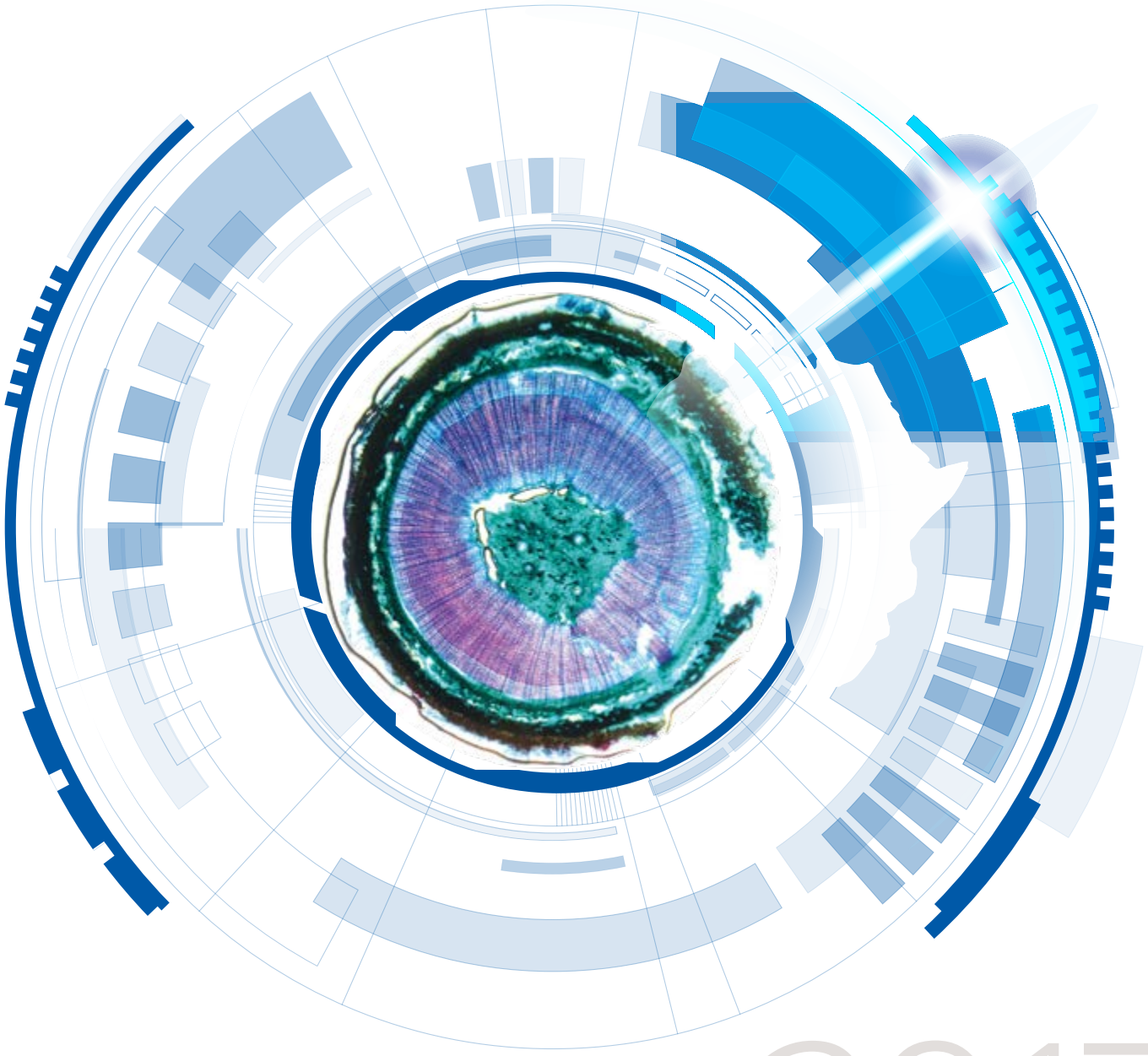
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



RESEARCH REVIEW 2017

Cover:
A stem cross-section of a *Ginkgo biloba* branch. Ginkgo is one of four major lineages of non-flowering seed plants (gymnosperms) that separated from flowering plants over 350 million years ago. It is a valuable species for understanding the evolution of wood formation through studying its wood properties and expressed genes.

Photo credit: Danielle Roodt, a PhD student in the Department of Biochemistry, Genetics and Microbiology, and the Forestry and Agricultural Biotechnology Institute.

Foreword

Professor Cheryl de la Rey, Vice-Chancellor and Principal

Each year the University of Pretoria publishes a research report that celebrates the rich and diverse work of some of our leading researchers and young emerging scientists. This 2017 Research Review provides evidence of the contribution that UP's research is making to our individual and collective futures, and of the multiple ways in which our committed researchers are succeeding in addressing the dual objectives of academic excellence and societal relevance.

Aligned with the global agenda for sustainable development, as expressed in the UN Agenda 2030, and the goals of South Africa's National Development Plan, the University's long-term strategic plan, UP 2025, is based on a commitment to pursue research that matters, research that addresses complex societal challenges and, in particular, challenges that are faced by the developing regions of the world. The research that we report on in this Review illustrates the successes we have had in working towards these goals.

Our research strategy is informed by the global trend, in addressing the complex challenges of real world problems, of multidisciplinary and transdisciplinary approaches, and our research has become increasingly team-driven. This Review casts the spotlight on the multidisciplinary, solutions-driven research that has been undertaken by researchers working in teams. There is also a special emphasis on including opportunities for young researchers, bringing new perspectives and different dimensions to our key research focus areas.

The achievements reported in this Review also highlight the growing importance of networks and multi-stakeholder partnerships in driving research impact. By building on areas of research strength, and actively developing networks and partnerships in areas of societal relevance in order to leverage maximum impact, the University has pursued its commitment to using science and innovation for development, and for the well-being of people, society and the environment.

Examples of research at UP that have achieved the objectives of excellence and societal relevance include work on food security that has resulted not only in the development of new approaches to nutrition and efficient food production, but also to a study of the potential value of one of Africa's lost indigenous crops, and, from a societal viewpoint, contributions to food-related policy change in Africa. A further example is research on the genetics, genomics and the bioengineering of trees and their pests and pathogens, where world-leading research contributes directly to development needs and the global competitiveness of the forestry industry in South Africa. There are many more examples: from crops to livestock, and from cancer and non-communicable diseases to precision medicine and the future of science. Our researchers are showing that fundamental research, and translational research with local relevance, go together towards making a difference.

We acknowledge that the success of our multidisciplinary research is founded on areas of expertise that have been built up over many years. In 2017, the UP held two centenary celebrations, in fields where we have sustained high-impact contributions, namely Agricultural Science, and Theology and Religion. The events that marked these milestones celebrated past research achievements as well as looking ahead to the future directions of research, as featured in this Review. We are especially proud to recognise the University's flagship Forestry and Agricultural Biotechnology Institute (FABI), which celebrated its 20th anniversary year under the theme of *The Road to Research Excellence*, showcasing the impact of world-class collaborative, interdisciplinary research in an area which is key to sustainability.

Along with these highlights of the research at UP, in 2017 our research productivity continued to grow, with increasing numbers of research publications, and upward progress in the international rankings. The impact of our research contributed to UP's strengthened position, especially in world subject field rankings where we are now ranked (in the QS rankings) in the broad areas of Arts and Humanities, Engineering and Technology, Life Sciences and Medicine, and Social Sciences and Management, and notably, in the subject field Theology, Divinity and Religious Studies, UP was ranked in the top 100 globally. Exceptionally pleasing was that UP was ranked 92 globally in the subject field Law, by the Times Higher Education world rankings, and second internationally in the field of Mycology, by the Centre for World Universities.

I wish to express my appreciation to all of our researchers and their research teams, partners, collaborators and funders, for their distinctive and exceptional contributions to the achievements of the University of Pretoria in 2017.

Introduction

Professor Stephanie Burton, Vice-Principal:
Research and Postgraduate Education

The University of Pretoria has an established reputation for research quality and excellence, and a research strategy focused on societal challenges, in particular the challenges faced by Africa. This Review highlights some of our research achievements in 2017 and underscores our commitment to contributing to the achievement of the United Nations Sustainable Development Goals (SDGs) and, closer to home, to the goals articulated in South Africa's National Development Plan. Research is one mode of response in fulfilling the role that universities can play in addressing these priority agendas.

We have grouped the research profiled in the 2017 Review under four broad themes:

Development and change. From food security to the economy, the theme is introduced with a positioning text about UP research and the SDGs, and how we seek to translate our research endeavours into policies and practices for sustainable development. The theme further includes a focus on water, land and agriculture.

People and contexts. The first grouping of research on texts and history illustrates the complexity of the present, and research on human rights and dignity, which are at the core of the SDGs and Africa's development trajectory. The theme concludes with research on what the future holds with a focus on artificial intelligence, digitalisation, and technologies that drive and depend on big data and data science.

Health and well-being. This theme illustrates how health and well-being tie together a number of the SDGs, and are precondition indicators as well as outcomes of successful sustainable development. The link between treatment and public health care policies is foregrounded, as is accessible and affordable health care. A further focus is on non-communicable diseases, which are of pandemic proportions in sub-Saharan Africa. The theme concludes with a brief focus on an approach to One Health to benefit communities, livestock and wild life.

Planet and sustainability. The final theme opens with texts on the bioeconomy, systems biology and agricultural biotechnology as catalysts for new research possibilities. This is followed by sections reporting on research on forests, trees and fungi, animal behaviour, competition and cooperation, and the study of survival, and, finally, research on microbial ecology and biodiversity.

In overview, our research achievements in 2017 included an increase in research output, continuing the trend leading to a 51% increase over the past five years. There has been a year-on-year increase in doctoral enrolments and, in 2017, a record number of 354 doctoral graduates. By the end of 2017, 65% of our academic staff held doctoral degrees, which has supported increasing research and postgraduate training capacity at UP.

With respect to our international standing, 35 leading researchers at UP were among the top 1% of scientists internationally in the Web of Science (WoS) indexes in 2017, based on citations. In the WoS Essential Science Indicators, UP was grouped within the top 1% worldwide in eight of 22 broad knowledge fields. The Scopus indexes show that 45% of UP's publications were co-authored with international scholars, and an impressive 10.8% fell in the top 10% of papers most cited internationally.

UP's research platforms and entities consolidate our research capacity, and make possible the multidisciplinary research teams needed to address the complexities that characterise development challenges. In 2017, the total of 125 UP research entities included 69 institutes and centres and 56 other entities, including South African Research Chairs Initiative (SARChI) Chairs, national Centres of Excellence, Communities of Practice, Medical Research Council Units, and Industry-sponsored Research Chairs.

An appropriate conclusion to the Review is our acknowledgement of the achievements of individual young scientists and leading researchers at the University of Pretoria. We list the recipients of the annual University of Pretoria Academic Achievers' Awards, and some of the most prestigious external awards. The final section provides short profiles of our A-rated scientists who are recognised internationally as leaders in their respective fields.

I would like to extend my sincere appreciation to those who are doing the excellent research we have showcased here, and to all who have contributed to this 2017 Research Review.

Acknowledgements

Dr Nthabiseng Taole, Director,
Department of Research and Innovation

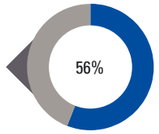
The production of the University of Pretoria's annual Research Review is always a highlight in the academic calendar, and is one of the important projects of the Department of Research and Innovation. Many researchers and staff contribute to the success of the Review, and I would like to acknowledge the contributions of the following individuals and departments:

- The researchers who provided texts, information and photographs.
- The group of expert researchers who served as critical readers: Professors Don Cowan, Robin Crewe, Michael Pepper, Bernard Slippers, and Brenda Wingfield.
- Dr Cheryl Tosh who served as editor of the research texts of the Faculty of Health Sciences.
- Bhaviksha Ramouthar for cataloguing images received, searching for more, and for her administrative support to the project.
- Colleagues in the Department of Research and Innovation for preparing the detail on UP's research publications in 2017, and Elize Nagel in the Department of Information Technology.
- Our colleagues in UP Libraries, Institutional Planning and University Relations.
- Hanlie Griesel who coordinated, planned and edited the Review.

The work of many more researchers at UP could be profiled, if it were not for the constraints of space and costs. We indeed plan that in the next Review new faces and new innovative research fields of excellence will be profiled.

Next-generation researchers

1 049
Research Master's graduates (overall 1 866 Master's graduates)



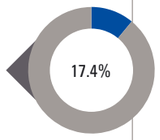
27%
Postgraduate students as % of overall enrolment

354
Doctoral graduates

61%
Black postgraduate contact students

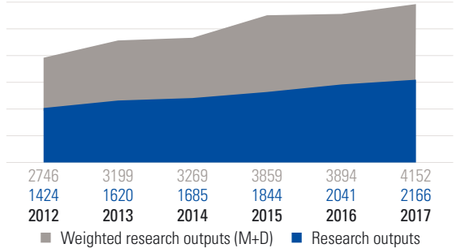
35%
International doctoral students enrolled

2 278
International postgraduate students



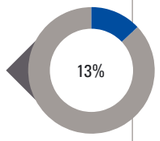
Researcher productivity and quality

UP RESEARCH OUTPUTS, 2012-2017



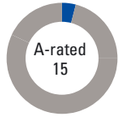
65%
Staff with PhDs

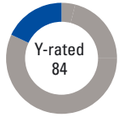
280
International academic staff



460
Total # UP researchers with NRF-rating

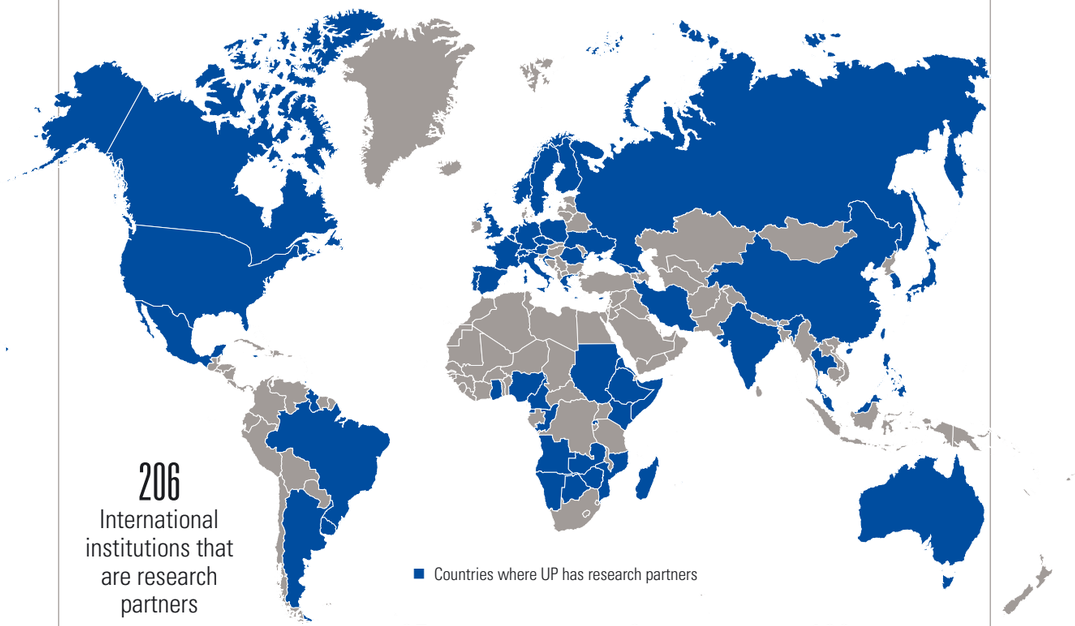
Research leaders recognised internationally for quality and impact





Young researchers recognised as potential future leaders

UP's international partners and standing



206
International institutions that are research partners

TOTAL NUMBER OF PARTNERS BY CONTINENT

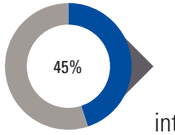
Africa	33
Asia	20
Europe	113
Middle East	3
North America	27
Oceania	3
South America	7
Total	206

35
UP researchers in the top 1% internationally[1]

8
Knowledge fields in top 1% of ESI[1] fields

100
Papers in top 1%, citations[1]

1 336
Publications in the top 10% most cited[2] (10.8%)

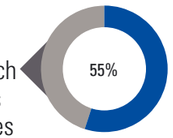


45%
of publications co-authored with international scholars[2]

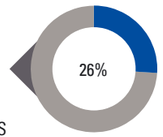
1 Essential Science Indicators (ESI), Web of Science; 2 SciVal, Scopus

Research entities strengthen collaboration and capacity

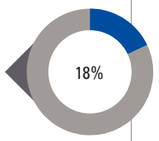
69
UP Research Institutes and Centres



33
Industry and public sector Research Chairs



23
DST-NRF SARChI Chairs, Centres of Excellence and MRC Units



DEVELOPMENT AND CHANGE

Shutterstock

UP research, development and the SDGs

Willem Fourie, The Albert Luthuli Centre for Responsible Leadership

The University of Pretoria's research strategy and projects are increasingly focused on the complexities of development in Africa, and how best to translate our research endeavours into policies and practices that sustain the well-being of all.

In Africa, development planning efforts over the past decades have taught us at least one lesson: ensuring both sustainable and inclusive development is a complex endeavour. There are clearly no so-called quick fixes, and no one societal actor or group has the knowledge, experience and expertise needed to address the challenges facing most societies in Africa. The adoption of the African Union's Agenda 2063 – a long-term transformative development vision – is testament to this sea-change.

At a global level, the 2030 Agenda for Sustainable Development and its Sustainable Development Goals (SDGs) express global consensus on the complexity of development. There are at least three reasons why the SDGs should be viewed with optimism.

The SDGs, firstly, place a great deal of attention on their 'indivisibility'; most simply put, developmental challenges are complex and interlinked. Access to quality education, for example, cannot be ensured without ensuring access to nutritious food, clean water and sanitation, and access to quality health care.

Their overarching emphasis on 'leaving no-one behind' positions this, secondly, as a moral agenda. Read in this way, the goals present a vision of development that seeks to promote distributive justice. Throughout these expansive goals the underlying assumption is that development should correct deeply unjust systems of distribution, while ensuring that these systems are reconfigured to function more sustainably.

Middle-income countries such as South Africa play an interesting role in realising this global agenda – also beyond our borders. On the one hand, we have the moral responsibility of sharing our expertise and resources; but on the other hand, this agenda should sharpen our vision to recognise and assist vulnerable groups in our country. And we should not equate vulnerability only with minority groupings, even though many smaller groupings are particularly vulnerable. Many South Africans are rendered vulnerable, at least partly due to their gender, age, ethnicity and place of living, and as a result of the intersectionality of these identities.

The SDGs, thirdly, emphasise the importance of partnerships in a new way. The 2030 Agenda is the first global development agenda applicable equally to developed and developing countries. And, for the first time, development agendas also explicitly include universities, business, governments and NGOs as fully-fledged partners.

It is clear that the fates of regions and countries, and sectors within countries, are intertwined. Few topics make this as clear as climate change – greenhouse gases and their effects are not bound by national borders.

Earthworld Architects

UP Experimental Farm, with the Future Africa campus in the foreground.

In an interconnected world, it has become possible for countries, regions and institutions to work towards the same set of goals. This is why the SDGs – despite criticism – can become the catalysts for substantive change, through a shared vocabulary and the sustained actions required to address complex development challenges.

What role should universities, especially in the developing world, play in realising this integrated, moral and collaborative agenda?

Two challenges stand out: firstly, the dissemination of high-quality research should be improved. This means that more resources should be invested in creating 'meta-platforms' that collect, synthesise and disseminate research in accessible formats to decision-makers in the public and private sectors. The research on evidence-informed policymaking is unambiguous on the importance of concerted and well-resourced initiatives in this regard.

Secondly, as both the International Council for Science (ICSU) and the Sustainable Development Solutions Network's Australia-Pacific network have indicated, scientists need to experiment to a greater extent with multidisciplinary research. This flows from the realisation, as expressed by the SDGs, that the global community has moved beyond an overly simplistic understanding of 'development' and the requisite responses to its underlying causes. Realising the 2030 Agenda's SDGs indeed require both high-quality discipline-specific and innovative multidisciplinary research.

THE GLOBAL GOALS
For Sustainable Development

The South African SDG Hub at UP

South Africa's universities produce a vast amount of research, a great deal of which is relevant to realising national, continental and global development goals. Yet, a relatively small proportion of this research reaches decision-makers in the public sector. This challenge is not unique to South Africa or the developing world.

A key barrier for the uptake of research into policymaking is the absence of appropriate platforms to collect, synthesise and disseminate potentially relevant research. In response to this challenge, **Professor Willem Fourie** at the **Albert Luthuli Centre for Responsible Leadership**, with the support of policymakers in the African Union and South African government, designed the **South African SDG Hub**.

The genesis of this initiative dates as far back as 2014. At that time, the 2030 Agenda and SDGs were still known simply as the post-2015 agenda. Yet, policymakers voiced the concern that the realisation of this agenda will be impeded by inadequate access to the most relevant African research. This challenge gave rise to the idea of collating and disseminating useful and potentially transformative African research and innovation to African policymakers and, by so doing, to build a research-informed and shared understanding of development challenges, and progress toward the achievement of what has come to be known as the SDGs.

By the end of 2017, more than 600 research items and numerous news features were assembled on the Hub's online platform.

The Hub's first iteration was launched in 2017 by Minister Jeff Radebe, then Minister in the Presidency, and it has since received support from a number of South African government departments.

The Hub currently consists of a network of online and face-to-face platforms. It is supported by the Department of Science and Technology (DST) and an increasing number of researchers from universities across South Africa form part of its network. Importantly too, its membership of the prestigious Sustainable Development Solutions Network – the premier global network of universities that is backed by the United Nations and supports the realisation of the SDGs – embeds the Hub in a network of like-minded institutions, thereby broadening information contribution and its dissemination reach.

In addition to these activities, an Artificial Intelligence (AI) grant from Microsoft is making it possible for a group of postgraduate students at UP to investigate the potential of AI to summarise and synthesise peer-reviewed research into policy-relevant formats.

It is maintained by a small group of enthusiastic workers, strengthened by a steady flow of information on translational research that informs and can contribute to the achievement of the SDGs in Africa.

From left: Sa'diyah Ebrahim, Willem Fourie, Isak van der Walt and Lebone Nkhumeleni

The Hub's online platform is available at www.SASDGHub.org.

FOOD SECURITY

The Food and Drug Administration (FDA) in the United States estimates that about 795 million of the 7.3 billion people in the world, or one in nine, are suffering from chronic undernourishment, and that almost all of these (780 million) live in developing countries. A further two billion people are micronutrient deficient and, at a similar scale, overweight or obese. Malnutrition, including micronutrient deficiencies and over- and undernutrition, are the main contributors to the global disease burden, a situation exacerbated in Africa, where the impact of climate change is already being experienced. Scientists at UP, from a range of knowledge fields, have focused on different dimensions related to food security, and three research entities have consolidated critical research capacity: the Institute for Food, Nutrition and Well-being (IFNuW), the SARChI Chair in Nutrition and Food Security, and the DST-NRF Centre of Excellence in Food Security, jointly hosted with the University of the Western Cape.

Media Club South Africa

Supporting food security policy change in Africa

Sheryl Hendriks, Institute for Food, Nutrition and Well-being

The resolve of African governments to meeting their national development priorities and international obligations and commitments towards addressing hunger, food insecurity and malnutrition in Africa has never been stronger.

Emerging evidence from international studies shows that there is an overall reduction in the proportion of people suffering from food insecurity on the continent. However, leaders recognise that much more needs to be done to speed up the rate of reduction. Driven by the comprehensive agenda of the SDGs, Africa's Agenda 2063 and the 2014 Malabo Declaration on accelerated agricultural growth and transformation for shared prosperity and improved livelihoods, African countries are actively engaged in policy review and strategic development planning efforts.

Led by **Professor Sheryl Hendriks**, **Director** of the **Institute for Food, Nutrition and Well-being** or IFNuW, a team of UP researchers had the opportunity to apply the knowledge and skills developed through their policy research work on food security and nutrition to support policy reform processes in a number of countries in West and East Africa. The research work was initiated through the UP Institutional Research Theme on Food, Nutrition and Well-being launched in 2012. The translation of this earlier work, funded by the USAID Feed the Future Innovation Lab for Food Security Policy, has been carried out in partnership with colleagues from Michigan State University, the International Food Policy Research Institute, and the Regional Strategic Analysis and Knowledge Support System.

The UP team has developed a number of policy assessment tools to help country teams review existing policies and design new strategies for food security, as well as in supporting countries to develop a deeper understanding of ways in which to mainstream gender in development policy. The African Union has integrated some of this work into guidance notes and toolkits.

One of the key contributions to the science of policymaking has been the development and testing of a new theoretical framework to understand how policy change occurs (or does not). The Kaleidoscope Model of policy change brings together a vast but dispersed knowledge base derived from empirical policy analysis, political economy literature and theoretical scholarship on policy processes. The model was validated through studying 38 episodes of policy change over a 50-year period in Malawi, South Africa and Zambia. A paper comparing the policy change episodes for fertilizer and micronutrients in Zambia was accepted for publication in the journal *World Development*. The model has already been adopted by key international agencies such as the World Bank.

The team has helped governments to better align their national development plans, sectoral policies and the monitoring and evaluation frameworks of medium-term strategic plans. The value of this work has been particularly evident in the refinement by national working groups designing five-year strategies for agriculture and food security in Malawi and Liberia, and in the adoption of suggestions to improve Malawi's Draft National Nutrition Policy 2016–2020.

In 2017, the lessons from these studies were published as technical working papers, policy briefs shared with African governments, widely read *Conversation Africa* articles, online blogs and journal articles, including articles in *PLOS one* and the *South African Journal of Clinical Nutrition*.

Mainstreaming gender in development policy

Elizabeth Mkandawire, Institute for Food, Nutrition and Well-being

One of the critical challenges in development policies is accurately to reflect gendered practices, particularly in rural communities, and thereby to challenge conventional wisdom about the respective roles of men and women most often excluded or at a distance from policy formulation processes.

The tendency in development policies is to entrench traditional gendered roles, especially with respect to childcare practices. Yet, far greater progress has been achieved in some instances than what is reflected in development policies.

This insight was borne out in a recent review of Malawi's Draft National Nutrition Policy 2016–2020. As part of the USAID Feed the Future Innovation Lab for Food Security Policy, PhD student **Elizabeth Mkandawire** and her supervisor, **Professor Sheryl Hendriks**, reviewed the draft policy, identifying that it was 'gender blind',

by focussing on women as the key gatekeepers in child nutrition. Yet, their engagement with a community in rural Central Malawi established that men play a vital role as caretakers, and in providing support to women during pregnancy. This role includes obtaining nutritious food for pregnant women, caring for children, and helping with household chores.

By bringing members of the community together with policymakers from the Malawian Department of Nutrition, HIV and AIDS, a platform for dialogue was created, as well as an opportunity for authentic interaction between policymakers and community members. The focus of the interaction was on how best to embrace a truly gendered approach in the National Nutrition Policy. In the process, community members were able to influence the final iteration of the policy, and policymakers had the opportunity to broaden their understanding of changing gender dynamics at community level.

Research undertaken in this community, and the engagement between the policymakers, members of the community and researchers, has directly informed the revision of the draft policy. Recommendations from the policy dialogue were shared in the form of a policy brief with the Ministry of Gender, Children, Disability and Social Welfare, and the Department of Nutrition, HIV and AIDS.

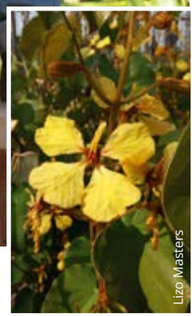
The work will be published in the journal, *Biomedical Central Pregnancy and Childbirth and Development Policy Review*, and was reported on in two *Conversation Africa* articles in 2017.

Elizabeth Mkandawire and Sheryl Hendriks

Realising the potential of Marama beans

Nigel Barker, Department of Plant and Soil Sciences

Marama beans have long been known for their food value, and have been identified as an 'orphan crop' and as one of the 'Lost Crops of Africa'*. While extensive research has been conducted on one species, *Tylosema esculentum*, the focus has been on its potential food value, and not its evolutionary history.



Nigel Barker and Lizo Masters
Inset: The Marama bean flower

Tylosema esculentum is endemic to the semi-arid regions of Namibia, Botswana and parts of South Africa. It is known to survive periods of drought, high temperature and low rainfall because of a massive underground tuber. The tuber, along with the seeds, are a staple source of food for local populations in the Kalahari Desert. In some cases, up to 75% of the vegetable content of Kalahari tribes' diet is made up of Marama bean. The nutritional quality of Marama seeds rivals not only that of soy and peanuts in terms of protein and oil content, but also most commercially available legumes and even other wild crops with agricultural potential.

