of the Centre for Sustainable Malaria Control, the Malaria Parasite Molecular Laboratory (M2PL) actively contributes to the fight against malaria. Internationally relevant and trend setting, the research is aligned to the WHO's Global Malaria Eradication Agenda. Nationally pioneering, it supports South Africa's goal to eliminate malaria by 2018.

"Our work is unique in that it contributes to knowledge about the interplay between malaria control and eliminating infection. We focus on both the pathogenic and transmission forms of malaria parasites, specifically the most deadly one – *Plasmodium falciparum*," explains Prof Lyn-Marie Birkholtz, DST-NRF SARChI Chair in Sustainable Malaria Control, Associate Professor and the M2PL's Principle Investigator.

Since the SARChI Chair was awarded in 2013, M2PL has delivered a number of cutting-edge firsts. Collaborating with researchers at the Wellcome Trust Sanger Centre (UK) and Penn State University (US), it produced the first description of pathways involved in the process of forming transmissible forms of the parasite. "This information is essential to understand and identify Achilles' heels in the parasite that could be used to design new transmission-blocking antimalarials," notes Prof Birkholtz.

In addition, the team initiated the first study to investigate how parasite transmission contributes to continued malaria transmission in malaria hot-spots in South Africa.

Under Prof Birkholtz's leadership, the M2PL also established the South African Malaria Transmission-Blocking Consortium – a unique initiative in Africa and the world – with funding from the MRC Strategic Health Innovation Partnership Programme.

There is close collaboration with the University of the Witwatersrand, the National Health Laboratory Service and the CSIR.

The consortium's other partners include UCT and NWU in South Africa, and BioFocus, Merck and the Medicines for Malaria Venture, internationally.

"The M2PL has established itself as the lead laboratory in South Africa and Africa for the screening of transmission-blocking antimalarials. This promises to pave the way towards the discovery of an African-owned malaria elimination antimalarial, while delivering internationally skilled researchers in antimalarial drug discovery."

"The M2PL ... promises to pave the way towards the discovery of an African-owned malaria elimination antimalarial, while delivering internationally skilled researchers in antimalarial drug discovery."

MRC Collaborating Centre for Malaria Research

The University of Pretoria **Centre for Sustainable Malaria Control** (UP CSMC) follows an integrated and transdisciplinary approach towards developing innovative, safer and more sustainable malaria control methods and strategies.

A significant achievement in 2014 was the Medical Research Council's awarding the Centre the status of MRC Collaborating Centre for Malaria Research.

Under the leadership of **Prof Tiaan de Jager**, the UP CSMC now includes more than 50 researchers from different departments in six faculties, with strong international collaboration. Research is done in three clusters, each focusing on a specific aspect of malaria – human, parasite and vector – with cross-cutting themes within and between the clusters.

Researchers in the Parasite Control cluster study the biology of the malaria parasite and the discovery of biochemical mechanisms that can be used to block transmission. Safer physical methods of mosquito control and integrated vector management are the focus in the Vector Control cluster, with biting behaviour studies enabling researchers to determine where best to target mosquitoes. The Human Health cluster focuses on studies pertaining to human and environmental health, especially the potential health effects associated with currently used insecticides for malaria vector control, but also the education of communities in malaria-endemic areas.

South Africa is currently in the control phase and aims to move into the elimination phase. Malaria in South Africa represents a small threat to overall public health, at least at current levels. However, because of the risk of resurgence if control efforts are removed, malaria will continue to receive high priority in research and interventions. Of direct relevance too is the assistance provided to neighbouring countries to ensure that their malaria burden is controlled, and to reduce the cross-border threat to South Africa, which is a major contributing factor to malaria incidence and mortality in the country.

Prof Tiaan de Jager heads up the Centre for Sustainable Malaria Control.

Phytomedicine and ethnoveterinary medicine

This research cluster focuses on the use of plants to address infections that affect people and animals. Both traditional knowledge and the wide screening of plants are used in identifying lead compounds.

The Phytomedicine Programme at UP, led by **Prof Kobus Eloff**, studies the potential of indigenous South African plants as sources of medical compounds.

Many of the discoveries have been patented. One recent discovery, patented internationally with funding from the Technology Innovation Agency, is an antifungal agent from indigenous sneezewood (*Ptaeroxylon obliquum*) trees for the treatment of *Candida albicans* infections.

Several researchers contributed to this development: Prof Kobus Eloff and **Dr Francien Botha** in the Department of Paraclinical Sciences; members of the Phytomedicine Programme in the Faculty of Veterinary Science; and Dr Candice van Wyk in the Department of Community Dentistry in the Faculty of Health Sciences.

This novel antifungal agent has proved itself to be an award-winning innovation. It was a runner-up at the South African Breweries (SAB) Social Innovation Awards on 30 October 2014, and was also placed second at the Gauteng Accelerator Programme Biosciences Awards held on 20 November 2014.

In addition to health-related problems of humans, there is great potential to develop plant-based products to increase animal productivity, particularly with regard to resource-poor, small-scale farmers. A current and future focus of research will incorporate studies on novel mechanisms of action in addressing potential drug leads related to problems caused by microbial infections and parasitic infestations.

The work of Prof Kobus Eloff, the founder of the Phytomedicine group, is well-recognised. He is author of over 240 articles on phytomedicine, and holds both the Gold Medal of the Academy of Science of South Africa and the MT Steyn Prize of the South African Academy of Science and Arts. He has supervised many postgraduate students, and notably since 2000, 15 postdoctoral fellows, the majority of whom are from African countries.

Prof Kobus Eloff and colleagues in the Phytomedicine Programme.

Nature's medicine plants and traditional practices

Prof Namrita Lall, a medicinal plant scientist in the Department of Plant Science in the Faculty of Natural and Agricultural Sciences, and her research team have explored and tested the use of indigenous plants to determine those that could possibly provide chemical compounds that could be of benefit to people.

Considering South Africa's immense biodiversity, particular methods are required to identify plants that may be of specific medicinal value. One such approach is ethno-botanical selection where the plant-use habits of indigenous communities are studied. Indeed, it was the wealth of information that already existed on South Africa's indigenous medicine that served as the starting point for Prof Lall's research.

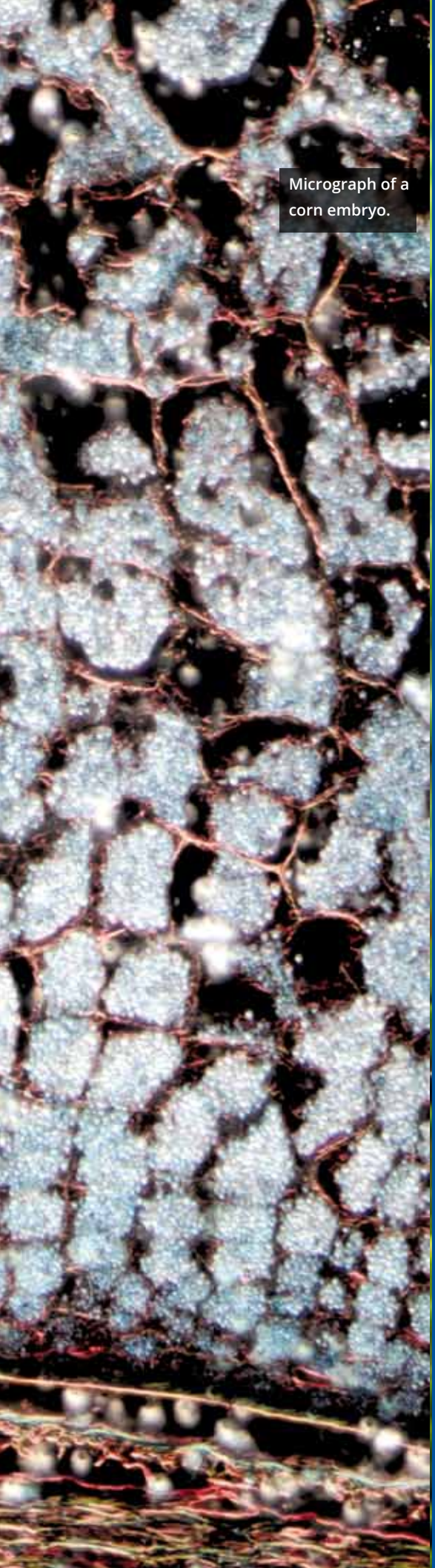
The research team has found promise in a plant traditionally used by indigenous communities to treat chest pains and the symptoms of TB. The research has attracted a number of national and international cosmeceutical companies that are willing to commercialise South African plant extracts and purified compounds that have emanated from the research.

