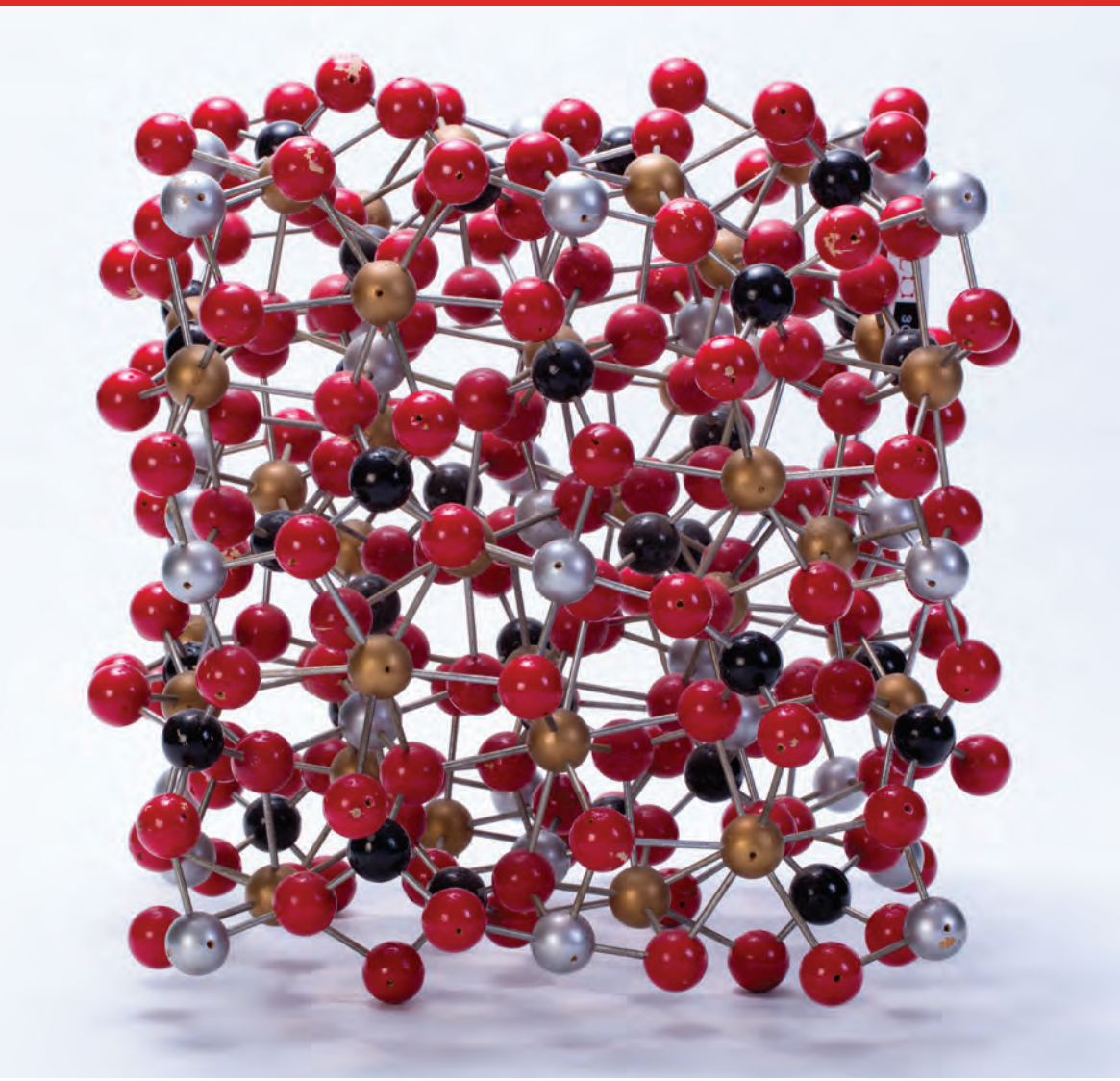
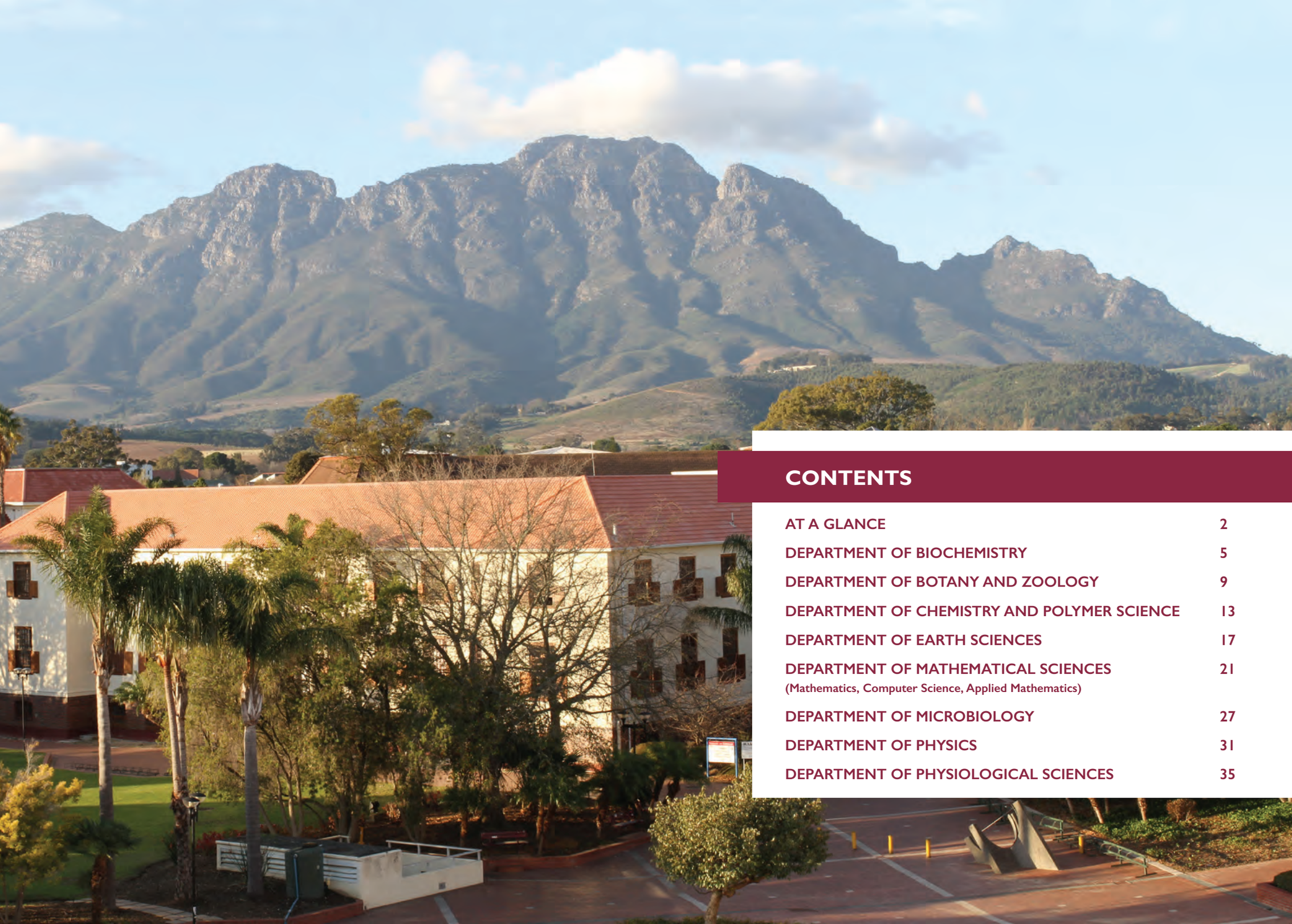
Faculty of Science
Stellenbosch University



UNIVERSITEIT
iYUNIVESITHI
STELLENBOSCH
UNIVERSITY

100
1918 · 2018



CONTENTS

AT A GLANCE

Stellenbosch University is among the top universities in Africa and the world. As one of the four founding faculties of Stellenbosch University in 1918, the Faculty of Science maintains an ethos of research excellence and remains committed to provide our students with a general formative education in the natural sciences.

OUR PEOPLE

173 permanent academics **119** NRF-rated researchers **104** postdoctoral fellows

OUR STUDENTS

2 264 undergraduate students

690 postgraduate students:

- 167 Honours
- 259 MSc and
- 264 full-time PhD students

In 2017 we successfully graduated 158 BScHons, 120 MSc and 49 PhD students

CENTRA AND RESEARCH CHAIRS

- 14 Centra and research institutes
- 11 Research chairs

RESEARCH EXCELLENCE

Since 2013, the accredited publication units have increased from 211.45 to 275.67 units in 2018

INTERDISCIPLINARY RESEARCH INITIATIVES

- Stellenbosch University Water Institute
- Centre for Bioinformatics and Computational Biology
- Institute for Biomedical Engineering
- African Microbiome Institute
- Data Science

COLLABORATORS AND PARTNERS

- African Institute for Mathematical Sciences
- iThemba LABS for Accelerator-based Sciences
- South African National Biodiversity Institute
- Council for Scientific and Industrial Research

DEPARTMENT OF BIOCHEMISTRY

WHO ARE WE?

The Department of Biochemistry was established in 1974 when the agricultural biochemistry research group in the Faculty of Agriculture joined forces with the biochemistry research group in the Faculty of Science. Today, the spirit of enquiry typical of a new discipline is seen in all of the department's well-established laboratories.

WHAT DO WE DO?

We are positioned at the interface between chemistry and biology, moving from molecular structures via macro-molecular activity to biological function. We undertake, inter alia, applied studies in waste water treatment, potato virus spread, contraceptives, drug discovery and malaria, and fundamental work in Systems Biology and P450 function. The department is also home to the South African research chair (SARChI) in Mechanistic Modelling of Health and Epidemiology.