T. esculentum is thus of considerable interest to disciplines associated with food security and, over the years, researchers at UP have studied a number of aspects related to its nutritional value. Before any serious efforts can be made to introduce this plant as an economically viable crop, a deeper understanding of its biology is needed.

To this end, **Professor Nigel Barker**, Head of the **Department of Plant and Soil Sciences**, and **MSc student Lizo Masters**, initiated a study in 2017 on the evolutionary relationships, population genetic diversity and comparative growth physiology of the plant. The study was undertaken in collaboration with Professor Christopher Cullis, Case Western Reserve University, US; Professor Karl Kunert, Extraordinary Professor in Plant and Soil Sciences at UP; and Professor Percy Chimwamurombe, Namibia University of Science and Technology.

Modern DNA technologies make it possible to obtain a detailed understanding of genetic diversity and local adaptation of *T. esculentum* and related species such as *T. fassoglense*. This information will be of value in future plant breeding experiments on this species, as such experiments require a clear understanding of species limits and population differences. A living collection of these plants is being established at the University of Pretoria's experimental farm situated on the Hillcrest Campus.

Preliminary results suggest that species limits based on plant morphology are not supported by the DNA data, indicating some intriguing historical evolutionary processes that are at play. In particular, *T. esculentum* (the typical Marama bean from the Kalahari) is genetically indistinguishable from samples of *T. fassoglense*, which occurs in the savannah regions. While these species differ in seed shape, it is possible that such differences are recently evolved and that this is simply one variable species complex, and that gene flow between populations is still ongoing. Alternatively, the Kalahari species is of such recent origin that there has been insufficient evolutionary time for it to acquire its own unique genotype. The fact that these species are very similar means that this variable gene pool can be exploited in future plant breeding programmes.

* National Research Council. 2006. Lost Crops of Africa: Volume II: Vegetables. Washington, DC: The National Academies Press. https://doi.org/10.17226/11763.

Waste, not food waste

John Taylor, **Riëtte de Kock** and **Janet Taylor**, Institute for Food, Nutrition and Well-being

Brewers spent grain (or BSG) is one of the biggest waste by-products in the brewing industry. A team of food scientists at UP is investigating ways in which this waste can be put to good use.

Professors John Taylor and Riëtte de Kock, and Dr Janet Taylor have been leading a group of postgraduate students to find ways to convert BSG into nutritious food, as well as environmentally-friendly packaging materials.

They are currently working on using BSG as a partial substitute for wheat in the production of a higher-fibre and high-protein bread. The team has shown that simple physicochemical modifications of BSG prior to its use as a functional food ingredient can potentially give quality, high-fibre wheat-BSG composite bread. The innovation also has a financial benefit that could help reduce the expense incurred when using wheat flour in bread, as wheat is mostly imported.

The researchers have also experimented with substituting some of the wheat in the production of a convenient snack biscuit. They have found that substituting 50% of the wheat flour with BSG results in nutritionally superior biscuits with a higher protein and fibre content than if only wheat were to be used. What is interesting is that the 50:50 ratio of wheat and BSG seems to be sensorially acceptable compared, for example, to a standard ginger biscuit. This is a good sign as to whether the product will be accepted as a good and nutritious snack.

An additional aspect of the project is the production of a rigid bioplastic food packaging material, by using a combination of BSG with another waste product from the cornstarch wet milling industry, called gluten 60. This cornstarch by-product contains almost 60% protein (mainly zein, the storage protein of maize kernels) and when combined with BSG, produces a material that resembles *papier mâché*. The team hopes that the product will add value to the takeaway foods industry in South Africa and further afield, as it is food-compatible and biodegradable.

Postgraduate student, Jillian Oosthuizen, prepares a tray of spent grain biscuits for baking.

WATER

Directly linked to SDG 6, water is the most critical of the world's life support systems and therefore central to the global sustainable development agenda and many of the other SDGs. Access to clean water is a basic human right. The lack of access to safe potable water predominantly affects those living in poverty in rural areas in developing regions, and on the margins of cities in informal settlements. The World Health Organization estimates that, globally, two billion people use a water source contaminated with faeces. This impacts on public health, as contaminated water can transmit diseases such diarrhoea, cholera, dysentery, typhoid and polio. Approximately 90% of diarrhoeal deaths worldwide are attributed to unsafe water, inadequate sanitation and poor hygiene*. It is estimated that by 2025 half of the world's population will be living in water-stressed areas.

Adriaan Oosthuizen, *Die Dam*

* http://www.who.int/en/news-room/fact-sheets/detail/drinking-water (*WHO*, 7 February 2018)

Water and health

Maureen Taylor, Rand Water Chair in Public Health, Department of Medical Virology, School of Health Systems and Public Health

Water resources are under threat due to increasing populations, land use change, chemical contamination and climate change, thereby creating challenges for the production and delivery of safe water for human consumption.

Professor Maureen Taylor, the Rand Water Chair in Public Health, in the **Department of Medical Virology** and the **School of Health Systems and Public Health** (SHSPH), addresses new and emerging issues of concern in the drinking water industry. As water and health-related issues are complex and diverse, Professor Taylor collaborates with **Dr Natalie Aneck-Hahn**, Environmental Chemical Pollution and Health Research Unit (ECPH), **Professor Marthie Ehlers** and **Dr Marleen Kock** in the Department of Medical Microbiology to identify the potential human health risks associated with reusing treated wastewater to produce safe potable water.

The Enteric Virus and Environmental Research Group, under the mentorship of Professor Taylor, focuses its research on the analysis, molecular epidemiology, clinical relevance and evaluation of risks of selected human pathogenic enteric viruses in water systems destined for agricultural, recreational and drinking water use. **Dr Janet Mans** in the Department of Medical Virology, champions the norovirus and associated diarrhoea research aspects of the programme. The enteric virus research involves several national and international collaborators, including the South African National Institute for Communicable Diseases, the Botswana International University of Science and Technology, and the University of Washington, Seattle

… Water and health

(US). The researchers have identified a novel and previously undescribed hepatitis A virus and high titres of sapoviruses in water sources destined for irrigation use, while an emerging norovirus GII.17 was detected in wastewater discharged into a dam used for recreational purposes. This information contributes to a better understanding of the epidemiology, dissemination and potential health of these viruses in the aquatic environment. In 2017, findings in the field of enteric viruses and water virology were published in *Infection Genetics and Evolution; Epidemiology and Infection*, and the *Journal of Water and Health*.

Another research focus has been on treated drinking water. South Africa is one of the few countries in the world where tap water is still regarded as relatively safe to drink, particularly in cities. However, the maintenance of water treatment facilities is expensive and is not always carried out effectively – especially in smaller municipal areas.

Irrespective of the water treatment process, South Africa's national drinking water quality guidelines predominantly focus on the microbial quality of the water to ensure the safety of drinking water. However, chemicals, which are not effectively removed by water treatment processes, get into water systems by way of direct discharge into water, sewage and wastewater effluent, leaching from landfill sites, agricultural and stormwater runoff and accidental spills. Long-term chronic exposure to some of these chemicals, known as endocrine-disrupting chemicals or EDCs, can have serious effects on people's health and even the health of their progeny. Disorders related to EDC exposure range from genital malformations, obesity, Type 2 Diabetes and endocrine-related cancers including testicular, prostate, breast, ovarian, endometrial and thyroid cancers.

Dr Catherina van Zijl, a senior medical scientist of the ECPH Research Unit, evaluated the levels of selected EDCs in tap and bottled water in South Africa as part of her PhD study, supervised by **Professor Christiaan de Jager** and **Dr Natalie Aneck-Hahn**. The study, funded by the Medical Research Council (MRC), compared the oestrogenic activity and levels of oestrogens, bisphenol A (BPA), nonylphenol, and phthalates in tap and bottled water.

Van Zijl evaluated 10 distribution points of tap water in Pretoria and 10 in Cape Town, and collected water samples seasonally, to account for seasonal variations on the quality of water. She analysed 10 of the most popular bottled water brands in South Africa, making sure the water came from a variety of sources such as spring water, dolomite lakes, treated water from different areas, and including different treatment methods. Tests included bioassays to indicate the total oestrogenic activity of each sample, as well as chemical analysis to determine the concentrations of specific EDCs. The results showed that oestrogenic activity was higher in tap water, which indicated that water treatment facilities were not able to remove all the activity. BPA, DINP (phthalate) and EE2 (synthetic hormone) were higher in bottled water, and oestrogenic activities were increased in some bottled water when exposed to temperatures of 40°C.

However, health risk assessments revealed acceptable health and carcinogenic risks associated with the consumption of the water and these results compared well to other countries, giving both tap water and bottled water the green light. Van Zijl notes, however, that this study only tested for oestrogenic activity and not other hazardous chemicals that might affect the thyroid and androgenic activities in the human body. The tests were also only conducted in two large cities and smaller municipalities' treatment processes may not be of the same standard.

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Microbial contamination of drinking water

Fanus Venter, Rand Water Chair in Water Microbiology,
Department of Biochemistry, Genetics and Microbiology

The most common and widespread health risk associated with drinking water is microbial contamination. Of particular concern is contamination associated with major urban systems, as this has the potential to affect large numbers of people.

Water utilities serving urban communities use a multiple barrier approach to minimise the risk to consumers. These barriers include effective treatment processes to remove potential water-borne pathogens, and measures to ensure the biological stability and safety of the drinking water in the distribution process.

Over the past five years, **Fanus Venter**, Professor in the **Department of Biochemistry, Genetics and Microbiology**, and the Rand Water Chair in Water Microbiology, has studied the microbial community and interactions within water treatment and distribution networks with his research team, to develop a better understanding of the microbial ecology of these urban water systems. Funding from Rand Water, and from the Water Research Commission and the Department of Trade and Industry in South Africa, has supported the research undertaken, as well as collaboration with Professor Ameet Pinto from the Northeastern University, Boston (US).

A recent paper published by the research group in the journal *Water Research* highlights the findings of a two-year study that focused on the microbial dynamics within an urban water distribution system in Gauteng. The study clearly demonstrated that disinfection, chlorination and subsequent chloramination are the main drivers shaping the microbial community in the water system, and that other physiochemical and environmental factors had a limited impact.

Developments in the field of next-generation genome sequencing have enabled microbiologists rapidly to determine the composition of the microbial community in a sample. By determining the sequences of the 16S rRNA region present in all bacteria, a detailed inventory of the bacterial species present in a water sample can be obtained. It also provides data on their relative abundance at the time of sampling. Based on the current research, the study concluded that the health risks posed are not of great concern as potential pathogens were only detected sporadically and at low abundances, in comparison with the total drinking water microbial community.

Based on their investigation of several treatment and distribution systems, the group demonstrated that these systems differed markedly from one another, and therefore that a universal model to predict the microbial community of the water supplied to the consumer would be difficult to achieve. The study also confirmed that understanding the ecology and the factors that shape the drinking water microbiome is essential in developing and implementing appropriate measures to manage the microbial community quality and associated health risks.

Water policy and governance

Magalie Bourblanc, Centre for Environmental Economics and Policy in Africa, Department of Agricultural Economics, Extension and Rural Development

Water scarcity and water governance were thrown into sharp relief in 2016 and 2017, with the water crises arising across South Africa, most urgently in the city of Cape Town.

Dr Magalie Bourblanc, a French Agricultural Research Centre for International Development (CIRAD) researcher seconded to the Centre for the Study of Governance Innovation (GovInn) at UP, has as her research focus, water policy and the way in which water as a scarce resource has been governed in South Africa and other parts of sub-Saharan Africa. She works with the **Centre for Environmental Economics and Policy in Africa** (CEEPA) in the **Department of Agricultural Economics, Extension and Rural Development**. Author of several peer-reviewed journal articles in 2017, Dr Bourblanc's research focuses on the implementation of southern African water policies.

Historically, South Africa has always had to contend with droughts and to manage water in line with the scarcity of the resource in the southern African region. Despite embracing the new global focus on water management that emphasises demand management and the reduction of water consumption, South Africa has, in effect, continued with a supply-side management agenda. Pointing to the role of competing political networks in such policy implementation challenges, Dr Bourblanc demonstrates, in research published in *Water Alternatives*, how such competition has hindered the transition to global good practices with respect to water management, and progress on large water projects.

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In research conducted in rural Mozambique, Dr Bourblanc showed that access to water is hampered by poor maintenance of the water points, and the distances between them. Further, in this research, water justice is not presented simply as access to water, but as participation in decision-making processes and ensuring enduring benefits within communities. This work was co-published with Raphaëlle Ducrot in the journal *Natural Research Forum*.

A third article published in the *Journal of Southern African Studies*, with fellow researchers Ducrot and Everisto Mapedza, focuses on strategic partnerships between smallholder and established farmers in the Limpopo Province, South Africa, with the analysis seeking to explain the continued use of policy instruments that have been shown to be ineffective. The research points to the use of strategic partnerships, as forced through by earlier policy decisions, resulting in limited future value for both decision-makers and those at the end of the chain: the water users.

The research conclusions, in all of Dr Bourblanc and fellow researchers' work, emphasise the power of policy instruments that are usually perceived to be purely technical issues but have, nonetheless, been able to neutralise specific regulatory provisions and public policy objectives that were at the heart of South Africa's transformation agenda. The conclusions are published in the French journal, *Natures Sciences Sociétés* in 2017.

Dave Berger

LAND AND AGRICULTURE

The achievement of SDG 15 – Sustainable use of terrestrial ecosystems – is closely related to land use and agriculture, and to water and food security.

A central concern relates to land degradation and sustainable land management. South Africa's National Development Plan foregrounds the main challenges related to land and agriculture as the marginalisation of the poor which requires changes in access to resources − land, water, education and skills. Climate-soil combinations leave only 12% of the country suitable for the production of rainfed crops. Most of South Africa's land (69%) is suitable for grazing, and livestock farming is by far the largest agricultural sector in the country. With population growth at close on 2% annually, sustainable land and agricultural practices are critical to food security and the well-being of South Africa as a whole*.

* http://www.wwf.org.za/land/?2580/WWF%20reveals%20Living%20Farm%20vision

Addressing geospatial information challenges

Serena Coetzee, Centre for Geoinformation Science, Department of Geography, Geoinformatics and Meteorology

Addresses play a vital role in society. They are used for city management, service delivery, emergency response and elections, or to navigate the way around and find friends. Yet many urban informal settlements and rural areas in developing countries are without an address infrastructure, which poses particular challenges.

In the case of an emergency, epidemic or a disaster, a lack of addresses can result in essential assistance or humanitarian aid arriving too late. Apart from serving pressing day-to-day needs and those that manifest under extreme circumstances, geographic information is increasingly used to monitor service delivery, such as health and education, or progress towards achieving goals set for development. Geospatial planning and information management have therefore become integral to what has become an interconnected world.

In informal settlements on the urban fringes of today's burgeoning cities, dwellings are scattered or clustered randomly and, where address numbers exist, they are often assigned in no particular order. Informal settlements are also fluid, so that today's sequential address numbering may be 'scrambled' tomorrow. Similarly, many rural areas in Africa are without an address infrastructure: instead of street names or house numbers, an intricate web of footpaths connect dwellings. Paved roads may connect villages and have road names, but smaller roads are nameless.

Researchers and postgraduate students in the **Centre for Geoinformation Science** (CGIS) at UP, led by **Associate Professor Serena Coetzee**, have been exploring possible solutions to address challenges.

In augmented reality, computer-generated information can be superimposed onto a live view of the real world. In 2017, CGIS developed such a prototype app that displayed addresses on a smartphone, and tested this in the Alaska informal settlement on the outskirts of Mamelodi East, Tshwane, in South Africa. In another project, three types of code-based addresses were tested for the Alaska informal settlement, and the CT informal settlement in Cape Town. While all three systems are well-suited for digital applications and the unstructured nature of informal settlements, each system presents challenges. A single what3words code (e.g. exact.puff.tickles) is easy to remember, but the three words do not provide any clues for way-finding. A what3words code as well as a mapcode uniquely identifies a 3x3m and 5x5m square, respectively. In the informal settlements they investigated, houses were so small and close together that some were assigned the same address. Datum-based addresses seem to fare better with way-finding and assigning unique addresses, but have their own limitations – the bigger the informal settlement, the longer the code. Further, three words in a what3words code have no association with the cultural identity of a specific informal settlement; while numbers are culturally neutral, they offer little in terms of affirming a group's identity.

A house in the Alaska settlement, Mamelodi, South Africa.

Serena Coetzee

The research findings of Professor Coetzee and her team point to challenges that may be encountered, particularly in informal settlements and rural areas, when local datasets are integrated into national datasets, and the latter into global datasets, one of the aims of the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM).

An analysis undertaken in collaboration with researchers from Flanders and the Netherlands revealed that a delicate balance of interests is required in setting up an address data governance framework. Without support, it is highly unlikely that providers of local data will have the commitment to contribute to a national address dataset that has only indirect or longer-term benefits for them. Additionally, strengthening capacity at smaller municipalities is essential to ensure accurate data capture and maintenance.

Transforming migrant labour societies through agriculture

Vusilizwe Thebe, Department of Anthropology and Archaeology

A basic problem that faces postcolonial states in Africa is how best to transform the migrant labour societies that were created, cultivated and impoverished by the settler colonial state into modern farming communities that contribute to food security and well-being.

For the past decades a key policy focus in postcolonial states has been to transform agrarian systems through restructuring rural societies and land reform, to create modern agrarian societies made up largely of small farmers. A central question in the research conducted by **Vusilizwe Thebe**, Professor in the **Department of Anthropology and Archaeology** is whether it is feasible to coerce these agrarian societies into following an agrarian livelihood; or, alternatively, to promote access to land, employment and migrant labour opportunities.

Thebe's research focuses on understanding agrarian societies in a constant search for better and relevant development policies informed by evidence, and which invariably counter popular narratives about rural societies and their futures. He writes that central to the transformation of rural societies is the need for both policymakers and development agencies to understand accurately material realities and expectations that constrain rural societies and make specific types of futures possible, while limiting others. This commitment has led to Thebe's development of a broad research project on the 'Complexity of Migrant Labour Society in Southern Africa', which has spanned three countries in the region.

Development policies have not alleviated poverty in rural areas. In an article published in *Africa Review* in 2017, he examines land reform, poverty reduction and social stratification in Zimbabwe, Lesotho and South Africa. Navigating through migrant labour societies, his research interrogates the worker-peasantry found in these societies: the contexts of their existence, their relationship to land and labour migration, agricultural systems and food security, and their interaction with state institutions and policy, in the broader context of societal change.

At the core of Thebe's study is an examination of expectations for well-being and livelihood preferences. By focusing on the socio-economic realities and the complexity entailed in migrant-labour societies, his study points to agrarian societies where there are few farmers left, and where processes of *depeasantisation* and *deagrarianisation* are truly underway.

Migration in sub-Saharan Africa

Bruno Losch and **Sara Mercandalli**, Centre for the Study of Governance Innovation and the French Agricultural Research Centre for International Development

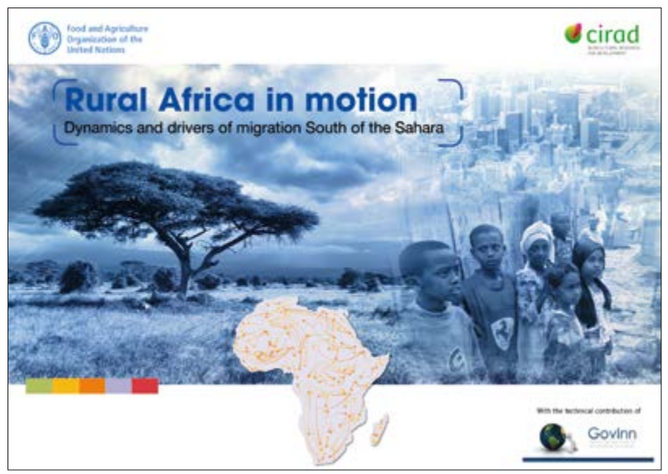
Migration from Africa has generated interest due to the reported numbers of migrants who have crossed the Mediterranean Sea into Europe. Yet in Africa most migration takes place within the continent and between African countries, particularly within sub-Saharan Africa.

The **Centre for the Study of Governance Innovation** (GovInn), in a collaboration with **Dr Bruno Losch** and **Dr Sara Mercandalli** (French Agricultural Research Centre for International Development, CIRAD), have edited a 2017 volume on rural migration that takes place within sub-Saharan Africa. The Atlas, *Rural Africa in Motion: Dynamics and drivers of migration south of the Sahara**, examines the patterns, the consequences and the impetus for migration that occurs within the continent.

Working in conjunction with the Food and Agricultural Organization of the United Nations (FAO), and engaging research partners in Senegal, Zambia, South Africa, and Madagascar, the authors unpack the variables affecting data collection on migration within sub-Saharan Africa and the complexity in understanding the underlying causes and motivations for migration. The Atlas includes contributions from three other GovInn researchers: **Dr Robin Bourgeois**, **Dr Christopher Nshimbi**, and PhD student **Pierre Girard**, all based at UP.

While much focus has been on the migrants leaving the continent, within-Africa migration patterns and motivations are far more difficult to measure due to the informality and diversity of movements. For instance, migration can take place within a single country with people moving between regions, or between the rural and urban spaces. The Atlas reports that up to 75% of sub-Saharan African migrants are migrating within Africa, with the average age of migrants being 29 years. This reflects the growing African population and the 'youth bulge', which has resulted in a large youthful labour force, putting pressure on local economies and encouraging migration as people search for income and employment opportunities.

Those migrants moving within rural areas continue to engage with rural activities, such as farming and mining, which in turn puts pressure on land and water resources already under threat. Natural environmental degradation and climate change have had a significant effect on rural activities and in influencing migration. The Atlas shows that these factors rarely act in isolation, but combine with social, political and economic factors.



The future of migration in sub-Saharan Africa is similarly complex. The Atlas demonstrates the need for context-appropriate policies to facilitate the free movement of people in search of economic opportunities, and points to the need for governments to invest in rural and urban development (particularly small towns) to anticipate the growing movement of people.

* Mercandalli, S and Losch, B (eds.) 2017. Rural Africa in motion. Dynamics and drivers of migration South of the Sahara. Rome, FAO and CIRAD.

Driving genetic improvement in South African livestock

Esté van Marle-Köster, Animal and Wildlife Sciences

Genomics is not only a tool for breeding selection but can be used to gain insight into the adaptive mechanisms, disease tolerance and unique traits of livestock resources in South Africa.

Developments in molecular technology have opened new ways for livestock breeders to study the genetics of farm animals and, consequently, to practise more effective selection for traits which are of economic importance. In addition, the mapping and completion of farm animal reference genomes have led to SNP (single nucleotide polymorphism) marker discoveries, and the development of high throughput technologies has opened up new possibilities for genomic research in livestock.

The **Department of Animal and Wildlife Sciences** was the first Animal Science department at a South African university to establish livestock genomics of farm animals as a research focus. In 2012, **Professor Esté van Marle-Köster** organised the first workshop on genomics for SA livestock at the University of Pretoria. This resulted in the establishment of a task team for livestock genomics in South Africa which, in turn, was the start of the Beef Genomic Programme (BGP) and the Dairy Genomic Programme (DGP), both funded by the national Technology Innovation Agency (TIA). Professor van Marle-Köster is the project coordinator of the industry-driven DGP, which involves researchers at UP and the Universities of Stellenbosch, Fort Hare and the Free State.

The overall aim of the two programmes is to establish routine genotyping for genomic selection in cattle. The indigenous cattle breeds in South Africa contribute significantly to livestock production and food security at a number of levels. Sanga breeds – such as the Drakensberger, Nguni and the composite South African Bonsmara – are unique genetic resources and therefore part of the genomic research focus of the Department. In the Animal Breeding and Genetics research group, postgraduate student projects have focused on population structure and genomic parameters in South African Hereford, Boran and dairy breeds, using genotypes from the BGP and DGP. In 2017, results from PhD projects were presented at national and international congresses, including the focus on imputation methodology in Drakensberger cattle, and the validation of the polled (Celtic) gene in Sanga breeds.

The first transcriptomic project on Nguni cattle has been completed, with promising results for further studies in nutrigenomics to improve production efficiency. In 2017, research findings on the population structure of the South African Bonsmara beef breed were published in *Livestock Science*. The influence of population structure on the compilation of the Bonsmara genomic reference population was published in *Advances in Animal BioSciences*, along with studies of the genetic variability in South African and Namibian beef cattle breeds.

Bonsmara cattle, a South African breed

UP celebrates 100 years of Agricultural Science

The University of Pretoria celebrated the centenary of agricultural science at UP, and the achievements, over the century-long history, that have positioned the University to contribute significantly to the challenges related to agriculture and food security.

Johan van Zyl, former Dean of the Faculty of Agriculture and UP Agriculturalist of the Century.

The Faculty of Agriculture was established at UP in 1917, incorporating three disciplines: phytopathology, soil science and livestock-breeding. Its name and identity evolved to become the Faculty of Agricultural Sciences in 1969, and later in 1994, the Faculty of Biological and Agricultural Sciences. In 1999, the faculty merged with the natural sciences to become the Faculty of Natural and Agricultural Sciences. This merger formalised the link between agricultural science and a number of other disciplinary fields, including the biological, mathematical and physical sciences, which strengthened multi-disciplinary research.

The Dean of the Faculty, **Professor Jean Lubuma**, has emphasised the importance of the focus on agricultural science in addressing food security and the well-being of people, linked to the UN SDGs. UP has a long history of being recognised globally, as among the top 1% of institutions in the Web of Science Essential Science Indicators, in the fields of agricultural science, plant and animal science, and ecology and the environment. This means that UP is well-positioned to contribute, through science and technology, to addressing some of the major challenges that face Africa and the world.

The centenary celebrations of Agriculture at UP also acknowledged partnerships with government and industry in advancing scientific research. The University's experimental farms have always been important facilities for collaborative research, and for the training of students from agricultural and veterinary sciences. A long-standing partnership with the Animal Feed Manufacturers Association is one example of many. So are partnerships with the Agricultural Research Council, and the Council for Scientific and Industrial Research in contributing to the development of South Africa's bioeconomy, and UP's active participation in the Africa-wide Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) in the training of next-generation agriculturalists.

The agricultural science milestone in the history of the University concluded with an event in November 2017 where **Dr Johan van Zyl**, former Dean of the Faculty, and Vice-Chancellor of the University, received the **UP Agriculturalist of the Century** award. Dr van Zyl was one of the masterminds behind the Postgraduate School of Agricultural and Rural Development in the Faculty, and played a major role in establishing the Forestry and Agricultural Biotechnology Institute (FABI) at UP, and he has served on the UP Council.

THE ECONOMY

Media Club South Africa

SDG 8 – Decent work and economic growth – promotes sustained economic growth, higher levels of productivity and technological innovation.

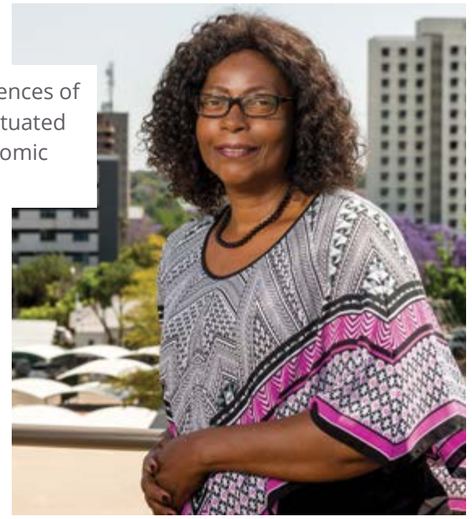
Globally, there are an estimated 300 million workers who live in extreme poverty and, according to the International Labour Organization, more than 204 million people were unemployed in 2015*. Since the 2008 economic crisis and global recession, the world has seen slower growth, widening inequalities, and not enough jobs to keep up with a growing labour force and the changing nature of work. In South Africa the lack of economic growth is a major concern, while the policy focus remains on inclusive growth – economic growth that is distributed fairly and creates opportunities for all.

* http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-8-decent-work-and-economic-growth.html

The impact of fiscal policies

Margaret Chitiga, School of Public Management and Administration

Understanding the intended and unintended consequences of public policies is of great interest to economists, accentuated in post-apartheid South Africa, where addressing economic growth and inequality are major systemic challenges.



The focus of **Professor Margaret Chitiga's** research in the **School of Public Management and Administration** is to understand, in considerable detail, the impact on the economy and welfare of fiscal policies. Her recent research shows that one of the most effective ways to study the impact of policies is through the use of extensive and massive computable general equilibrium (CGE) models that capture all relevant components of an economy, and the modelling of their interactions.

Her research seeks to provide scientific insights into the implications of spending on infrastructure, social welfare and environmental policies, and into the implications of raising revenue through tax instruments. The CGE methodologies make it possible to test the effects of policies that are currently implemented, and the effects of other possible policy scenarios, were these to be implemented. Dynamic modelling techniques can precisely demonstrate the impact of policies, for example, on poverty and inequality or on special groups such as women and children. Professor Chitiga was part of a team of researchers who advocated a pro-poor VAT increase with recycling, that might well have influenced policy in light of the recent VAT increase in South Africa.