The key national benefit of the research is in bridging the gap between farmers, researchers and customers. Communities have had few opportunities to develop local indigenous crops due to the inability of researchers to transfer their knowledge to market and create a demand for the farmers' crops.

Prof Namrita Lall received the prestigious Order of Mapungubwe Presidential Award in 2014 for outstanding research in medical sciences. More recently she was awarded the SARChI Chair in Indigenous Knowledge Systems.

THEME 5

SUSTAINABILITY AND SOCIAL JUSTICE



Micrograph of a corn embryo.

Research on sustainable development and social justice is receiving increasing attention at the University of Pretoria.

The fair distribution of wealth, opportunities and privileges in society requires peace and security, rule of law and a healthy respect for human rights, as well as attention to issues of governance. The sustainability of wealth creation and opportunities for growing participation in social and economic life in an environment challenged by violent conflict, precarious security provision and climate change is currently one of the main issues on the global agenda.

In its quest to remain relevant and to develop solutions to many of the social ills persisting within South Africa and the wider African continent, the University focuses on a range of themes and topics aimed at promoting sustainability and social justice.

Poverty, unemployment and inequality have remained the core problems with which South Africa has been wrestling over the past two decades, with democratic consolidation and its implied contribution to social justice remaining high on the country's political agenda.

Equally, South Africa has identified the development of the continent as one of its core foreign policy priorities. The research projects described in this cluster cover aspects ranging from food security, peacemaking and land reform, to human rights, unlawful killing and practical theology. What they all have in common is a deep commitment to address the country's – and the continent's – ideals of Batho Pele (People First) and Ubuntu.

EXPERT LECTURE | A SUMMARY

Reflections on 20 years of democracy – a crisis of leadership?

In her expert lecture delivered on 5 March 2014, **Prof Maxi Schoeman**, Head of Political Science, sought to provide an answer to the question: How do we explain the current high levels of protest and resistance manifesting in service delivery protests and wide-spread labour unrest?

Maxi Schoeman is Professor and Head of Political Sciences at the University of Pretoria. She was awarded the 2014 Claude Ake Visiting Chair at the University of Uppsala.

This is a pertinent question, especially in the face of the achievements of the past two decades in providing basic material needs to large sections of the population. A part of Prof Schoeman's explanation, summarised here, is as follows: the protests and resistance point to an unresolved class struggle based on the kind of settlement negotiated between the various political stakeholders in the country in the early 1990s.

The negotiated settlement that ended apartheid and initiated South Africa's transition to democracy was the product of a very particular historical context that saw the triumph of global capitalism, most strikingly symbolised by the end of the Cold War. South Africa was not immune to the larger global upheavals of the time: it had, and still has, an open economy, firmly integrated into the global economy.

Our settlement was therefore not negotiated as an exclusively domestic agreement, but was heavily influenced by the broader international political economic and ideational context. What the negotiators had to contend with was what Maxi Schoeman refers to as finding a compromise

between the 'supply side' and the 'demand side' of ideas, or what can also be called the tension between constraints and needs.

On the supply side, we had an international context in which, by the end of the 1980s, capitalism had entered into a transnational stage, increasingly capable of influencing state policy across the world. The transnational nature of capital is important for our understanding of the unresolved class struggle in South Africa: the elaborate financial markets that emerged in the last half of the 20th century have had two crucially important implications for the more traditional productive activities of the industrial and agricultural sectors of economies.

First, financial capital moves freely and at lightning speed across borders, resulting in a pattern of accumulation in which profit-making occurs increasingly through financial channels rather than through trade and commodity production. Secondly, productive activities have become dependent on market speculation – it flows out overnight in search of other speculation opportunities for profit.

South Africa's negotiated settlement echoed these new trends and was one cemented in a core neo-liberalist paradigm, as would be evidenced in the dismantling of the Reconstruction and Development Programme (RDP) a few years hence and the choice of Growth, Employment and Redistribution (GEAR) as the preferred economic policy.

Looking back, we see the impact of this strategy: Foreign ownership of the JSE increased from 6% in 2000 to 31% in 2012. In principle, this is not necessarily bad as the stake of foreign ownership in an economy can in certain circumstances support an economy under siege. But such statistics often reinforce perceptions that deprivation continues because of foreign ownership of the economy that concentrates wealth in the hands of only a few.

The new South Africa was negotiated against the background of enormous expectations on the part of previously disenfranchised citizens. Economic growth, though initially (and up to the middle of the first decade of the new century) fairly robust, could not reach the desired 'five per cent plus' deemed necessary to attain economic emancipation.

The new South Africa was negotiated against the background of enormous expectations on the part of previously disenfranchised citizens. Economic growth, though initially fairly robust, could not reach the desired 'five per cent plus' deemed necessary to attain economic emancipation.

The building of a black economic elite that, it was assumed, would grow a black middle class, was prioritised through Black Economic Empowerment. Yet, the result was a tiny new elite who joined the ranks of a shrinking white economic elite, but with little change in the economic status and access of the vast majority of citizens. In short, South Africa had settled for a form of liberal democracy that allows for the perpetuation of a capitalist model that benefits only very small sections of our population.

And in this lies the significance of the current struggle of the working class: it is a struggle for a more inclusive and equitable social order, and this struggle increasingly rages outside of formal institutions, in the form of violent street protests, civil disobedience, and unprotected strike action. What we see is a struggle for new or renewed leadership, mainly through a realignment of the left in the face of its initial emasculation with the adoption of a political economic model that has failed the working class.

Prof Laurie Nathan, Director of the Centre for Mediation in Africa.

Mediation – the challenge of managing complexities

The goal of the **Centre for Mediation in Africa** (CMA), in the Department of Political Science, is to help make mediation efforts throughout Africa more effective. It researches best practices, offers academic and practical courses in mediation, and supports organisations, such as the United Nations and the African Union, and African governments involved in mediation processes.

Research is characterised by three types of publications that illustrate the nature of the Centre's work – from research and policy briefs, to practical solutions:

- Publications of empirical research and policy briefings on mediation case studies, thematic aspects of mediation and other issues related to peace and security;
- Mediation Arguments, a working paper series that explores the dynamics and outcomes of mediation efforts; and
- Practitioner Notes, a series focused on the critical insights and lessons of mediators and other peace practitioners.

So, for example the Mediation Arguments published in 2014 included a paper that examined the mediated agreements reached in Liberia, Burundi and the Democratic Republic of Congo; and the second in the working papers series, an analysis of the reasons for the absence of significant international mediation in South Africa's transition to democracy.

A paper on mediation published by the BRICS Policy Centre (July 2014) sets out some of the reasons for the complexity of mediation in the context of intra-state conflict and civil war. It examines the disposition of the parties and the multiplicity of actors, systems and structures and concludes that, in essence, effective international mediation is about managing complexity.

Distinguished fellow – peace and security

Prof 'Funmi Olonisakin, a research fellow in Political Sciences in the Department of Political Science in the late 1990s, is a distinguished fellow and contributes to the research theme on Peace and Security in the Humanities, and the Ubuntu project.

Since her first association with UP, Prof Olonisakin has remained a regular visitor and contributor to research at UP. She is developing a joint PhD programme in Leadership, Peace and Security between UP and King's College, London. As founding director of the African Leadership Centre (ALC) at King's College and the University of Nairobi, she is also involved in setting up a regional hub of the African Leadership Centre (ALC) at the University of Pretoria.

In 2014 Prof Olonisakin was appointed to the United Nations Secretary General's Advisory Group for the Review of the UN Peacebuilding Architecture, a position she is very well qualified for, given her extensive knowledge of the field of peace and security, her substantial publication record, and her previous work within the UN as an advisor to the Secretary General's Special Representative on Children and Armed Conflict.

Photo by Liezl Rees

Land reform – rethinking development

Research in the Postgraduate School of Agriculture and Rural Development focuses on several issues related to agriculture and rural development. A dominant focus is on small-scale farmers and how they are affected by land acquisitions and land investments.