RESEARCH FIELDS

Immunology, Plant Bioinformatics and Molecular Systematics

Research focuses on the evolution, and detection, of viruses and bacterial pathogens that infect potatoes and fruit trees. We use immunoassay and PCR-based techniques for the detection of viral and bacterial pathogens, while gene sequencing and molecular systematic approaches are used to understand the nature of the evolution of viruses and bacteria infecting potatoes and fruit trees in South Africa. Much work has also been done to investigate disease-causing organisms in ostriches and specifically organisms that have an impact on ostrich production in South Africa. For example, we were involved in establishing an ELISA and immunization schedules for Newcastle Disease Virus, as well as the development of ELISA for *Clostridium perfringens* toxins, and currently the development of DNA-vaccines against mycoplasmas.

Discovery and development of novel antibiotics and biocides

Our research efforts are broadly focused on increasing our understanding of the enzymology of coenzyme A (CoA) and other medicinally-relevant low molecular weight thiols, and applying the knowledge to biocatalysis and antibiotic drug development. Our aim is to identify new drug targets in important human pathogens such as *Staphylococcus aureus*, *Mycobacterium tuberculosis* and *Plasmodium falciparum* that exploit their dependence on these essential cofactors.

We also investigate resistance towards, mechanism of action and structure-activity relationship (SAR) of antimicrobial peptides and membrane active antibiotics, using both natural and novel synthetic compounds. These antimicrobials are directed against a number of targets such as resistant bacterial pathogens in particular *Listeria monocytogenes*, fungal plant pathogens, and parasites causing malaria and African

sleeping sickness. More specifically, we focus on the development of antibiotic peptides produced by soil organisms as natural fungicides and antimicrobials for application in food preservation, agriculture and the medical field.

Steroids

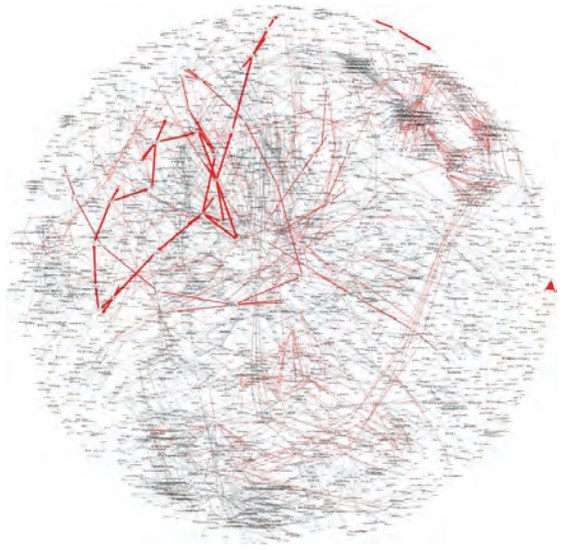
Steroid hormones play a vital role in the regulation of metabolism, inflammation, immune function, salt and water balance, stress management, and reproduction in all mammals. While these hormones are essential to normal physiological function, they also contribute to the pathogenesis of a number of disease states. Steroid research is well established in the Department, with six active research groups investigating various issues in this field:

- Study of adrenal steroidogenic pathways by the heterologous expression of enzymes, together with investigations into the metabolism of steroids in adrenal and prostate cell models. These metabolic pathways form the basis of ongoing studies into the biological activities of natural plant products and their influence on the human endocrine system.
- Understanding the fundamental mechanisms of how compounds such as progestins and bio-identical hormones used in hormone replacement theory contribute to the development and progression of inflammation and breast cancer.
- Study of the effects of specific compounds, such as Compound A and phytoestrogens, or physiological conditions such as stress, on steroid hormone signal transduction via cognate receptors, such as the glucocorticoid receptor (GR) and oestrogen receptor.
- The role of the adrenal steroid hormone 11OHA4 in castration resistant prostate cancer, and the identification of novel biomarkers for prostate cancer. Techniques used include molecular biology, tissue culture, protein expression and purification, enzymatic assays and UPLC-MS/MS.
- The role that glucocorticoids, via the glucocorticoid receptor and inflammation, have on insulin signaling.

Systems Biology

Three research groups in this field investigate the control and regulation of cellular processes using theory, computer modelling and experimental approaches. More specifically, research activities include the following:

- Development of a theoretical framework, based on control analysis, for describing metabolic regulation in an integrative cellular context that includes metabolism, signal transduction and the genetic hierarchy. Aspects of this theory are studied experimentally in yeast, bacteria, and the malaria parasite using controlled cultivation in bioreactors and quantitative analysis with HPLC, mass spectrometry and NMR.



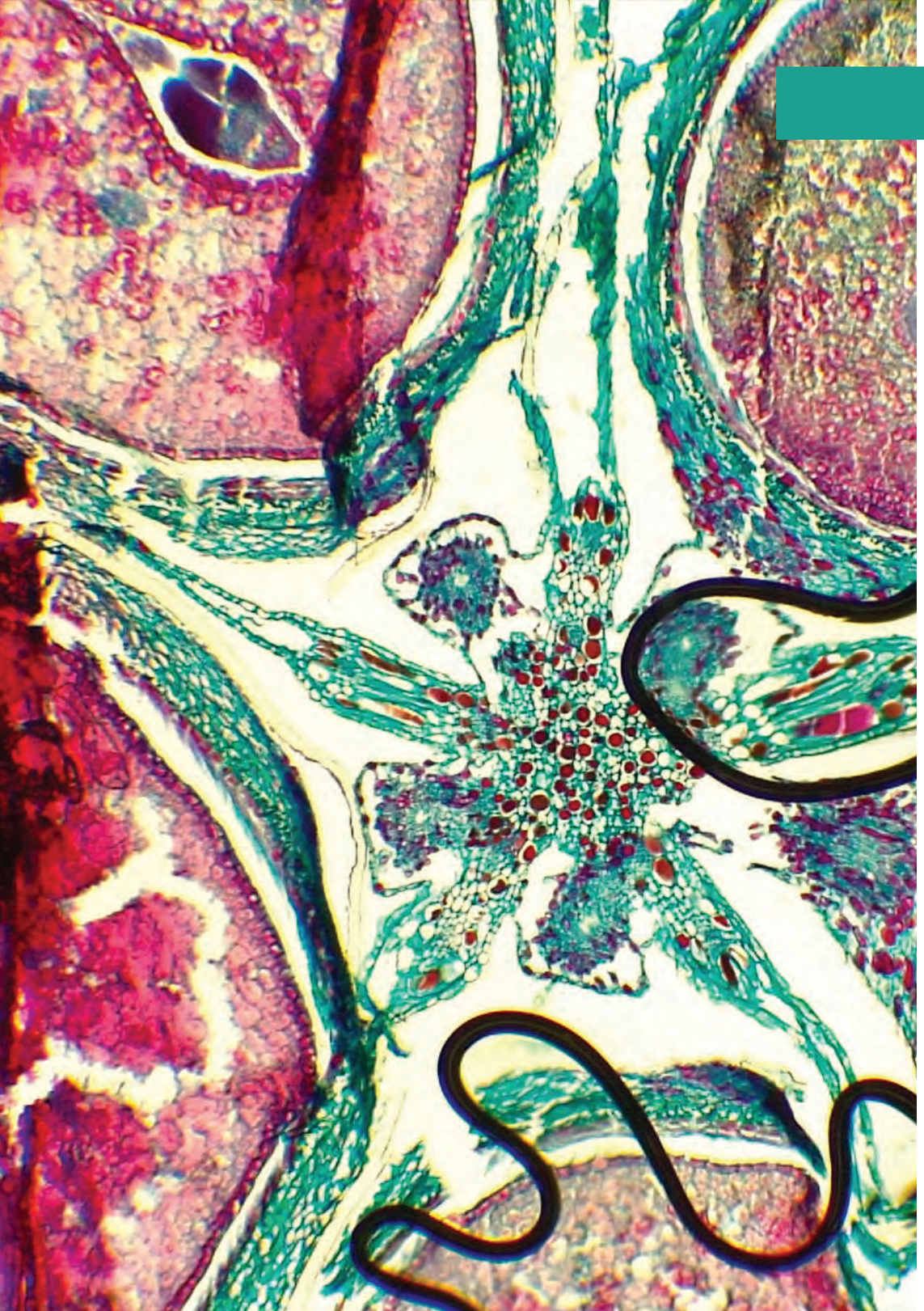
- Metabolism of human pathogens such as *Plasmodium falciparum*, *Mycobacterium tuberculosis*, and on modelling disease states such as Type 2 diabetes and HIV pathogenesis at a whole body level.
- Construction of unified frameworks for analyses of pharmacological effects of drugs and disease response in patients and populations. This is accomplished by combining detailed mechanistic mathematical models of metabolism and signal transduction with statistical and phenomenological models of disease, pharmacology and epidemiology.
- Enzyme kinetics for Systems Biology, Living Cell Theory and Code Biology.

Epigenomics and Bioinformatics

The analysis of epigenomic data requires significant computation resources, and research questions require the development of new bioinformatics methods and tools. Work in this research group include the development of tools for generic analysis such as the processing of ChIP-seq data, and development and coding of novel programs, dependent on specific research questions.

Please contact us

Professor Johann Rohwer, Head of Department
Tel: +27 (0)21 808 5843 | E-mail: jr@sun.ac.za
http://www.sun.ac.za/english/faculty/science/biochemistry/



DEPARTMENT OF BOTANY AND ZOOLOGY

WHO ARE WE?

The Departments of Botany and Zoology were founded as separate academic departments in 1903. Today the Department of Botany and Zoology, formed in 2005, is home to a vibrant community of more than 34 staff members, 24 postdoctoral fellows and a large postgraduate student body of nearly a hundred full-time students.

WHAT DO WE DO?

We strive to achieve a deep understanding of the unique southern African flora and fauna and particularly its societal value in an African and global context. We achieve this through world-leading research directed at preserving the diversity of animal and plant life.

The DST/NRF Centre of Excellence for Invasion Biology (CIB), hosted in the department, covers all aspects of biological invasions, all taxonomic groups and all ecosystems. Through its research, the CIB makes scientific information available to assist policy makers and managers with rational decision-making options regarding invasive alien species.