Given that most countries have long-term development plans, and policies typically have long-term effects, it is important to project the effects of policies into the future. This makes it possible to gauge the extent to which a county would be able to meet its plans, as well as the possible intended and unintended consequences of policies.

Professor Chitiga has also combined techniques to sharpen the focus on poverty and inequality analysis, and to show asymmetries that can result over time with respect to the impact of policies. With a number of national and international researcher collaborators, she has pioneered the use and analysis of sophisticated tools for research in Africa. International collaborators include researchers from Université Laval, Quebec (Canada); the University of la Havre, Normandie (France); and the International Food Policy Research Institute (IFPRI), Washington DC (United States).

Professor Chitiga was invited to participate in the Green Jobs Assessment Institutions Network (GAIN) of the International Labour Organization, and was part of a select group who wrote a training guidebook, *How to measure and model social and employment outcomes of climate and sustainable development policies*. Launched at the 3rd GAIN conference held in Geneva in December 2017, the book has created substantial interest, including by the United Nations Framework Convention on Climate Change. The idea of the book is to share state-of-the-art methodologies, including partial and general equilibrium modelling, to enable an understanding of the impact of green technologies on economic growth.

Professor Margaret Chitiga is the Director and Head of the School of Public Management and Administration at UP.

Modelling and forecasting market behaviour

Rangan Gupta, Department of Economics

The volatility of markets, and policymaking to guide economic decisions in developed and emerging markets, are complex terrains for researching macroeconomic variables that affect market behaviour.

Professor Rangan Gupta in the **Department of Economics** is a prolific writer who in recent years has consistently been placed among the top young economists globally in the Research Papers in Economics (RePEc) rankings, a bibliographic database of research in economics. His research interests are mainly in monetary theory and policy, and time series econometrics, while he also works in areas such as health economics, energy economics, environmental economics, socio-economics, real estate economics and finance. These issues are of great importance with respect to policymaking in any economy, but more so in developing countries and emerging economies. Hence, his research has not only dealt with the developed economies of the world, but also emerging markets, including South Africa.

In 2017 alone, Professor Gupta co-authored 69 papers, and considers his most important contribution a paper published in a special issue of *Empirical Economics**. The paper forms part of a long-term research agenda, which he initiated more than a decade ago, whereby the idea was to develop Dynamic Stochastic General Equilibrium (DSGE) models for South Africa to model and forecast business cycles. The models are immune to the problems associated with standard econometric models, which are widely used for such purposes.

Using the DSGE framework, Professor Gupta, with his co-authors, has worked on many issues relating to South African business cycles, including the roles of productivity, monetary policy, asset markets and commodity market shocks. More recently, the South African Reserve Bank has developed its own DSGE model, which validates the usefulness of this approach. The linear framework of the DSGE model has also been extended to a nonlinear structure which, in turn, requires the usage of particle filters. In the 2017 paper, they seek to identify evidence of regime-switching behaviour in the monetary policy response function and the variance of the shocks.

This model, the first of its kind developed for South Africa, makes two important contributions. It shows that in-sample and out-of-sample model behaviour can be quite different; thus, it is important not to rely on standard measures of model fit. Similarly, the paper confirms that the South African Reserve Bank has been consistent in its behaviour.

* This paper appears in a special issue of *Empirical Economics* in the honour of well-known econometrician, Professor Kajal Lahiri, and is on the invitation of the editor, Professor Badi H Baltagi, a world-renowned econometrician himself.

PEOPLE AND CONTEXTS

Uncovering South African's publishing history

Elizabeth le Roux, Department of Information Science

What was the first book published in South Africa? Who wrote it? Who read it? What has happened to it since? And what does all of this tell us about our history, culture and identities over time.

These are the kinds of questions that first prompted **Elizabeth le Roux**, an associate professor in the **Department of Information Science**, to become interested in book history, a field that examines how people generate, produce, and use printed materials. Print remains a significant medium because people use it to communicate thoughts and ideas. Governments are often acutely aware of the power of print, and have used it to promote their own ideas (for instance through propaganda), and to limit certain kinds of communications through censorship.

Le Roux writes that censorship was a key tool of the apartheid government, and that its full reach and impact is still not fully understood. Her research into the development of crime fiction showed that this genre was subjected to more censorship than any other; the censors referred to crime and pulp fiction more broadly as 'printed trash and poisonous scum'. This did not stop South Africans of all races from avidly reading the genre, and actively writing and publishing crime fiction – long before the days of Deon Meyer.

Her earlier research on publishing histories in South Africa is now being extended to examine more closely the role of publishing companies, especially Ravan Press, as platforms for subversion and protest. This project on 'Histories of Publishing under Apartheid' is undertaken in collaboration with Dr Caroline Davis of Oxford Brookes University (UK), with funding from a Newton Mobility Grant, the Global Challenges Research Fund, and the British Academy. To investigate the role of printed materials in apartheid South Africa, the researcher needs to combine a variety of tools: examining the books themselves, uncovering neglected and even forgotten publishers' archives to read correspondence and production notes, and interviewing publishers, editors, authors and readers to gain a detailed picture of their experiences and memories.

Elizabeth le Roux organises annual conferences to raise the profile of book history and encourage more researchers to work in this area. She is a Y1-rated researcher, and is co-editor of *Book History*, the journal of the Society for the History of Authorship, Reading and Publishing (SHARP). She published the first study of South Africa's university presses in 2016 (*A social history of the university presses in apartheid South Africa: Between complicity and resistance*, Leiden: Brill); and in 2017, co-authored a book on South African crime fiction (*A survey of South African crime fiction*, Pietermaritzburg: UKZN Press), a work described by German scholar Christine Matzke as a milestone in the study of this popular genre.

Liesbie du Toit

Africa is not 'bookless'

Reading and writing are such fundamentally important skills that we don't always think about the broader social role of books and print. We also tend to make assumptions about these skills because they are common. Sometimes, the role of book history research is to challenge these assumptions – and one of the more prevalent and damaging ones is the perception that Africa is a 'bookless' continent without a reading culture.

In fact, there has been printing and publishing in African countries since the invention of print in the 15th century, not to mention a much older textual history of manuscripts circulated across the Sahara desert. Research on Ajami texts – manuscripts written in African languages using Arabic script – shows that these were produced as early as the 11th century, which challenges the standard assumption that society progresses from orality to literacy and then to print.

Africa's written heritage is thus much older than previously believed, and predates colonisation in various areas. Can we really see print as a foreign import, when people in Africa have been adapting it to their own ends for several hundred years?

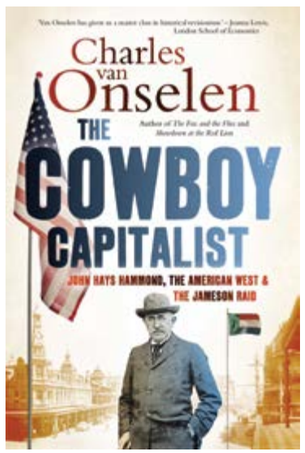
Cowboy Capitalist

Charles van Onselen, Centre for the Advancement of Scholarship

In many countries with weak ethical, moral and political foundations there is often a deep chasm between those who have financial power and those who hold high political office. The resulting divide is most frequently bridged via large-scale corruption.

Those in powerful state offices seek to enrich themselves by using their influence and fraudulent instruments to plunder the private or the public sectors of the economy, while those in high finance or industry seek to gain improperly by offering an assortment of inducements to politicians and those in their extended patronage networks. In order to understand more fully the long-term rise or decline of political systems and societies, scholars in the humanities and social sciences often need to hone in on the two-way link between crime and politics.

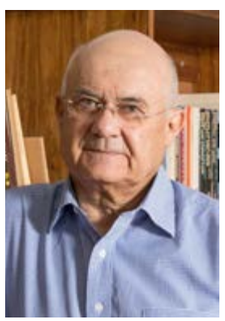
Living through the seemingly never-ending process of 'nation-building', modern South Africa often comes across as being hopelessly corrupt and morally bankrupt. While there may be a good deal of evidence to underpin this gloomy perception, it is frequently accompanied by profound amnesia on the part of those who feel that systemic crises of these proportions are peculiar to the 21st century, or that they can be traced back to failings that can also be defined racially.



Those who live with this dangerous, simplistic notion need constant reminding that South Africa can trace its modern, 20th century incarnation back to precisely the same nexus of divides between money and power on the one hand, and culture and class on the other; problems that are considered peculiar to the here-and-now.

It was the class and cultural divide between the Boers and their ruling agrarian political elite in Pretoria, men with a land-focused vision of the future, and their adversaries in Johannesburg (the so-called 'Randlords') who insisted on an economy that was to be predicated immediately and nearly exclusively on industry, that gave birth to the unsuccessful Jameson Raid of 1895. That led to the Anglo-Boer War of 1899-1902 which, in turn, was followed by the cobbled-together and racially exclusionary 'settlement' of whites-only rule in 1910.

Not long after the epoch-changing mineral discoveries of the 1870s and 1880s, gangs of indigenous Africans such as the 'Ninevites', and immigrant whites, such as those in the 'Irish Brigade', were involved in crimes that were often informed by a sense of injustice. The Witwatersrand gold mine owners, the conspirators behind the Jameson Raid, were also intent on larceny but their ambitions were loftier than those of mere bank robbers, burglars or highwaymen. They aspired, by means of a *coup d'état*, to steal an entire country to address their own sense of injustice that a newly industrialising country was being run by an ill-educated rural elite. If the under-classes of the 1890s were intent on crime-as-politics, then the new, aspirant Rand ruling class was engaged in politics-as-crime.



The Cowboy Capitalist (Jonathan Ball Publishers, 2017) is the story of the arch conspirator behind the plot to steal the Zuid Afrikaansche Republiek in 1895: John Hays Hammond. He was an avaricious American who peddled his experiences of mining in California and the Wild West to Rhodes and Jameson so that they might foment a *coup d'état* that might benefit the British Empire. As in many societies that are bent on self-destruction by refusing to distinguish clearly between crime-as-politics and politics-as-crime, the book offers an engaging historical tale as well as a set of lessons for life in South Africa today.

An ethnographic encounter with a hyena

Fraser McNeill, Department of Anthropology and Archaeology

Chris Eason

Anthropology is the field of study in the social sciences that reveals most starkly the methodological limits of studying 'the other', that is, beliefs and practices that are unfamiliar. The positionality of the researcher either renders understanding through the eyes of the other impossible, or limits the accuracy or usefulness of analyses because of what becomes known and is therefore taken for granted.

Professor Fraser McNeill in the **Department of Anthropology and Archaeology** has been conducting ethnographic research in the Venda region of South Africa for 15 years, and has developed an approach to anthropological analysis he calls medical ethnomusicology. As part of this research, he has learned the music and magic of female initiation, through which young girls are transformed into socially responsible adults. The ritual elder of this process, a teacher and long-term friend, holds the reputation as a powerful traditional healer, and was in the process of teaching him her craft when disaster struck. He relates the story as follows:

Her ex-husband bewitched their eldest son, and I witnessed the process. 'You will be dead before the sun comes up' he whispered, and indeed, the son died in a car crash that night. As an act of retaliation, the traditional healer cut off her husband's head as he slept in a drunken stupor, and she was duly arrested the next day. 'Talk to Thitupulwi (my Venda name), he will explain everything,' she told the investigating officer. I had been informed by the King to remove myself from the process, and did not get involved. Driving past the scene of the crime late at night a few weeks later, a huge Brown Hyena ran parallel to the car. I turned and stared at it, and it returned the stare. It was the length of my bakkie*, and kept up the pace with ease. This was in a reasonably built up area, hundreds of kilometres from the Kruger National Park. In all my years working there, I had never heard of hyenas in the region. I knew what it was. I had to go and visit my friend in jail. She laughed as I entered the visitors' room. 'Ah, so you saw me last night? Where were you going at such an hour, anyway?' 'OK,' I replied, I'll talk to the police, I'll tell them what I saw, and why you did what you did'. 'I know you will,' she said – and changed the subject to ask about my family in Scotland.*

How does an anthropologist write about such an encounter? How do we make sense of things that we cannot explain from the frames of reference available to scientifically trained researchers? What does it *mean*? These are questions anthropologists grapple with, and which bring into focus contemporary debates around the 'ontological turn' in anthropology and the social sciences more generally. What is truth?

McNeill writes that science and its practitioners like to hold up a specific form of sorcery as providing 'proof'. But it does this by constantly proving itself wrong. So the 'truth' can only ever be fleeting and partial. Did the traditional healer control her shape to shift into the form of a hyena? She firmly believes that she did become the hyena running alongside his vehicle, and some contemporary anthropological theories urge us to take our interlocutors' ideas seriously. His current work deliberately weaves the local political economy of traditional leadership in Venda with threads of the ontological turn in an attempt to make sense of what would appear to be an act of witchcraft, and in which he, as researcher, has become deeply embedded.

Tracing the arrivals of South African Chinese

Karen Harris, Historical and Heritage Studies, and the University Archive

Piecing together the history of South African Chinese is like the proverbial Chinese puzzle – invisible, intermittent and interstitial. Yet their presence in southern Africa can be traced back some three centuries, if not even earlier.

Professor Karen Harris, **Head of the Department of Historical and Heritage Studies**, and **Director of the University Archive**, writes that, for the most part, the Chinese have been relegated to the periphery of mainstream South African history, in the interstitial spaces between whites and blacks, both before and after the new democratic dispensation. Her published studies capture the twisted nature of racial discrimination evident in this three-century history, with two papers published in 2017, one in the Netherlands *Journal of Chinese Overseas*, and the other in the South African *Fundamina: Journal of Legal History*.

Cape Archives Depot C1109, n.d.

The Chinese and China are not newcomers to the African continent. It is believed that China first made an appearance as early as the 1400s with the voyages of Cheng Ho (1405-1433). While there is much conjecture about these encounters, Bushman rock art reflects this possible encounter, and scientists of the likes of Raymond Dart expounded on China's pre-colonial African encounter as early as the 1940s. Shortly after the Dutch East India Company's arrival at the Cape of Good Hope in the mid-17th Century, a few Chinese arrived as small-scale traders and crafters, while others who had been banished by the Dutch from Batavia as convicts served out their sentences here. Despite their miniscule numbers, already at this time Dutch burghers protested against the Chinese as competitors, and regulations were instituted to contain their trade.

In the mid-19th Century, coinciding with the South African mineral revolution and the global immigration of some two million people from China, a second wave of Chinese (*Namfeechow*) arrived in South Africa. They came as free and independent individuals, to set up small-scale businesses in the burgeoning coastal and inland towns. These immigrants were to be the ancestors of many of today's South African-born Chinese. The third wave followed at the turn of the 20th Century with the importation by the gold industry of over 60 000 indentured labourers to work on the Witwatersrand mines. Strictly regulated and proscribed, the scheme lasted a mere half dozen years before it was terminated, with indentured labourers having contributed to the restoration of a profitable mining sector in the post-South African War period. This experiment had, however, serious repercussions for the free Chinese communities living in the South African colonies. The Cape Colony introduced the Chinese Exclusion Act (1904), which made the Chinese one of the first identifiable groups to be singled out and discriminated against, while the Transvaal Colony introduced the Asiatic Registration Act (1906). Besides the humiliation caused to South African-born Chinese, these legislations effectively put an end to the immigration of the Chinese to South Africa, a situation entrenched by the 1913 immigration legislation that designated the Chinese as 'prohibited immigrants' along with other so-called 'aliens' that the Union government was intent on excluding.

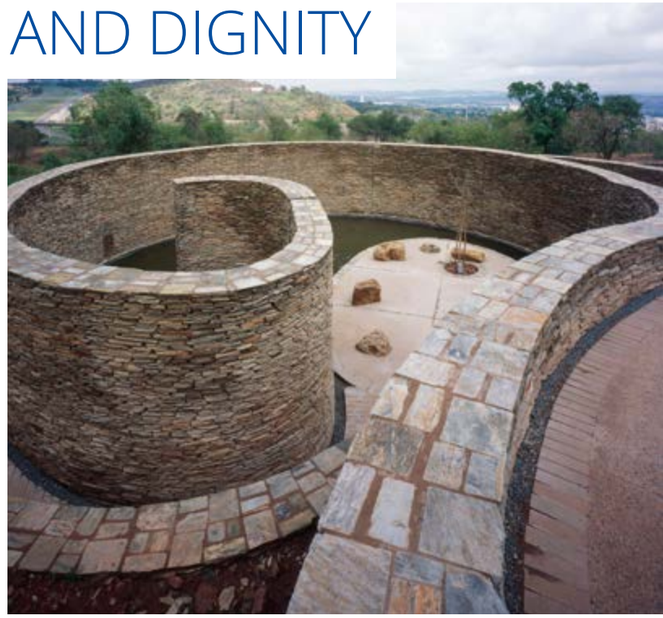
The fourth wave of Chinese immigrants to South Africa was to appear in the latter half of the 20th Century, when apartheid South Africa developed trade relations with the Republic of China, via Taiwan.

When the new democratic South Africa was founded and immigration regulations were relaxed, a fifth wave of Chinese from the People's Republic of China (PRC) began arriving in South Africa as small-scale traders and shop owners, now also in rural areas. This influx of immigrants was further enhanced by South Africa forming official diplomatic relations with PRC in 1998.

However, the South African-born Chinese were to find themselves excluded from the benefits of the new South Africa inaugurated in 1994. Although having been classified as 'non-white' under apartheid, they were now considered 'not previously disadvantaged' and were thus forced to take the matter to court (in 2000) to rectify their dignity and their place in South African society and history. The court case dragged on for eight years. Professor Harris was intimately involved in this case, with an affidavit given, based on her two decades of research and publications on the Chinese in South Africa. Renowned human rights Advocate George Bizos appeared in the High Court, where it was finally declared that the Chinese fall within the definition of black people in the Constitution.

Nevertheless, having been ostracised from the outset of their arrival in the Cape, continually restricted and prohibited by colonial and apartheid authorities, and initially excluded by the new democratic South Africa, many of the younger members of the community formed a sixth wave out of South Africa. This move signifies the loss of one of the oldest and most professionalised communities in southern Africa who, although marginalised, have been integral to the fibre of this society.

HUMAN RIGHTS AND DIGNITY



Freedom Park, Pretoria

The UN Agenda 2030 and SDGs are grounded in the Universal Declaration of Human Rights, adopted in 1948. The Agenda envisages a world of universal respect for human rights and dignity, the rule of law, justice, equality and non-discrimination; of respect for race, ethnicity and cultural diversity; and of equal opportunity. It also affirms the commitment to the implementation of the SDGs to be in a manner that is consistent with the rights and obligations of states under international law.

South Africa's Bill of Rights, adopted in 1996, powerfully sets the scene for the attainment of human rights and dignity, and incorporates both the expectations of South Africans, and the universal rights of all people, as outlined in the Universal Declaration of Human Rights.

Hanging on a Wire

Siona O'Connell, UP Arts

Sophia Klaase took photographs over a period of 15 years of life in Paulshoek, Namaqualand. In 2017, a book on her photography and essays on poverty, marginalised communities and ways of living was published.

Together with co-editor Dr Rick Rohde of Edinburgh University, Senior Lecturer in **UP Arts**, **Dr Siona O'Connell** was awarded the 2017 National Institute for Humanities and Social Sciences (NIHSS) non-fiction edited volume award for *Hanging on a Wire: The Photographs of Sophia Klaase*. The book foregrounds the extraordinary photographs taken by Sophia Klaase – 'Vykie' – of her small home village of Paulshoek in Namaqualand. Klaase's images first came to O'Connell's attention when she curated an exhibition of women photographers at the Centre for African Studies at the University of Cape Town in 2010 and realised the under-representation and paucity of acknowledgement of the work of black women photographers in South Africa.

After making contact with Professor Timm Hoffman of the University of Cape Town's Plant Conservation Unit (who has been involved with Paulshoek for more than 20 years), and Dr Rick Rohde of the Centre for African Studies at the University of Edinburgh who first introduced photography to a teenaged Klaase in 1998, O'Connell was shown the remarkable and substantial collection. It can be argued that Vykie, as she was known, was one of the very few, if not the only, black woman in South Africa to have photographed the daily life of the same rural space for over 15 years.

Together with Dr Rohde, O'Connell went on to curate the first solo exhibition of Klaase's work at the District Six Museum in Cape Town in 2013 and the idea of a book emerged as a consequence. In 2017, Ottobein University in Westerville, Ohio, USA, hosted the exhibition which attracted significant interest and was included in a teaching programme.

The book, conceptualised as an interdisciplinary endeavour, privileges Klaase's work as an entry point into attendant threads of the aesthetic, poverty, land and ways of living in a corner of South Africa that appears to be forgotten. The images, in Klaase's unapologetic and unique sense of the world, show lives of humanness in an inhospitable landscape. She photographed the daily grind and pleasures of life: portraits, landscapes and celebrations, as well as funerals.

Through her lens, the viewer is compelled to see that despite hardship, the lives of her subjects exhibit celebration as well as defiance. Klaase's subjects confront the lens with a sense of purpose that challenges representations of who and what they are supposed to be. Her photographs reflect her innate sense of composition and appreciation of the subject, urging the viewer to see that 'these lives matter', offering a nuanced representation of the cultural and social practices of Paulshoek residents that counter any idea of her subjects – or indeed herself – as victim.

Klaase's collection draws attention to South Africa's rural poor. Because of Paulshoek's legacy as a marginalised 'coloured reserve', its inhabitants can speak with authority about the lived and residual realities of apartheid. The village, consisting of about 100 households, battles with high unemployment, and those who work receive very low wages; alcohol and drug abuse is rife. Her images are often constructed as tableaux, posed and acted out as if the camera provides a stage for impromptu fantasies and playful inventions. They refer indirectly to the moderating influence of the church, at one extreme, and the sporadic eruption of alcohol-fuelled violence, at the other. In an intensely personal manner, Klaase's work facilitates an engagement with the South African past, through the lens of a young woman whose body bears the scars of this history.

Sophia Klaase's untimely death at the age of 34, in 2017, is South Africa's loss as well as a reminder of the long reach of our violent past. The NIHSS award money will be used in its entirety to support Klaase's mother and to provide some much-needed assistance to the Paulshoek Primary School.

A picture taken of young Sophie Klaase at her home in Paulshoek.

Collaborative African scholarship on human rights

Frans Viljoen, Centre for Human Rights

Three collections of essays, edited by staff at the Centre and alumni of programmes, appeared in 2017. All three publications respond to important issues of contemporary concern in Africa and are excellent examples of quality collaborative African scholarship.

African constitutional courts

The first is *Constitutional adjudication in Africa*, edited by **Professor Charles Fombad**, and published by Oxford University Press. The book contains edited papers presented at an annual seminar, dealing with constitutional adjudication in Africa. Since the 1990s, the role of constitutional courts has become a critical aspect to the ongoing process of constitutional construction, reconstruction, and maintenance worldwide, including in Africa. These developments appear, at least from the texts of the revised or new constitutions, to have resulted in fundamental changes in the nature and role of courts exercising jurisdiction in constitutional matters.

The chapters in this book undertake a critical and comparative examination of the interplay of the diverse forms of constitutional review models on the continent. Collectively, the contributions by scholars from around the African continent, identify and examine the different models of constitutional review in Africa, provide a comparative study of the contemporary constitution adjudication practice, and study the extent to which constitutional courts are furthering constitutionalism and rule of law on the continent.

Comparative analyses are particularly important given the fact that over the past two decades, constitutional courts in Africa have been asked to decide a litany of hotly-contested and often sensitive disputes of a social, political and economic nature. By identifying and examining the different models of constitutional review adopted, these chapters consider the extent to which these courts are contributing to enhancing constitutionalism and respect for the rule of law on the continent.

The publication shows how the long-standing negative image of African courts is slowly changing.

Protecting the rights of sexual and gender minorities

Some five years ago, the Centre for Human Rights introduced a week-long intensive course on the rights of sexual and gender minorities in Africa, aimed at government officials and postgraduate students from across Africa. Students from its flagship master's programme in Human Rights and Democratisation in Africa (HRDA) also annually attend this thematic week.

A number of graduates of the programme have subsequently started working in this field of human rights protection.

Following a colloquium on the theme, two alumni, **Sylvie Namwase** and **Adrian Jjuuko**, edited a book of essays, to which mainly HRDA graduates contributed. The book, *Protecting the human rights of sexual minorities in contemporary Africa*, was published by the Pretoria University Law Press (PULP) in 2017.

The Centre for Human Rights at the Faculty of Law at UP is an internationally recognised university-based institution that combines academic excellence and activism to advance human rights through education, research and advocacy. The diversity and variety of work in the Centre is formalised into 10 Units that address pivotal human rights issues. The Centre was granted observer status in 2017 with the African Committee of Experts on the Rights and Welfare of the Child, and is among a few African NGOs with observer status with both this Committee and the African Commission on Human and Peoples' Rights, as well as consultative status with the UN Economic and Social Council.

Protecting civilians in armed conflict

Following a colloquium concerned with one of Africa's intractable problems, the protection of civilians in armed conflict raging in many parts of Africa, a book, *By all means necessary: Protecting civilians and preventing atrocities in Africa*, edited by **Dan Kuwali**, Extraordinary Professor in the Centre for Human Rights, and **Professor Frans Viljoen**, Director, was published by PULP.

The book deals with the protection of specific populations of civilians: refugees and internally displaced persons in armed conflicts; potential and actual victims of sexual and gender-based violence in Africa; minorities; those at risk of violent extremism; and children. Lessons learned in the protection of civilians in armed conflicts are drawn from experiences in West Africa, the Great Lakes Region, the Horn of Africa, North Africa and the Middle East, and also by way of Africa's key peace and security agenda.

Focusing on means and strategies for dealing with mass atrocities, a number of essays look into the role in the protection of civilians of humanitarian agencies, of the United Nations Security Council, the UN Human Rights Council, and courts. A few concluding essays deal with the future of protecting civilians and preventing atrocities.

Frans Viljoen, Director of the Centre for Human Rights

UN representatives in the Faculty of Law

UN Photo (Jean Marc Ferré)

Christof Heyns

Christof Heyns, Professor of Human Rights Law and Director of the Institute for International and Comparative Law (ICLA), has served and continues to serve in several United Nations expert positions.

Professor Heyns was the UN Special Rapporteur on extrajudicial, summary or arbitrary executions for the period 2010-2016. This is the premier human rights position in the UN on the protection of life. He undertook investigations for the UN into unlawful killings in trouble spots such as the Russian-occupied Ukraine, the border conflict in Kashmir, sorcery-related killings in Papua New Guinea, and the narcotics trade in Mexico. He also presented reports on topics such as armed drones and killer robots to the UN General Assembly in New York.

One of the main tasks of Professor Heyns was to lead a group of researchers to update the Minnesota Protocol, the global standard on the investigation of homicide, including forensics. He served as Chair of the UN Independent Investigation on Burundi, where more than 600 executions and widespread torture were documented.

Professor Heyns currently serves as one of the 18 expert members of the UN Human Rights Committee. Very few human rights experts have held such a wide range of human rights positions in the international system.

Dire Tladi

Dire Tladi, Professor of International Law and Research Fellow at ICLA, is a member of the UN International Law Commission, a subsidiary organ of the UN General Assembly with the mandate for the progressive development and codification of international law.

Professor Tladi was first elected in 2011 for a five-year period and, in 2016, for a further five-year term. In 2015, he was appointed by the Commission as Special Rapporteur for the topic peremptory norms of general international law (*jus cogens*). Peremptory norms are the most important rules of international law from which states, under any circumstances, cannot deviate.

Professor Tladi has thus far produced three detailed analytical reports on various aspects related to *jus cogens*. The reports are based on an analysis of state practice, treaties, and domestic and international court cases. To date, the drafting committee of the International Law Commission has adopted 10 drafting conclusions on the basis of the work of Professor Tladi, with 13 draft conclusions to be considered by the Commission in 2018.

Ann Skelton

Professor Ann Skelton, Director of the Centre for Child Law at UP, was elected to the UN Committee on the Rights of the Child for the period 2017-2021. Professor Skelton also holds the UNESCO Chair in Education Law in Africa.

The UN Committee is made up of 18 independent experts from around the world, and monitors the compliance of states with the UN Convention on the Rights of the Child. A large part of the work is the consideration of progress reports presented by the states. The Committee also receives complementary reports from civil society, including NGOs, human rights commissions, and UN agencies, as well as individual complaints. A relatively new role of the Committee is to undertake inquiries, an aspect that Professor Skelton is particularly interested in, and where lawyers on the Committee have a specific role to play.

The Committee is currently reviewing its general comment on children in the international criminal justice system. This is one of Professor Skelton's specific areas of expertise, and she has been appointed to lead the Committee's work on the review.