The Postgraduate School of Agriculture and Rural Development at UP is responsible for developing consistent data with regards to agriculture and land governance, and for coordinating data collection, research, networking and communications for Africa.

Research on land reform, agricultural and rural finance, the role of agriculture in poverty reduction, market participation of smallholder farmers, together with baseline studies, make possible the monitoring and evaluation of development programmes and projects.

Within the broader Land Matrix partnership, particularly with the Agricultural Research Centre for International Development (CIRAD) and the Centre for the Study of Governance Innovation (GovInn), UP's contributions to the development of the Land Matrix have been a significant achievement. It is a global land monitoring initiative that is viewed as a 'Global Observatory' and 'an open tool for collecting and visualising information about large-scale land acquisitions'.

Dr Ward Answeeuw, one of the founding members, notes that it has evolved from a database into a public tool promoting greater transparency in decision-making over land and investment at a global level.

A further achievement has been the series, initiated in partnership with GovInn at UP, of seminars and working papers on Rethinking Development. Through the engagement of academics, policy-makers and development practitioners, the series engages with old and new development alternatives and paradigms, and ways in which they impact on society.

Prof Lorenzo Fioramonti, Director of GovInn's book, *Gross Domestic Problem: The politics behind the world's most powerful number*, dealt specifically with the governance implications of transformation to a post-growth society.

Governance innovation

The Centre for the Study of Governance Innovation (GovInn), in the Department of Political Sciences, is the first research institution in Africa dedicated entirely to governance innovation – in a range of spheres locally and internationally. In 2014, the Centre continued to generate new thinking about governance, development and migration.

"Our research has focused on alternative forms of development and migration, placing particular emphasis on the supranational regional dimension. We explored the possibility of southern African countries experimenting with new systems of economic development, including land and water governance, as well as moving beyond GDP in assessing economic success," says **Prof Lorenzo Fioramonti**, Director of GovInn and the first and only Jean Monnet Chair in Africa. This Chair is awarded by the European Commission to distinguished academics in regional integration studies.

"In addition, we looked at innovative relations among countries and networks operating across the Atlantic. In the context of migration, we investigated under-researched trends in the field of cross-border trade and assessed the possibility of people-driven regional cooperation producing innovations."

This kind of research, both innovative and unconventional, has set the Centre apart, making it a thought leader in its field. "By collecting data on new forms of governance, we strive to bridge the gap between innovative research, social change and policy impact. Our world and our region are facing many converging challenges. We need new thinking to address them. GovInn contributes to this by thinking 'outside the box' and making its research available to a wide range of actors in society," mentions Prof Fioramonti.

GovInn has 20 team members and is expanding.

Highlights in 2014

- GovInn's work was featured in various publications with one project, The Land Matrix, receiving a 2014 Prixars Honorary Mention.
- Projects were expanded and a new research initiative, focusing on South Africa's land governance, launched.
- The Centre's annual conference, Governance Innovation Week, saw over 400 people participating, as well as more than 70 international speakers.
- It hosted a high-profile workshop with chief statisticians from seven African countries to discuss a regional method to move beyond GDP in national income accounting.
- GovInn completed a regional project on migration, MIWORC, which allowed it to launch a UNESCO Chair in Regional Integration, Migration and Free Movement of People. It is held by Prof Fioramonti.
- Relationships were maintained with various donors, including the European Union (through various streams of funding), the Belmont Forum, numerous international agencies, the NRF, DST and private foundations.

Food security

"Every South African must be able to develop their full potential and this can't be done on an empty stomach. This is why this new Centre of Excellence in Food Security is so unique – it must lead to interventions that will positively change people's lives and combat food insecurity in our country."

This was the message of the Minister of Science and Technology at the launch of the DST-NRF Food Security Centre of Excellence in April 2014. The Centre is co-hosted by the Universities of Pretoria and the Western Cape and brings together several South African and international institutions to study the systemic and structural factors that shape food access and food security strategies. Building on the established research strength of UP's **Institute for Food, Nutrition and Well-being** (IFNuW), eight projects were approved in 2014 for UP-led research teams under the Centre of Excellence, with three additional projects to follow in 2015.

Food insecurity is widespread. In South Africa, an estimated 45% live below the poverty line, one in five children are stunted, and about one in five households experience chronic food shortages.

The Institute provides a platform that brings together extensive expertise related to food security across seven faculties and over 35 disciplines. In 2014 the Institute had over 100 expert Associates and 65 postgraduate students. This critical mass of researchers seeks to address food insecurity and find ways of building a more resilient agriculture and food system to reduce hunger and malnutrition, and to promote consumption behaviour that ensures human productivity and overall well-being.

The focus has been on applying science to solve issues related to producing more food in sustainable ways; food safety; exploiting the health-promoting properties of foods to improve nutrition; influencing what people eat and investigating the impact of policies on food security.

There have been many positive outcomes in the short existence of the IFNuW, with research outputs far exceeding the targets set for the first three-year cycle, and with strong regional and international networks now firmly established. The research projects active in 2014 resulted in 150 multi-authored publications, eight of which were policy briefs.

Prof Sheryl Hendriks, Director of the Institute and co-Director of the Food Security Centre of Excellence, sums up the foundations to the achievements in 2014 as relating to the people, partners and projects that have defined the Institute and now the Centre of Excellence. Two examples are chosen to illustrate the nature of some of research work (see overleaf).

Prof Sheryl Hendriks is one of three experts from Africa appointed to the first Committee for World Food Security (CFS) High Level Panel of Experts on Food Security and Nutrition. She was re-elected for a second term in 2013.

Photo by Sheryl Hendriks

Feed the Future Innovation Labs

Achieving international, continental and national targets for reducing hunger and poverty will require significant policy change. The Feed the Future Innovation Labs is a USAID-funded initiative led by US universities that draws on expertise at top universities and research institutions in tackling some of the world's greatest challenges in agriculture and food security.

The University of Pretoria is the only South African university selected to collaborate in a series of projects funded by the Feed the Future Innovation Labs. The Feed the Future Research Strategy aims to create productive crops, to intensify sustainable agricultural production systems, to ensure food security, and to enhance access to nutritionally improved diets.

As part of the Feed the Future Innovation Lab for Food Security Policy (FSP), UP researchers – working with colleagues from Michigan State University and the International Food Policy Research Institute – have developed a novel transdisciplinary framework for understanding the policy change process related to agriculture, nutrition and food security.

The policy research programme seeks to inform a variety of ongoing policy initiatives related to promoting food security in developing countries. For instance, it can help explain why countries facing similar agricultural and nutrition challenges choose very different policy options to address those challenges. Likewise, it can assist with pinpointing the causes of bottlenecks to the implementation of improved policies.

Policy briefs on food security in South Africa

The Comprehensive Africa Agriculture Development Programme (CAADP) is at the heart of the African Union/ NEPAD initiative to accelerate growth and eliminate poverty and hunger in Africa. A UP team led by **Prof Sheryl Hendriks**, in partnership with the Department for Agriculture, Forestry and Fisheries (DAFF), puts evidence-based policy-making into practice in identifying a set of priority programme actions for DAFF to pursue in meeting the country's commitment to the African growth agenda.

The team of UP researchers and postgraduates has engaged in a stock-taking process to review policies, programmes, frameworks and strategies, and also available food security and macroeconomic statistics and trends. This was conducted alongside one of the country's most in-depth and largest policy consultation processes. Over 200 people engaged in a facilitated review of the current status of growth, development and food security and identified priority actions.

Consultative workshops in each province, with the private sector and youth, were attended by between 40–60 smallholders drawn from almost every district in the country. The discussions provided rich reflective narratives of food security experiences in the everyday lives of communities, and offered a rare opportunity for government to listen to farmers.

Five policy briefs have been presented to DAFF to assist in the preparation of a national agriculture and food security investment plan for South Africa.

Photo by Liezl Rees

Human rights and social justice

There are several research projects at the University that focus on human rights and social justice. Researchers in the Faculty of Law play a significant role in legal research in South Africa and Africa, with highlights chosen from this faculty to illustrate some of the achievements in 2014. In particular, we present brief summaries of the work undertaken by the Centre for Child Law, the Human Rights Centre, and the Institute for International and Comparative Law, as well as the Human Rights Centre.