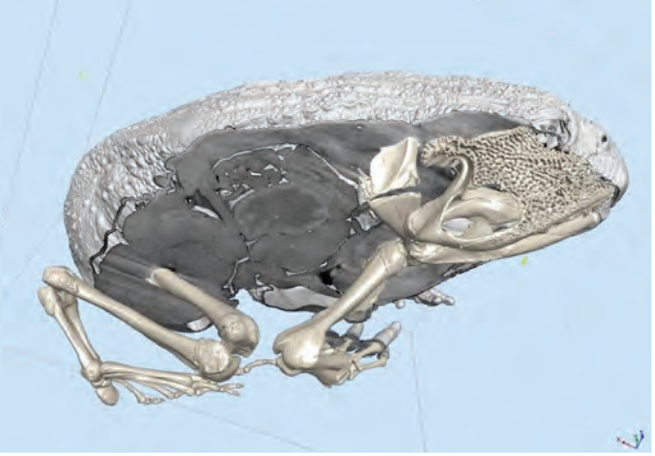
RESEARCH FIELDS

Behavioral Ecology

We research animal communication, in particular the evolution of signals – whether olfactory, acoustic or visual – of a wide range of organisms such as wasps, invasive and native ants, great white sharks and European starlings. Other topics include honey bee diseases, honey production and parasite loads associated with stress in lions and penguins.

Biological Interactions

We research the form and function of plants and how their ecology, evolution and diversification is shaped by selective agents, from fungi and bacteria to pollinators and herbivores, as well as the abiotic environment. This includes the ecological and evolutionary effects of plants on the morphology and community structure of the organisms that interact with them. We examine the forces that drive variation in the structure of communities, and how those different communities drive variation between populations. The loop is closed by identifying patterns and causes of diversity in plants and the organisms with which they interact.



Ecophysiology

We have a broad interest in functional aspects of vertebrates, in particular amphibians and reptiles. We investigate physiological responses to climate change and chemical pollution in aquatic environments; thermoregulation in reptiles and how the predicted climate warming may affect local populations; and the potential disruption of the reproductive and thyroid endocrine systems by man-made chemicals known to pollute the aquatic environments.

Global Change

We study the risk and impacts of global change in one of the richest biodiversity regions on the planet. We want to understand the underlying mechanisms of species response and adaptation under changing environmental conditions, particularly how important species will respond to anticipated future risks, including changing climatic conditions.

Marine Genomics and Conservation

We use genetic and genomic approaches for studying various aspects of marine systems in Africa and southern Africa, with a strong emphasis on using molecular techniques for conservation and biodiversity planning.

Drivers, patterns and impacts of marine invasions

We focus on understanding what regulates the spread and patterns of marine invasions and on quantifying the impacts of these species around the South African coast. This includes the intra-regional spread of marine aliens, the complex interplay between environmental regulation and biotic interactions, and quantification of the impacts.

Eastern Cape forest fauna

Forests make up only 0.56% of South Africa's land area, and of that the Eastern Cape contains an estimated 46%. These forests display unusually high biodiversity, but to date the faunal diversity has been poorly documented. We compare the genetic diversity of populations of more mobile species, such as birds and bats, to more sedentary ones, like land snails and shrews. Using DNA barcoding, we want to establish a digitized reference encyclopaedia of the taxa in these forests.

Evolutionary Genomics

The conservation of biodiversity depends to a large extent on explaining the evolutionary patterns and processes associated with living organisms. Southern Africa is known for its rich terrestrial and marine biodiversity, associated with a complex landscape. This environment lends itself to test various hypothesis associated with evolution and speciation. By studying the interplay between life history, biogeography and ecology, we address systematic uncertainties at all taxonomic levels, using a variety of molecular techniques. Current research focuses on parasite-host codivergence at the phylogeographic and species level; stock assessment and conservation of marine resources; comparative phylogeography of terrestrial vertebrates; and the evolution and systematics of free-living and parasitic arthropods.

Molecular Plant Physiology

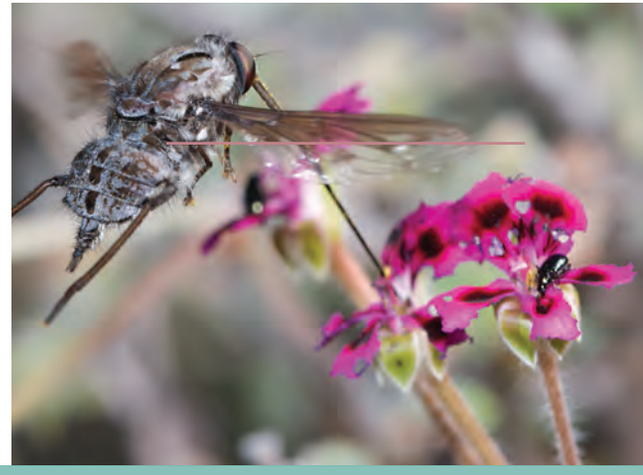
We focus on the molecular plant physiology of phosphorus nutrition during plant-microbe interactions, specifically the phosphorus nutrition of legumes in symbiosis with yeasts, mycorrhizas and nitrogen fixing bacteria. We integrate classical plant physiological methods with modern tools such as qRT-PCR, micro-array analysis, proteomics and retro-transposon insertional-mutant lines of *Medicago truncatula*.

Medicinal Plant Biology

The exploitation of medical plants is largely attributed to the wealth of pharmacologically relevant active chemicals which these plants are able to synthesize through secondary metabolism. We apply a broad-based biotechnological approach to facilitate use of plants efficiently, in a non-destructive sustainable manner to gain insights into the regulation of secondary metabolism.

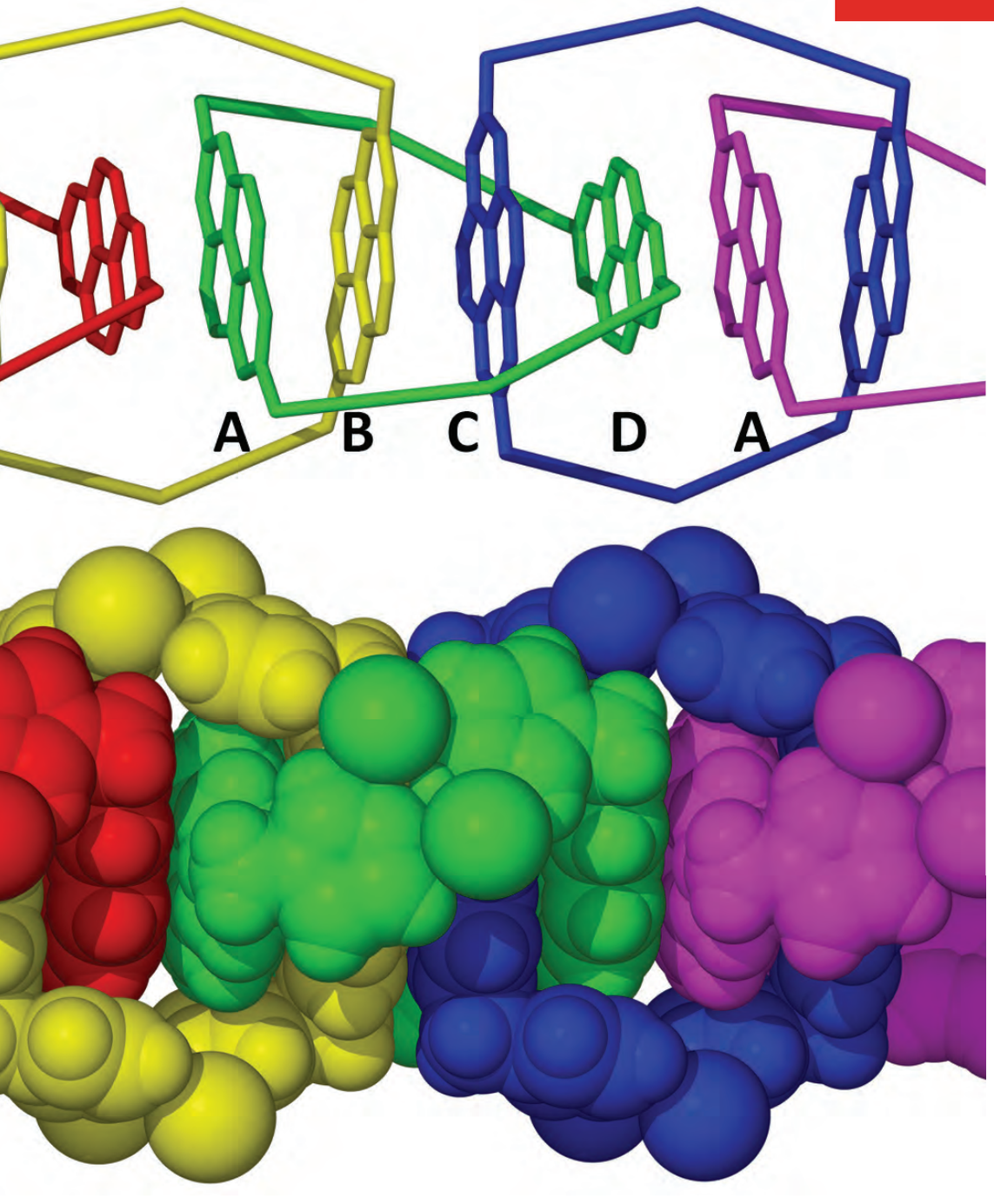
Vertebrate Functional Biology and Herpetology

We study the life histories of southern African lizards, and specifically the evolution of viviparity in scincomorph lizards, the evolution of placental nutrient transfer in scincomorph lizards, and the evolution of asynchronous breeding in lizards occurring in a fire-prone ecosystem.



Please contact us

Professor Conrad Matthee, Head: Department of Botany and Zoology
Tel: +27 _21 808-3957 | E-mail: cam@sun.ac.za
http://www.sun.ac.za/english/faculty/science/botany-zoology



DEPARTMENT OF CHEMISTRY AND POLYMER SCIENCE

WHO ARE WE?

The Department of Chemistry and Polymer Science is one of the pre-eminent research departments in chemistry in South Africa, and is engaged in a wide range of research areas, including the largest research effort in polymer science in South Africa.

WHAT DO WE DO?