Commissions of inquiry as accountability mechanisms

Christof Heyns and **Thomas Probert**,
Centre for Human Rights

Field work in six African countries examines the circumstances under which national commissions of inquiry can play a helpful role within accountability processes aimed at investigating violations of the right to life.

As part of a University-wide collaboration, the **Faculty of Law** has for the past three years been investigating the role that national commissions of inquiry can play as accountability mechanisms for violations of the right to life. This was part of a broader research project, supported by the Templeton World Charity Foundation, examining how traditional African moral resources, such as Ubuntu, continue to shape contemporary governance.

The project was led by **Christof Heyns**, **Professor of Human Rights Law**, and **Dr Thomas Probert**, **Extraordinary Lecturer** in the **Centre for Human Rights**. They were joined by **Meetali Jain** and **Anyango Yvonne Oyieke** from the Law Faculty, as well as by several researchers from the **Faculty of Humanities** and from a local NGO. The research project was designed to reinforce the work of revising the UN's main resource on investigating suspicious deaths, the Minnesota Protocol.

The researchers selected six individual case studies of national commissions of inquiry: in Chad, Burkina Faso, Kenya, Malawi, South Africa and Nigeria. In each case, a lead researcher travelled to the country in question, sometimes joined by another from the team at UP, or by a local research assistant, and conducted interviews with key participants. These included some of the commissioners themselves, evidence-leaders or other key lawyers around the work of the commission, those working for prominent NGOs working with the legacy of the commission, representatives of Ministries of Justice, and others.

The objective was to establish to what extent the commission of inquiry was able to function as an

Thomas Probert

effective investigation of what happened, and also the extent to which it has contributed to other elements of human rights accountability, namely remedy for victims and reform of structural issues. Underlying this was a question about whether commissions might in some circumstances conduct the investigation in a manner more compatible with traditional approaches toward justice, being more participatory, less binary and more holistic in its approach to the question of the right to life than would be the case in straightforward police investigations.

In several of the cases examined, commissions of inquiry appear to have contributed to accountability in ways that were not foreseen by those who established them. The *ad hoc* character of a commission often allows discretion of action to its members, and in several instances proactive commissioners, or civil society organisations working around a commission, have driven forward accountability, in novel ways. The findings have been collated in a book to be published by the Pretoria University Law Press in 2018.

Weerlose Weerstand

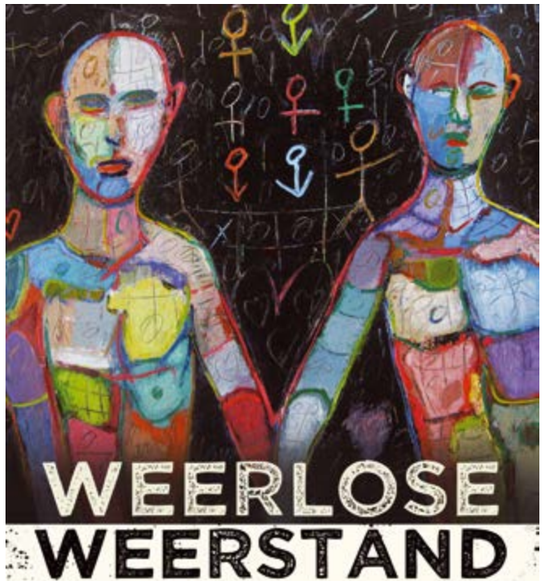
The gay debate in the Dutch Reformed Church

André Bartlett, Centre of the Formation of Ministry (Excelsus)

Homosexuality is a major concern in Christian churches all over the world, as is the case in South Africa. Debate often reveals deep theological differences and proves to be highly divisive in most churches.

Dr André Bartlett's research in the **Centre of the Formation of Ministry** at UP gives an important insight into the thought processes and theological reflection around human sexuality and the position of sexual minorities. In this book, *Weerlose Weerstand* (vulnerable resistance), published by Protea Boekhuis in 2017, he gives an account of the gay debate in the Dutch Reformed Church, covering the period from the 1980s to the present.

The importance of the debate is that the Dutch Reformed Church was the first mainstream church in South Africa, and in the rest of Africa, that not only accepted gay believers as full members, since 2004, but also recognised, in 2015, same sex unions and allowed its ministers to officiate at ceremonies where such unions are celebrated. Even though the last decision was overturned in 2016, the church is still at the forefront of the movement towards recognising the full human dignity of sexual minorities among its members and in society.



Written with a church member in mind, the book gives an account of the research findings of study commissions and theologians of the church. The findings focus mainly on the interpretation of biblical texts, the insights of the social and health sciences, and the life stories of LGBTI members of the church. There is no consensus that the biblical texts provide an unambiguous condemnation of homosexuality, or of committed same-sex relationships. The book also highlights the consensus in scientific circles that homosexuality is not a choice but a genetic orientation and a normal variation of human sexual expression. The scientific facts are confirmed by numerous life stories of individuals struggling to come to terms with their sexual identity, and by the witness of therapists working in the field of sexuality.

Although written by a single author, the book is based on the work of numerous other participants in the debate. It provides an insight into the often conflicting positions on sexuality and other related issues in South African churches, and gives an indication of the shifting of positions that necessarily takes place in the processes of research and deliberation.

The author is still involved in this ongoing process in his own church, and is working on research in other African churches and in African society in general. He is especially interested in the development of strategies to overcome bias and stereotypes with regard to sexual diversity.

Centenary celebrations of Theology and Religion

Over the course of 2017, the Faculty of Theology marked 100 years of service to the church, the academy and the broader African community with a series of events, awards and publications. It is the oldest theological faculty at a South African university.

The theme for the centenary celebration, Open Gates, was chosen in recognition of the role of theology and religion in public universities, and the Faculty's commitment to integration and diversification.

Notable among the centenary events was the hosting of the World Council of Churches summit, held on 16 June, the national Youth Day in memory of the Soweto Uprising of 1976, and the Religion in Dialogue conference held in August, co-hosted with the Centre for Interreligious Dialogue at the University of Tehran and the South African Department of Arts and Culture. The summit and conference brought together religious leaders and scholars from across the world to address historical and contemporary issues, with the focus on the root causes of violence associated with religion.

These, along with other events that made up the centenary celebrations, highlighted the Faculty's commitment to ensuring that the next 100 years will build on the strengths of the past. At the heart of the change that will usher in the next 100 years is the Faculty's name change to the Faculty of Theology and Religion, signifying a movement from exclusivity to inclusivity.

The Faculty of Theology formally concluded its centenary celebrations on 31 October 2017 with a Reformation Day service commemorating 500 years of Reformation in church and society. The theme of the ecumenical service was based on John 17: 'Let us be one'.

Professor Johan Buitendag, Dean of the Faculty of Theology for the period 2009-2017, in his vote of thanks, made reference to the Faculty's position within world rankings. In 2017, the Faculty was ranked as the top Theology faculty in Africa, and placed in 14th and 28th positions globally with respect to research impact and citations. This global recognition of excellence was an appropriate achievement in the year of its centenary celebrations.

Cheryl de la Rey, Vice-Chancellor and Principal, Johan Buitendag, Dean of Theology, and Fanie Snyman, Dean of Theology at the University of the Free State.

Law and the right to education

Ann Skelton, Centre for Child Law

The right to education builds the capacity of individuals to claim other human rights. Yet, the 2013/14 UNESCO Global Monitoring Report on Education for All (EFA 2014) shows that 57 million children do not attend primary school, which should be free and compulsory under international law.

Professor Ann Skelton, who holds the **UNESCO Chair in Education Law**, and is the **Director of the Centre for Child Law** in UP's Faculty of Law, is engaged in a research project that explores what the law can do to remove barriers to education, particularly on the African continent.

Access to free primary education was the focus of a case brought before the Swaziland (Eswatini) courts. The Constitution of Swaziland (2005) had promised free primary education for all children within three years of the Constitution coming into operation. That date having passed, a civil society group took the matter to court, demanding immediate rollout. The case initially fared well in the High Court, but in a subsequent application to apply the original order, the court baulked at making an immediately enforceable order, citing lack of resources as an obstacle. That approach was upheld by the Supreme Court.

Research undertaken by Professor Skelton and **Professor Serges Djoyou** was published in the *Journal of African Law* in 2017, 'Broken promises: Constitutional litigation for free primary education in Swaziland'. The article compares the approach of the Swaziland appeal courts to that of South African courts, and finds that the Swaziland courts could have ordered a starting date for the rollout of free primary education, and could have monitored compliance in the manner that judges in South Africa have been doing, in cases such as the recent 'text books' case.

In South Africa, while enrolment in schools is good and no child is excluded on the basis of being unable to pay, other barriers to learning are evident. An urgent problem in 2017 was protest action and its devastating effects on the rights of learners to attend schools. Professor Skelton was a panellist in a South African Human Rights Commission hearing on protest and schools. This collaboration led to an article co-authored by Professor Skelton and **Martin Nsibirwa** entitled '#Schools on Fire: Criminal justice responses to protests that impede the right to education', published in the *SA Crime Quarterly*. The article explores the competing constitutionally protected rights of protest and education. It concludes that although the right to protest is central in a democracy, it must be exercised peacefully with minimal disruptions to the right to education. However, the article is sceptical about the efficacy of criminal sanctions, and encourages a preventive approach.

Lebone College of the Royal Bafokeng, Rustenburg

Children's literacy levels remain low

Celeste Combrinck, Centre for Evaluation and Assessment

The international Progress in International Reading Literacy Study (PIRLS) 2016 results, released in December 2017, showed no significant progress in children's literacy levels since the previous assessment in 2011, and placed South Africa last out of 50 countries participating in the study.

Researchers at the **Centre for Evaluation and Assessment** were responsible for the South African part in this global study on reading and literacy levels among Grade 4 and 5 learners.

The CEA works closely with the International Association for the Evaluation of Educational Achievement (IEA), as well as several international research organisations that coordinate and collaborate on the PIRLS study across the globe. At the end of 2015, the CEA tested the reading ability and literacy skills of 12 810 Grade 4 learners across South Africa in all 11 languages. In addition, more than 5 000 Grade 5 learners were tested in Afrikaans, English and isiZulu. The data were processed and analysed by the international research group and then returned to the CEA for further analysis.

The PIRLS assessment is undertaken at five-year intervals. In the 2016 study, more than 319 000 learners participated worldwide. The results show that almost 80% of South African Grade 4 learners fall below the lowest internationally recognised level of reading literacy in their language of learning. This means that the majority of learners cannot read well enough to learn successfully, across the curriculum. The Grade 5 benchmark data show a glimmer of improvement: results of students assessed in reading literacy in isiZulu, as well as in English and Afrikaans, show a moderate improvement. Although learners still fall well short of the international average, this may suggest that given an extra year to settle into a new language (the school years up to Grade 4 being in children's home languages), reading literacy improves.

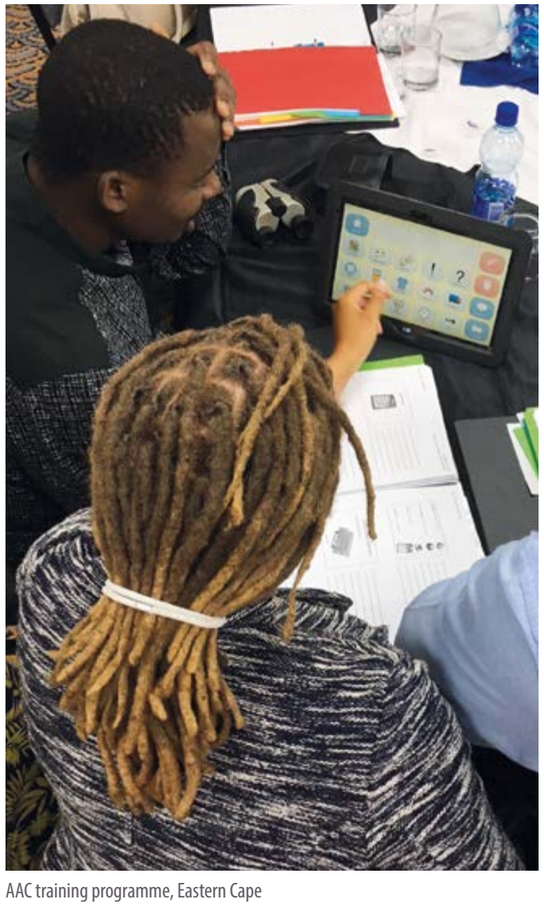
Alongside the CEA's responsibility for the PIRLS assessment in South Africa, CEA researchers also investigated over 1 000 other factors in the school, classroom and home environments to find contributing factors to the poor performance of children in South Africa. The groups most at risk were those in deep rural areas and townships, those learning in African languages, and boys. Except for the gender imbalance, which is similar internationally, the other factors mirrored the material realities of contexts in which access to quality education remains grossly unequal.

CEA published three detailed country reports in 2017, which are available on their website: https://www.up.ac.za/centre-for-evaluation-and-assessment.

Participation of people with disabilities

Juan Bornman, Centre for Augmentative and Alternative Communication

The UN Convention on the Rights of Persons with Disabilities reaffirms the basic human rights and dignity of people with disabilities and advocates for the full participation in all aspects of life. Participation is particularly relevant for people with disabilities, as embodied by the World Health Organization in the International Classification of Functioning, Disability and Health.



AAC training programme, Eastern Cape

In 2017, the **Centre for Augmentative and Alternative Communication** (AAC) focussed its research projects on the construct of participation through the use of graphic symbols.

Graphic symbols are designed to make concepts tangible, thereby capturing information where individuals are unable to express themselves in spoken or written language. **Associate Professor Shakila Dada** has used graphic symbols in her work with adults with aphasia and motor neuron disease, especially in communicating areas of importance to their rehabilitation. She has also used graphic symbols as a conversational tool with children to discuss their participation in activities at home, at school and in leisure activities, and with adults with low literacy levels about their coping strategies and well-being in raising a child with disability, and their understanding of health information.

Dr Ensa Johnson has also used graphic symbols in her communication work with vulnerable persons with disability in intensive care settings, and in determining effective communication strategies for nurses. The outcomes of this research have shown encouraging results in pain management and in the participation of vulnerable patients in expressing their pain in terms of location, intensity and type.

In 2017, the AAC continued to focus on the participation of persons with disability in the judicial system; from initial statements taken by police officers, to testifying in court and post-trial debriefing. Research with police officers has shown that a short two-day, custom-designed training programme increased their knowledge and skills with respect to taking statements from persons with significant communication challenges. This has resulted in a request to train staff of the National Prosecuting Authority and the South African Judicial Education Institute.

Professor Juan Bornman, Director of the Centre, underscores the relevance of the African proverb, and of the research undertaken: 'until the lion learns to speak, the story will always be told by the hunter'.

LAW AND BUSINESS

The legal system of a country provides rules and legal mechanisms that protect companies, groups and individuals.

In order to ensure their effective contribution to the SDGs, businesses need to make appropriate linkages between the goals, in order to contribute to economic growth and the well-being of individuals and communities. For example, a focus on economic growth alone may not result in the well-being of workers, or be to the benefit of communities and society, and hence the importance of legal mechanisms in advancing social justice and fair business practices.

Real Security Law – property rights and securing payment of debts

Reghard Brits, Department of Mercantile Law

The purpose of the category of property rights in law, referred to as real security rights, is to secure the payment of outstanding debts. If the debtor cannot pay, the secured creditor – that is, the one who holds a real security right – will have access to the value of the particular asset to settle its claim.

Dr Reghard Brits, senior lecturer in the **Department of Mercantile Law**, was awarded the Vice-Chancellor's Book Award for his monograph, *Real Security Law*, published by Juta and Company. The monograph contains a comprehensive investigation into the category of property rights, referred to as real security rights. The last comparable book on this topic, in South Africa, was published in the 1980s. The purpose therefore was to reinvestigate forms of real security in light of more recent developments.

Perhaps the best known example of a real security right is the one created when a mortgage bond is registered over immovable property that serves as collateral for the repayment of a loan, as is typical with home loans. Other examples include pledges and notarial bonds over movable property, security cessions of intangible assets, the landlord's tacit hypothec, rights of retention and various statutory security rights.

A particular focus of the book is to provide a contemporary update in view of South Africa's Constitution of 1996, and detailed attention is given to ways in which the constitutional rights of the parties involved have had an impact on the law. The book also considers the implications of other novel statutes, such as the National Credit Act of 2005, and includes comprehensive and detailed references to case law and legislation that set out the legal rules surrounding real security rights, and the views of other authors.

The theoretical and practical value of the book is well illustrated by the fact that it, along with some of the author's other publications, has been cited by the Constitutional Court in *Jordaan v Tshwane* in 2017, and contributed to the resolution of that dispute. The case concerned the correct interpretation of section 118(3) of the Local Government: Municipal Systems Act of 2000, which provides municipalities with a real security right over a person's land if there are outstanding property taxes and other fees payable. There was, however, great uncertainty as to whether the municipality could enforce its security right by having the property attached and sold to settle the debt, even after the property in question had been transferred to a new owner. Dr Brits argued in this monograph, as well as in two other publications, that this interpretation is incorrect, and that the municipality can only enforce the security right against the current owner who actually incurred the debt. The Constitutional Court agreed and expressly referred to Dr Brits' work.

In light of the fact that the book has been relied on by the highest court in South Africa, and has already been cited by other academic scholars, it is clear that it strikes a good balance between theoretical rigour and practical relevance. For the informed reader and scholar, it also provides valuable comparative perspectives of important developments in other jurisdictions.

Reform of company law and the protection of minorities

Maleka Femida Cassim,
Department of Mercantile Law

Companies play a vital role in society, and have an impact on investors, shareholders and consumers, as well as on employees and the communities where the companies operate.

Maleka Femida Cassim, Associate Professor in the **Department of Mercantile Law**, is engaged in research on the reform of company law and South Africa's Companies Act of 2008. Her focus is on the protection of minority shareholders within the domain of company activity, in particular protection from oppression, prejudice, and abuse of powers by company directors.

In view of the host of recent corporate scandals that have had a direct impact on many ordinary citizens (including pensioners, widows, orphans and employees), the protection of minorities is undoubtedly crucial. Her analysis of the prominent case of *Juspoint Nominees (Pty) Ltd v Sovereign Food Investments Ltd* was published in 2017 in the *South African Mercantile Law Journal*, while three further articles on other facets of minority protection have been accepted for publication in 2018.

A burning issue currently is the encroachment of the business rescue provisions of the Companies Act on the rights of lessors and other property owners. The chief predicament of a property owner who finds her/his property in the possession of a company under business rescue is the focus of Cassim's first paper on the topic, also published in the *South African Mercantile Law Journal* in 2017. Her second (forthcoming) article discusses the protective measures that should be available for such property owners. She also co-authored a paper on the widely published decision of the Constitutional Court on the lucrative 'Please Call Me' service of Vodacom, in which Nkosana Makate sought remuneration from Vodacom for the company's use of his idea in developing this service, from which Vodacom has reaped billions of rand.

Cassim's research has made a significant contribution to the legal, commercial and accounting community. Her book on minority protection, published by Juta in 2016, was quoted with approval by the High Court in two important judgments: *Lewis Group Ltd v Woollam* (in 2017); and *Mbethe v United Manganese of Kalahari (Pty) Ltd* (in 2016). In total, the courts have to date adopted her work in no less than 10 judgments of the High Court and two judgments of the Supreme Court of Appeal.

Understanding leadership

Caren Scheepers and **Shireen Chengadu**, Gordon Institute for Business Science (GIBS)

Making sense of the influence of contexts on leadership is an area that is of interest to researchers, especially in dynamic and fast-changing settings, such as is the case in emerging markets.

Dr Caren Scheepers at the **Gordon Institute for Business Science** (GIBS) studies organisational leadership and uses complexity theory to understand the influence of organisational contexts on leadership. Her recent co-authored work includes the 'moderator' and 'mediator' effects of external variables, such as the environmental dynamism in our African context, as well as organisational variables, in particular an organisation's structure and support, and its openness to innovation. Dr Scheepers and co-researchers have used structural equation modelling to study such effects, which allows for the inclusion of multiple variables in the conceptual and measuring stages of modelling.

Dr Scheepers' research is focused on exchanges between leaders' characteristics and the responsiveness and levels of engagement or ambidexterity of co-workers or 'followers'. A particular interest has been contexts of organisational crises, such as turnarounds, the disruptions of mergers and acquisitions, and high customer demands during diversification. At a practical and applied level, her research findings have informed leadership selection and development, and have helped match leadership styles to contextual requirements.

Her basic thesis is that a complex phenomenon such as leadership can only be understood within context; that is, ways in which people experience an organisational setting are filtered through their biases, assumptions and values. In order to harness this complexity in making sense of the actions of leaders and co-workers or followers, Dr Scheepers uses a case study methodology to capture the unique context-specific dynamics of leadership, and co-authored five studies in 2017, published by *Emerald Emerging Markets Case Studies*.

Dr Scheepers received the GIBS research award for the 'most prolific researcher' in 2017.

Women leadership in emerging markets

Shireen Chengadu and **Dr Caren Scheepers** at GIBS co-edited a book entitled, *Women leadership in emerging markets* (Routledge, 2017) that ties together two issues that are highly relevant to contemporary business organisations: women in leadership roles and women in emerging markets. The book brings to life the professional lives of women through 46 examples and profiles of women across Africa, the Middle East, and the Far East.

Globally, women constitute half of the population, yet they count for only up to 40% of the labour force. While there is now good evidence that women in leadership roles deliver better financial results for business organisations than where they are not in leadership roles, women leadership roles remain low, averaging 25% globally. In emerging markets this figure varies. In the African region, for example, we are one of the leaders in respect to diversity performance, with 30% of senior roles held by women in 2017*.

Throughout the book, the editors and contributors present evidence to illustrate why women, and women leaders, matter in the business sector.

The economics of gender is one imperative for gender equality but the moral and leadership diversity imperatives are equally important. Recent evidence points to the world's need for relational leadership and women, according to research, possess more of these leadership dynamics.

* https://www.bbrief.co.za/content/uploads/2018/03/grant-thornton-women-in-business-2018.pdf

FOURTH INDUSTRIAL REVOLUTION

Rapid advances in technology will profoundly affect societies, with the term 'Fourth Industrial Revolution' (4IR) increasingly accepted globally. There is no doubt that – characterised by innovations such as artificial intelligence, automation, and biotechnology – 4IR will transform existing systems of production, management and governance*.

It is anticipated that, at least initially, 4IR will increase inequality between those countries that can leverage technology and connectivity, and those that are slower to adapt. The challenge for South Africa as a developing country is to leapfrog the constraints of a traditional and bipolar economy to developing a strong technologically advanced and connected economy that is less dependent on natural resources.

* http://www.asia-pacific.undp.org/content/rbap/en/home/library/sustainable-development/Asia-Pacific-Development-40.html

Artificial Intelligence – myth or reality?

Nelishia Pillay, Department of Computer Science

There are many expectations – some well-founded and others perhaps not – of the contributions that artificial intelligence can make to society and the quality of life, and in shaping a future that we have come to know as the *Fourth Industrial Revolution*.

For some time now artificial intelligence has played an important role in industry with applications ranging from the scheduling of jobs, vehicle routing, airplane landing, financial forecasting and, more recently, in media and broadcasting, smart cities, mining, and in areas such as autonomous vehicles and energy consumption.

In education, artificial intelligence makes possible the provision of individualised tutoring by means of intelligent tutoring systems and automated teaching assistants, assessment and data analytics in identifying individual learners' learning difficulties. Artificial intelligence has also made inroads into society. In 1997, the artificial intelligence chess-playing programme Deep Blue beat world champion Gary Kasparov. Twenty years later, Alpha Go, a machine-learning Go player, beat number one Go player in the world, Ke Jie, at the Future of Go Summit. In the domain of the creative arts, artificial intelligence has produced a new generation of artists and composers who use artificial intelligence techniques such as evolutionary algorithms to produce artwork and music compositions.

In South Africa artificial intelligence has contributed to growth in agriculture and the financial sector, as well as in combating crime by predicting incidents such as cable theft and rhino horn poaching. It is anticipated that artificial intelligence will contribute significantly to economic progress by 2030.

The **Nature Inspired Computing Research Group** (NICOG) at UP, led by **Professor Nelishia Pillay**, **Head of the Department of Computer Science**, focuses on using artificial intelligence in search techniques to solve a range of problems in scheduling, automatic programming, network intrusion detection, data mining, routing problems, packing problems, game playing and automated design, among others. These search techniques take an analogy from nature, such as Darwin's theory of evolution, in providing solutions to optimisation problems.

A current focus area of the group is hyper-heuristics, a fairly new optimisation technique aimed at providing more generalised solutions to real-world problems. The first book on hyper-heuristics, *Hyper-Heuristics: Theory and Applications*, co-authored by Professor Pillay, will be published by Springer in 2018. Professor Pillay's current collaborations include the University of Nottingham in the UK, on hyper-heuristics, with MultiChoice on solving problems in broadcasting, and with the Department of Physics at UP and the Square Kilometre Array (South African Radio Astronomy Observatory) on scheduling problems. In 2017, Professor Pillay's work on hyper-heuristics was published by the Institute of Electrical and Electronic Engineers (IEEE), Springer *Science and Business Media*, and in conference proceedings on *Progress in Artificial Intelligence*, also published by Springer.

4IR communication systems

Sunil Maharaj and **Attahiru Alfa**, School of Engineering

Due to growing demand, radio resources for communication systems are limited. Everyone wants access, capacity, reliability and speed at all times. There has been an increasing interest in cognitive radio networks as a possible driver for next-generation xG wireless communication and as a technology appropriate to the context.

Attahiru Alfa, Babatunde Awoyemi, and Sunil Maharaj

Two research chairs in the **School of Engineering** have been addressing challenges related to radio communication in Africa: the **SENTECH Chair in Broadband Wireless Multimedia Communications** (BWMC), led by **Professor Sunil Maharaj**, and the **SARChI Chair in Advanced Sensor Networks**, established in 2015 and led by **Professor Attahiru Alfa**.

Collaborative research between the two groups is breaking new ground in next-generation xG communication technologies. Specifically, researchers build mathematical models to better understand the performance of communication systems under different allocation scenarios, and test the best use of limited resources for the benefit of the users. They have developed strategies that help 'squeeze' the most out of new technologies to provide users the best service at the lowest cost, while ensuring that service providers' projects are profitable. Their research uses queuing theory, Markov chains, network theory, and optimisation tools to achieve the 'best fit' scenarios. One such tool was reported in a paper co-authored with a postdoctoral fellow, **Dr Babatunde Awoyemi**, and published in the journal, *Digital Communications and Networks*.

Network failures (outages) due to link failures are common, especially in developing countries, and network service providers are continuously looking for fast network restoration tools. The researchers' recent work focuses on network restoration algorithms that will help telecommunication companies reroute traffic after complex network failures have occurred. Quick restorations resulting from link failures in networks will be a major issue in wireless sensor networks that drive the Internet of Things (IoT). For IoT to be successful, fast network restoration tools for node failures are crucial, as there will be thousands of IoT sensors and devices connected to the network, and reliability will be of utmost importance.

The xG communications prototypes being investigated are particularly relevant for the development of telecommunications in Africa. The prototypes are designed to help bridge the digital divide, and to improve mobile and data penetration, especially in the rural and remote parts of the continent. An important consideration is to make broadband available and affordable, in order to provide a platform for developing Africa's smart cities, and improved healthcare, agriculture and transportation, among the imperatives associated with 4IR.

The Research Chairs' capacity, and the strong network of international scholars with whom they collaborate, led to the hosting of Africa's first IEEE Summit: 5G in Future Africa − The role of IoT, cognitive radio and cybersecurity in networking the next billion, held at UP in May 2017.

Algorithms – finding the set of optimal trade-offs

Mardé Helbig, Department of Computer Science

Complex problems in real-world contexts are dynamic and invariably have conflicting objectives which means there can be no single solution and trade-offs are necessary. The same is the case with optimisation problems where either an objective function or constraint can vary over time.

The work of the **Computational Intelligence Research Group** (CIRG) in the **Department of Computer Science** focuses on computational intelligence and nature-inspired algorithms, which include swarm intelligence, evolutionary computation and neural networks. The research of **Dr Mardé Helbig** focuses on using these algorithms to solve a type of optimisation problem referred to as dynamic multi-objective optimisation problems.

Where objectives and/or constraints change over time, and where improving on one objective results in worsening at least one of the other objectives, there can be no single solution. Algorithms, and especially nature-inspired algorithms, help find the set of optimal trade-off solutions. This type of algorithm typically uses a population of entities to search for solutions and delivers multiple possible solutions after a single run. The algorithm also does not need gradient information to find the solutions. The nature-inspired elements of the algorithm evolve the solutions over time. Once the solutions are available, the decision-maker is presented with the set of trade-off solutions from which to select one solution, based on her or his expert knowledge.