The Centre for Child Law

The protection of the rights of vulnerable children is a universal human rights issue and speaks to the core of social justice. Children's rights advocates around the world have used strategic litigation as an effective advocacy tool to challenge children's rights violations.

The **Centre for Child Law** at the University of Pretoria is known for fiercely defending the rights of children, and is a national leader in the law relating to children in the criminal justice system. Director of the Centre, **Prof Ann Skelton**, also holds the UNESCO Chair in Education Law.

The Centre carries forward research outputs into legislative drafting and the pronouncements of the courts. The interaction between legal theory and practice is beneficial for both academia and the profession, with the Centre's contribution to child and family law documented more broadly.

In 2014, several issues were pursued – through research, litigation, education and advocacy campaigns. For example, research on surrogate motherhood was used to support submissions to the High Court relating to the constitutionality of aspects of the law relating to surrogacy. As South Africa's surrogacy laws are among the most advanced in the world, the research outputs have relevance at a comparative and international level.

The Centre has successfully fought a legal battle for desks and chairs for poor schools in the Eastern Cape.

The rights of child offenders were addressed against the backdrop of the Constitution and the Register for Sex Offenders, and the decriminalisation of adolescent consensual sex. Both relate to important judgments of the Constitutional Court, in which the Centre for Child Law was directly involved. These judgments bind all courts in South Africa, and also stand as useful jurisprudence for other legal systems.

The **UNESCO Chair in Education Law**, led by Prof Skelton, is focused on the right to basic education, an important social justice theme. The Chair's research supported ongoing litigation by the Centre for Child Law on school infrastructure, particularly in the Eastern Cape. It was established that the right to basic education comprises decent infrastructure and basic requirements such as desks, chairs, stationery and books. The Centre commissioned a monograph entitled 'Mud to Bricks: A review of school infrastructure spending and delivery' published during 2014. The right of children to be free from violence within school settings was also a research theme during 2014, including bullying in South African schools, and the effective enforcement of the prohibition against corporal punishment. The latter was examined extensively by doctoral student, F Veriava, in a monograph which was launched at a conference organised by the South African Human Rights Commission in 2014. Several journal articles and chapters in books on the theme of social justice were published by Centre staff during 2014.

Prof Frans Viljoen, Director of the Centre for Human Rights, and students.

The Centre for Human Rights

The Centre for Human Rights (CHR) works towards human rights education in Africa, a greater awareness of human rights, the wide dissemination of publications on human rights in Africa, and the improvement of the rights of women, people living with HIV, indigenous peoples, sexual minorities and other disadvantaged or marginalised persons or groups across the continent.

The Master's Programme in Human Rights and Democratisation in Africa saw 27 new graduates join a closely knit network of alumni across Africa.

In 2014 the Centre, led by **Prof Frans Viljoen**, continued towards its primary aim of strengthening human rights in Africa, with a particular focus on supporting and improving the African regional human rights system, established under the auspices of the African Union (AU).

Examples of notable research achievements in 2014 are chosen here to illustrate the nature of the work of the CHR.

Among several publications, the highlight of 2014 was the two journals appearing under the Centre's editorial auspices, the *African Human Rights Law Journal* and the *African Disability Rights Yearbook*, both of which became available as fully on-line open access journals.

Two volumes of essays were published that deal with topics thus far considered to be inadequately covered in the academic literature, namely: Convergence and conflicts of human rights and international humanitarian law in military operations; and Africa's responsibility to protect.

In support of the Special Rapporteur on Freedom of Expression and

Access to Information, the Centre continued working on decriminalising restrictions of free speech, through the submission of two *amicus curiae* briefs – to the African Court on Human and People's Rights, and the South African High Court, with interventions targeting Swaziland, Tanzania, Zambia and Zimbabwe.

In the case of Konate v Burkina Faso, the landmark judgment by the African Court on 5 December 2014 upheld the arguments of the amici. The case received considerable publicity. Earlier in the year, non-governmental organisations had intervened as 'friends of the court' to address growing concerns over the use of criminal defamation laws to censor journalists and others in Africa.

One of the most prominent academic programmes of the Centre, the Master's Programme in Human Rights and Democratisation in Africa, marked 15 years of existence in 2014 with 27 new graduates joining a closely knit network of alumni across Africa. The LLM (International Trade and Investment Law in Africa) saw 18 new graduates becoming part of a newly established Alumni Association. In addition, six doctoral candidates completed their studies and graduated in 2014.

Konate v Burkina Faso

The Institute for International and Comparative Law in Africa (ICLA)

The role and rule of law in Africa is the focus of the Institute for International and Comparative Law (ICLA), a research institute in the Faculty of Law. There were several notable achievements in 2014 with some profiled here to illustrate the relevance and impact of advanced research.

With Co-Directors, **Profs Erika de Wet** and **Christof Heyns**, the ICLA houses doctoral students and visiting scholars and arranges seminar opportunities for government officials, judges, international civil servants and civil society.

An extensive network of research collaboration, including the United Nations and the African Union, allows ICLA researchers and fellows to engage in collaborative projects on the continent and abroad.

A central feature is the Law of Africa Collection, the most comprehensive and up-to-date collection of primary legal materials of African countries in the world today. Hence, the ICLA's involvement in providing technical assistance to African governments and international organisations engaged in legal reform on the continent.

Prof Erika de Wet, Co-Director of ICLA.

Prof Christof Heyns, Co-Director of ICLA and UN Special Rapporteur.

A researcher in the ICLA offices.

On promoting constitutionalism in Africa, and under the auspices of Profs Erika de Wet and **Charles Fombad**, ICLA researchers finalised country reports for Burundi, Rwanda and South Sudan for a leading publication in its field – *Oxford Constitutions of the World* (OCW).

Members of ICLA served as advisors to the Working Group on the drafting of the Protocol to the African Charter on the Abolition of the Death Penalty.

Significant too is ICLA's housing of the research unit related to the mandate of Prof Christof Heyns, United Nations (UN) Special Rapporteur on Extrajudicial, Summary or Arbitrary Executions.

In 2014 Prof Heyns presented a thematic report to the UN Human Rights Council on international standards on the use of force during law enforcement, as well as thematic reports to the UN General Assembly on resuming the death penalty; the role of regional systems in protecting human rights and the right to life; the increased de-personalisation of the use of force; less lethal and autonomous weapons and law enforcement; and the role of statistics in protecting the right to life.

Sources, beliefs and practices

The Faculty of Theology's overarching research theme is Ecodomy – Life in its fullness, with three sub-clusters of enquiry: sources, beliefs, and practices. The multidisciplinary research focus on enhancing life means that issues of social justice, poverty, homelessness, marginalisation, diversity and xenophobia are important aspects of research and an emerging focus on urban public theology.

Addressing vital social and socio-economic issues requires fundamental reflection on contemporary views on being human, on personhood, on living conditions and resources. It also means taking responsibility for our lives and values, and issues related to understanding morality and leadership in Africa from a Christian perspective. The former is done within the context of theology-science discourses, the latter from the best current ethical approaches to leadership and values.

Several examples illustrate the research productivity of academics in the fields of theology and religion and the extensive international networks of scholars that enrich research.

It makes sense, therefore, that the newly established **Centre for Spirituality and Culture in Africa**, with **Professor Tinyiko Maluleke** as Director, should find its intellectual home in the Faculty of Theology.

Practical Theology

We use one example from Practical Theology to illustrate the nature of some of the research, and the relevance to contemporary societies, including South Africa.

The recent turn towards lived theology or religion is what Prof Johann-Albrecht Meylahn describes as a double shift that brings into conversion Christian tradition and cultural-religious experiences and practices – or Text and Context – now no longer seen as opposites but as mutually dependent and influencing each other.

The second shift is out of the church and into the public sphere. Thus the focus is no longer exclusively on the practices of the church, but on investigating religious dimensions of various human practices.

These shifts are reflected in several publications in 2014, addressing:

- The role Practical Theology plays in service delivery protests and increasingly violent industrial action, as epitomised by Marikana;
- The local worshipping community as a site for the spiritual formation of citizens to become agents of transformation in public life – and through their witness and praxis, challenging the dominant discourses by offering redeeming alternatives. And what would the challenge entail in developing an inclusive spirituality?, and
- Analysis of ways in which people seek to find meaning and purpose for their lives in alternative places to institutionalised religion.