We use high level research in the chemical sciences to generate new knowledge and promote independent thinking. We are home to three research chairs: the South African research chair in Nano-structured Functional Materials, the South African research chair in Advanced Macromolecular Architectures, and the SASOL research chair in Analytical Polymer Science.

RESEARCH FIELDS

Analytical Chemistry

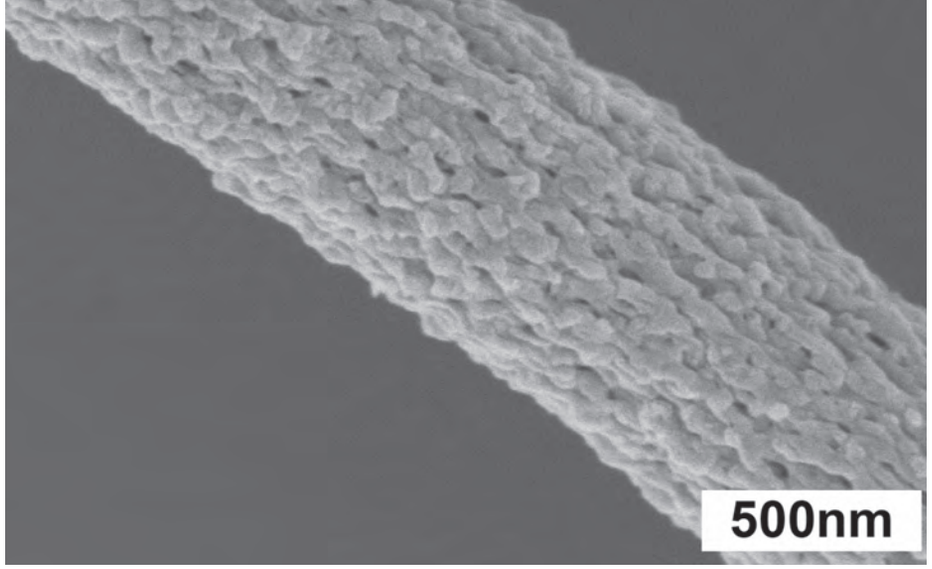
We use state-of-the-art instrumental techniques to solve analytical problems of academic and industrial relevance. Broadly, this entails advanced chromatographic and mass spectrometric methods for the detailed characterization of complex mixtures, with a special focus on South African natural products, and advanced multinuclear liquid and solid-state Nuclear Magnetic Resonance spectroscopy applied to the study of the recovery, separation and fundamental chemistry of the Platinum Group Metals.

Supramolecular and Material Chemistry

This consortium of research groups focuses on the design, synthesis and characterisation of functional crystalline materials. The principles of crystal engineering are used to develop novel materials with useful properties such as tailored porosity, magnetism and anomalous thermal responses. The structural characteristics of such materials are investigated experimentally using single crystal and powder X-ray diffraction, and computationally using quantum mechanical and force field calculations. These techniques are employed to rationalise the relationship between molecular structure and packing, and the observed physical properties.

Inorganic and Organometallic Chemistry

Research is focused on the development of novel metal-containing materials, included amongst which are discrete metal complexes as well as metal nanoparticles. These systems are evaluated in a range of applications, which include catalysis, wastewater remediation as well as biological applications, especially new metallodrugs for the treatment of cancer and infectious diseases.



Chemical Biology

Research is focused on the application of chemistry to the study of molecular events that occur in biological systems. This involves the use of chemical tools (synthesis, analysis etc.) to probe the mechanism, and develop drugs or early detection assays against diseases such as malaria, cancer and HIV/AIDS.

Organic Chemistry

We focus mainly on the synthesis of both novel and previously known organic molecules for application as probes to study or modulate enzyme or protein function, as ligands for new catalysts and as functional materials. The development of novel approaches to new organic compound classes is also of importance, as is the valorization of organic scaffolds from nature and industry.

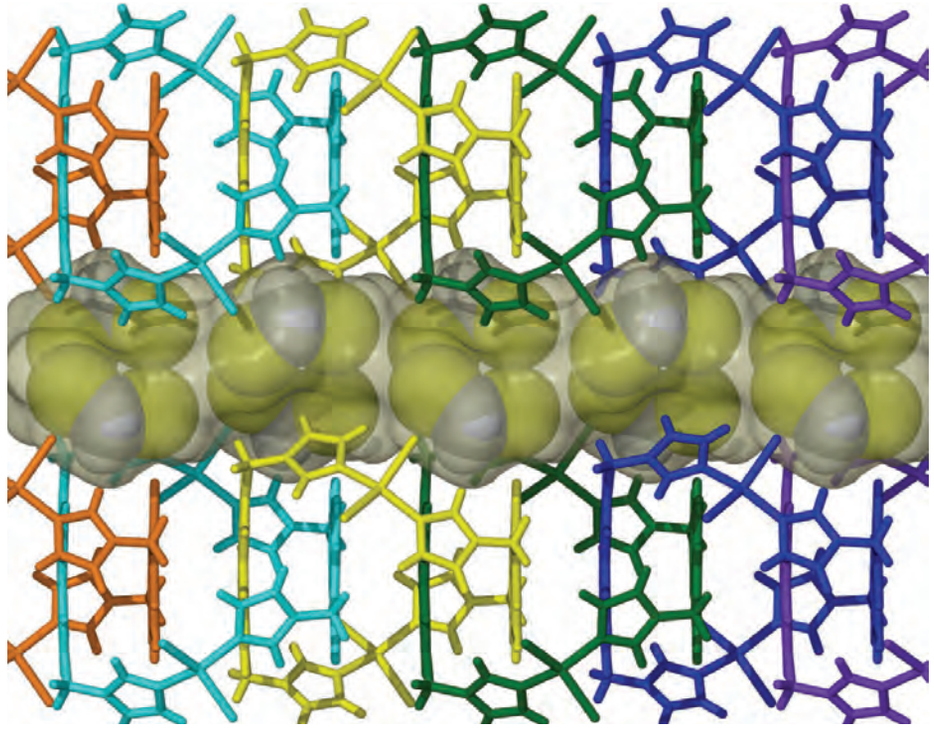
Polymer Science

We are the only chemistry department in South Africa with an in-depth focus on Polymer Science. Research areas include synthetic polymer chemistry, analytical polymer chemistry and structure property relationships of polymers and nano-composites. More specifically, we focus on:

- Design and synthesis of advanced macromolecular structures through reversible deactivation radical polymerization in combination with various other polymerization techniques;
- Investigation of the structure property-relationship in complex polymer materials such as semi-crystalline polymers, multiphase copolymers, nano-structure polymers and nano-filled polymer composites;
- Development of multidimensional analytical techniques for complex polymer systems; and
- Investigation of the relationship between molecular make-up of polyolefins and macroscopic properties of both commercial and experimental polyolefins.

Physical Chemistry

The focus of this research field is the use and development of computational techniques, supported by experimental measurements, for the analysis of structure-property relationships of isolated molecules and crystalline systems, and the application of this information to elucidating chemical and physical processes.



Please contact us:

Professor Peter Mallon, Head of Department
Tel: +27 – 21 808 2971 | E-mail: pemallon@sun.ac.za
http://www.sun.ac.za/chemistry

DEPARTMENT OF EARTH SCIENCES

WHO ARE WE?

Founded in 1895, the Department of Earth Science at Stellenbosch University has a long and proud history that can be traced back to the discovery of diamonds in 1867 and gold in 1886.

WHAT DO WE DO?

The Department of Earth Science is one of the leading training and research centres in South Africa in general Geology, Experimental Petrology, and Geochemistry.

RESEARCH FIELDS

Metamorphisms, Magmatism, Igneous and Crustal Evolution

We have a long history of petrological research and is home to the South African research chair (SARChi) in Petrology. We focus on understanding high-temperature processes involved in continental evolution, specifically the origins of granites as the primary constituents of the continents. Another research interest is the study of Large Igneous Provinces (LIPs) which typically formed during the break-up of a supercontinent. Multi-disciplinary research efforts into Precambrian mafic dykes offer a wealth of information about how ancient LIPs formed, were emplaced, related to supercontinental breakup and eventually got dispersed on their host fragments. Supercontinental reconstructions provide an even larger group of geologists with a more complete geological puzzle picture to work on.

Marine Geochemistry

The chemical cycles in the oceans are closely related to processes in the atmosphere and terrestrial ecosystems, as well as to biological and anthropogenic activity. Marine geochemistry studies all the processes that influence the chemistry in the water, sediments, pore waters, as well as the abiotic and biotic processes that take place within the sediment. At Stellenbosch University, we focus on the Atlantic section of the Southern and Antarctic Ocean and the west coast of southern Africa.

Environmental Geochemistry

In groundwater systems, isotopes provide means of understanding the origins and movement of water through the meteorological cycle and the mechanisms and pathways of transfer. Our work focuses on groundwater systems in the Naukluft Mountains, Namibia, the Buffels River in the northern Cape and the Verlorenvlei catchment in the Western Cape.

Sedimentology and Paleontology

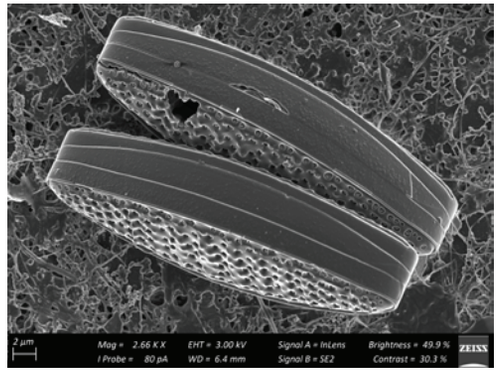
We utilize facies and architectural analysis coupled with various stratigraphic methods to address questions of environmental change at various scales and its affect to biological life in deep time. We couple this with basin tectonic models to better understand regional and global relationships. In the field of geochronology we utilise chemical tracers within fossil entombing sediments to provide a probable age date for the fossil assemblage, and to elucidate sediment provenance and rates of infill (e.g., detrital zircon geochronology; Lu-Hf isotopes). Lastly, we investigate the evolution and diversification of major lifeforms (archosaurs) between 250-66.5 Ma. This dynamic period in Earth's history includes the seperation of Pangea into the northern Laurasia and southern Gondwana, which resulted in the isolation and subsequent diversification of once cosmopolitan life forms. Here we utilise contextual clues preserved within fossil assemblages to address questions of biogeographical relationship and extinction events between major clades at a global scale.