Dr Mardé Helbig is one of the recipients of the UP Exceptional Young Researcher Award, and in 2017 was selected as a member of the executive committee of the South African Young Academy of Science (SAYAS).

Recently, CIRG researchers have developed approaches where a decision-maker guides the algorithm's search by incorporating her or his knowledge during the search process. They have applied algorithms to the inverse kinematics problem of an animated character, for example, by specifying a position where a hand or foot should be placed and then calculating the angles of all the joints to bring the hand or foot as close as possible to the specified position. This process can also be applied to the field of robotics, while algorithms have been developed to determine when to buy or sell foreign currency, for example.

Unsplash (Ray Hennessy)

The next step is to find suitable ways to visualise the set of trade-off solutions, especially when the problem has more than three objectives. Helbig has published on visualising trade-offs with **Professor Andries Engelbrecht**, the research leader of CIRG. While people can easily understand a three-dimensional image, the question is how to visualise solutions in, for example, 10 dimensions, or the population of the algorithm in the search process, so as better to understand the behaviour of the algorithm during the run. The latter is especially important when solving dynamic problems, where it is necessary to understand the effect of change on the performance of the algorithm.

The research of Helbig and her colleagues can be applied to a vast range of problems, such as optimising the treatment of water, the costing of electricity or the scheduling of jobs at a production plant.

Institute for Big Data and Data Science

In a significant development in transdisciplinarity as a new frontier in research, the **Institute for Big Data and Data Science** was established in 2017. Led by **Professor Andries Engelbrecht**, the Institute aims to address the complexities entailed in the tremendous increase in the amount of data being generated globally, and the demand for new efficient data analysis techniques that have spawned the Big Data revolution.

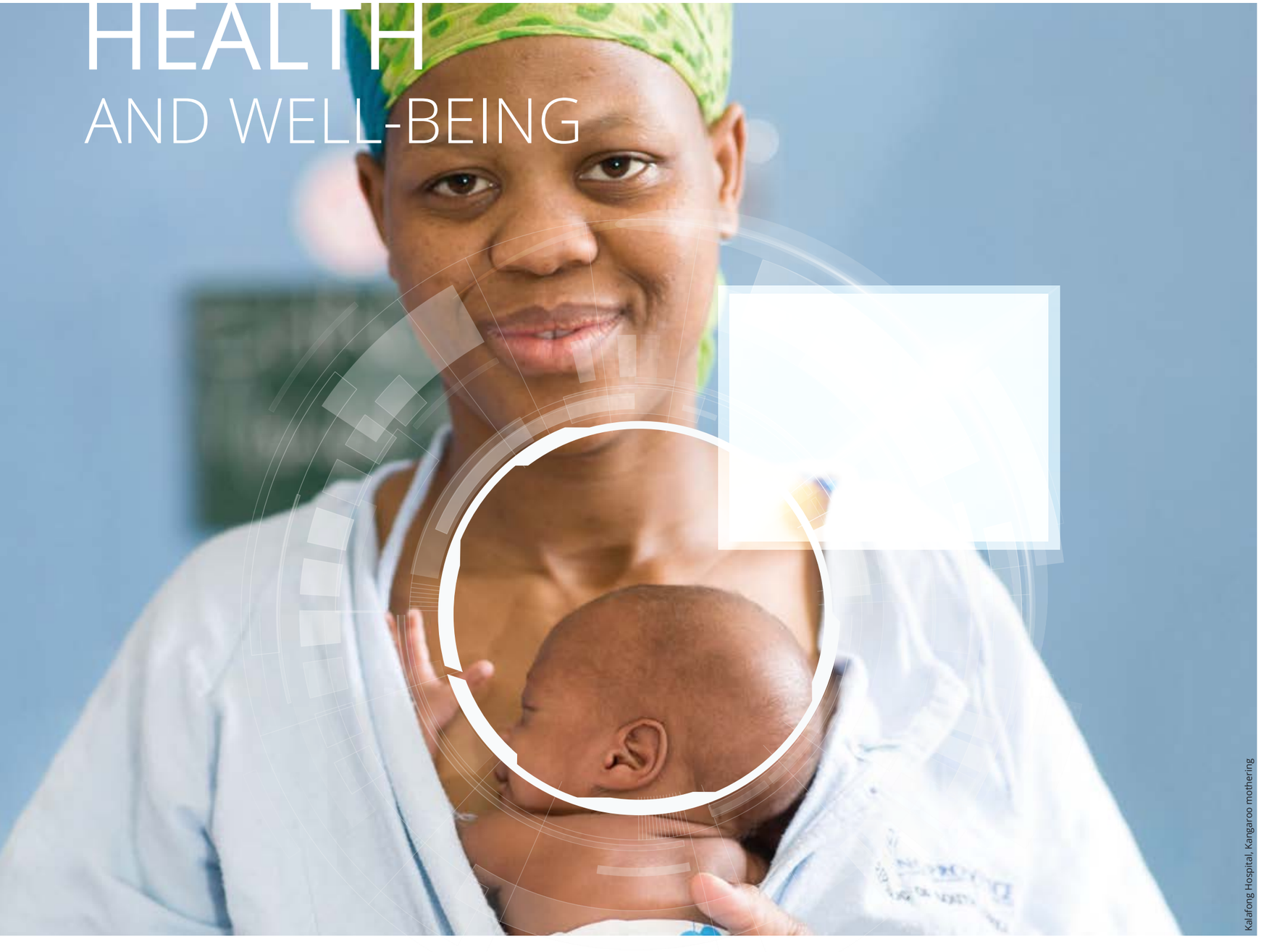
The Institute draws strength from a number of academic departments, Research Chairs and research entities at UP. The **SARChI Chair in Artificial Intelligence**, with Professor Engelbrecht as the chair holder, and the affiliated CRIG, are already well known for work on swarm intelligence and its application to solve complex optimisation problems, and research in the development of new machine learning approaches to extract meaning from data.

There are a number of internationally recognised research entities within the University producing large bodies of data, which provide challenges for the Big Data (BD) and Data Science (DS) communities. Examples include primary health care; lifestyle research; genomic data and bioinformatics; cellular and molecular medicine; infectious diseases; and transport development, all of which are examples of data-intensive research.

Linked to the Institute is the newly established Absa-funded **Chair in Data Science** located in the **Departments of Computer Science and Statistics** that focuses on data analytics, the science of examining big data to uncover hidden patterns, unknown associations, and other useful information to improve decision-making abilities. Data analytics is central to the banking environment, for example, for the purpose of sentiment analysis; product cross-selling; risk management; security and fraud management; digital forensic investigations; customer segmentation and profiling; and the analysis of the spending patterns of customers.

Also linked to the new Institute, and as part of the DST-NRF South Africa-Canada Research Chairs Mobility Initiative, the SARChI Chair in Artificial Intelligence secured funding for a collaborative project entitled, Bayesian Joint Analysis of Neuroimaging and Genetic Data. The significance will be the development of new statistical mixture models and tools to examine the influence of gene-gene interaction on either the function or structure of the brain, and the development of software that will be made freely available to neuroscientists conducting studies on genetics and neurological disease.

HEALTH AND WELL-BEING



Kalafong Hospital, Kangaroo mothering

The interconnectedness of health, well-being and the SDGs

Tiaan de Jager, Faculty of Health Sciences

Health, well-being and sustainable development are considered to be intrinsically connected, with health regarded as a precondition indicator as well as an outcome of successful sustainable development.

The 2030 Agenda for Sustainable Development is a plan of action for people, planet and prosperity. It recognises that opportunities to improve health not only lie in specific health interventions (primarily SDG 3), but also through social justice (SDGs 4, 5, 10, 16, 17), environmental protection (SDGs 2, 6, 7, 11–15), and shared prosperity (SDGs 1, 8, 9). Measures of health and well-being can therefore be used to assess progress in the implementation of a number of SDGs.

This theme on Health and Well-being combines research from within the University of Pretoria, mainly driven by and coordinated from the Faculty of Health Sciences, that focus on the improvement of health and well-being by addressing the interplay between the different sustainable development goals.

Opening the theme is a grouping of texts around reducing the mortality rates in children under the age of five, specifically related to HIV transmission between mothers and their infants, concluding with a discussion on public health and how policy needs to translate to the health programmes implemented around child care. A second set of research looks into affordable and accessible diagnostic tools and methods to assist with the early detection of preventable diseases. Internationally, the UN SDGs, and the World Health Organization's End TB Strategy, have recognised the severity of the problem, and have one common objective: to end the global TB epidemic. In addition to TB, sub-Saharan Africa is plagued by the diseases of HIV/AIDS and malaria, thus calling for integrated and novel research approaches to design pioneering public health interventions and strategies to address these diseases.

Non-communicable diseases (NCDs) are responsible for more than 65% of all deaths worldwide, and are of pandemic proportions in sub-Saharan Africa and South Africa. Studies within the Sport, Exercise Medicine and Lifestyle Research Institute (SEMLI) at UP focus on how sport and exercise can alleviate this burden of NCDs. The focus on cancer presents a case for fighting cancer with nuclear therapy that targets cancer cells while sparing healthy tissue. The next grouping of research illustrates the relevance of precision medicine that uses the distinct characteristics of patient populations to provide customised health care solutions. Concluding the theme, and providing a link to the next theme, is the focus on One Health at the human-animal-ecosystem interface that includes disease ecology and emergence.

Professor Tiaan de Jager is Dean of the Faculty of Health Sciences, and Director of the Institute for Sustainable Malaria Control.

UP ISMC postgraduate students and postdoctoral fellows on a field excursion in malaria-endemic Tshikondeni in Vhembe District, Limpopo Province.

Integrating malaria research and management strategies

The control and eventual elimination of malaria is still a major public health challenge in Africa, and requires novel, safer and sustainable methods and strategies.

The University of Pretoria Institute for Sustainable Malaria Control (UP ISMC) is a research entity with several research platforms that link research partners and the translation of high-impact research – fundamental and applied – to innovations, education and health promotion. Research practice is taken from laboratory to community and, by so doing, contributes towards a malaria-free Africa. Since its inception in 2011, the UP ISMC has gone from strength to strength, attaining new milestones, identifying and collaborating with high-profile partners and expanding its international footprint.

The DST-NRF South African Research Chairs Initiative (SARChI) Chair in Sustainable Malaria Control was approved for another five-year cycle and upgraded to a Tier 1 level. The Chair harnesses expertise in malaria parasite biology to enable sustained malaria control in Africa. **Professor Lyn-Marie Birkholtz** has been the incumbent of the Chair since its inception in 2013, and also leads the Parasite Control Cluster within the UP ISMC. In 2017, a DST-NRF Community of Practice in malaria elimination was established at UP, and will incorporate the expertise of five DST-NRF SARChI holders from four research universities in South Africa. The foci include the discovery of novel drug leads, used with optimised delivery systems against both the malaria parasite and mosquito vectors, and modelled within a malaria-elimination setting.

COMMUNICABLE DISEASES

Globally an estimated 6.3 million children under 15 years died in 2017, mostly of preventable causes. The vast majority of these deaths – 5.4 million – occurred in the first five years of life, with newborns accounting for around half of the deaths. Globally, in 2017, half of all deaths occurred in sub-Saharan Africa where 1 in 13 children died before their fifth birthday. In high-income countries, that number was 1 in 185. Within countries, disparities persist. Mortality rates among children under five in rural areas are, on average, 50% higher than among children in urban areas.

Adapted from http://www.who.int/news-room/detail/18-09-2018-a-child-under-15-dies-every-5-seconds-around-the-world-

Ensuring the health of South African children – HIV research

Ute Feucht and **Theresa Rossouw**, Department of Paediatrics, and Centre for Maternal, Foetal, Newborn and Child Health Care Strategies

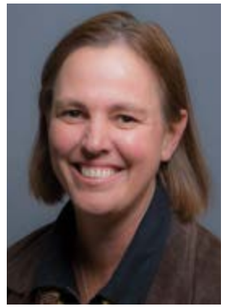
South Africa has the largest HIV pandemic in the world with approximately 7.9 million people infected with the virus. Pregnant women are especially vulnerable. Almost one-third of South African pregnant women are HIV-infected and can potentially pass the virus on to their infants during pregnancy, delivery or breastfeeding. Left untreated, up to 40% of infants will become infected through maternal transmission.

The introduction of potent combined antiretroviral therapy (cART) during pregnancy and breastfeeding has greatly improved the health of HIV-infected mothers and significantly reduced the number of HIV-infected children. However, studies show that HIV-exposed-but-uninfected children potentially have significant additional health needs compared to their unexposed counterparts. They are more likely to develop infections, have metabolic abnormalities and may have special learning and development needs requiring additional care and educational support. It is currently unclear whether this is caused by the mother's HIV infection and associated immunological changes, or whether cART toxicity may influence the infant's development, specifically the maturation and function of the immune system. This sets infants on a path towards suboptimal growth and development, as well as lifelong compromised immune function. With approximately 356 000 HIV-exposed infants born in South Africa every year, it is of critical importance to better understand this phenomenon.

A multidisciplinary research team at UP has embarked on a research project called the *Siyakhula study*. The study is funded by the International AIDS Society (CIPHER) to follow a cohort of 300 HIV-infected and HIV-uninfected pregnant women through pregnancy, until their infants are two years old. The *Siyakhula study* will evaluate how maternal HIV status and early life factors (breast milk and secondary infections) modify relationships between HIV exposure and key developmental outcomes, including infant growth, cognitive development and immune function. To this end, researchers are monitoring infants' growth and neurodevelopment, and are taking matched maternal-child blood samples, placenta, breast milk and faecal samples to evaluate immunological function, the microbiome, and metabolome.

The *Siyakhula study* brings together researchers from a number of departments at UP, namely Paediatrics, Obstetrics and Gynaecology, Medical Immunology, Family Medicine, and Human Nutrition, as well as two South African Medical Research Council Units: the Maternal and Infant Health Care Strategies Unit and the Health Systems Research Unit. Researchers are collaborating with researchers at Carleton University, Canada, working on the developmental origins of health and disease, and in immunology and infectious diseases, who will give input into immune and microbiome analyses, which could provide important new data on the reasons for the changes seen in affected children. In addition, UP researchers have partnered with the Centre for Human Metabolomics at North-West University in South Africa where the metabolomics testing will be performed. To date, 120 mothers have been recruited and preliminary results are expected by the end of 2019.

The clinical component of the *Siyakhula study* is led by **Professor Ute Feucht**, a paediatrician at UP and the Research Centre for Maternal, Foetal, Newborn and Child Health Care Strategies. She obtained her PhD in Paediatrics studying the implementation of the Paediatric HIV programme in South Africa. The laboratory lead of the *Siyakhula study* is **Professor Theresa Rossouw**, who is a clinical researcher with a double PhD – in Philosophy and Medical Immunology. She has been treating patients with HIV for more than a decade and also has a keen interest in biomedical and research ethics.



Theresa Rossouw and Ute Feucht

Siyakhula study, Kalafong Hospital

Maternal and child health – closing the gap between policy and programmes

Ameena Goga, Health Systems Research Unit, SA Medical Research Council

Far too often countries adopt excellent health policies to improve health, but subsequent health programmes do not reflect these policies, providing no benefit for mothers and their children.

Dr Ameena Goga, at the **Health Systems Research Unit** of the **South African Medical Research Council** (SAMRC), and an extraordinary professor and clinician at the UP and **Steve Biko Academic Hospital**, is working with a team of researchers to investigate the gap between policy and practice, with a specific focus on newborn infants and HIV infection. Approximately 32% of South Africa's newborn infants are exposed to HIV infection through their mothers. Because HIV-related care should improve child health and survival, while reducing HIV transmission from mother to child, such programmes should strengthen or complement other health services.

The research collaboration involves the National Department of Health and the South African National AIDS Council (SANAC) and, further afield, the Center for Disease Control and Prevention (CDC), the United Nations Children's Fund (UNICEF), and the Global Fund to fight AIDS, TB and Malaria.

The research has a five-pronged approach, focusing on: a) the effectiveness of the national programme to prevent HIV transmission from mother to child (PMTCT), at six weeks and postnatally, and factors associated with PMTCT effectiveness; b) the uptake and quality of maternal and child health care in the context of HIV; c) the uptake and impact of the PMTCT programme on adolescent mothers; d) the association between maternal antiretroviral use and infant growth; and e) the long-term survival and health of HIV-exposed and unexposed mother-infant pairs. Much of the work conducted or published in 2017 addressed the last three research foci specifically.

The SAMRC team and collaborators conducted three national surveys to monitor PMTCT effectiveness at six weeks post-delivery, and one national observational study measured the long-term effectiveness of programmes that prevent mother-to-child HIV-transmission. These studies enrolled more than 9 000 mother-baby pairs per survey. Dr Nobubelo Ngandu, from the SAMRC, found higher (22.4% vs 20.6%) uptake of early HIV testing, before attending an antenatal clinic, among pregnant women in the poorest (<40%) sub-group compared to pregnant women in the wealthiest (>40%) subgroup. The women in the poorest sub-group also had higher HIV prevalence compared to women in the wealthiest sub-group (43.7% vs 33.9%). These findings highlight inequity in testing uptake and antenatal HIV prevalence in South Africa.

There have been a number of other studies with some of the findings including that adolescent mothers had three times less PMTCT access, compared to older mothers, and a three-fold increase in mother-to-child-HIV-transmission. There were more child deaths but fewer hospitalisations among HIV-exposed infants (HEI), and there were higher chances of pre-term delivery, low birth weight and small-for-gestational-age among HEI infants, compared to infants unexposed to HIV. HEI with no antiretroviral exposure, or whose mothers initiated HIV treatment post-conception, had almost twice the odds of pre-term delivery, compared with mothers who started HIV treatment pre-conception, but no increased odds for other outcomes.

The research team also sought to measure adherence to maternal HIV treatment and infant prophylaxis. Sixty percent of mother-infant pairs received the recommended three postnatal clinic visits during the first six weeks of life, uptake was significantly higher (63%) among HEI compared to unexposed infants (58%), and less than 65% of mothers adhered to HIV treatment. Less than 75% of the infants received preventive treatment at 18 months post-delivery. This is a shocking finding, given the high prevalence of HIV in South Africa, and the policy and implementation shift to lifelong HIV treatment for pregnant and lactating women.

Very early infant diagnosis (VEID) of HIV

Nicolette du Plessis, Paediatric HIV Clinic, Steve Biko Academic Hospital

Mother-to-child transmission of HIV (MTCT), also known as vertical transmission of HIV, can occur during pregnancy, labour and delivery, or via breastfeeding. Without preventive measures, MTCT varies from 10-30% in non-breastfed infants to 25-45% among breastfeeding mother-child pairs. If the mother is infected with HIV, MTCT can be successfully prevented by using combination antiretroviral therapy (cART) both to treat maternal HIV and as post-exposure-prophylaxis for the infant. Using cART in very young infants to prevent MTCT via breastfeeding depends on the early diagnosis of HIV, especially if the HIV status of the mother is unknown.

The very early infant diagnosis (VEID) study, conceptualised by **Professor Nicolette du Plessis**, Head of the **Paediatric HIV Clinic** and a member of the Infectious Diseases group, was initiated in June 2014 after Kalafong Hospital became one of only two Department of Health (DoH) sites to roll out universal HIV birth testing. At the end of 2014, after the initial VEID study findings showed that birth testing was feasible and effective, the DoH decided to implement HIV birth testing nationally.

The VEID study group comprises the Medical Research Council (**Professor Ameena Goga**), the Department of Medical Immunology, Faculty of Health Sciences (**Professor Michael Pepper**), and the National Institute for Communicable Diseases (**Dr Ahmad HaeriMazanderani**). The group works closely with the Early Infant Diagnostic Unit at the University of the Witwatersrand (Professor Gayle Sherman).

The enrolment of infants in the VEID study ended in December 2017. Initial results suggest that targeted birth HIV PCR testing, using risk-scores, is feasible in resource-constrained settings with limited access to laboratory testing. The most significant risk factors predicting HIV infection in newborn infants were detectable maternal HIV viral load (VL), maternal cART duration of <1 month and whether the infant was symptomatic at birth. The VEID study aims to compare growth in relation to birth parameters of HIV-exposed infected and uninfected infants, as well as following the outcomes of birth-infected, early-treated infants.

Identifying affordable, non-invasive measures of health

Vinet Coetzee, Facial Morphology Research Group, Department of Genetics

Africa has an immense burden of disease, but limited access to health care, funds, infrastructure and trained personnel result in many people suffering from conditions that could be treated effectively and affordably if they were diagnosed early.

The work of **Dr Vinet Coetzee**, principal investigator of the **Facial Morphology Research Group** and the **African Longitudinal Facial Appearance and Health** (ALFAH) study in the **Department of Genetics**, and her co-researchers, focus on developing novel diagnostic tools to detect a variety of conditions.

Dr Coetzee and her research group and collaborators recently filed a provisional patent for a rapid, affordable and non-invasive method to screen for malaria. The method uses sensitive skin colour measurements in the palm of the hand, coupled with artificial intelligence, to predict whether someone has malaria. Once implemented, this device can facilitate wide-scale malaria screening, even in the most remote areas, bringing us one step closer to a malaria-free world.

Current collaborators include **Professor Tiaan de Jager** and **Dr Taneshka Kruger** from the UP **Institute for Sustainable Malaria Control**; Professor Dominik Endres from the Philipps-University Marburg, Germany, who developed novel machine learning algorithms for the research group; and Drs Alida Melse and Martin Mwangi from Wageningen University, the Netherlands who facilitated the data collection.

Another focus of the research group is on inborn conditions. In Africa, children with Downs syndrome are often only diagnosed around eight months of age. To address this problem, the researchers have developed an affordable 3D facial imaging system at one-tenth of the price of commercial systems. The system is used to photograph infants with and without Downs syndrome and to train artificial intelligence algorithms to predict Downs syndrome. The long-term goal is to develop a 3D facial screening tool and 2D mobile app which can assign probability of Downs syndrome, and other inborn conditions, from facial images alone.

Multidisciplinary collaboration has strengthened the scope of the research. This includes PhD student **Kishen Mahesh** and **Dr Engela Honey** in the **Department of Biochemistry, Genetics and Microbiology**; **Dr Emad Ghabrial** in the **Department of Orthodontics** who uses the 3D facial imaging system for his work on cleft lip studies; and **Professor Tania Hanekom** in the **Department of Electrical, Electronic and Computer Engineering** who is developing an affordable 3D camera.

Two further areas of work in Dr Coetzee's research group include the development of novel diagnostic tools for micronutrient deficiencies, which is undertaken in partnership with the **Institute for Food, Nutrition and Well-being**. The other is the ALFAH study, which is the first of its kind in Africa, and will initially recruit 4 000 African men and women over a period of five years and then follow up on their health and well-being over the next three decades. The study will collect a range of health measures, genetic information and facial images from participants.

In 2017 Dr Coetzee was selected as a Next Einstein Fellow. It is a distinct honour for a young researcher to participate in this African platform that connects science and society in Africa, and the rest of the world, with the goal of leveraging science for human development globally.

An invisible epidemic

De Wet Swanepoel, Department of Speech-Language Pathology and Audiology

Hearing loss affects more than a billion people annually and is ranked as the 4th leading contributor to the global burden of disease according to years lived with disability. More than 80% of affected people live in low- and middle-income countries where access to hearing care is mostly inaccessible or unavailable.

For children, hearing loss has far-reaching consequences for speech, language and cognitive development, and is a major barrier to socio-emotional well-being and educational success. In adults, the effects include social isolation, depression, cognitive decline and a three-fold increase in the risk of dementia.

In a project aimed at addressing the inaccessibility of hearing health care, **Professor De Wet Swanepoel** was awarded a National Institutes of Health (NIH) grant with US co-investigator, Professor David Moore from the Cincinnati Childrens' Hospital Medical Center.

Professor Swanepoel is based at the **Department of Speech-Language Pathology and Audiology** at UP, with adjunct positions at the University of Western Australia and the Ear Science Institute, and the University of Texas, Dallas (US). With his research team, he has capitalised on the growth in information and communication technologies to explore, develop and evaluate innovative service delivery models and applied solutions to improve access to early childhood development and health services, particularly in ear and hearing care.

The NIH grant was awarded in 2017 for a two-year period in the category of mobile health technology and outcomes in low- and middle-income countries. This research project will leverage the power of smartphones to develop a self-contained solution to the most common forms of mild and moderate hearing loss. Although applicable worldwide, this approach may provide a unique solution to people living in low- and middle-income countries where the world's highest prevalence of disabling hearing loss is found, but where services are scarce and unequally distributed. In sub-Saharan Africa, for example, there is less than one audiologist for every one million people.

This project builds on the success of HearZA™, a free downloadable App for smartphones, released as South Africa's national hearing test in March 2016 from Professor Swanepoel's laboratory. The App measures a person's ability to perceive speech in the presence of background noise accurately with smart features to download data and connect people to hearing health care professionals. To date, more than 35 000 tests have been done and thousands have been identified with hearing loss and connected to care.

The NIH project proposes further enhancements to this tool for increased accuracy. The use of a novel stimulus and test method can improve the sensitivity of the test to several types of hearing loss, all in the same three-minute test time. This allows for the rapid upscaling of hearing loss detection at a fraction of current costs.

In 2017, Professor Swanepoel presented the University's expert lecture, 'Rise of an invisible epidemic – fighting hearing loss with technology and connectivity'.

Gael Kazaz

TB – one of the biggest killers

Bernard Fourie, Department of Medical Microbiology

South Africa is one of the countries with the largest number of TB incident cases each year, and is battling to reduce the magnitude of the epidemic. In many cases, patients are diagnosed with recurrent TB, requiring re-treatment.

Professor Bernard Fourie, TB expert and researcher in the **Department of Medical Microbiology** in the Faculty of Health Sciences, recognises that short-term actions need to be improved if long-term sustainable interventions are to follow. For the *End-TB* targets to be reached, Professor Fourie says that the current BCG vaccine given to babies at birth needs to be dramatically improved, TB needs to be diagnosed using simple, accurate and immediate diagnostic tests, and new or repurposed antibiotics or treatment strategies are needed that can cure TB in weeks rather than months.

Scientists in the Faculty of Health Sciences are collaborating on innovative research projects with these ideas in mind. One such collaboration, the TB@UP Research Group, aims to contribute meaningfully to the attainment of the *End-TB* goals.

As part of the collaboration, Professor Fourie is leading research at UP to optimise rapid, molecular-based diagnosis of TB, inhaled therapeutics and vaccines, and biomarkers of disease risk. His research also looks into refining molecular procedures for diagnosing drug-resistant TB. The aims are to evaluate the potential of a simple specimen collection-to-detection system with enhanced diagnostic efficiency in specimens with very low bacterial load, which currently poses a challenge for existing TB tests. A major feature of this project is that the system should be independent of storing or transporting patient specimens under refrigeration. Such tests detect patients with early-stage TB, and simplify the prescription of suitable antibiotics, especially if the patient has drug-resistant TB. Working closely with **Professor Jannie Hugo** and his team in the **Department of Family Medicine**, these tests are being piloted in the community, with encouraging early results.

Only one vaccine for TB, the BCG vaccine, is licenced globally. While about 80% effective in babies and infants, the effect of this vaccine wanes over time and fails to protect adults against pulmonary TB. Research across the world is looking to develop a vaccine that is effective against TB at all ages. Professor Fourie and his research team, collaborating with **Professor Anton Stoltz** in the **Department of Internal Medicine**, are involved in exciting research, funded by the National Research Foundation, which could dictate a new approach to vaccination.

As the disease spreads through the air, Professor Fourie is targeting the lung as the portal for vaccination. He was part of an international team that developed an inhalable powder form of the BCG vaccine and is busy testing pulmonary administration of the vaccine, a global first. The **UP Airborne Infection Research Facility** (directed by Professor Stoltz) is a unique experimental unit that studies disease transmission via the lung. This facility will allow researchers to test the performance of the vaccine against TB, closely mimicking natural TB infection in the exposed human subject. Fourie is confident that the inhalable vaccine will be superior to the injected vaccine. If successful, it would be a great advance in the development of a new vaccine.

A new avenue being explored by Professor Fourie and **Professor Mike Sathekge** in the **Department of Nuclear Medicine** is the application of PET/CT scanning imaging technology to define predictive lung damage and inflammation markers in 'cured' TB patients that correlate with specific immunological biomarkers of risk for recurrent TB disease. This project runs under a global effort to develop biomarkers of TB disease that could be turned into interventions, coordinated in South Africa by Professor Mark Hatherill at the University of Cape Town.

Anti-microbial resistance complicates TB pandemic

Nontuthuko Maningi, Department of Medical Microbiology

The treatment of TB is made more complex as a result of the ability of different *Mycobacterium tuberculosis* strains to mutate and develop resistance to existing treatments. Researchers need to be one step ahead, if we are to win the fight against TB.