In 2014 Prof Johann-Albrecht Meylahn of the Department of Practical Theology was granted the Alexander von Humboldt Research Fellowship for Experienced Researchers at the Humboldt Universität in Berlin, Germany. He will pursue the theme of a Practical Postfoundational Theology as Public Theology in response to the challenges of lived religion in contemporary southern Africa.

Prof Malcolm McIntosh (Griffiths University, Australia) delivered the Keynote address at the Centre's 3rd International Conference on Responsible Leadership.

Leadership for Africa

The Leadership for Africa project of the **Albert Luthuli Centre for Responsible Leadership** (ALCRL) led by **Prof Derick de Jongh**, is committed to developing next-generation leaders who believe in social justice and environmental sustainability.

Three questions frame the research on responsible leadership at the ALCRL: How do we define responsible leadership? What constitutes responsible leadership? How can we develop responsible leadership?

Linked to these questions, a number of research projects investigate the emergence and development of responsible leadership within changing contexts.

The Leadership for Africa project is one such project. Designed and implemented with the support of the UONGOZI Institute in Dar es Salaam, Tanzania, a baseline project was undertaken in 2014 to identify key enablers in transformative leadership in Africa. The outcomes in this pilot phase show that while institutional and collective leadership is important, the most important enablers are at the level of individuals and include agency as well as appropriate skills.

The results were published in 2014, Leadership for Africa (LFA) Tanzania Pilot Project Report.

A second example that showcases research in 2014 was a study conducted on research gaps in the field of integrated reporting. The study was commissioned by the Integrated Reporting Committee of South Africa Working Group (IRC WG). The final report highlighted key research gaps in the field of Integrated Reporting (IR), and positioned the ALCRL as an important contributor to advancing the body of knowledge on IR in South Africa and internationally.

PART 3 Profiling leading researchers and faculties

UP's A-rated scientists

Research awards and recognition

Faculty profiles

- Engineering, Built Environment and Information Technology
- Education
- Economics and Management Sciences
- Humanities
- Law
- Theology
- Natural and Agricultural Sciences
- Health Sciences
- Veterinary Science
- Gordon Institute of Business Science (GIBS)

Acronyms and abbreviations

Prof Nigel Bennet in the Department of Zoology holds the UP Austin Roberts Chair of African Mammalogy (since 2006).

Nigel C Bennett

His research investigates the ecological and physiological factors that affect the control of reproduction and the evolution of sociality. Molecular approaches, together with innovative laboratory and field methods, are used to unravel the mechanisms by which evolution can shape change in socially occurring vertebrate species. The family *Bathyergidae* has turned out to be an ideal model group for investigating the evolution of sociality and, as a consequence, contributes to interdisciplinary efforts in the study of the causes and consequences of sociality.

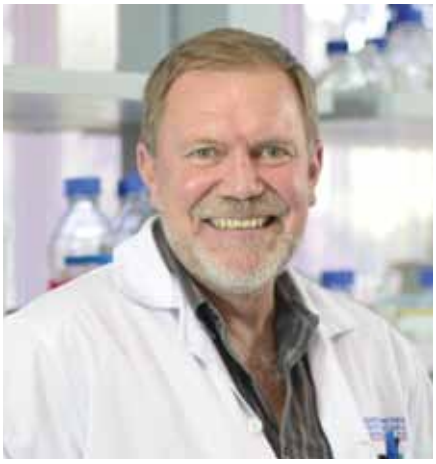
www2.up.ac.za/zoology
http://repository.up.ac.za/browse?value=Bennett%2C+Nigel+C.%2C+1961-&type=author

Prof Drucilla Cornell is in the Department of Jurisprudence and Director of the Ubuntu Project.

Drucilla LC Cornell

Her work has covered areas such as ethical humanism aimed at reviving black existentialism and radical constitutionalism to counter dominating historicism, imperialism and neo-colonialism. She has also researched female and racial subordination and liberalism post-9/11, particularly in the face of wars in regions such as Afghanistan and Iraq. Of importance, too, is her work with the uBuntu project at UP. Established in 2012, the project promotes the status and importance of indigenous values and ideals across various areas of society.

http://polisci.rutgers.edu/cb-profile/userprofile/dcornell
http://repository.up.ac.za/browse?value=Cornell%2C+Drucilla&type=author



Prof Don Cowan is the Director of the Genomics Research Institute and the Centre for Microbial Ecology and Genomics.

Don A Cowan

He has a primary interest in the microbial ecology of soil habitats, including hot and cold desert soils. For the past decade he has worked at both ends of the biological temperature, studying the psychrophilic microbiology of the Dry Valleys of Eastern Antarctica, and the thermophilic microbiology of the Namib Desert. He also collaborates with local, national and international researchers on many other metagenomic projects, ranging from studies of the roles of microbial communities on agricultural crop productivity, in sub-Antarctic peat bogs, to the development of human prostate cancers. His newest research programme is the development of a large consortium of researchers to undertake a landscape-scale survey (for the first time) of the microbial diversity of southern African soils.

www.up.ac.za/CMEG
http://repository.up.ac.za/browse?value=Cowan%2C+Don+A.&type=author

Prof Andries Engelbrecht is Head of the Department Computer Science in the Faculty of Engineering, Built Environment and Information Technology. He is the current incumbent of the South African Research Chairs Initiative (SARChI) in Artificial Intelligence.

Andries P Engelbrecht

His main research focus is artificial intelligence with a specific focus on computational intelligence, particularly computational swarm intelligence, learning from zero knowledge using competitive coevolution, evolutionary algorithms, artificial neural networks and image and data analytics. His research team developed an open source library of computational intelligence algorithms, which is increasingly being used internationally. They were the first to provide convergence proofs of particle swarm optimisers (PSO), to develop PSO algorithms to find multiple solutions to optimisation problems, to solve optimisation problems where solutions are represented as sets, to develop PSO-based hyper-heuristics, to use PSO for secondary RNA structure prediction, and to use PSO for image segmentation. They have also developed new measures to characterise fitness landscapes of continuous-valued optimisation problems.

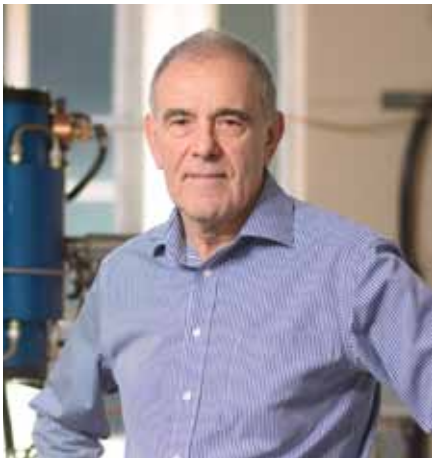
http://www.cs.up.ac.za/research
http://repository.up.ac.za/browse?value=Engelbrecht%2C+Andries+P.&type=supervis

Prof Robert Millar is Director of the Mammal Research Institute (MRI) and of the Centre for Neuroendocrinology.

Robert P Millar

His work has made major impacts in areas of human reproduction, hormone replacement and the treatment of disease such as cancer. His recent research has focused on gonadotropin-releasing hormones (GnRH), pioneering the discovery of GnRH prohormones and novel GnRHs. His group participated in a collaborative effort for the first cloning of the GnRH receptor and the discovery of GnRH subtypes. As a result, great strides have been made in the development of anti-cancer drugs. Furthermore, he has been involved in successfully taking eight drugs into the clinic for treating diseases such as prostatic cancer, endometriosis, infertility, and polycystic ovarian syndrome. Most recently his group discovered molecules that can rescue function of mutant human receptors, which has implications for conditions such as *retinitis pigmentosa* causing blindness.

http://www.up.ac.za/mammal-research-institute/
http://repository.up.ac.za/browse?value=Millar%2C+Robert+P.&type=supervisor



Prof Brian Rand is in the Department of Chemical Engineering and holds the DST-NRF SARChI Chair of Carbon Technology and Materials.