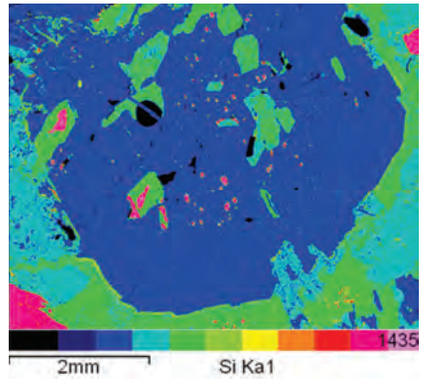
Economic Geology and Mineral Geochemistry

While the status of power supply in South Africa remains a critical issue, there is strategic incentives to more fully understand the geology, geochemistry and geometallurgy of raw materials such as coal and uranium. Research is focused on banded iron formations, such as the Sishen deposit, with particular emphasis on their mineralization and the implications for the evolution of the earth's atmosphere and early biogeochemical systematics. This research could lead to findings that are beneficial to the industry's needs, while at the same time making a significant contribution to broader scientific understanding.

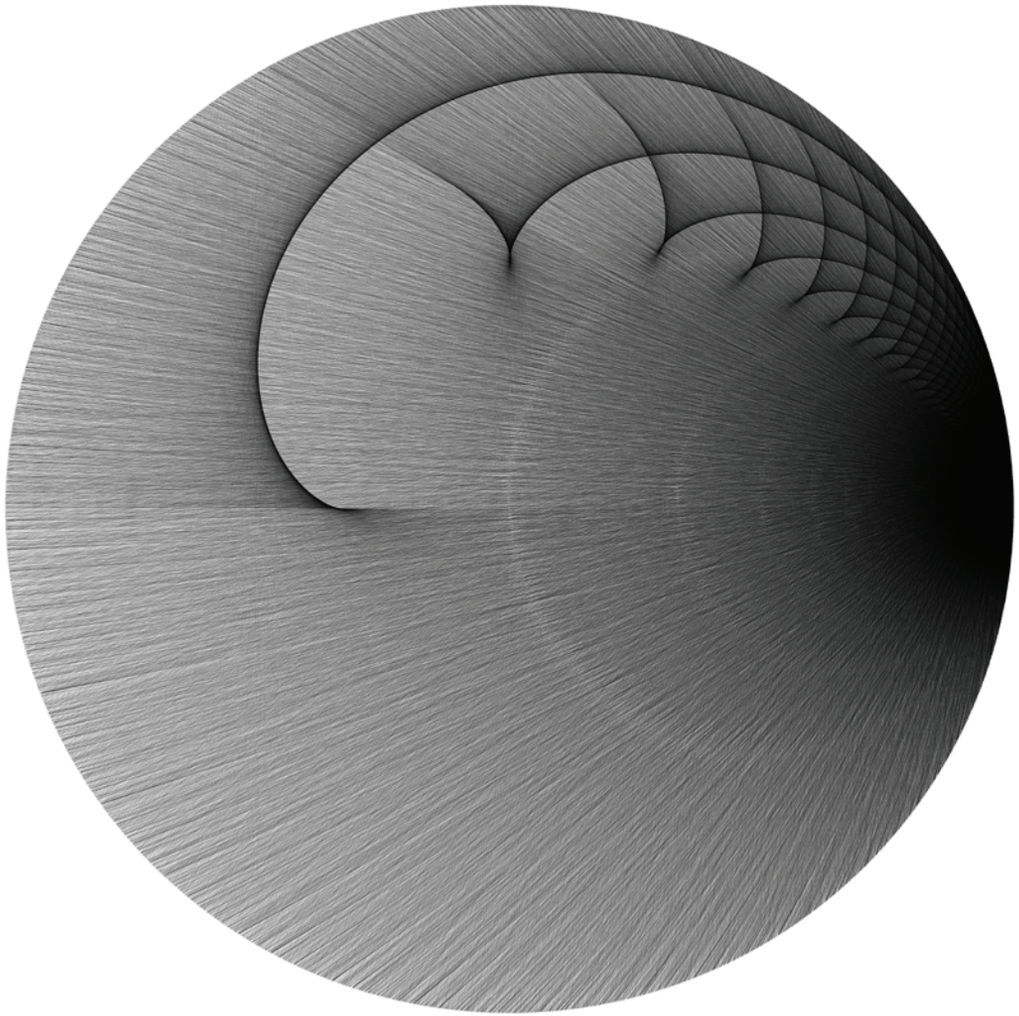
Structural Geology and Tectonics

Research is mainly field-based and revolves around the geology of mid-crustal, high-grade terrains and associated partial melting and granite plutonism, and, secondly, the controls of deformation on hydrothermal fluid flow, with applications in economic geology and lode-gold mineralization.





Please contact us:
Professor Alex Kisters, Head of Department
Tel: 021-808-3113 | E-mail: akisters@sun.ac.za
Web: http://www.sun.ac.za/english/faculty/science/earthsciences



DEPARTMENT OF MATHEMATICAL SCIENCES

WHO ARE WE

Applied Mathematics, Computer Science and Mathematics form the three divisions of the Department of Mathematical Sciences. With nearly 50 full-time researchers and a large cohort of postgraduate students, the department strives to enhance the enrichment and transfer of knowledge to empower society to analyse and solve complex problems.

WHAT DO WE DO

Mathematics and computational science are utilized in almost every discipline of science, engineering, industry and technology. In the field of Applied Mathematics, for example, our work finds application in engineering, medicine, the environment, and the defence industry. Applications of machine learning is found across a broad spectrum of disciplines.

The Mathematics Division is also home to the South African research chair (SARChI) in Mathematical and Theoretical Physical Biosciences, as well as the DST-NRF Centre of Excellence for Epidemiological Modelling and Analysis (SACEMA). The Computer Science Division hosts the Telkom-Siemens Centre of Excellence in ATM and Broadband Networks and their Applications.

RESEARCH FIELDS IN MATHEMATICS

Algebraic Number Theory and Arithmetic Algebraic Geometry

Research interests are in the fields of algebraic number theory, arithmetic geometry and in the application of the above topics in experimental number theory, computational algebra and algebraic coding theory. Questions studied involve the arithmetic and geometry of curves over p-adic and finite fields, their automorphism groups and Galois covers, function field arithmetic and Drinfeld modules.

Algebra

Research in this area includes non-commutative algebras, in particular various kinds of matrix rings and their substructures and algebraic properties; commutative algebras and group theory; algebras of functions associated with a given algebraic structure, and near vector spaces.

Category Theory and Duality

Category theory is a relatively recent unifying theory in mathematics, with applications in geometry, algebra, and logic, and specifically in computer science. An important research focus of the Mathematics Division lies in categorical algebra, where algebraic structures that occur in various branches of mathematics are studied from the point of view of category theory.

Functional analysis

Involving the study of normed, Banach and Hilbert spaces, the operators on them and generalizations of these concepts, this key area of mathematics underpins much of the research and applications in areas of analysis such as measure and probability theory, financial mathematics, quantum field theory in theoretical physics, approximation theory and differential and integral equations.

Discrete Mathematics

Research interests in this field cover various branches of discrete mathematics, including enumerative, probabilistic and analytic combinatorics, graph theory, discrete algorithms and the analysis of algorithms. Discrete mathematics has connections to various other branches of mathematics as well as other fields, such as computer science, chemistry and physics.

Mathematical and Theoretical Physical Biosciences

This group works on the interface between mathematics and biology. The focus is on the development of novel and applying available methods in mathematics, statistics and theoretical physics for unlocking the mechanisms behind realistic biological patterns, especially patterns related to the heterogeneity of species distributions and their genetic structures, the hierarchy of biological networks and the size of adaptive traits.

Boolean Functions and Lattice Theory

Research is focused on specific lattice structures and on the application thereof in combinatorics and nonlinear signal processing. Other research efforts involve using the techniques of logic and universal algebra to investigate the structure of certain classes of lattices, e.g. varieties and quasivarieties.

Model Theory

Model theory is a branch of mathematical logic which interacts with several other parts of mathematics including combinatorics, number theory, algebra and geometry. Research includes work on connections between pure model theory and certain ideas from combinatorics, work on o-minimality and analytic functions and work on connections between model theory and category theory.

Quantum Topology

Over the last two decades, the impact of ideas from quantum field theory on geometry has spawned a new field called quantum topology. This new field tries to understand the physicist's most powerful tool, the path integral, and to utilize the resulting structures to compute new invariants of geometric objects such as knots as manifolds. This endeavor draws on many parts of modern mathematics such as higher category theory, homotopy theory and representation theory.

RESEARCH FIELDS IN APPLIED MATHEMATICS

Computer Vision, Pattern Recognition and Machine Learning

Automated recognition systems, reconstruction of 3D data from images, tracking of objects in video sequences, vision in robotics, image processing and handwriting analysis.

Fluid Dynamics and Modelling

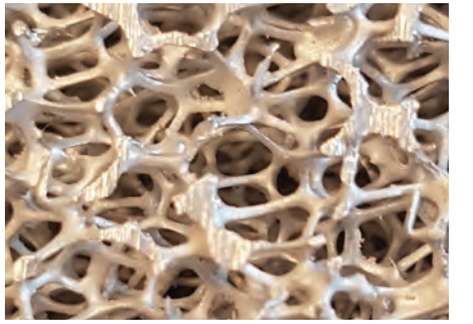
Transport phenomena in porous media; permeability, diffusion, dispersion, the flow of non-Newtonian fluids through porous media, multi-phase flows, coastal engineering, heat transfer, electrical conduction and percolation; computational fluid dynamics.

Numerical Analysis and Scientific Computing

Numerical analysis is a growing field as industry is looking for new ways to numerically and accurately solve equations that arise from engineering, fluid dynamics, fluid mechanics, biological mathematics and economics. Research interests include numerical solution of differential equations; matrix computations, numerical integration, computation of special functions and integral transforms, wavelets and mathematical software.