In collaboration with Professor Bernard Fourie, **Dr Nontuthuko Maningi** from the **Department of Medical Microbiology** has been working to describe the genomes of antimicrobial-resistant organisms, as well as testing the effectiveness of different diagnostic techniques to identify susceptibility to antibiotics. The susceptibility of *Mycobacterium tuberculosis*, the organism responsible for TB disease, to antimicrobial drugs, has been linked to specific mutations in the DNA of the bacteria. Interestingly, different mutations are responsible for resistance to different drugs. These mutations also occur at different frequencies within different populations, necessitating the profiling of *M. tuberculosis* at a regional level.

M. tuberculosis can contain various mutations coding for resistance to a suite of drugs, often with multiple mutations causing resistance to a single drug. These mutations and subsequent resistance to antimicrobial agents complicate the treatment of TB, often delaying early diagnosis and treatment, and lengthening the time needed for treatment.

Dr Maningi has been working to assess the frequency of the mutation Arg463Leu in the katG gene in multidrug-resistant TB (MDR-TB). These mutations lead to isoniazid (INH) resistance, and the frequency of these mutations varies within individual organisms and geographical areas. The current, commercially available assay used to identify INH resistance, does not target the Arg463Leu mutation, potentially missing 20 to 40% of INH-resistant organisms. At the moment, the assay only targets codon 315 and InhA mutations. Including the Arg463Leu mutation in the assay will improve the ability to detect INH resistance.

In 2017, Dr Maningi completed a study profiling a historical sample of *M. tuberculosis* isolates. Using line probe assay and whole genome sequencing, Dr Maningi and co-authors found that almost 71% of isolates were resistant to multiple antimicrobial drugs. Of the isolates that were susceptible to antimicrobial agents, only 26% were wild-type, or occurring naturally in host populations. Alarmingly, many of the *M. tuberculosis* isolates contained novel mutations, not tested for using standard assay techniques. Three of their multidrug-resistant *M. tuberculosis* (MDR-TB) isolates showed mutations in the *gyrA* and *rrs* genes, indicating that extensively drug-resistant *M. tuberculosis* was present in South Africa, long before it was first formally recognised in 2006. Dr Maningi and co-authors also completed a study testing the efficacy of different drug susceptibility assays to detect susceptibility to different antimicrobial agents. They concluded that in South African populations, assays available for rapid diagnosis of MDR-TB and extremely drug-resistant TB (XDR-TB) perform with high specificity and sensitivity. The widespread use of these assays in high-burden settings is integral for speeding up diagnosis, creating appropriate treatment plans and improving outcomes.

NON-COMMUNICABLE DISEASES

Non-communicable diseases (NCDs) are responsible for more than 65% of all deaths worldwide, and are of pandemic proportions in sub-Saharan Africa and South Africa. More than 80% of NCD-related deaths occur as a result of four disease groups: heart and blood vessel disease, cancer, diabetes and chronic lung disease. Tobacco use, harmful substance abuse, being sedentary, and unhealthy diets are considered to be the main risk factors. Exercise is considered to be critically important for the prevention of NCDs.

The health and injuries of athletes

Martin Schwellnus and **Christa Janse van Rensburg**, The Sport, Exercise Medicine and Lifestyle Institute

Chronic diseases of lifestyle, or non-communicable diseases (NCDs), represent the most important current and future health threat to both the developed and developing world. Researchers at the Sport, Exercise Medicine and Lifestyle Institute (SEMLI) are focussing their efforts on the effects of physical activity on health, and on the performance of athletes.

Professor Martin Schwellnus, **Director of SEMLI**, and a team of researchers have published a study that compared a cohort of long-distance runners with a history of muscle cramping to a control group. Runners with a history of muscle cramping were more likely to have a history of chronic disease, to use medication, to have a history of sports-related injury, or to be experienced runners. The team concluded that clinicians should consider the possibility of underlying chronic disease when treating athletes who complain of exercise-related muscle cramping. The team also found that long-distance runners with a history of chronic diseases were more likely to use anti-inflammatory medication before and during race events. Their research highlights the importance of regular fitness and health checks for leisure athletes.

The researchers have also focused on the types of injuries that are more likely to occur during specific events. When they followed a cohort of cyclists in the 2014 Momentum 94.7 cycle challenge, they found that female and younger cyclists were more likely to sustain trauma injuries and that adverse events, including trauma and cardiovascular illness, prevented cyclists from finishing the race. They suggest that this knowledge is vital for implementing safety measures during races and making sure that the correct medical support services are on duty. Pre-race screening of cyclists competing in a mass event in Cape Town also pointed to the need for interventions to be in place to prevent injuries and adverse effects.

Sport physicians at SEMLI have also profiled the incidence of injuries in a wide range of professional sports being played in South Africa. In one of their studies published in 2017, **Professor Christa Janse van Rensburg**, **Head of Sports Medicine**, and co-researchers showed that professional football players in South Africa had low rates of injury. The few who did sustain injuries were more likely to be injured during matches and knee injuries were the most common. In contrast, mixed martial arts athletes had higher rates of serious trauma to the head and traumatic brain injury compared, for example, to their American counterparts. The researchers identified a need to assess the quality of refereeing in South Africa to minimise the potential of serious brain injury.

Professional rugby players are also prone to contact injuries, which seem to be increasing as the level of competition increases. In a study also published in 2017, SEMLI researchers showed that the incidence of injuries in the Super Rugby Tournament is increasing over time, and that most injuries occur during matches. Given the high intensity of the game, rugby players who suffer severe injuries often struggle to regain their fitness and form, with long-term consequences.

Varsity Sports, Netball Tournament

Fighting cancer with nuclear therapy

Mike Sathekge, Department of Nuclear Medicine

Targeted alpha therapy (TAT) or alpha radiation is a fairly new approach to cancer treatment that targets specific genes or proteins found in cancer cells, and thereby stops the cancer from growing and spreading.

Professor Mike Sathekge and a team of researchers in the **Department of Nuclear Medicine** and at the Steve Biko Hospital have, through UP, entered into a collaborative agreement with the European Commission's Joint Research Centre (JRC) to develop a groundbreaking treatment for cancer patients. The Department of Nuclear Medicine is one of only three platforms in the world that uses targeted alpha therapy or alpha radiation to treat advanced-stage prostate cancer specifically, by using alpha isotopes known as Ac-225-PSMA.

Targeted alpha therapy (TAT) is still extremely expensive and there are strict international security standards regarding its use. This collaboration has enabled the Department of Nuclear Medicine to treat patients using TAT, which has resulted in an 85% success rate in patients with advanced-stage prostate cancer.

The success of TAT, compared to other radio-immunotherapy treatments such as beta therapy, rests in the ability to kill the cancer cells by causing double-strand DNA breaks and DNA cluster breaks in the cancer. Alpha radiation can thus kill cells which otherwise exhibit resistance to treatment with beta- or gamma-irradiation or chemotherapeutic drugs. TAT offers a therapeutic option for patients resistant to conventional therapies, such as chemotherapy and hormone therapy. Alpha radiation is also advantageous because it has a very short range, specifically targeting cancer cells while sparing healthy tissue.

Patients, particularly those with advanced stage cancer, undergo an imaging process to detect abnormal cells and, depending on the aggressiveness of the cancer, Professor Sathekge and his team are able to determine an appropriate course of radioactive therapy.

Professor Sathekge and his colleagues advocate a multidisciplinary approach to achieve optimal success in treating any form of cancer, from diagnosis through to treatment. The approach, they advocate, should be patient-specific and the course of treatment based on the results obtained from an individualised screening of each patient. The team of experts should include nuclear physicians, oncologists, radiologists, and surgeons working together to determine the best course of treatment for the patient.

The research team: Professor Mike Sathekge, Professor Mariza Vorster, Dr Otto Knoesen, Cindy Davis, Johncy Mahapane, Celia Corbett, Dr Florette Reyneke, Dr Ismaheel Lawal, and Dr Thabo Lengana.

Staff members in the Department of Nuclear Medicine

Precision medicine uses the distinct characteristics of patient populations to provide customised health care solutions. In this model, disease prevention, diagnosis and treatment are customised according to patient data generated from various sources, including 'omics'-based testing such as genomics, proteomics, metabolomics, and from information related to digital pathology, lifestyle and the environment.

INTO THE FUTURE

New possibilities in genomic medicine and cellular therapies

Michael Pepper, Institute for Cellular and Molecular Medicine

The University of Pretoria, being located in sub-Saharan Africa, is ideally placed to undertake high-impact biomedical research as a result of the unique genetic diversity of our populations together with the high disease burden in our region.

These combined factors – genetic diversity and a high disease burden – create the opportunity to address some of the most important health issues on the sub-continent. The high disease burden includes both communicable (HIV, TB, malaria) and non-communicable (cardiovascular disease, cancer, obesity, diabetes) diseases, as well as factors that contribute to high infant and maternal mortality rates. Many of the potential solutions arising from this research can be applied in other parts of the world, both in lower-to-middle and high-income countries.

The **Institute for Cellular and Molecular Medicine** (ICMM), directed by **Professor Michael Pepper** in the **Department of Immunology**, focuses on four thematic areas: the human genome, cell-based therapies, infectious diseases, and the neurosciences. The Institute includes the South African Medical Research Council's Extramural Unit for Stem Cell Research and Therapy.

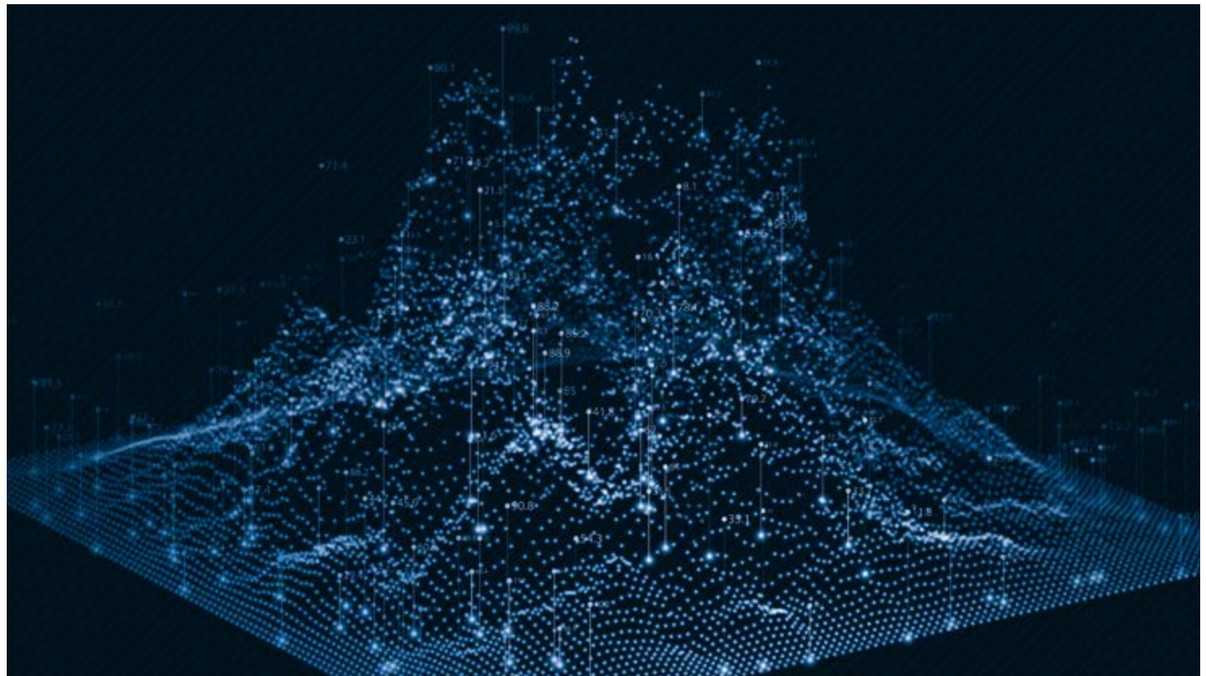
The human genome contains a wealth of information that can now be easily accessed due to rapid advances in sequencing technology and analytical tools. While everyone's DNA is highly similar, the differences in our genome give rise to unique individual traits that may predict whether we are predisposed to a particular disorder or disease. In some cases, genetically linked disorders, such as cancer, may present in specific cells or tissues at different times for different individuals, and understanding the genetic changes that occur in the cancer may facilitate accurate diagnosis and planning of treatment. Precision medicine based on cell-based therapies, which use gene-engineered cells in the immune system, are now able to specifically target and destroy blood cancers such as leukemias and lymphomas.

Recently, a team of South African researchers, including Professor Pepper at the ICMM, confirmed the high level of genetic diversity in South Africans. Their study analysed the whole genomes of 24 South Africans. The study generated large datasets, which were stored at three institutions. The twenty-author manuscript was exclusively authored by South African researchers, and is the first research on African genomes to be funded by an African government (the Department of Science and Technology, South Africa)*.

With South Africa's high burden of HIV and related illnesses, gene therapy aimed at rendering the immune system resistant to HIV would clearly be of benefit. Researchers at the ICMM are using patented proprietary gene therapy techniques, developed in collaboration with the Universities of Geneva and Zurich in Switzerland, to generate an HIV-resistant immune system. The group is also studying the effect of HIV on the formation of blood cells (haematopoiesis). This work addresses an important clinical manifestation of HIV disease, namely its haematological complications.

The future of medicine, undoubtedly, lies in acquiring and analysing large datasets, and is highlighted by the emergence of computational biology, including bioinformatics, as key disciplines in scientific discovery. These fields are linked to both precision (population-based) and personalised (individualised) medicine, which will lead the way in the future in disease prevention, diagnosis and management.

* NATURE COMMUNICATIONS, 8: 2062, DOI: 10.1038/s41467-017-00663-9.



Precision medicine in South Africa – the way of the future?

Peace Mabeta and **Jeanne van Rensburg**, Department of Physiology, and Institute for Cellular and Molecular Medicine

Precision medicine is increasingly being practised in South Africa and is set to change the treatment of many diseases, from genetically-linked cancers and other conditions, to lifestyle-linked non-communicable diseases.

Peace Mabeta

The genetic diversity of the South Africa population makes this region a central hub for precision medicine research. Because of this diversity, a disparity exists in population-specific genetic data between South Africa and other countries, where populations are less diverse.

At UP, postgraduate students and young researchers are striving to find answers in this novel field. In her MSc dissertation, **Jeanne van Rensburg*** highlighted the diversity of cystic fibrosis variants in different populations. Her research emphasised the need for 'omics' research centred on genetically unique South African populations, because precision medicine solutions cannot necessarily be transferred between global regions or population groups.

Jeanne van Rensburg

Precision medicine holds potential for the treatment of cancer. While investigating the ability of different drugs to inhibit the growth of new blood vessels, on which cancer growth is dependent, **Dr Peace Mabeta**** found that the metabolic signatures of tumour vasculature in benign and malignant cutaneous diseases played an important role in identifying potential therapeutic targets. This work was conducted at the Wellington School of Medicine, New Zealand. In 2017, she published a paper on potential therapeutic targets downstream of the vascular endothelial growth factor receptor-2 pathway. In an ongoing study, her research group is unravelling the metabolic patterns in benign and malignant cutaneous neoplasms. These studies, coupled to the declining cost of genomic tests and the improved fidelity in high throughput 'omics' technologies, may soon make precision medicine a reality for the South African patient in this area.

Precision medicine relies on algorithms to identify patients with similar molecular signatures and lifestyle patterns, enabling healthcare providers to match the patient's condition to the right healthcare approach. To develop these algorithms, information can easily be collected by smartphones. This information has important applications for the treatment of tuberculosis, cancer, HIV and non-communicable diseases, all of which impact heavily on South African and African communities.

** Dr Peace Mabeta is a Principal Investigator in the Angiogenesis Laboratory, Department of Physiology. Her research focuses on the underlying mechanisms of vascular development in both the physiological and pathophysiological settings, and using this knowledge to detect and develop treatments for neoplastic diseases.

* Jeanne van Rensburg is currently based at the University of Pretoria's Institute for Cellular and Molecular Medicine in the Department of Immunology as a project manager.

Whole genome sequencing advances cancer research

Vanessa Hayes and **Riana Bornman**,
School of Health Systems and Public Health

Riana Bornman

Prostate cancer has the highest incidence of all male-associated cancers and the second highest mortality rate in the western world. In most African countries, the incidence of prostate cancer is uncertain, while in South Africa it is estimated that at least one in every 23 men will develop prostate cancer within their lifetime.

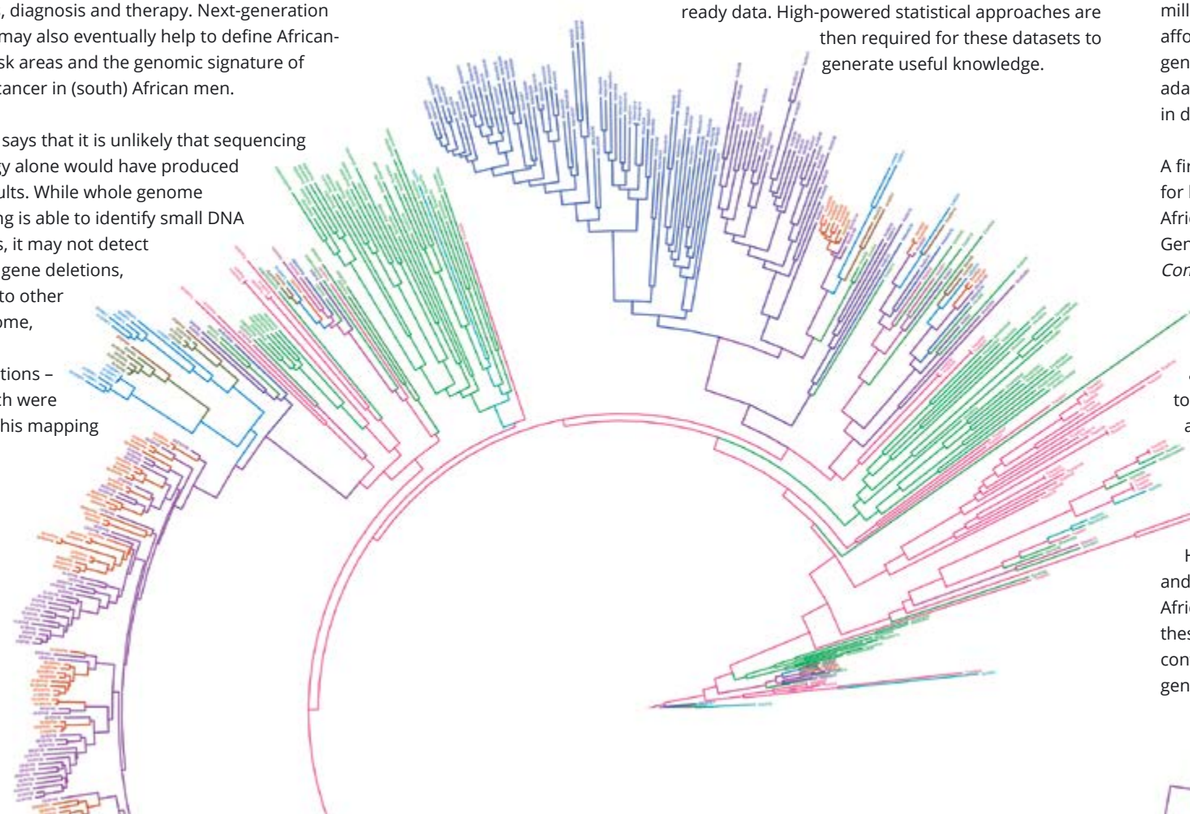
Researchers at UP's **School of Health Systems and Public Health** have collaborated with the Garvan Institute of Medical Research and the University of Sydney in Australia to, for the first time, map the entire genome of a prostate cancer tumour.

The team, led by **Professor Vanessa Hayes**, Extraordinary Professor at UP's School of Health Systems and Public Health, and Head of the Human Comparative and Prostate Cancer Genomics Laboratory at the Garvan Institute, published their findings in the journal *Oncotarget* in March 2017. The study views the disease through an entirely new lens. **Professor Riana Bornman**, Senior Research Professor at the School of Health Systems and Public Health, and one of the co-authors of this paper, has been researching prostate cancer, specifically among African men, for many years and has been collaborating with Professor Hayes.

Very little is understood about the genetic drivers of prostate tumours, despite the fact that prostate cancer has been well researched. The treatment of prostate cancer is complicated by the difficulties associated with identifying tumours that are going to spread and become life-threatening, as opposed to benign tumours, which spare patients harsh and unnecessary treatments.

Significantly, using next-generation mapping technology in combination with whole genome sequencing, the researchers uncovered the most complete picture of prostate cancer's genomic landscape to date. They studied a prostate tumour from a South African man with a Gleason score of 7, the most commonly diagnosed form of prostate cancer, which is clinically highly unpredictable. They eventually identified 85 large structural rearrangements, more than a third of which have a direct impact on genes known to have cancer-promoting potential. The team uncovered ten times more chromosome genomic rearrangements than previously detected with older technology. The study proves that next-generation mapping is feasible for cancer studies and has potential clinical utility for prognosis, diagnosis and therapy. Next-generation mapping may also eventually help to define African-specific risk areas and the genomic signature of prostate cancer in (south) African men.

The team says that it is unlikely that sequencing technology alone would have produced these results. While whole genome sequencing is able to identify small DNA mutations, it may not detect complete gene deletions, transfers to other chromosome, or gene multiplications – all of which were found in this mapping study.



Bioinformatics empowering modern biological science

Fourie Joubert, Centre for Bioinformatics and Computational Biology

The nature of experimental approaches to biological research has changed rapidly in recent years, particularly with the advent of omics-based technologies. These include genomics, transcriptomics, proteomics, metabolomics and other related fields.

These technologies often generate massive datasets for many molecules in parallel, and are regularly applied to hundreds or even thousands of samples simultaneously. The raw outputs are massive datasets, swiftly expanding the big data pool for biological science. These datasets require extensive pre-processing before analysis, often increasing the amount of data by a factor of x10 to generate analysis-ready data. High-powered statistical approaches are then required for these datasets to generate useful knowledge.

While classical statistical analyses have long been crucial for analysing large datasets, the wealth of information now becoming available is fast necessitating new approaches to the detection of intricate patterns in such datasets, and the application of this knowledge to new data. Machine learning approaches and deep learning tactics are steadily becoming the standard to mine such large biological datasets. The models developed in this way can subsequently be applied to newly-generated biological data to rapidly extract information from it. This is valuable for research performed in developing countries, where knowledge gained from massive experimental studies costing millions, can be extrapolated for use in smaller affordable local studies. Local population-specific genetic diversity, however, may often necessitate the adaptation of models built with data from populations in developed regions of the world.

A first step to gauge the suitability of models built for large European and Asian populations to South African ethnic groups was the South African Human Genome Project, which was published in *Nature Communications* in 2017 (see page 76). **Professor Fourie Joubert** at the **Centre for Bioinformatics and Computational Biology** was involved in identifying variants in the genomes of Sotho, Xhosa and Coloured individuals to highlight differences to other population groups where big datasets are available. Another project to highlight differences in genes involved with breast cancer in African vs European populations is currently ongoing in the Centre. Importantly, the H3Africa (Human Heredity and Health in Africa) consortium has recently designed and produced genotyping resources customised to African populations. The widespread application of these resources in African research studies will greatly contribute to knowledge of South African and African genetic diversity.

ONE HEALTH

The World Health Organization describes One Health as an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. The areas of work in which a One Health approach is particularly relevant include food safety, the control of zoonoses (diseases that can spread between animals and humans), and combating antibiotic resistance. Many of the same microbes infect animals and humans, as they share the ecosystems they live in. Efforts by just one sector cannot prevent or eliminate the problem*.

The Mnisi tribal area bordering the Kruger National Park.

* http://www.who.int/features/qa/one-health/en/

Herding for Health

Vinny Naidoo, Veterinary Science

The One Health approach adopted by the Faculty of Veterinary Science, in collaboration with researchers in the Health Sciences and a number of disciplinary fields, is defined by its focus on the human-animal (livestock and wildlife) ecosystems interface. This includes disease ecology and emergence, zoonoses, livestock production and trade, land use, and the sustainable use of natural resources.

The work is undertaken in the Mnisi tribal area bordering the Kruger National Park and is one example that illustrates the success of translational research and multipronged interventions.

The **Herding for Health** project is an example of a pro-poor, rural development project that aims to respond to pressing local challenges. Herd monitors (with knowledge of primary animal health care) and ecorangers (herders with training in environmental and livestock management) work with scientists, local government departments, and communities to improve livestock production, while restoring degrading rangelands. In addition, the Herding for Health partners also support local farming cooperatives to take advantage of economic opportunities and improve their livelihoods.

The **Hluvukani Animal Clinic** serves people in the community by working to keep their animals healthy and disease-free. The resident veterinarian is supported by UP veterinary students who in their final year do two-week clinical rotations in the Mnisi community. Students also visit schools and dip tanks for animal health awareness and information sessions, and the clinic serves as a centre to coordinate clinical research in the area, including longitudinal studies and sampling.

The clinic forms part of the **Hans Hoheisen Research Platform** that provides an appropriate local setting in which UP researchers and international collaborators can study zoonotic diseases. For example, bovine TB has become common in animals in the Kruger National Park, and has spread into rural cattle farming areas. Bovine brucellosis in buffaloes can spread to domestic cattle, and from there into human populations. Other zoonotic diseases studied are tick-bite fever, Q-fever, Rift Valley fever, leptospirosis, bartonellosis, and arthropod-borne viruses. UP researchers and partners also study the rabies virus and a range of other fields of relevance, such as foot-and-mouth disease, epidemiology, tick ecology, genetics, veld management and herding behaviour.

There are a number of other One Health projects at UP, with research in Veterinary Science now recognised by the Food and Agricultural Organization of the United Nations, and the World Organisation for Animal Health.

Professor Vinny Naidoo was Acting Dean of the Faculty of Veterinary Science in 2017.

PLANET AND SUSTAINABILITY

Unsplash


Wilhelm de Beer

Bioeconomy, systems biology and technology as catalyst

Eshchar Mizrachi, Forest Molecular Genetics Research Programme (FABI), Department of Biochemistry, Genetics and Microbiology

Inside a plant cell one-hundredth of the size of a pinhead, sugar molecules are broken down and in some cases converted to phenolics, moved around and delivered to protein machines that synthesise the biopolymers cellulose, hemicelluloses and lignin, to build a reinforced and waterproof cell wall. Almost all sugar not required for basic cell survival is invested in this process, until eventually the cell wall is complete, resources are spent and the cell dies, leaving a hollow but reinforced tube. This process is simultaneously coordinated across hundreds of thousands of cells of a tree stem every day and repeated as wood is formed.

Globally, trees are increasingly on the radars of many plant biology and biotechnology researchers, industry players and science policymakers. The main driver is the realisation that a global economy dependent on fossil fuels and finite mined materials is unsustainable and will not serve the world's growing and economically developing population. A solution, therefore, is the sustainable management, growth and production of biomaterials and biofuels from plant biomass for a greener and more circular bioeconomy, and almost nothing beats fast-growing plantation forestry for a renewable resource of this biomass.

But the economy is only one driver of this trend, and a move towards replacing fundamental and ubiquitous raw materials is dependent on a crucial catalyst – revolutionary technology.

Addressing South Africa's bioeconomy strategy

South Africa was one of the first countries globally to publish a formal bioeconomy strategy, through its Department of Science and Technology, in 2013. The forestry and forest products industry, in particular, is a major contributor to GDP and employment, even though commercial planted forests take up only around 2% of the land. Since climate and soil limits expansion into new land, research programmes at the University of Pretoria's **Department of Biochemistry, Genetics and Microbiology**, and **FABI**, have been involved in partnership with many players in the South African forestry industry to address tree improvement through biotechnology. Major focus areas are the biology and genetics influencing growth, wood properties and the processability of trees, as well as tree pest and disease resistance.

In the past decade several technologies have emerged, evolved, converged and aligned to transform the landscape of agricultural biotechnology. In particular, high throughput DNA sequencing, undergoing several generations of improvement since 2007, has meant a tipping point in reading DNA and whole genomes of hundreds of economically important species and populations within these species, which accelerates gene and pathway discovery and breeding predictions based on DNA. In 2007, there were genomes for only four land plants. Today there are hundreds of biologically, commercially and/or evolutionarily important plant genomes available to researchers around the world. Reference genomes now make it possible to involve other 'omics related to the biology of the plant (such as gene and protein expression, or valuable metabolic products) and, by so doing, to discover and identify regions in the genome linked to traits of industrial or commercial interest. Computational methodology and processing power are applied to model this 'systems biology' – integrating information from hundreds of samples, and tens of thousands of genes, proteins, metabolites and other measurable cellular components.

More recently, genome editing has accelerated the rate and regulatory implication of altering the genetic code of a plant and, alongside this, the nascent field of synthetic biology promises the engineering of entire pathways and even chromosomes for advanced metabolic engineering of plants.