Brian Rand

His research interests are in carbon, graphite, nuclear graphite, refractories and ceramic processing. A major feature of his research has been the study of carbonaceous mesophase and its use in the fabrication and control of the structure of carbon fibres, composites and films. He has developed a novel approach to the transformation of pitch to carbon products. He has built a new highly active group researching carbon materials and mentoring local staff ultimately to ascend to the DST-NRF SARChI Chair of Carbon Technology and Materials.

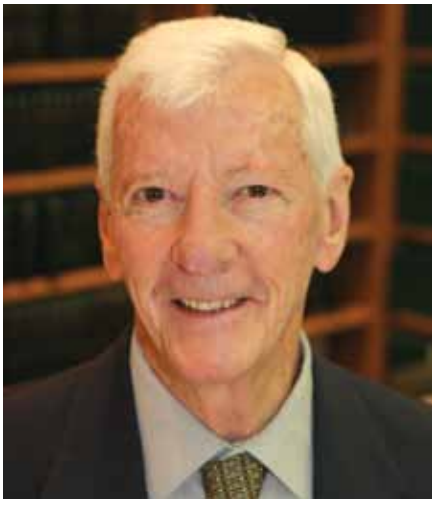
http://repository.up.ac.za/browse?value=Rand%2C+Brian&type=author

Prof Yves van de Peer is in the Department of Genetics in the Faculty of Natural and Agricultural Sciences.

Yves van de Peer

He was the first to suggest a correlation between whole genome duplication events in different plant lineages and the Cretaceous–Paleogene boundary, caused by the Cretaceous–Paleogene extinction event that wiped out about 70% of all organisms, including dinosaurs. Although whole genome duplications are usually an evolutionary dead end, research in Prof Van de Peer's laboratory suggested that, during periods of environmental upheaval, entire genome duplications can provide organisms with a selective advantage so that polyploids can out-compete their diploid progenitors.

http://bioinformatics.psb.ugent.be/people/profile/yvesvandepeer
http://repository.up.ac.za/browse?value=Van+de+Peer%2C+Yves&type=author



Prof Johan van der Vyver is in the Department of Private Law.

Johan van der Vyver

He is an expert on human rights jurisprudence and the international criminal court, and actively participated in efforts to end apartheid and bring constitutional reform to his native South Africa. Prof Van der Vyver has also served as a fellow in the Human Rights Program of The Carter Center of Emory University. His research interests and publications include human rights, international criminal law and a great variety of other subject matters.

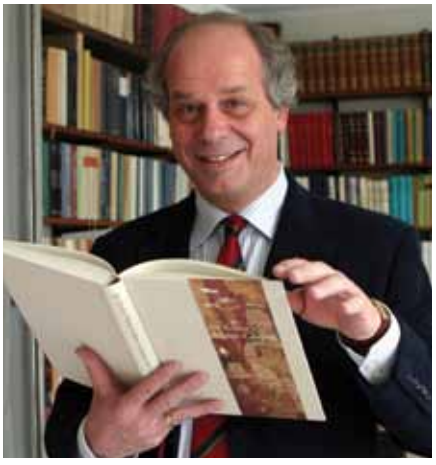
http://cslr.law.emory.edu/people/person/name/van-der-vyver/
http://repository.up.ac.za/browse?value=Van+der+Vyver%2C+J.D.+%28Johan+David%29&type=author

Prof Charles van Onselen is in the Centre for the Advancement of Scholarship.

Charles van Onselen

His particular interest lies in the phenomena of crime-as-politics, as exemplified by issues of social banditry, and politics-as-crime, as manifested in the ways in which members of the political elite engage in criminal activities to facilitate the accumulation of corporate personal wealth, as enabled through the processes of systemic corruption. Although these historically rooted problems occur in many parts of the world, they are particularly prominent themes in contemporary South African history.

http://www.up.ac.za/centre-for-the-advancement-of-scholarship/article/1929472/prof-charles-van-onselen
http://repository.up.ac.za/browse?value=Van+Onselen%2C+Charles&type=author



Prof Johannes van Oort is in the Department of Church History in the Faculty of Theology.

Johannes van Oort

His areas of research are the rise of Christianity in the Jewish, Greek and Roman contexts; the history of the Early Church, with particular emphasis on Gnostic movements; and the theology, sources and influence of Augustine of Hippo.

https://up-za.academia.edu/JohannesvanOort
http://repository.up.ac.za/browse?value=Van+Oort%2C+Johannes+%28Hans%29&type=author

Prof Brenda Wingfield is the Deputy Dean (Research) in the Faculty of Natural and Agricultural Sciences and a Professor in the Department of Genetics.

Brenda D Wingfield

Her research group enjoys substantial international recognition with respect to research on the molecular systematics and population genetics of fungal pathogens. The group is considered as one of the leading teams worldwide that is involved in the development of molecular diagnostic techniques for the identification and classification of pathogenic fungi.

http://www.fabinet.up.ac.za/index.php/people-profile?profile=908
http://repository.up.ac.za/browse?value=Wingfield%2C+Brenda+D.&type=author

Prof Mike Wingfield is the founding Director of the Forestry and Agricultural Biotechnology Institute (FABI).

Michael J Wingfield

His research focuses on fungal diseases that threaten forests and forestry globally. Using a broad range of approaches (especially molecular genetic techniques), pests and pathogens arising in many different countries of the world are identified – often for the first time. Research efforts seek to understand the drivers of tree pest invasions and to find methods to reduce the damage that they cause. He is passionate about forestry research and education in general, and as IUFRO President is promoting efforts to enhance evidence-based policy formulation on which the future of forests and the associated ecosystem services and global food security depend.

http://www.fabinet.up.ac.za/mwingfield
http://repository.up.ac.za/browse?value=Wingfield%2C+Michael+J.&type=author

Prof Xiaohua Xia is Director of the Centre of New Energy Systems and holds the Exxaro Chair in Energy Efficiency.

Xiaohua Xia

He heads the South African National Hub for the Postgraduate Programme in Energy Efficiency and Demand-side Management. His research interests include non-linear feedback control, observer design, time-delay systems, hybrid systems, modelling and control of HIV/Aids, control and handling of heavy-haul trains and energy modelling and optimisation.

http://www.ee.up.ac.za/~xxia
http://repository.up.ac.za/browse?value=Xia%2C+Xiaohua&type=author

Group photo taken at the 2014 Academic Achievers Awards.

Research awards and recognition

Internal awards

Each year the University honours and celebrates researchers and academic achievers for their contribution to UP. There are four categories of awards:

- exceptional academic achievers;
- exceptional young researchers;
- National Research Foundation (NRF)-rated researchers; and
- the Chancellor's award.

The Chancellor's Award: Research – Prof Don Cowan in recognition of exceptional achievement in the field of research aimed at the advancement of science and the associated promotion of the interests of the University.

The Vice-Chancellor's Book Awards – there were two recipients, respectively in the fields of Humanities and the Social Sciences, and the Natural and Applied Sciences:

- **Prof Lorenzo Fioramonti** (2013), *Gross Domestic Problem: The politics behind the world's most powerful number* (Zed Books); and
- **Prof Jan CA Boeyens** (2014), *The Chemistry of Matter Waves* (Springer).

Exceptional Academic Achievers Awards – in recognition of senior academics who are regarded highly by their peers and have consistently excelled in the areas of under- and postgraduate teaching and learning, research, community service and administration. For the year 2014, six awards were made to:

- **Prof Wlady Altermann**, Kumba-Exxaro Chair, Department of Geology;
- **Prof Walter Focke**, Director of the Institute of Applied Materials, Department of Chemical Engineering;
- **Prof Rashid Hassan**, Director of the Centre for Environmental Economics and Policy in Africa (CEEPA) in the Faculty of Natural and Agricultural Sciences;
- **Prof Marion Meyer**, Department of Plant Science;
- **Prof Michael Pepper**, Director of the Institute for Cellular and Molecular Medicine, Department of Immunology; and
- **Prof Clarke Scholtz**, Department of Zoology and Entomology.

Exceptional Young Researchers – two awards were made in 2014:

- **Dr Irene Barnes**, a research fellow at the Forestry and Agricultural Biotechnology Institute (FABI) and the Department of Genetics; and
- **Prof Naushad Emmambux**, an associate professor in the Department of Food Science.

Prof Don Cowan with Prof Stephanie Burton.

Prof Jan CA Boeyens with Prof Cheryl de la Rey.