Graph theory and coding theory

Research interests include the protection of graphs, with a specific interest in domination, and games on graphs. The domination problem finds application in the facility location problem where the optimal positions of facilities, under certain constraints, are calculated.



RESEARCH FIELDS IN COMPUTER SCIENCE

Theory and Applications of Automata and Grammars

Research interests include the theory of nondeterministic finite automata, mostly as it pertains to the descriptional complexity of formal systems. In addition, the theory of automata and grammars is applied to many real-world problems. Specific application areas include:

- Layout optimization with cellular automata;
- Music generation in the style of a give composer using probabilistic automata;
- Probabilistic automata on parse trees of English sentences for automatic grammar corrections; and
- Finding denial-of-service attacks in regular expression libraries.

Software Engineering and Verification

Since 1990, we have been involved in the development of operating system kernels, protocols, and verification tools. We investigate the development of highly reliable system software by using a combination of computer-aided verification of designs, systematic testing, and defensive programming techniques. Our specific focus areas include:

- Automated testing techniques to find deep errors in software programs. We specifically work on symbolic execution and fuzzing for Java programs;
- Finding concurrency issues in both C and Java programs using model checking; and
- Constraint solving and model counting for program analysis.

Artificial Intelligence, Machine Learning, and Data Science

We consider almost any aspect of the general decision-making problem, including sequential decision-making under uncertainty. Major sub-problems are planning, machine learning, and search algorithms. Our approach is grounded in probability theory and game theory for managing uncertainty and multi-agent systems. Our specific focus areas include:

- Search and planning for probabilistic systems with incomplete information (for example games such as Go);
- Understanding noise propagation in Deep Neural Networks; and
- The analysis of data from earth observation satellite sensors and radio interferometers.

Please contact us

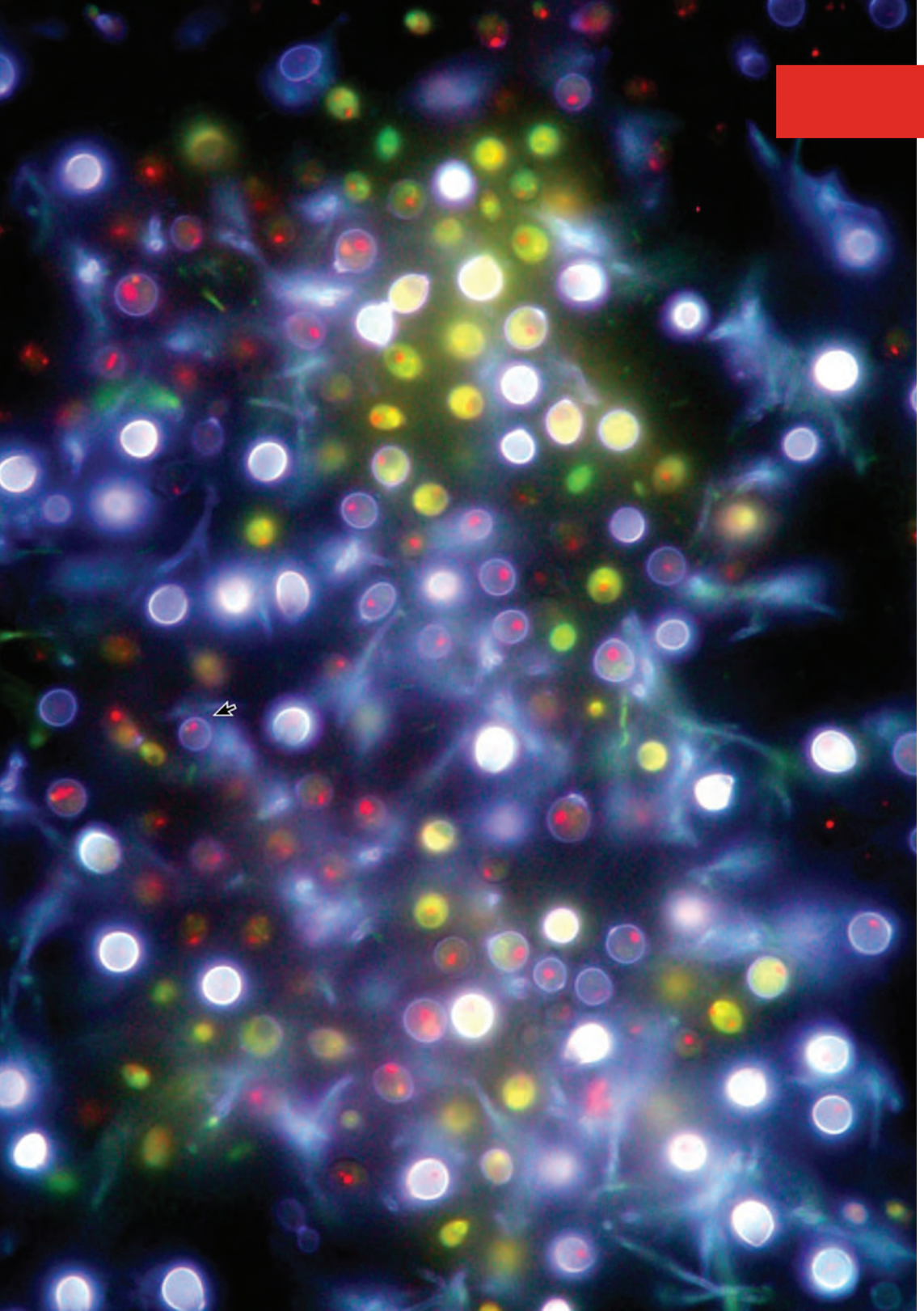
Prof. Ingrid Rewitzky, Head: Department of Mathematical Sciences
T: +27 021 808-3282 I E: rewitzky@sun.ac.za

Prof. Stephan Wagner, Head: Mathematics Division
T: +27 021 808-3269 I E: swagner@sun.ac.za

Prof. Bernd Fischer, Head: Computer Science Division
T: +27 021 808-4232 I E: bfischer@sun.ac.za

Dr. Willie Brink, Head: Applied Mathematics Division
T: +27 021 808-4215 I E: wbrink@sun.ac.za

http://mathsci.sun.ac.za/



DEPARTMENT OF MICROBIOLOGY

WHO ARE WE?

The Department of Microbiology's historical roots can be traced back to 1918 when plant pathology was recognized as a field of expertise in the then Faculty of Agriculture. Today, the Department has eight research groups working in state-of-the-art laboratories in the JC Smuts building.

WHAT DO WE DO?

Micro-organisms represent more than 50% of live biomass on earth and are omnipresent. We study a wide variety of micro-organisms, as they play a role in nature, renewable energy, human health and modern biotechnology.

RESEARCH FIELDS

Biological Processing of Plant Material

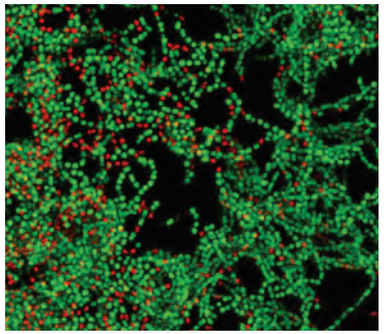
Microbial enzymes are evaluated for the hydrolysis of local feed stocks for the production of bio-ethanol. Projects include the recombinant expression of different alpha- and gluco-amylases to identify the best combination for optimal hydrolysis of raw starch; evaluating the impact of different secretion signals on the recombinant expression of gluco-amylases; and evaluation of the expression of α-amylases under the control of different promoters in the yeast *Saccharomyces cerevisiae*.

Interactions between yeast and their biological, chemical and physical environment

Our research focuses on the interactions of fungi, including opportunistic fungal pathogens of mammals, such as yeasts belonging to the *Cryptococcus neoformans/ Cryptococcus gattii* species complex. Symbioses of plant growth promoting soil yeasts are also studied with the goal of developing biofertilisers for different crops, including wheat and lupin.

Lactic Acid Bacteria

We focus on the antimicrobial peptides (bacteriocins) and probiotic properties of lactic acid bacteria. Regulation of the genes encoding these peptides and the effect of the latter on pathogens are studied in vitro and in vivo. Genome mining led to the discovery, and construction, of novel antimicrobials. Carrier molecules are developed to protect, transfer and direct these peptides to sites of infection. Slow release drug carriers, constructed at nano-scale sizes, are inserted into dressings and prosthetic devices to fight infections. We recently patented the technology that forms the basis for the world's first NanoPoc point-of-care device. A leading pharmaceutical company is funding its development into a blue-tooth device. Backed by more than 50 scientific papers, the probiotic entiro™ was launched three years ago. A year ago we discovered a novel antibacterial and antifungal non-ribosomal antibiotic – clinical trials will commence in 2020.



Microbial Ecology and Mycology

We investigate the diversity and structure of microbial communities from soil, with a special interest in the soil microbial communities of the fynbos biome and agricultural systems. We study the effect of human activities on soil communities and its impact on soil processes and ecosystem services. Some of the main microbial groups include *Penicillium, Trichoderma* and the rhizobial bacteria.

Water Treatment

We aim to provide communities in urban informal settlements and ultimately rural areas with a sustainable solution to water shortage and availability, by the utilization of rainwater. Main projects are the design, construction and monitoring of sustainable domestic rainwater harvesting solar pasteurization and disinfection treatment systems; identification of the primary microbial and chemical source tracking markers in harvested rainwater for the detection of faecal contamination; application of biological control for rainwater treatment; and bioprospecting for novel biosurfactants and biosurfactant producing bacteria.