The near future will see an even larger explosion of data, including phenomics (high throughput measurements of hundreds to thousands of plant traits), environmental conditions, the microbiome, and data on the interactions between genotype and these factors. Analysis of data of this scope and size will in all likelihood require the application of artificial intelligence (AI) through machine learning, to integrate and make accurate predictions from complex inter-related datapoints, to drive the new biotechnology of plant biomass. Emerging markets around wood-pulp polymers and their derivatives in many industries, as well as solid wood applications for modern building such as cross-laminated timber, are promising areas driving investment in woody biomass research.

Modelling wood formation and its evolution

Biopolymers produced in the wood of trees (e.g. cellulose, hemicelluloses and lignin) serve as raw material for many commercial high-end value derivatives.

Fast-growing tree species such as *Eucalyptus* are important sources of biomass for these polymers worldwide, and South Africa is a major player in this context. The forestry industry is also gaining relevance in the emerging global bio-based/green economy, due to the immense contribution it can make towards renewable bioenergy and biomaterials such as biodegradable polymers, surfactants, bio-bitumen or cross-laminated timber for sustainable building materials.

The research group of **Dr Eshchar Mizrachi** focuses on reverse engineering of wood formation as a system, to understand how it works and which key points are available for rational intervention and improvement through biotechnology. Mizrachi's specific interest has been in constructing a model of the regulatory network (genes, proteins and pathways) that plays a role in influencing wood development, and identifying candidate genes and pathways for biotechnological improvement of trees (e.g. applied via breeding using molecular selection tools, or genetic modification).

The main technology applied in their research is second-generation transcriptome sequencing technology, which has allowed unprecedented insight into the dynamics of expressed genes. Other 'omics techniques are also used to complement the transcriptomic research. Applying these technologies at a population level is filling in the gap between genetic variation and complex wood properties. By integrating various layers of biology, the research group published a study in 2017 that uses a novel methodology to link the variation of genes and entire pathways to industrially relevant tree growth, wood formation and wood processing traits. The publication was a collaboration between Mizrachi and **Professor Zander Myburg**, who established the **Forest Molecular Genetics programme** at UP, and **Professors Kathleen Marchal** and **Yves van de Peer**, both Extraordinary Professors at UP*.

Plastids (specialised 'metabolic factory' compartments within each plant cell) are the reason almost all plants are green and can produce sugars using light, water and CO_2, but they are also responsible for the starch in potatoes and many of the vitamins in fruit and vegetables. Mizrachi and colleagues, especially the work of PhD student, **Desre Pinard**, also study a hitherto largely ignored element of wood biology – the role of plastids in wood development. Plastids are a key carbon partitioning point between polysaccharide and phenolic biopolymers, and greater understanding of how carbon metabolic flux is regulated in these compartments is key to developing advanced biotechnology solutions to biomass-related crops.

As a developmental system, xylogenesis (wood formation) offers an attractive model for understanding complex systems and their response to perturbations. Mizrachi and his group (especially **Danielle Roodt**, a PhD student) are studying the evolution of this system by comparing dozens of plant genomes, as well as generating new genomic resources for and analysing under-studied 'missing link' plants, such as Ginkgo, cycads and the herb Ephedra.

* Mizrachi E et al., (2017). Network-based integration of systems genetics data reveals pathways associated with lignocellulosic biomass accumulation and processing. PNAS 114(5):1195-1200.10.1073/pnas.1620119114

FABI, FORESTS AND FUNGI

Wilhelm de Beer

In 2017 the Forestry and Agricultural Biotechnology Institute (FABI) stood at the verge of its 20th anniversary (1998-2018). A celebration symposium was planned to follow in January 2018, themed *The Road to Research Excellence*, an event that would attract research collaborators, alumni, postgraduate students, members from the forestry industry and government, and foreign delegates – a reflection of FABI's national and international footprint and impact.

FABI presents a unique structure within the University: while closely linked to academic departments, it is a postgraduate institute that makes possible the collaborative, interdisciplinary space for experimenting with techniques and in frontier fields to drive research and excellence. It also has the critical mass to engage with and impact on both academic networks and non-academic stakeholders in government and industry. By the end of 2017, FABI had a staff and student complement of more than 200, and over 420 master's and doctoral students had graduated over the 20-year period. Also significant is that among FABI's lead researchers are a number of highly rated NRF scientists, including A-rated scientists, and who are positioned in the top 1% of scientists globally.

At the forefront of research on pests and diseases of plants and trees relevant to Africa, FABI researchers are recognised for building research capacity and networks, and developing new innovations for pest and pathogen management.

Recently, through the application of biotechnology and bioinformatics, and systems genetics, major breakthroughs have been published in high-impact international journals, including *Science* and *Nature*, and in 2017, in the prestigious *Proceedings of the National Academy of Science of the United States of America* (PNAS). These breakthroughs are of direct relevance to forest and plantation health, and to economic development.

Fungi and tree health

Bernard Slippers and **Mike Wingfield**, Forest Molecular Genetics Research Programme

One of the core areas of research undertaken by students and their advisors in the Forestry and Agricultural Biotechnology Institute (FABI) concerns the health of trees, and among the most serious threats to trees are fungi, perhaps best known as those organisms that include mushrooms.

Fungi cause some of the most serious tree diseases by infecting either roots, stems, shoots or leaves directly, or via physical wounds caused by insects, for example. They threaten forests and plantations, as well as global food security and biodiversity.

Professor Bernard Slippers, the new director of FABI, focuses his research on tree diseases caused by insects and fungi. In 2017 he joined forces with colleagues **Professor Mike Wingfield** (past director of FABI) and **Professor Pedro Crous**, an Extraordinary Professor of FABI and the Director of the Westerdijk Fungal Biodiversity Institute in the Netherlands, to publish a special issue of the journal *Fungal Biology** that focused on an important group of tree-infecting fungi known generally as *Botryosphaeria*. This special issue brought together important concepts relating to tree health, and included many articles by FABI staff and students.

A fascinating aspect of the *Botryosphaeria* fungi is that they can live inside trees without resulting in disease. Typically, the fungi begin to cause disease when trees are stressed or where they are growing outside their natural environments. The fact that this type of fungus can live in healthy plant tissues, such as fruit, means that the pathogen can be moved between countries and continents without being detected. When these organisms arrive in new areas where trees have not evolved with them, they can cause serious disease problems.

Studies published in the special journal issue presented a number of new discoveries about the *Botryosphaeria* fungi. The studies showed, for example, that these fungi are hybridising in nature, leading to new disease-causing agents that could pose serious threats to trees in the future. The fact that these fungi are also moving between fruit trees (such as mango) and native trees in South Africa (such as Maroela, a relative of mango), was also discovered in one of the FABI-led studies.

FABI is internationally recognised for its work on fungi and has played an important part in positioning the University of Pretoria as one of the strongest centres in the world where these organisms can be studied. Fungi such as the *Botryosphaerias* are examples of the many other fungal and related organisms that are included in the Institute's focus on plant health and, linked, the focus on food and fibre security.

Michael Wingfield, Réunion Island
Inset: Bernard Slippers

* Fungal Biology, 121, 4 (2017). ISSN 1878-6146, https://doi.org/10.1016/S1878-6146(17)30027-2.

Fungi – the good and the bad

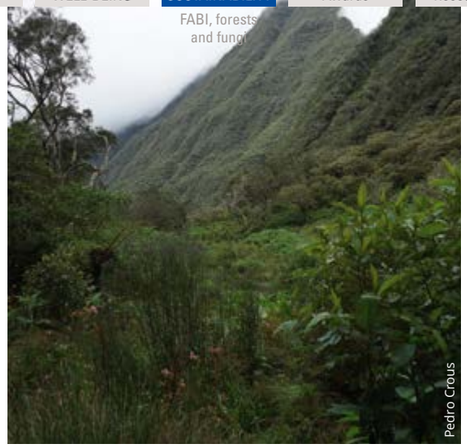
Pedro Crous, Westerdijk Fungal Biodiversity Institute, the Netherlands, and FABI

Although the concept of biodiversity may conjure images of beautiful animals and plants and, increasingly also, of threats to their survival because of human-induced damage to natural habitats, few would think of fungi being part of this biodiversity and essential to the health of ecosystems.

With 2.2 to 3.8 million predicted species, fungi represent one of the most speciose kingdoms on this planet. Yet, we have recognised only around 120 000 species, which have taken us more than 250 years to discover. The global community of mycologists are describing around 2 000 species a year, suggesting that it will take another 1 830 years to describe the remainder of the species.

Fungi are rarely considered to be organisms that can be threatened, or whose activities are essential to the health of ecosystems. Without fungi, plants would not have a mycorrhizal root network to enable them to grow in adverse environments, litter would not be degraded, and most ecological processes would cease to function. Bad fungi, however, can spoil our food and water, cause crop losses and disease (and sometimes even epidemics), and those who study fungi know them best for these negative characteristics.

What of the beneficial fungi? Yeasts play a major role in our intestines, boost our immune systems, and there are 10 times as many microbial cells in the human body as there are human cells. In the environment, fungi break down waste, maintain chemical balance, and can be used to produce biofuels, novel antibiotics or antifungals. Simply put, we all hate athlete's foot, dandruff, and yeast infections, but none of us would wish for a life without bread, cheese, wine or beer.



Pedro Crous

It is clear fungi play a major ecological role in our lives. We must consequently capture and preserve as many of the cultivatable species as possible; some of these likely hold keys to improve our quality of life. One such initiative is the Fungal Planet project, which aims to describe 1% of all new fungal species occurring on Earth.

The names and descriptions of all newly described species are captured in the global online database MycoBank, while the DNA data are added to international initiatives such as AFToL (Assembling the Fungal Tree of Life), using the procedures and DNA protocols as outlined in IBoL (International Barcode of Life).

As part of this initiative, researchers from the University of Pretoria, together with colleagues from the Westerdijk Fungal Biodiversity Institute in the Netherlands, undertook a recent survey of microfungi on Réunion Island. Preliminary results revealed many new species, and more than 20 of these have been published to date, including three new genera and two new families. Although these species are now being screened to reveal potentially new metabolites and enzymes, one fungus, *Roussoella solani*, has already been identified as the causal organism of a corneal infection in a Japanese hospital patient.

Considerable interest remains in elucidating the new molecules that these new fungi can produce. Surely, South Africa with its unique plant and animal biodiversity, will also harbour a fungal flora that could potentially hold the key to new medicine, an ideal biofuel, or improved industrial processes?

Diaporthe ocoteae on pine needles, newly described by P Crous and MJ Wingfield, from leaves of *Ocotea obtusa* collected on Réunion Island.

How fungi do it

Andi Wilson and **Brenda Wingfield**, Forest Molecular Genetics Research Programme, FABI

While it might seem strange that such seemingly simple organisms are even able to sexually reproduce, fungi exhibit some of the most fascinating and diverse sexual strategies of all the species on this planet.

Researchers at the **Forestry and Agricultural Biotechnology Institute** (FABI) study sexual reproduction in a number of fungi, including important tree pathogens. Understanding how sexual reproduction takes place in disease-causing fungi is specifically important as it provides a platform from which to develop management, treatment and prevention strategies. Such strategies are critical if the introduction and spread of fungal pathogens are to be controlled from continent to continent and forest to forest.

Andi Wilson, a doctoral student working with **Professor Brenda Wingfield**, has discovered that *Huntiella moniliformis*, a species from a family of notorious plant pathogens, is unisexual. This means that this fungus is able to sexually reproduce in the complete absence of a mating partner and without genes that have long been thought of as essential for sex. Understanding this system has significant ramifications for the management of this and potentially other unisexual fungi. Recently, Andi and her colleagues were able to show that it is likely that the uncontrolled expression of mating pheromones in *H. moniliformis* allows it to sexually reproduce in isolation.

Andi Wilson

Postdoctoral fellows **Markus Wilken** and **Melissa Simpson** are investigating mating type switching in the genus Ceratocystis. Melissa has recently shown in her PhD work that these species need to delete an entire region of the MAT locus in order for sexual recombination to occur. Markus has shown that species in related genera also undergo this mating type switching, indicating that this mechanism is perhaps not as unique as had been thought previously.

In heterothallic, or self-sterile fungal species, identifying the genes in the MAT locus provides tools to understand the genetic diversity of a species. In some cases, disease outbreaks are clonal lineages, whereas in others, the fungus may be more diverse. The latter are more difficult to control and it is thus essential to study the genetic diversity of a fungus early on in the diagnostic process. With the decreasing costs of genome sequences, a number of researchers in the group, including **Tuan Duong**, **Aquillah Kanzi** and **Wilma Nel**, are sequencing increasing numbers of fungal genomes in order to elucidate the MAT locus in the species they study. While mating and sexual recombination of fungi may on the surface seem to be somewhat obscure, understanding the mating system of a fungus, and particularly a tree pathogen, is a critical first step in developing management strategies to combat these pathogens. Trees are after all an essential component of our natural environment, literally providing the oxygen we breathe.

Recent research articles on sexual reproduction in tree pathogens have been published in the journals *Fungal Biology*, *Fungal Biology Reviews*, *Fungal Genetics and Biology*, and *PLoS One*.

Resistance mechanisms against insect pests

Sanushka Naidoo, Department of Biochemistry, Genetics and Microbiology, and FABI

Sanushka Naidoo and postgraduate student Stefan Ferreira

Tree resistance mechanisms are integral components of the plant disease triangle. The magnitude and timing of a tree's defence mechanisms will determine the extent of damage that can be caused by pests or pathogens.

Climate change is a reality and South Africa's local forest plantations only recently started recovering from a devastating drought. Drought conditions induce a stress response in trees, thereby compromising an adequate defence against pests and some pathogens. Worldwide, anthropogenic activity has resulted in the spread of pests and diseases and it is anticipated that climate change may extend the breeding period for certain insect pests and create favourable environments for pathogens not previously identified in certain regions or hosts.

Sanushka Naidoo, Associate Professor in the **Department of Biochemistry, Genetics and Microbiology**, is leading a team of **FABI researchers** who study tree resilience. Together they have started to unravel the complex defence network that exists in forest trees. The deep molecular analysis of the host-pest/pathogen interaction is made possible by the many molecular tools that are now available for studies such as transcriptomes for *Eucalyptus* and Pine, markers for *Eucalyptus*, and genomes for pests and pathogens.

In recent work, the team collaborated with Mondi Forests and the Trahar Technology Centre in South Africa, and identified markers associated with resistance against the gall-forming insect pest, *Leptocybe invasa*. They coupled these findings with expression patterns that differed in resistant and susceptible genotypes. Many of these are candidate insect defence genes. Further collaboration with researchers at University of Pretoria, University of North Carolina (US), and Australian National University resulted in the identification of specialised plant metabolites associated with resistance against this pest. Some of their recent work was published, in 2017, in journals *Molecular Plant Pathology* and *Tree Physiology*.

Future research will entail examining whether such metabolites act as attractants or repellents to the pests, or have direct anti-insect activity, in order to understand the mechanisms of resistance to *Leptocybe invasa* in forest trees. It is anticipated that some of the approaches could be adopted in future forest management of pests, as part of climate change mitigation strategies.

Sanushka Naidoo was one of two recipients at UP, in a group of 18 in Africa, to receive the Next Einstein Forum Fellow Award in 2017, a distinct honour in recognition of exceptional academic talent. The other recipient is Dr Vinet Coetzee (see p.68).

Chemical interactions between trees, pests and diseases

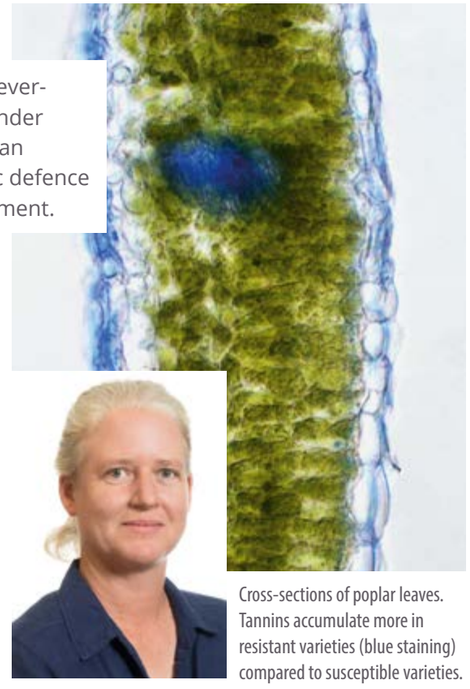
Almuth Hammerbacher, Department of Zoology and Entomology, and FABI

Due to their longevity, trees are prone to attack by an ever-increasing number of pests and diseases. To survive under constant attack, they defend themselves by deploying an impressive array of chemical, molecular and enzymatic defence mechanisms that kill or retard their attackers' development.

Dr Almuth Hammerbacher in the **Department of Zoology and Entomology** and **FABI** has a specific interest in the chemical interactions of forest trees with insects and microorganisms. Her research combines methodologies from diverse fields of specialisation and, in partnership with researchers at the Max Planck Institute for Chemical Ecology in Germany, she has been investigating the molecular and chemical responses of trees against single and simultaneous attacks by different pests and diseases, and the ecological consequences of such attacks. To understand tree defence mechanisms, the research team has used a multidisciplinary research approach: analysing the chemical changes in trees by using both liquid and gas chromatography, coupled to mass spectrometry. Where there are significant chemical changes in resistant trees, they have also investigated the degree of toxicity of individual chemical compounds.

The research team is also interested in the signalling networks and genes involved in mediating the trees' defence responses, and to this end have used transcriptional analyses and enzymology to pinpoint networks and genes involved in the survival of trees. By manipulating environmental conditions, they have extended their analyses to understand how global change might affect interactions between attacker and trees and, finally, to determine the ecological impact of tree responses to specific combinations of attack, and how chemical changes in trees may affect the environment.

Their latest research, published in the journals *New Phytologist* and *Plant Physiology* in 2017, illustrates that multiple attacks by different organisms on the same tree have complex ecological consequences. For example, simultaneous attacks by gypsy moth caterpillars and a rust fungus on poplar trees result in increased feeding by caterpillars due to their preference for the smell of fungal spores. Fungus infection reduces the amount of defence chemicals trees produce as a defence against the caterpillar. Fungus infection, on the other hand, results in increased levels of complex phenolic compounds known as tannins, which generally inhibit fungal growth. Tannins also render leaf litter recalcitrant to decomposition by saprophytic microorganisms, thereby affecting the microbial community on the forest floor. Finally, altered levels of volatile compounds emitted by fungus-infected trees in response to caterpillar feeding reduces the risk of predation for caterpillars and therefore negatively affects higher levels in the food chain.



Cross-sections of poplar leaves. Tannins accumulate more in resistant varieties (blue staining) compared to susceptible varieties.

The status of coastal forests

Pieter Olivier, Conservation Ecology Research Unit (CERU), Department of Zoology and Entomology

Fragmentation of the world's forests is affecting biodiversity directly through the loss of core forest habitat, and indirectly by creating forest edge areas. It is estimated that approximately half of the world's forests are now situated within 500 metres of a forest edge.

Dr Pieter Olivier's work on coastal forests in South Africa during his doctoral and postdoctoral studies in the **Conservation Ecology Research Unit** (CERU), Department of Zoology and Entomology, contributed to an international study that considered the global impact of forest edges on forest vertebrates. Led by Dr Marion Pfeifer, Newcastle University, and Dr Robert Ewers, Imperial College London, the study assessed the impact of human-induced forest fragmentation on the abundance of 1 673 species of mammals, birds, reptiles and amphibians around the globe.

The study, published in 2017 in the journal *Nature**, found that 85% of all vertebrate species are affected by forest edges globally. As a result, the community of animals that persists near edges bears little resemblance to that found in the forest core. Half of the world's forests now house disrupted vertebrate populations. In particular, the researchers found that 11%, 30%, 41% and 57% of bird, reptilian, amphibian and mammalian species, respectively, show strong declines in abundance towards forest edges.

The researchers used a new method that accounts for the continuous changes in habitat quality across fragmented landscapes, making their analysis markedly different from previous global analyses of biodiversity responses to land-use changes, which typically do not incorporate gradations of change.

Dr Olivier's earlier work on coastal forests in South Africa, supervised by **Professor Rudi van Aarde**, **Director of CERU**, was based on modelling estimates of forest loss. Their results show that as much as 82% of coastal forests in this country have been lost over the past two centuries. Forest fragments are now also smaller, fewer, further apart and more 'hemmed in' by human-land use than in the past. This extent of forest loss means that forests are now likely to harbour an 'extinction debt'; this means future biodiversity losses that current or past habitat destruction will incur, but which have yet to be realised, because of the time delays in extinction.

Working on bird species, researchers at CERU found that insectivorous bird species are the group most likely to be negatively affected by forest fragmentation. Their research further suggests that extinctions may be prevented by conserving natural or restoring anthropogenic matrices (that is, habitats that surround forest fragments), as well as by increasing forest areas. When matrix habitats are natural (for example, grasslands and woodlands) small and large forest fragments harbour similar numbers of bird species. However, when the matrix is compromised by human land use (for example, sugarcane and *Eucalyptus* plantations), small forest fragments have far fewer species than larger fragments. Matrix transformation may therefore cause local extinctions in smaller forest fragments.

Survey team: Pieter Olivier (UP), Marion Pfeifer (University of Newcastle), Thabani Mthethwa (field assistant), and Marc Freeman (MSc student, UP).

* M Pfeifer et al. Creation of forest edges has a global impact on forest vertebrates. *Nature*, 551, 187–191 (09 November 2017).

ANIMAL BEHAVIOUR

David Gaynor

All animals exhibit a unique set of behaviours which enable them to survive and reproduce on just about every continent of the planet.

Aquatic, terrestrial, aerial and subterranean animals are able to exist in their respective habitats and niches because of the particular set of behaviours that they exhibit. When the behaviour of animals are taken into context with their physiology and ecology, it can enlighten us about the secret lives that many organisms operate under in order to survive some of the harshest environments in the world.

Cooperation and competition

David Gaynor, Mammal Research Institute, Department of Zoology and Entomology

Life is a balance between knowing when to cooperate and when to compete. This is especially so for meerkats inhabiting the inhospitable Kalahari desert where cooperation can be the key to survival.

The **Kalahari Meerkat Project**, a collaboration between the **Mammal Research Institute** and Universities of Cambridge and Zurich, has continued its long-term study of more than two decades on social cooperation and competition in meerkats in the Kalahari desert in southern Africa.

Kalahari meerkats are famously known for their distinctive cooperative breeding where members of the group forgo their own breeding to help the dominant breeders by baby-sitting and feeding their young. But this system is not only collaborative; the dominant females actively attack subordinate females who attempt to breed by chasing them out of the group. This aggression is a response to competition between the dominant female and older subordinate females who might attempt to breed and compete with the single dominant female.

Dr David Gaynor, who coordinates the project, has collaborated with **Professors Nigel Bennett** and **André Ganswindt** at UP, and Professor Tim Clutton-Brock at the University of Cambridge, in investigating the hormonal basis for cooperation. Their findings have indicated a correlation between the levels of the stress hormone cortisol in different individuals and their contributions to cooperative behaviour. In an experiment spanning six years, they have manipulated the levels of cortisol by feeding individual meerkats with scorpions laced with cortisol or a cortisol antagonist.

The findings showed that increased cortisol activity increased cooperative behaviour, both in babysitting and pup feeding in subordinate females, demonstrating the potential of dominant females to manipulate subordinates by being aggressive to them, and thereby increasing their cortisol levels and their levels of cooperative behaviour. Further analysis, however, failed to show that females adaptively modified their level of aggression to increase cortisol levels when the need for help was higher, which suggests that the function of the observed aggression directed at subordinates was primarily to reduce the probability that they would breed. The researchers published this in the *Proceedings of the Royal Society B*.

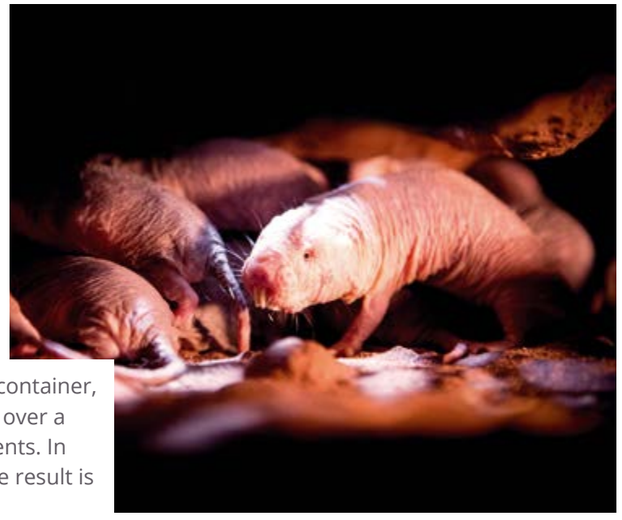
In a separate study published in *Biology Letters* the researchers found that by experimentally increasing the food supply to dominant females, their aggression to subordinate females increased, demonstrating that reproductive competition was the reason for their aggression rather than competition for food (which was alleviated by feeding the dominant female). The importance of reproductive competition in explaining the aggression of dominant females towards subordinate females was confirmed in a paper published in *Behavioral Ecology* where the researchers reported that subordinate females experienced higher aggression levels and associated cortisol levels when dominant females were pregnant and about to breed. This was not the case for subordinate males, who are obviously not reproductive competitors but otherwise shared the same social and ecological conditions as the subordinate females.

These results highlight that cooperation cannot exist or be studied in isolation of competition and the associated social conflict and aggression. For meerkats surviving in a harsh desert world, evolution dictates a delicate balance between cooperation and competition.

David Gaynor

Death and resurrection in a long-lived mammal

Nigel Bennett and **Heike Lutermann**, Mammal Research Institute, Department of Zoology and Entomology



Can you imagine putting 70 small rodents into a small container, sealing the container shut and subsequently burying it over a metre underground? The result would be 70 dead rodents. In fact, if any animal is deprived of oxygen for too long the result is fatal, but there is an exception – the naked mole-rat.

If the naked mole-rat is completely deprived of oxygen, it stops breathing, its heart rate drops and it ultimately dies. But, death in this unusual mammal is temporary and if within a certain time it is provided with oxygen again, it comes back to life!

Professor Nigel Bennett and **Dr Heike Lutermann** of the **Mammal Research Institute** in the **Department of Zoology and Entomology** have recently published an exciting study looking into anoxia in mole-rats in the journal *Science**. Professor Thom Park of the University of Illinois in the USA, the principal investigator of this study, commented: 'This was a challenge so big that it took three labs on three continents to solve it'. Professor Gary Lewin of the Max Delbrück Centre for Molecular Medicine at the University of Berlin, Germany, was the other lead investigator in the study.

While naked mole-rats are adapted to the high levels of carbon dioxide (hypercapnia) in their underground castles of clay, this study observed the results when mole-rats had no access to oxygen at all. During these periods, the naked mole-rat reduces its heart rate to the extent that it almost appears to have stopped, but it keeps it pumping just enough to circulate blood.

The research team discovered that when the naked mole-rat is deprived of oxygen, it uses internal pathways, used by no other mammal, to survive. It alters its metabolic systems to function more like a plant than an animal, releasing fructose into the blood, which is then taken up by the cells in the brain. It is the brain that contains cells that can make use of fructose, enabling cellular functions to continue. Aerobic energy production stops and the animal operates on anaerobic systems, relying on fructose for energy instead of glucose. Once oxygen is present they revert back to their usual pathways.

Nigel Bennett and Heike Lutermann

* Park TJ, Reznick J, Peterson BL, Blass G, Omerbasic D, **Bennett NC**, Henning P, Kuich JL, Zasada C, Browe BM, Hamann W, Applegate DR, Radke MH, Kosten T, **Lutermann H**, Gavaghan V, Eigenbrod O, Begay V, Amaroso VG, Govind V, Minshall RD, St J Smith E, Larson J, Gotthardt M, Kempa S, Lewin GR (2017). Fructose driven glycolysis supports anoxia resistance in the naked mole-rat. *Science* 356: 307-311

If one can understand the biochemistry of the naked mole-rat and unlock the mechanisms that switch the pathways during oxygen deprivation, increasing and activating the number of brain cells that are able to use fructose, this could hold great promise for humans, improving our chances of survival in extreme situations. Indeed, this could hold promise for people prone to strokes.

The naked mole-rat is a fascinating animal that defies most characteristics of a mammal. Naked mole-rats can live for over 30 years and studies suggest they are immune to cancer. They are also the only cold-blooded mammal. Their social structure resembles that of social insects such as bees, rather than mammals. These model animals hold much promise for science and one day they may provide insights into how to increase human life-spans or how to fight cancers and tumours.