External awards

External awards demonstrate recognition of the status of UP's researchers and their achievements. In 2014, several UP researchers received such awards as the following summary of highlights shows.

The NSTF-BHP Billiton Awards recognise outstanding contributions by individuals and teams to science, engineering, technology and innovation (SETI). In 2014 UP had four winners:

- **Prof Brenda Wingfield**, for her outstanding contribution to SETI through research capacity development over the past five to ten years, an award sponsored by Eskom;
- **Prof Don Cowan** shared the first place in the capacity building category with Professor Wingfield;
- **Prof Wanda Markotter** won in the category honouring emerging researchers who have made an outstanding contribution to SETI over a period of up to six years after obtaining a PhD; and
- **Prof De Wet Swanepoel** was the winner in the category for an outstanding contribution SETI through research leading to innovation.

The Order of Mapungubwe

Prof Namrita Lall, an expert in Medicinal Plant Science at UP, received the Presidential Award for outstanding research in medical sciences.

The National Research Foundation (NRF) special recognition award

Prof Stella Nkomo, Deputy Dean for Research and Post-Graduate Studies in the Faculty of Economic and Management Sciences, received the NRF award 'Champion of Research Capacity Development at South African Higher Education Institutions'.

The Stals Prize of the South African Academy of Science and Arts

Prof Kobus Maree from the Department of Educational Psychology in the Faculty of Education was awarded the Stals Prize for exceptional research and contribution to education.

The AIDS Society (IAS) and the Coalition for Children Affected by AIDS

Prof Irma Eloff, Dean of the Faculty of Education, won the international Prize for Excellence in HIV Research Related to Children from the International AIDS Society (IAS) and the Coalition for Children Affected by AIDS, in Melbourne.

Student awards

The University of Pretoria takes great pride in the development and achievements of students and, in particular, postgraduates as the pipeline to becoming the next generation researchers. Below are a few of the many awards our students received in 2014.

National Treasury Scholarships

Leoné Walters and **Mariska Steyn**, two postgraduate students from the Department of Economics, were awarded Economic Research Southern Africa (ERSA) scholarships. ERSA is a research programme funded by the National Treasury of South Africa.

DST Women in Science Awards

Lungile Sitole and **Cynthia Joan Henley-Smith**, both PhD students at UP, won Department of Science and Technology (DST) fellowships.

The Gauteng Department of Agriculture and Rural Development (GDARD), in partnership with The Innovation Hub

Dr Steven Hussey, a postdoctoral fellow in the Department of Genetics and the Forestry and Agricultural Biotechnology Institute (FABI) in the Faculty of Natural and Agricultural Sciences, was awarded a Biotech Fundi Student Award for his PhD research.

The SABS Young Standards Professional Award for 2014

Victoria Rautenbach, a PhD Geoinformatics student in the Department of Geography, Geoinformatics and Meteorology, received the SABS award for her exceptional contribution to the Standards Development fraternity.

An exceptional publication and winner of the Tertiary Mathematics Olympiad

Henry Thackeray's honours project resulted in an article published, with **Prof JE van den Berg**, in the Journal of Algebra in 2014. In his final BSc Mathematics year, he achieved the highest score in the South African Tertiary Mathematics Olympiad. He has received a bursary to continue his postgraduate study at Princeton University, US.

Faculty of Engineering, Built Environment and Information Technology (EBIT)

Dean: Prof Roelf Sandenberg (2001 – September 2014)

Dean: Prof Sunil Maharaj (October 2014 –)

Academic staff:	214	**NRF-rated:**	54	**Postdoctoral fellows:**	13
Research output – journal article units, 2014:	207.41				
Students:	Overall enrolment: 11 430 International students: 1 091 Master's and PhD students enrolled: 1 907 M and D graduates in 2014: 371				
Institutes:	Carl and Emily Fuchs Institute for Mico-Electronics (CEFIM) Eskom Power Plant Engineering Institute (EPPEI) Industrial Metals and Minerals Research Institute (IMMR) Institute for Technological Innovation (ITI) Institute of Advanced Materials (jointly with NAS)				
Centres:	African Centre of Excellence in Information Ethics Centre for Advanced Sensor Networks Centre for Electromagnetism Centre for Radio and Digital Communication Centre for Telecommunications Engineering for the Information Society (CeTEIS) Centre of Excellence in Pyrometallurgy Centre of New Energy Systems (CNES) SAIW Centre for Welding Engineering Specialist Centre in Plant Asset Management				
Other:	National Hub for Demand-side Management and Energy Efficiency				

Research Chairs

DST-NRF SARChI Chairs:	Advanced Sensor Networks
	Artificial Intelligence
	Carbon Technology and Materials
	Fluoro-Material Science and Process Integration
Industry Chairs:	Anglo American Chair in Pyrometallurgy
	Bateman Chair in Minerals Processing
	CBI Electric Low Voltage Chair in Power Electronics
	Chair in Electronic Defence Research (CEDR)
	Chair in Maintenance Engineering
	Exxaro Chair in Energy Efficiency
	Gijima AST Chair in Informatics
	Harmony Chair in Computational Rock Engineering and Numerical Modelling
	Rand Water Chair in Civil Engineering – Water
	Rand Water Chair in Mechanical Engineering – Water
	SAIW Chair in Welding Engineering
	Sasol Chair in Safety, Health and the Environment
	Sedibeng Chair in Water Utilisation Engineering (X2)
	Transnet Chair in Railway Engineering
	Sentech Chair in Broadband Wireless Multimedia Communication
	Xstrata Chair in Modelling of Pyrometallurgical Processes
Web link:	http://www.up.ac.za/faculty-of-engineering-built-environment-it

Economics and Management Sciences

Dean: Prof Elsabé Loots

Academic staff: 170	**NRF-rated:** 24	**Postdoctoral fellows:** 8
Research output – journal article units, 2014:	115.36	
Students:	Overall enrolment: 8 620	
	International students: 691	
	Master's and PhD students enrolled: 992	
	M and D graduates in 2014: 245	
Institutes, Centres and Units		
Institutes:	African Tax Institute	
	International Institute of Internal Auditing	
Centres:	Albert Luthuli Centre for Responsible Leadership	
	Centre for Communication and Reputation Management	
Units:	Forensic Accounting	
Research Chairs:	SARChI Chair in Tax Policy and Governance	
	South African Reserve Bank Chair In Monetary Economics	
Web link:	http://www.up.ac.za/en/faculty-of-economic-and-management-sciences	

Faculty of Education

Dean: Prof Irma Eloff

Academic staff: 72	**NRF-rated:** 22	**Postdoctoral fellows:** 3
Research output – journal article units, 2014:	43.3	
Students:	Overall enrolment : 17 912 (including distance)	
	International students: 150	
	Master's and PhD students enrolled: 476	
	M and D graduates in 2014: 1 943	
Centres and Units		
Centres:	Centre for Education Law and Education Policy (CELP)	
	Centre for Evaluation and Assessment (CE)A	
	Centre for the Study of Resilience	
	Joint Centre for Maths, Science and Technology Education (JCMSTE) – joinly with NAS	
Units:	Living Lab for Innovative Teaching at UP (LLITUP)	
	Unit for Distance Education	
	Unit for Education Research in AIDS (ERA)	
Web link:	http://www.up.ac.za/faculty-of-education/article/30572/boodskap-van-die-dekaan	

Faculty of Health Sciences

Dean: Prof Eric Buch

Academic staff: 217	**NRF-rated:** 25 **Postdoctoral fellows:** 19
Research output – journal article units, 2014:	204.83
Students:	Overall enrolment: 6 369 International students: 612 Master's and PhD students enrolled: 1 081 M and D graduates in 2014: 404
Institutes, Centres and Units	
Institutes:	Institute for Molecular and Cellular Biology Institute for Sport Research
Centres:	Applied Morphology Research Centre Comprehensive Physical Rehabilitation Centre Forensic Anthropology Research Centre UP Centre for Sustainable Malaria Control
Units:	Environmental Chemical Pollution and Health Research Unit MRC Unit for Inflammation and Immunity MRC Unit for Maternal and Infant Health Care Strategies MRC Stem Cell Research and Therapy Unit MRC Collaborating Centre for Malaria Research
Research Chairs:	Rand Water Chair in Water and Public Health Chair in Philosophy and Ethics of Mental Health
Web link:	http://www.up.ac.za/en/faculty-of-health-sciences/article/30851/message-from-the-dean