Fungi Biotechnology for Bioenergy and the Bioeconomy

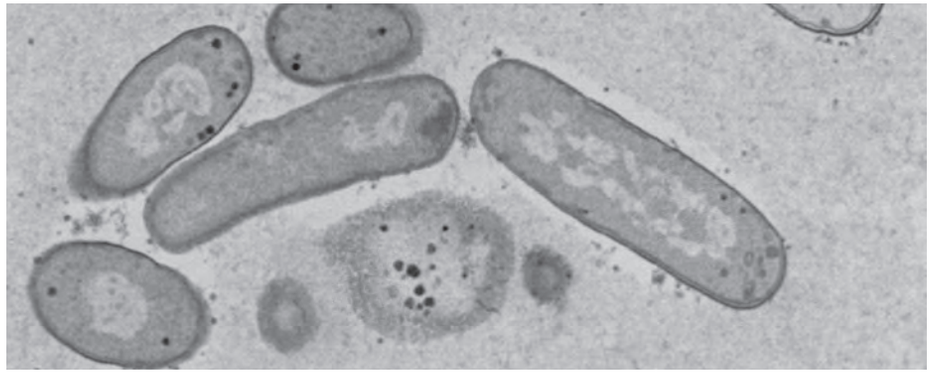
This is an established research field that investigates the microbiology and biochemistry of plant degrading enzymes. We focus on the recombinant production of these enzymes in baker's yeast, and in the mould *Asperfillus niger,* for the production of biofuels and other valuable chemicals. Main projects include the evaluation of native yeasts for their potential for second generation bioethanol production; development of CBP yeast for raw starch and cellulosic conversion to biofuels; development of enzyme-producing fungal cell factories for lignin conversion to green chemicals; and development of a carboxylate platform for production of green chemicals using rumen microbial cultures.

Functional Microbial Bioinformatics

We employ functional bioinformatics approaches to study yeast physiology. This involves comparative molecular profiling of yeast genome sequences and/or transcriptome/proteome profiles to generate a molecular portrait of specific physiological responses in yeast. In the process, high-throughput technologies such as whole-genome next generation sequencing, RNA-seq and LC-MS/MS-based proteomics are employed to generate comparative genome-wide QTL/SNP, transcriptome and proteome datasets respectively. New insights into yeast physiology can be applied to decode the genetic basis of yeast phenotypes, reverse engineering of industry-specific tailored yeast strains using a true systems biological approach, the discovery of unchartered paths to antifungal drug target discovery; and new function prediction of (un)characterized yeast genes and proteins.

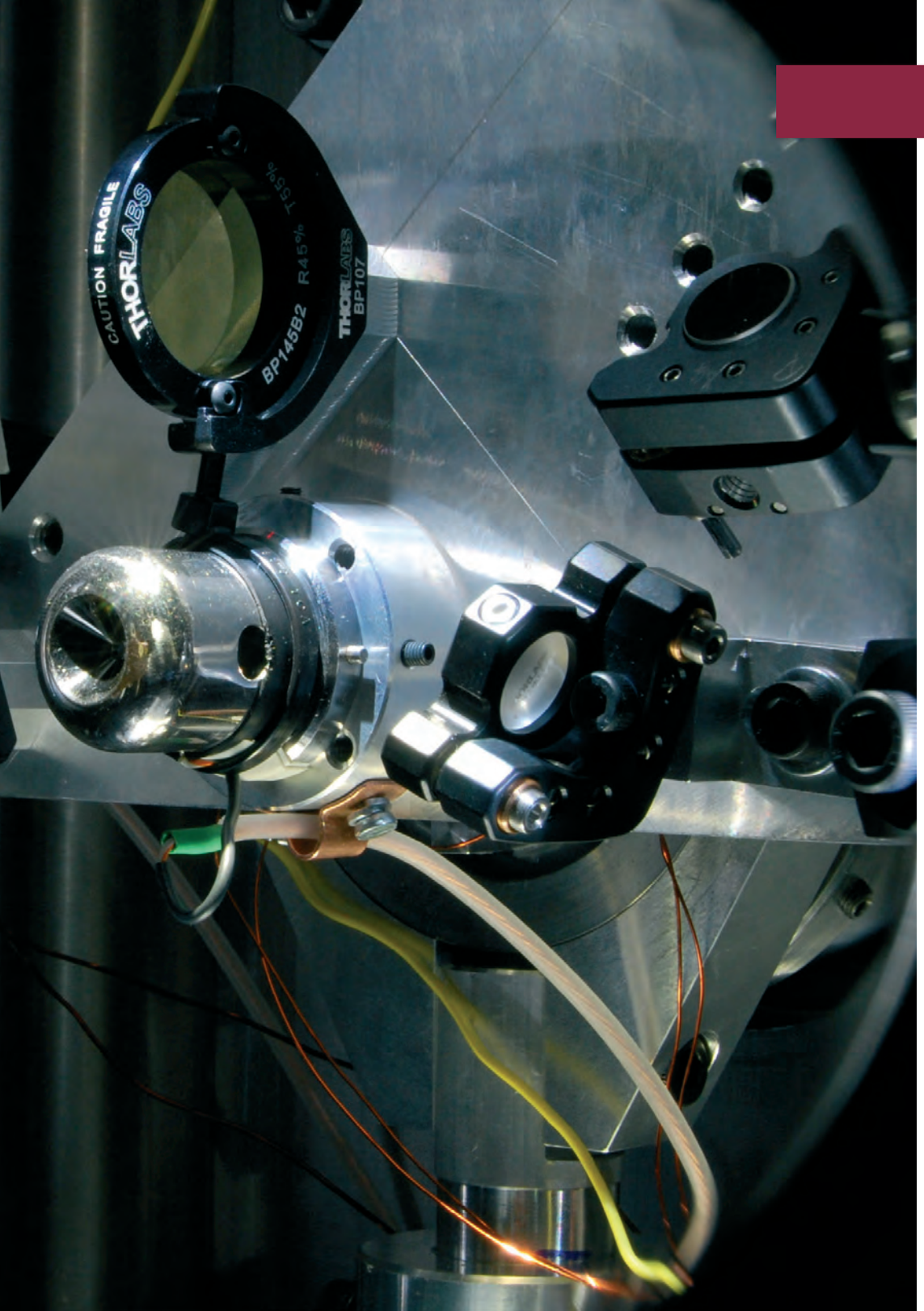
Biotechnologies for Water Treatment

Our focus is to improve efficiency in biotechnology such as water treatment, and to find solutions to microbially-related problems such as biofouling, infection and contamination. Main projects include investigation of the persistence of micro-pollutants such as pharmaceuticals, personal care products and antimicrobials; management of pathogens; and biotechnology for resource recovery; water purification and supply using novel technologies; implication of microbial processes on large-scale operations, such as biofilm formation and facilitated precipitation in industrial and agricultural water lines, and the long-term performance of repositories of nuclear waste; lastly, bacterial persistence at solid-air interfaces and the role of biofilms in antibiotic resistance.



Please contact us

Prof. Alf Botha, Head: Department of Microbiology
T: +27 (0)21 808-5856 | E: abo@sun.ac.za
http://www.sun.ac.za/english/faculty/science/microbiology/



DEPARTMENT OF PHYSICS

WHO ARE WE?

The Department of Physics, established in 1903, is one of the oldest physics departments in South Africa. Throughout its history, members of the Department have been involved in the establishment or continue to contribute to national research institutions such as iThemba LABS, the National Laser Centre, the African Laser Centre, and the National Institute for Theoretical Physics.

WHAT DO WE DO?

The Department of Physics is an active research environment, with many international and national collaborations in all the fields listed below. Our research covers three broad themes: Laser Physics, Nuclear Physics and Theoretical Physics. We are also home to two research chairs, the South African Research Chair in Photonics and Ultrafast Laser Science, and the CSIR/Stellenbosch University Research Chair in Quantum Optics and Atomic Physics.

RESEARCH FIELDS

Ultrafast Laser Science

We investigate photo-induced reactions of atoms and molecules in matter with microscopic resolution in time and space. We study and modify microscopic dynamics in organic and organo-metallic molecules, and photo-induced macroscopic phase transitions in crystals.

Spectroscopy and Laser Diagnostics

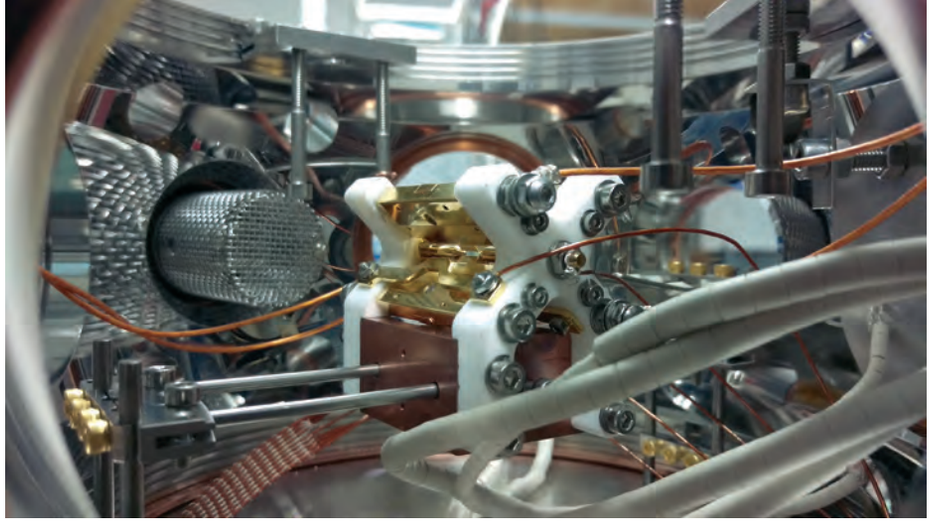
We focus on a laser method allowing highly selective ionization of particular molecules, atoms or isotopes from a gaseous sample, aiming for application to medical radioisotopes. We probe the charge dynamics at buried silicon-silicon oxide interfaces relevant to the miniaturization of electronics. We have developed a depth profiling method using non-ionizing radiation.

Laser Development

We develop custom fibre lasers for scientific projects.

Trapped Ion Quantum Control

Atomic traps have become an important tool for studying physics in the quantum regime. They are, for example, one of the potential technologies for quantum computers. Exploitation of the quantum regime promises a host of advances in physics, including quantum information and communication, quantum simulation, quantum metrology and quantum coherent control.



Biophotonics and Imaging

The imaging research focusses on laser source development and control for biophotonics imaging applications. These range from second- and third harmonic imaging, Coherent Antistokes Raman Spectro-microscopy (CARS-microscopy) and two-photon fluorescence microscopy. Development of wide field single molecule microscopy, Raman imaging, optical tweezers, and remote sensing form part of this initiative.