Studying the social life of one of Africa's iconic animals

Tanja Wolf, Department of Anatomy and Physiology

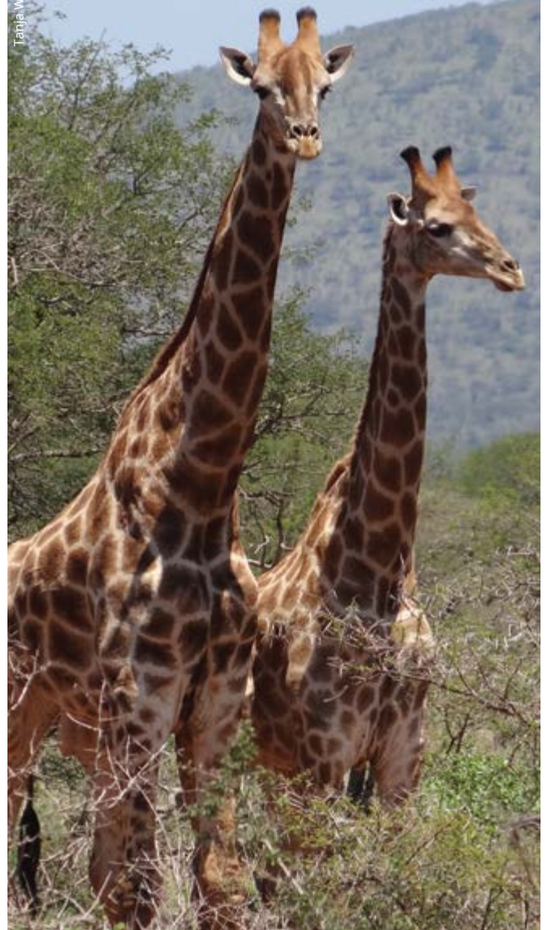
While there are differences between subspecies and population groups, the giraffe population in Africa is now listed as 'Vulnerable' on the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species. Threats to their survival include habitat loss, fragmentation and poaching.

Dr Tanja Wolf completed her PhD in the **Department of Anatomy and Physiology** on the stressors in free-ranging male giraffe (*Giraffa camelopardalis*), under the supervision of **Professors André Ganswindt** and **Nigel Bennett** at the **Mammal Research Institute**, and **Dr Richard Burroughs** at the **Centre for Veterinary Wildlife Studies**. She has subsequently extended her work on environmental, social and anthropogenic influences.

Giraffe occur in a highly flexible 'fission-fusion' social system where group compositions can change on a daily basis. Bulls display a roaming strategy in the search for fertile females. Wolf monitored a population of giraffe in the Pongola Game Reserve in the province of KwaZulu-Natal over the course of a year and collected faecal samples which were analysed for androgen metabolite (fAM) and glucocorticoid metabolite (fGCM) concentrations. The analysis was undertaken at the Endocrine Research Laboratory, led by Professor André Ganswindt.

Faecal analysis is a non-invasive method for studying the physiological response of wildlife to a variety of stressors. In co-authored articles published in *General and Comparative Endocrinology* in 2017, the researchers report that fAM levels are seasonally dependent. Additionally, older bulls showed significantly higher fAM levels than younger bulls, especially during the summer months, a time when many females give birth and become fertile again. When these bulls are in all-male groups, their fAM levels were significantly lower. This is in line with the behavioural findings that the group structure of giraffes changes with the seasons, with bulls tending to associate more in all-male groups during the winter months when mating opportunities and intra-sexual competition for mates are reduced.

The results also showed that older bulls have higher levels of fGCM when they are in mixed-sex groups and sexually active. By contrast, the younger bulls showed the highest levels of fGCM when they are in all-male groups, which is probably linked to the age-related hierarchy of bulls.



The world is teeming with invisible microorganisms: a teaspoon of garden soil may contain 100 million microbial cells of a thousand different taxa.

Just in the last decade, and largely driven by the advent of very high-volume and relatively low-cost DNA sequencing, we have come to appreciate just how diverse and how important microorganisms are in natural environments, whether in agricultural soils, marine waters or the human gut. Microbiomes are now seen as critical elements of human (and other animal) well-being, crop productivity, soil health and environmental control, for example, and as important agents for bioremediation and environmental protection. They are also increasingly viewed as valuable genetic resources, and targets for bioprospecting.

MICROBIAL ECOLOGY AND BIODIVERSITY

Don Cowan

Antarctic terrestrial microbial ecology

Don Cowan, Centre for Microbial Ecology and Genomics

The McMurdo Dry Valleys of South Victoria Land, Antarctica, represent one of the most extreme environments on Earth. Summer temperatures might rise a few degrees above 0°C for a few months during the 24-hour daylight period, but water is always scarce.

Through the long winter months, during three of which the sun never rises, soil temperatures can plummet to -60°C. It is perhaps surprising that anything can survive these conditions, but two decades of research by **Professor Don Cowan** and members of his team from the **Centre for Microbial Ecology and Genomics**, with his international collaborators, have demonstrated that a wide diversity of soil microorganisms thrive under these extreme conditions.

The most active and complex terrestrial soil microbial communities exist in protected 'niche' habitats, either inside or underneath transparent rocks. These endolithic and hypolithic communities represent biodiversity, biomass and functional 'hotspots' in otherwise low-biomass environments. These are the 'tropical rainforests' of the Antarctic Dry Valleys.

Professor Cowan's Antarctic terrestrial microbial ecology studies are principally funded through the National Research Foundation's SANAP programme. This new research project represents another step forward in the ongoing investigations of extreme microbiology: this time focusing on adaptation and community structural and functional resilience. The latter is currently at the forefront of the minds of the world's ecologists, since climate change patterns have already resulted in significant warming trends across much of coastal and maritime Antarctica. The way in which sensitive, specialised and unique Antarctic biological communities may respond to these climate changes is currently unknown and is a cause for concern among the Antarctic conservation community.

Under the auspices of his new Antarctic microbiology project, Professor Cowan has collected a new set of environmental samples from the Antarctic Dry Valleys. These samples will be the basis for a series of experiments, based on modern Next Generation sequencing of total environmental DNA (broadly termed *metagenomics*), and aimed at investigating functional responses, capacity and resilience in soil microbial communities.

When ‘dark matter’ matters

Thulani Makhalanyane, Centre for Microbial Ecology and Genomics, Department of Biochemistry, Genetics and Microbiology

Human activity, including the combustion of fossil fuels, cement production and deforestation, is responsible for about a third of the carbon dioxide (CO_2) released into the global atmosphere. As a result of sustained increases in CO_2 emissions over the past 150 years, current atmospheric CO_2 levels are estimated at above 410 ppmV.

Increasing concentrations of carbon dioxide (CO_2) and higher temperatures are significant threats, as identified by the Congress of the Parties (COP) 21 meeting in Paris in November 2015 and supported by scientists globally. A key resolution at the COP21 meeting was to curb temperature increases to 2°C above pre-industrial levels. Yet, there has been an apparent reluctance to implement the resolutions due to the anticipated short-term negative impact on the economies of highly industrialised nations. Alarmingly, the levels of CO_2 emissions are expected to rise for one or more decades, even if the COP21 agreement is implemented as envisaged. It therefore remains essential to understand the effects of increasing CO_2 levels on the Earth’s ecosystems.

A very large proportion of atmospheric CO_2 is taken up in the marine carbonate system. In the past two decades, approximately 124 billion metric tonnes of carbon have been absorbed by the oceans, resulting in shifts in the physicochemical composition of ocean environments. Increased marine water recovery of atmospheric CO_2 leads to a reduction in ocean pH, directly affecting the viability of marine ecosystems such as corals, molluscs, and biota echinoderms, fish and algae. In some regions, oceans are also increasing in temperature and becoming more stratified. Increased temperatures directly affect the metabolic rates of organisms and the associated water column stratification restricts the flow of nutrients to the surface. A consequence of oceanic warming appears to be the expansion and intensification of oxygen minimum zones (OMZs), regions in which oxygen saturation in seawater is at its lowest. This increase in OMZs will have direct effects on the biogeochemical cycling of nitrogen (N), phosphorus (P), iron (Fe) and CO_2 in the world’s oceans. The effect of changes in nutrient cycles will directly affect marine biota, although the impacts on microbial communities and the processes they mediate remain unclear.

Previous studies estimate the number of prokaryotic (that is, bacterial and archaeal) cells in the world’s oceans at 1.2 x 1029 (120 000 000 000 000 000 000 000 000 000) with most heterotrophic prokaryotes found in the upper 200m of the open ocean. The identification of these microorganisms has been a significant contemporary challenge, which has resulted in a high proportion of uncharacterised microorganisms with no cultivated representatives (termed ‘microbial dark matter’, (Rinke et al., 2013)*. Attempts to characterise these microbial communities in the laboratory traditionally relied on culture-based molecular approaches that mimic environmental growth conditions (such as complex micronutrients). But such approaches are known to target only the fast-growing microorganisms whose nutritional and growth requirements are easily reproducible in laboratory settings.

The fairly recent advent of culture-independent approaches, which rely on detecting microorganisms by assaying their genes, has made possible the complete characterisation of microbial communities in complex environments. Such approaches have begun to reveal the true extent of microbial diversity and microbially-mediated functions in natural environments. Scientists are now beginning to understand the roles played by microbial communities in crucial ecosystem processes such as nutrient cycling, organic matter decomposition and carbon sequestration. Several recent studies have shown the complexity of ‘microbial dark matter’ and the importance of microorganisms in both terrestrial and marine ecosystems. However, we still have very limited understanding of the role of climatic factors as drivers of the abundance and diversity at regional and global scales. This is primarily due to the high levels of microbial diversity and the fact that environmental variability such as temperature may shape community abundance differently at different spatial scales. In marine ecosystems, the complexity associated with water masses and current properties may shape diversity and functionality differently in different oceans.

South Africa is surrounded by important marine ecosystems separating the cold South Atlantic waters from the warm Indian Ocean Agulhas Current along the East Coast. The Southern Ocean, located south of 40 degrees of latitude, is a crucial component of the global carbon cycle and is thought to take up half of the atmospheric CO_2 produced through anthropogenic activities. The past few decades of research in this ocean have provided new insights into the links between ocean-atmospheric physics and the availability of trace elements (such as iron, which are present at very low concentrations) in the Southern Ocean. These studies have shown, for instance, that a limitation in iron and other trace metals impacts on the productivity of biological communities. However, these studies have largely focused on phytoplankton and macro-algal community composition and biomass. Despite the known importance of microorganisms in regulating biogeochemical cycling, surprisingly few studies have assessed microorganism community dynamics in this region.

* Rinke C et al. Insights into the phylogeny and coding potential of microbial dark matter. *Nature*, 499, 431.

Thulani Makhalanyane

Mesocosms to shed light on microbial dark matter

Thulani Makhalanyane, Centre for Microbial Ecology and Genomics

Since 2016, Dr Thulani Makhalanyane and members of his team at the Centre for Microbial Ecology and Genomics have initiated a series of programmes on marine microbial ecology.

Funded by the National Research Foundation's South African National Antarctic Programme (SANAP), the studies aim to elucidate the role of 'microbial dark matter' in the Southern Ocean, and to determine the role played by microbial communities in carbon sequestration.

Dr Makhalanyane and his team use culture-independent approaches and are testing the effect of environmental perturbations on microbial communities by using field studies and mesocosm simulations. Mesocosms are valuable experimental systems which provide a crucial link between field studies and controlled laboratory-based experiments. While field studies have provided important insights into microbial community interactions and functionality, such studies represent results from single timepoints (i.e. snapshots) and cannot provide insights into responses to environmental perturbations. In contrast, microcosms may provide important information on community responses to several environmental stressors such as temperature increases across various ecosystems including, for instance, the effects of ocean acidification on marine organisms.

CMEG researchers published papers on both aspects in 2017, the first on microbial community interactions in *Environmental Microbiology*, and the second on microbial functionality in *Frontiers in Microbiology*.

By testing the response of microbial communities to environmental stressors, the team aims to contribute to current monitoring efforts in the Southern Ocean, which have largely ignored the role of marine dark matter. Ultimately, the data from this project may be applied in Earth System Models, which attempt to elucidate the role of marine dark matter in the Southern Ocean in a global context.

AWARDS AND ACHIEVEMENTS

An appropriate conclusion to the 2017 Research Review is our acknowledgment of lead researchers at the University of Pretoria. We first list the recipients of the research awards at the UP Academic Achievers' Awards, followed by some of the most prestigious external awards achieved by our academics. The Review concludes with short profiles on the 15 A-rated scientists who are recognised internationally as research leaders in their respective fields.

Juan Bornman

Ann Skelton

Christof Heyns

Christo J Botha

Internal UP Awards

The annual Academic Achievers' Awards honour and celebrate academic achievers and researchers for their scholarly contributions. There are five categories of research awards: the Chancellor's Award (also awarded for teaching and learning), the Vice-Chancellor's Book Awards, the Exceptional Supervisor's Award, the Exceptional Academic Achievers Awards, and the Exceptional Young Researchers Awards.

The Chancellor's Award: Research

The Chancellor's Award is the highest award in recognition of outstanding research and international stature over an extended period. **Professor Nigel Bennett** received the award for his research on the ecological and physiological factors that affect the control of reproduction and the evolution of sociality, using the African mole-rat as his model group.

The Vice-Chancellor's Book Awards

Dr Reghard Brits, Department of Mercantile Law, received the award for his book titled, *Real Security Law*.

Exceptional Postgraduate Supervisor's Award

Professor Lyn-Marie Birkholtz, Department of Biochemistry, Genetics and Microbiology, and the DST-NRF SARChI Chair in Sustainable Malaria Control, was recognised for her exceptional contribution to postgraduate student success and achievement.

Exceptional Academic Achievers Awards

These awards are made to senior academics recognised by their peers for consistently having excelled in their academic fields:

Professor Juan Bornman (Director: Centre for Augmentative and Alternative Communication, Faculty of Humanities)

Professor Ann Skelton (Director: Centre for Child Law, Faculty of Law)

Professor Christof Heyns (Professor in Human Rights and Director: Institute for International and Comparative Law in Africa, Faculty of Law)

Professor Christo J Botha (Department Paraclinical Science, Faculty of Veterinary Science).

Marde Helbig

Sim H Mayaphi

Eshchar Mizrachi

Tjaart Kruger

Exceptional Young Researchers

The awards are in recognition of early career achievements in research:

Dr Marde Helbig (Department of Computer Science, Faculty of Engineering, Built Environment and Information Technology)

Dr Sim H Mayaphi (Department of Virology, Faculty of Health Sciences)

Dr Eshchar Mizrachi (FABI, and the Department of Biochemistry, Genetics and Microbiology, Faculty of Natural and Agricultural Sciences.

Dr Tjaart Kruger (Department of Physics, Faculty of Natural and Agricultural Sciences).

External Awards

Numerous awards were made to academics at UP for their leadership and research excellence, both nationally and internationally. Some of the most prestigious include:

Professor Cheryl de la Rey, Vice-Chancellor and Principal, was named the 2017 winner in the education category of the 37th Businesswomen's Association of South Africa Businesswoman of the Year Awards.

Professor Stella Nkomo, Strategic Professor in the Department of Human Resource Management, received the International Leadership Association Lifetime Achievement Award for her lifetime contributions to the creation and development of the discipline of leadership.

Professor Brenda Wingfield, FABI and the Department of Biochemistry, Genetics and Microbiology, was awarded honorary membership of the Mycological Society of America, the highest honour for a mycologist, and was also selected as a Fellow of the American Phytopathological Society in recognition of her research achievements and outreach to young scientists. In 2017 she was named as one of 11 inspirational SA women authors with highly cited papers by Clarivate Analytics (previously Thomson Reuters), based on InCites and Essential Science Indicator data.

Professor Mike Wingfield, founding director of FABI, received the Chinese Government Friendship Award for 2017 to acknowledge his 20 years of collaboration with Chinese colleagues in the field of tree health.

Professor Charles van Onselen, Research Fellow at the Centre for the Advancement of Scholarship, was awarded the Annual Medal in the Social Sciences and Humanities by the Human Sciences Research Council.

Professor Robert Millar, Director of the Centre for Reproductive Neuroendocrinology, was awarded the Harry Oppenheimer Fellowship for his work in neuroendocrinology. He also received the highest award of the African Union, the Kwame Nkrumah Continental Award for excellence in scientific achievement.

Professor Brenda Wingfield (FABI) and **Professor Nigel Bennett** (Zoology) were elected Fellows of the African Academy of Sciences, while **Professor Don Cowan** (Genetics) was elected an Associate Fellow.

In the DST's 2017 Women in Science Awards, **Professor Henriëtta de Kock** (Food Science) received the Distinguished Woman Researcher: Research and Innovation Award; **Professor Roula Inglesi-Lotz** (Economics) won the Distinguished Young Woman Researcher: Humanities and Social Sciences Award, and **Professor Saloshna Vandeyar** (Education) was the first runner-up in the Distinguished Woman Researchers: Humanities and Social Sciences.

Dr Thulani Makhalanyane (Centre for Microbial Ecology and Genomics, and the Department of Biochemistry, Genetics and Microbiology) was named as one of the Young Independents 100 Inspiring and Aspiring Leaders Awards of the Independent Media Group.

Professor Jacqui van der Waals (Department of Plant and Soil Sciences) received the Applied Plant Pathologist Award at the 50th Anniversary Congress of the Southern African Society for Plant Pathology.

Dr Vinet Coetzee and **Professor Sanushka Naidoo** (FABI, and the Department of Biochemistry, Genetics and Microbiology) were selected as Next Einstein Forum Fellows from 2017–2019.

A-Rated Scientists

NIGEL C BENNETT

Professor Bennett's 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 the interdisciplinary efforts in the study of the causes and consequences of sociality. Professor Bennett was made a Fellow of the African Academy of Sciences, and in 2017 was awarded the Chancellor's medal for research.

Professor Bennett is in the Department of Zoology and Entomology and holds the UP Austin Roberts Chair of African Mammalogy and the SARChI Chair of Mammalian Behavioural Ecology and Physiology.

DRUCILLA LC CORNELL

Professor Cornell's work has looked at 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. She founded the uBuntu Project in 2003 in the Western Cape, a project that promotes the status and importance of indigenous values and ideals across various areas of society. Her most recent work is on the contribution of African socialism to debates about economic justice.

Professor Cornell is Extraordinary Professor in the Department of Jurisprudence at UP and Distinguished Professor in Political Science at Rutgers University, US.

DON A COWAN

Professor Cowan has a primary interest in the microbial ecology of soil habitats, including hot and cold desert soils. For the past decade and a half he has worked at both ends of the biological temperature scale, studying psychrophilic microbiology of the Dry Valleys of Eastern Antarctica, and the *thermophilic* microbiology of the Namib Desert. He collaborates with local, national and international researchers on many other metagenomic projects, ranging from studies of the roles of microbial communities in agricultural crop productivity, to assessing the microbial ecology of soils from sub-Antarctic islands. 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 sub-Saharan African soils. With two other members of his research team, Pedro Lebre and Pieter De Maayer, Professor Cowan published a review in the prestigious international journal *Nature Reviews Microbiology*.

Professor Cowan is Director of the Centre for Microbial Ecology and Genomics, and of the Genomics Research Institute in the Faculty of Natural and Agricultural Sciences.

PEDRO CROUS

As a phytomycologist Professor Crous' main interest lies in the evolution and phylogeny of plant pathogenic fungi, especially those related to food crops. Understanding and defining species means that the importance of sex (recombination) cannot be ignored. His research has shown that many plant pathogens have both mating type genes, and may be having cryptic sex, which also has serious implications for disease control and rates of evolution. He is interested in intra- and interspecies variation, and how this relates to host specificity and speciation. Professor Crous actively pursues integrating DNA data with morphology and ecology. He is included in the list of highest cited researchers (Plant and Animal Science) by Thomson Reuters.

Professor Crous is an Associate Professor in FABI, linked to the DST-NRF Centre of Excellence in Tree Health Biotechnology and the Tree Protection Co-operative Programme. He is Director of the Westerdijk Fungal Biodiversity Institute in Utrecht, The Netherlands.

ERIKA DE WET

Professor De Wet's research examines the legal consequences that the exercising of public power by international organisations such as the United Nations and the African Union have for states and for those living in their territories. This includes the problems states face in implementing binding decisions of international organisations while giving due effect to other international obligations and constitutional principles of fundamental importance. She has held a number of national and international editorial positions and is a member of the Scientific Advisory Board for Development Policy of the Max Planck Foundation for International Peace and the Rule of Law, as well as of the General Council of the International Society of Public Law, and is an Honorary Professor in the Faculty of Law at Bonn University. Professor De Wet has been awarded a German Academic Exchange Service scholarship which she will spend at Bonn University to work on a monograph, 'Intervention by Invitation and the Use of Force' under contract with Oxford University Press.

Professor de Wet is Professor of International Law in the Faculty of Law and holds the DST-NRF SARChI Chair in International Constitutional Law.

ANDRIES P ENGELBRECHT

Professor Engelbrecht's research interests include swarm intelligence, evolutionary computation, neural networks, artificial immune systems, machine learning, and the application of these paradigms to data mining, games, bioinformatics, computational finance, data analytics, and difficult optimisation problems. His research team has developed an open source library of computational intelligence algorithms, which is used internationally. They were the first to provide convergence proofs of particle swarm optimisers (PSO). The research team has developed PSO and differential evolution algorithms to cluster non-stationary data, and very efficient PSO algorithms to solve multi-objective, many-objective, and dynamic multi-objective optimisation problems. A new statistical approach to compare the performance of multi-objective optimisation algorithms has been developed, and new measures to characterise fitness landscapes of continuous-valued optimisation problems.

Professor Engelbrecht is the Director of the Institute for Big Data and Data Science, and holds the DST-NRF SARChI Chair in Artificial Intelligence.

JOSUA P MEYER

Professor Meyer's research focus is on thermal sciences and fluid flow, and more narrowly on heat exchangers. His heat exchanger work is at the level of fundamental transitional flow regimes, nanofluids and condensation, and at an applications level, on thermal, solar, wind and nuclear energy. Professor Meyer has received a number of national and international awards for his research: the Thomas Price Award, the Rand Coal Award, the LT Campbell-Pitt Award, the Literati Award, and the Will Stoecker Award. He is a member or fellow of a number of professional institutes and societies, including the Royal Aeronautical Society. He serves on the editorial board of 13 journals and has been the editor of seven journals. At the University of Pretoria he has received six exceptional achiever awards, and also the Exceptional Supervisors Award.

Professor Meyer is Head of the Department of Mechanical and Aeronautical Engineering and Chair of the School of Engineering, and leads the Clean Energy Research Group at UP.

ROBERT P MILLAR

Professor Millar's work has made a major impact in areas of human reproduction, hormone replacement and the treatment of disease such as cancer. His most recent research focuses on the breakthrough discovery that function can be restored to inactivating mutations in human G-protein-coupled receptors, which are responsible for most cell communication. This discovery unlocks the possibility for precision, personalised pharmaceuticals with the potential to treat a variety of diseases. Professor Millar is President of the International Neuroendocrinology Federation, and in 2017 received the Platinum Medal of the Medical Research Council and the Harry Oppenheimer Fellowship and Gold Medal. He is a Fellow of the Royal Society (Edinburgh), a Fellow of the Royal Society of South Africa, and a Fellow of the Academy of Science of South Africa. In 2017 he also received the highest award of the African Union, the Kwame Nkrumah Continental Award for excellence in scientific achievement. He is currently Programme Chair of the International Congress of Endocrinology.

Professor Millar is Director of the Centre for Neuroendocrinology in the Faculty of Health Sciences.

STELLA NKOMO

Professor Nkomo's research focus is on race and gender and managing diversity in organisations and her scholarly contributions have helped to shape the discourse internationally. In addition to her scholarship, her greatest satisfaction comes from the supervision of postgraduate students and assisting young scholars in South Africa and Africa. She has held several national and international leadership positions. As founding President of the Africa Academy of Management (AFAM), she has focused on building a premier continental association for management scholars in Africa and the diaspora who are committed to management knowledge building for and about Africa. She serves or served on the editorial board of several international journals, and was recently appointed Senior Editor for the Diversity Management section of the Oxford Research Encyclopaedia of Business and Management. In 2017, Professor Nkomo received the Black Management Forum (SA) President's Award and the International Leadership Association Lifetime Achievement Award.

Professor Nkomo is Strategic Professor in the Department of Human Resource Management, Faculty of Economic and Management Sciences.

YVES VAN DE PEER

Professor Van de Peer 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 Professor 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 outcompete their diploid progenitors. His research group is widely recognised for their expertise in gene prediction and genome annotation and comparative and evolutionary genomics, and is involved in several international genome projects.

Professor Van de Peer is part-time Professor at the Genomics Research Institute at UP, and Professor in Bioinformatics and Genome Biology in the Department of Plant Biotechnology and Bioinformatics, Ghent University, and the Department of Plant Systems Biology, VIB.

CHARLES VAN ONSELEN

Professor van Onselen's most recent book, published in Cape Town, in 2017 by Jonathan Ball and by the University of Virginia Press, in the United States, is *The Cowboy Capitalist; John Hays Hammond, the American West & the Jameson Raid*. It offers a radical, new, interpretation of a key event in southern African history by underscoring the importance of an American, imperialist, thrust into the region at a crucial moment in its development. In August, 2107, the author was awarded the HSRC's Gold Medal for a distinguished contribution to Social Sciences and Humanities in South Africa. He is currently researching the unusual historical relationship that developed between colonial Mozambique and South African during the first half of the 20th century and hopes to publish his findings via the medium of a set of inter-connected essays.

Professor Van Onselen is Research Professor in the Centre for the Advancement of Scholarship at UP.

JOHANNES VAN OORT

Professor Van Oort's areas of research are the rise of Christianity in its Hebrew/Aramaic, Greek, Latin and Coptic contexts; the history of the Early Church, with particular attention to Gnostic-Christian movements; and the theology, sources and influences of the African church father Augustine of Hippo (354-430). In the past few years, the focus of his research has been on Gnostic-Christian influences on a number of Augustine's theological and philosophical doctrines. Presently he is preparing a new commentary on the Confessions as well as new editions of Augustine's anti-Manichaean writings in the UNESCO supported series Corpus Fontium Manichaeorum of which he is an editor-in-chief. The first volume of his Collected Essays will appear in 2019.

Professor Van Oort is Extraordinary Professor in the Department of Church History in the Faculty of Theology at UP.

BRENDA WINGFIELD

Professor Wingfield's research focus is on speciation and evolution of fungi, predominantly non-model *Ascomycetes*. This includes research on genetic variation within as well as between species. Her research group enjoys substantial international recognition with respect to research on the molecular systematics and population genetics and genomics of fungal pathogens, and is considered as one of the leading teams worldwide involved in the development of molecular diagnostic techniques for the identification and classification of pathogenic fungi. Professor Wingfield also has an interest in basic evolutionary biology based on ribosomal RNA-genes, which extends beyond fungi, and has a variety of collaborations with research groups working on a range of organisms. In 2017, Professor Wingfield received the American Phytopathological Society Fellow Award, and was awarded Honorary Member of the Mycological Society of America, the highest honour for an international mycologist.

Professor Wingfield holds the SARChI Chair in Fungal Genomics in the Department of Genetics. She is a member of the DST-NRF Centre for Excellence in Tree Health Biotechnology and the Tree Protection Cooperative Programme in FABI.

MICHAEL J WINGFIELD

Professor Wingfield's 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. His research programme falls under the umbrella of two major programmes: The Tree Protection Cooperative Programme, a cooperative venture between the University of Pretoria, all forestry companies in South Africa and the DST-NRF Centre of Excellence in Tree Health Biotechnology. As President of International Union of Forest Research Organisations, he actively promotes efforts to enhance evidence-based policy formulation on which the future of forests depends. He was awarded honorary doctorates from the University of British Columbia (Canada) in 2012 and North Carolina State University (USA) in 2013. Professor Wingfield received the Distinguished Leadership Award for International Scientists by his *alma mater*, the University of Minnesota, in 2016 and in 2017 he was awarded the China Friendship Award by the Chinese Government.

Professor Wingfield is the founding Director of the Forestry and Agricultural Biotechnology Institute (FABI) at UP, a position from which he stepped down in 2018. He is also President of the IUFRO, one the largest and oldest scientific unions representing more than 15 000 forestry scientists globally.

XIAOHUA XIA

Professor Xia heads the South African National Hub for the Postgraduate Programme in Energy Efficiency and Demand-side Management, hosted by the Centre of New Energy Systems in the Faculty of Engineering, Built Environment and Information Technology. His research interests are control systems and automation, and more recently, the modelling and optimisation of energy systems. This includes 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.

Professor Xia is Director of the Centre of New Energy Systems (CNES) and holds the Exxaro Chair in Energy Efficiency.

Ginkgo biloba has survived mass extinctions such as the Cretaceous–Paleogene extinction event that led to the demise of 75% of life on Earth, as well as the Hiroshima bombing during World War II, making the characteristic fan-shaped Ginkgo leaf a symbol of longevity, endurance and profound resilience.

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