Humanities

Academic staff: 210	**NRF-rated:** 35	**Postdoctoral fellows:** 24
Research output – journal article units, 2014	162.29	
Students:	Overall enrolment: 6 359 International students: 628 Master's and PhD students enrolled: 1 073 M and D graduates in 2014: 178	
Institutes, Centres and Units		
Institutes:	Institute for Strategic and Political Affairs (ISPA)	
Centres:	Centre for Augmentative and Alternative Communication (CAAC) Centre for Mediation in Africa (CMA) Centre for Sexuality, AIDS and Gender (CSAG) Centre for the Study of Governance Innovation (GovInn) Centre for Japanese Studies	
Units:	Unit for Academic Literacy (UAL) Unit for Creative Writing (UCW) UP Cochlear Implant Unit (UP-CIU)	
Other:	Itsoseng Clinic	
Research Chairs:	Jean Monnet Chair in Regional Integration and Governance Studies Chair in Regional Integration, Migration and Free Movement of People	
Web link:	http://www.up.ac.za/faculty-of-humanities	

Dean: Prof Norman Duncan (May 2012 – July 2014)

Acting Dean: Prof Hennie Stander (August 2014 –)

Law

Dean: Prof André Boraine

Academic staff: 64	**NRF-Rated:** 14	**Postdoctoral fellows:** 6
Research output – journal article units, 2014	112.42	
Students:	Overall enrolment: 1 972 International students: 311 Master's and PhD students enrolled: 586 M and D graduates in 2014: 169	
Institutes, Centres and Units		
Institutes:	Institute for International and Comparative Law in Africa (ICLA)	
Centres:	Centre for Advanced Corporate and Insolvency Law Centre for Child Law Centre for Human Rights Centre for Intellectual Property Law Centre for Law and Medicine Sports Law Centre in Africa	
Units:	International Development Law Unit (IDLU)	
Research Chairs:	SARChI Chair in International Development Law & African Economic Relations Barclays Chair in Banking Law in Africa UNESCO Chair in Education Law in Africa	
Web link:	http://www.up.ac.za/en/faculty-of-law/article/2054363/message-from-the-dean-	

Theology

Dean: Prof Johan Buitendag

Academic staff: 24.5	**NRF-rated:** 16	**Postdoctoral fellows:** 11
Research output – journal article units, 2014:	175.58	
Students:	Overall enrolment: 749 International students: 95 Master's and PhD students enrolled: 454 M and D graduates in 2014: 77	
Centres:	Centre for Contextual Ministry (CCM) Centre for Public Theology (CPT) Centre for Sustainable Communities Excelsus (Dutch Reformed Church: Centre for Continuing Ministerial Development) Centre for African Spirituality and Culture	
Other:	HTK (Netherdutch Reformed Church College	
Web link:	http://www.up.ac.za/en/faculty-of-theology/article/33395/message-from-the-dean	

Natural and Agricultural Sciences

Dean: Prof Anton Ströh (May 2004 – August 2014)

Acting Dean: Prof Brenda Wingfield (August 2014 –)

Academic staff: 248	**NRF-rated:** 165	**Postdoctoral fellows:** 103
Research output – journal article units, 2014:	331.55	
Students:	Overall enrolment: 6 858 International students: 854 Master's and PhD students enrolled: 1 440 M and D graduates in 2014: 287	

Institutes, Centres and Units

Institutes:	Forestry and Agricultural Biotechnology Institute (FABI) Genomics Research Institute Institute for Food, Nutrition and Well Being (IFNUW) Institute of Applied Materials (jointly with EBIT) Mammal Research Institute (MRI) UP Water Institute
Centres:	African Centre for Gene Technologies (ACGT with CSIR and WITS) Centre for Environmental Economics and Politicy in Africa (CEEPA) Centre for Environmental Studies (CFES) Centre for Geo-Information Sciences (CGIS) Centre for Microbial Ecology and Genomics (CMEG) Centre for Wildlife Management DST-NRF Centre of Excellence for Food Security (co-hosted with University of the Western Cape) DST-NRF Centre of Excellence for Tree Health Biotechnology Joint Centre for Maths, Science and Technology Education (JCMSTE) – jointly with Education SADC Centre for Land Related Regional and Development Policy UP Natural Hazard Centre, Africa
Units:	Bioinformatics and Computational Biology Unit Conservation Ecology Research Unit (CERU)

Research chairs

DST-NRF SARChI Chairs:	Chair in Statistics Chair in Mammal Behavioural Ecology & Physiology Chair in Complex Systems Chair in Mathematical Models and Methods in Bioengineering and Biosciences Chair in Sustainable Malaria Control
Industry Chairs:	Barclays Chair in Actuarial Sciences

	Barclays Chair in Agribusiness Management Aon Benfield Chair in Geology Exxaro-Kumba Chair in Geodynamics Mondi Chair in Tree Pathology Rand Water Chair in Water Microbiology SAFCOL Chair in Forestry Sappi and Mondi Chair in Forest Genomics and Biotechnology
Web Link:	http://www.up.ac.za/en/faculty-of-natural-agricultural-sciences/

Veterinary Science

Academic staff: 97	**NRF-rated:** 32	**Postdoctoral fellows:** 13
Research output – journal article units, 2014:	101.95	
Students:	Overall enrolment: 1 337 International students: 185 Master's and PhD students enrolled: 271 M and D graduates in 2014: 56	
Centres:	Centre for Veterinary Wildlife Studies Equine Research Centre Exotic Leather Centre UP Biomedical Research Centre	
Research Chairs:	Chair in Primary Animal Healthcare (PAHC) Research Chair in Poultry Health and Production air in Poultry Health and Production	
Web link:	http://www.up.ac.za/en/faculty-of-veterinary-science/article/33527/message-from-the-dean	

Dean: Prof Gerry Swan
(October 2005 – July 2014)

Dean: Prof Darrell Abernethy
(August 2014 –)

Gordon Institute of Business Science (GIBS)

Dean: Prof Nick Binedell

Academic staff:	NRF-rated: 3
Students:	Overall enrolment: 693 International students: 75 Master's and PhD students enrolled: 627 M and D graduates in 2014: 239
Centres:	Centre for Business Analysis and Research (CBAR) Centre for Dynamic Markets Centre for Leadership and Dialogue
Other:	Enterprise Development Academy
Web link:	http://www.gibs.co.za/about-us/na_5/directors-message.aspx
Profile:	Founded in 2000, the University of Pretoria's Gordon Institute of Business Science (GIBS) is an internationally accredited business school, based in Johannesburg, South Africa's economic hub. As the business school for business, we focus on general management in dynamic markets to significantly improve individual and organisational performance, primarily in the South African environment, through the provision of high-quality business and management education. In May 2014 the annual UK *Financial Times* Executive Education rankings, a global benchmark for providers of executive education, once again ranked GIBS as the top South African and African business school. This was the 11th year running that GIBS was ranked among the top business schools worldwide. In October 2014 the GIBS MBA was ranked among the top 100 business schools globally in the prestigious *Financial Times* Executive MBA Rankings. GIBS is the only business school in Africa to appear in this ranking. GIBS is accredited by the Association of MBAs (AMBA), the Council on Higher Education (CHE) and is a member of the South African Business Schools Association (SABSA), the Association of African Business Schools (AABS) and the European Academy of Business in Society (EABIS).

Acknowledgements

Several individuals and groups made possible the production of UP's Research Review 2014. The Department of Research and Innovation Support would like to thank the researchers whose work is profiled here, the critical readers who made certain that we stayed on track in the choice of content and illustrative examples, and the photographers whose images capture the contexts that make UP's research endeavours so exceptional. We also wish to acknowledge UP Library Services, the Finance Department, and most especially, Ingrid Clarke and her production team at Words'Worth.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Make today matter.

Department of Research and Innovation Support, University of Pretoria
Private Bag X20, Hatfield 0028, Pretoria, South Africa

Tel + 27 (0) 420 5006 | **Email** dris@up.ac.za

For publication data and an online version of this report, see
http://www.up.ac.za/research-innovation