Additive Manufacturing, X-Ray Imaging and Biomimicry

Our research involves additive manufacturing, especially laser powder bed fusion of metals (3D metal printing), improving the processes and advancing design using scaffold structures (lattices) and topology optimization. This promises new light-weight material designs. High resolution X-ray imaging allows biomimetic design. Advances in X-ray tomography applications are also covered.

Solitons in Field Theory

Configurations with localised energy-densities (solitons) emerge in almost any non-linear field theory. Solitons have particle properties and can be used to study baryon properties that (so far) evade direct computation from quantum chromodynamics, the fundamental theory describing the strong nuclear force. Also, solitons induce corrections to energies on the quantum level. We compute these corrections in field theories like the standard model of particle physics. We ask whether these energy corrections can stabilise solitons that would be unstable classically.

Quantum Phase Transitions and Exceptional Points

Exceptional points are singularities of spectrum and eigenstates when they are continued into the complex plane of, for instance, a strength parameter. Their proximity to the real axis plays a crucial role in quantum phase transitions as well as in quantum chaos.

Multiparticle Correlations and Bayesian Physics

Bayesian analysis is investigated in its foundations, and we also develop applications of Bayesian tools to various problems. Theoretical and experimental aspects of multiparticle correlations in elementary particle physics and heavy ion collisions are studied.

Condensed Matter Physics

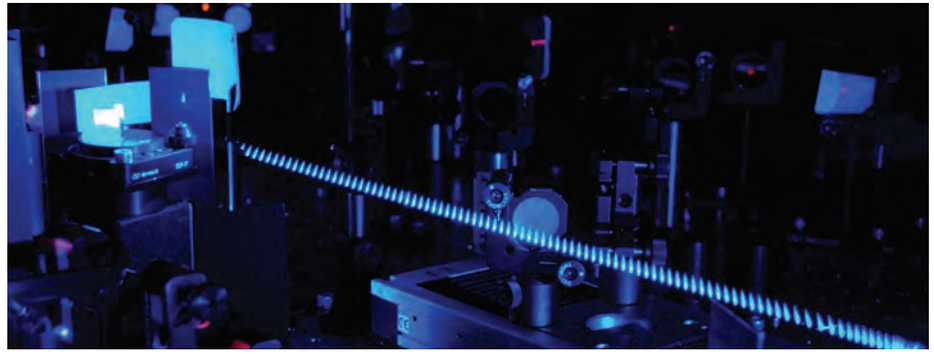
We study the physics of condensed matter with a focus on interacting quantum systems and closed quantum systems out of equilibrium. We develop applications of methods such as continuous unitary transformations and algebraic techniques within this setting.

Soft Condensed Matter and Biological Physics

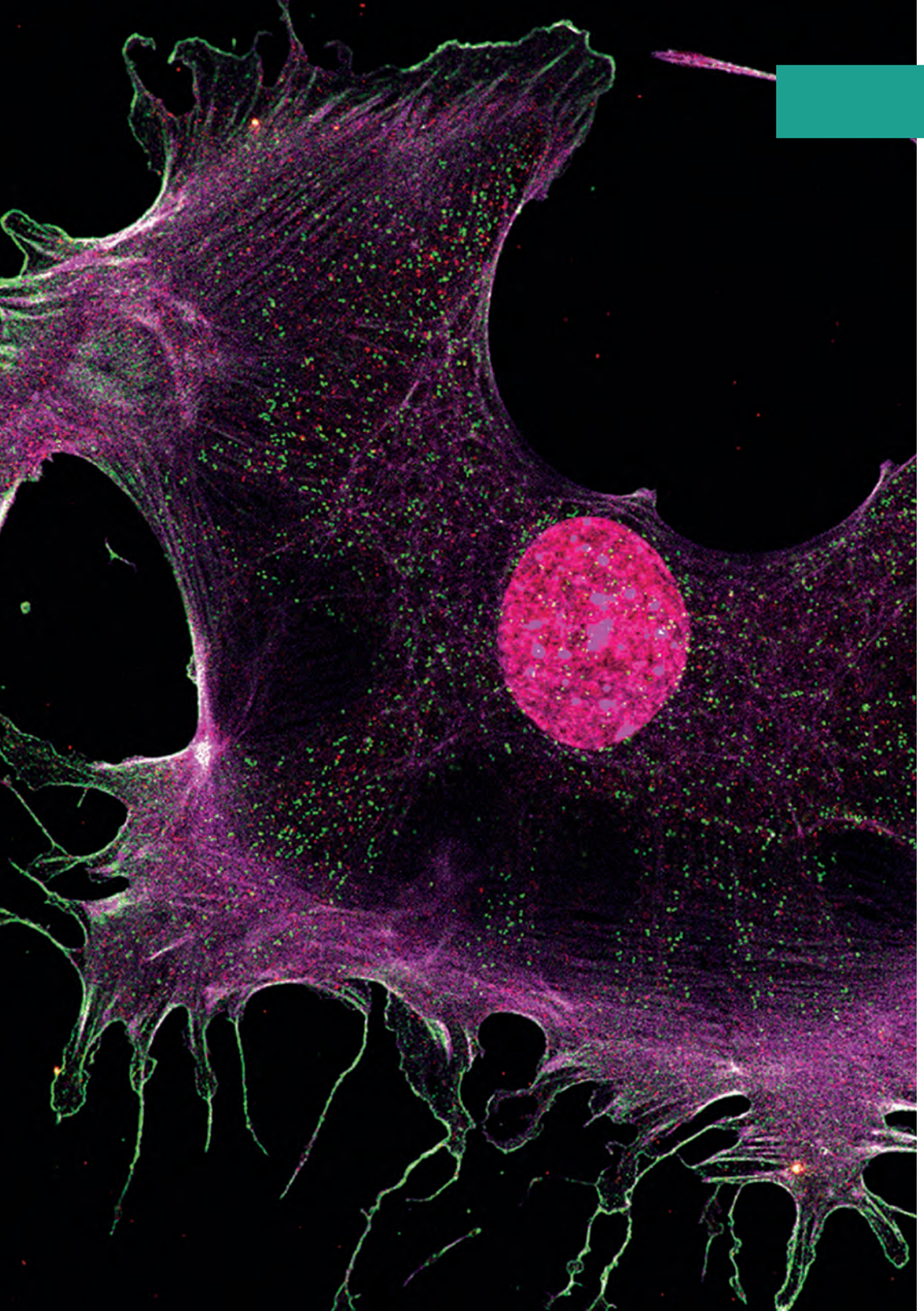
We study equilibrium and dynamical properties of polymers, when they form networks, are confined, or driven by molecular machines. Theoretical and computational insights are applied to gels, cytoskeleton, and other cellular-level processes or structures, including cells' active machineries.

Nuclear Physics

Research in this field ranges from the development of new detectors for nuclear physics experiments, theoretical developments, and through to the study of radiation in the environment. Many of the activities are centred around the facilities at iThemba LABS.



Please contact us
Prof. Kristian Müller-Nedebock
T: +27-21-808-3386 | E: kkmn@sun.ac.za or physoffice@sun.ac.za
http://www.sun.ac.za/english/faculty/science/physics



DEPARTMENT OF PHYSIOLOGICAL SCIENCES

WHO ARE WE?

The Department of Physiological Sciences, established in 1922, strives to be a world-class operation that concentrates on excellence and innovation in teaching and research to enhance human development, welfare and health.

WHAT DO WE DO?

We undertake investigative research to better understand the health challenges facing South Africa and aim to deliver students who will contribute to this effort. The rationale is to gain a deeper understanding of the underlying mechanisms that drive the onset of pathophysiologic states, with the ultimate aim of designing novel therapeutic or disease preventative interventions. In this regard we employ integrative models to investigate research questions of national importance, using cutting-edge technologies such as advanced tissue culture, fluorescent microscopy, electron microscopy, flow cytometry, CRISPR and muscle exosome technology.

RESEARCH FIELDS

Cancer research

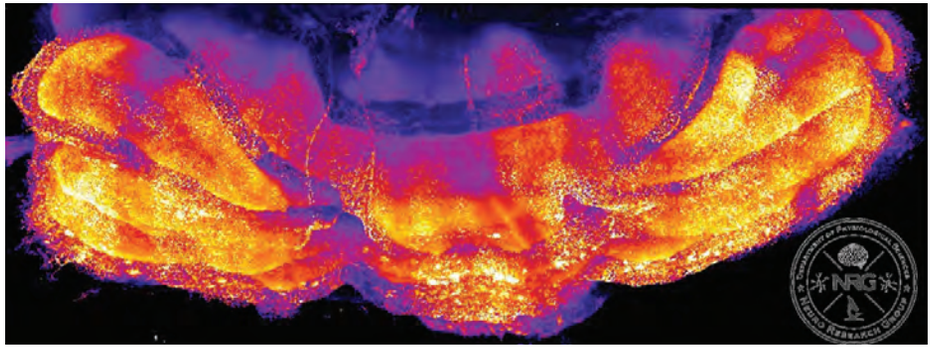
While anthracyclines such as doxorubicin has proven to be one of the most successful approaches to cancer treatment, it induces various side effects such as nausea, vomiting, hematopoietic suppression and cumulative, dose-dependent cardiac toxicity. Cancer cells are also becoming increasingly resistant to chemotherapy-induced cell death. We explore new avenues of chemotherapy and adjuvant treatments that would favor the use of lower concentrations with less side-effects to normal healthy cells, while maintaining satisfactory levels of cancer cell death.

Cardio-oncology research

We investigate the side effects of chemotherapy, particularly doxorubicin, on the heart. Cardiotoxicity, defined as a range of adverse effects on the heart's function induced by therapeutic molecules, is now considered one of the most important consequences of chemotherapy, leading to an increase in morbidity and mortality of cancer survivors.

Multidisciplinary Stress Biology

Our main research interest is in the maladaptation of the body's control systems (endocrine, immune and nervous) in the context of chronic stress, which results in a myriad of modern chronic diseases, such as Type II diabetes, the metabolic syndrome, inflammatory and neurodegenerative diseases. A specific strength is our capacity for interdisciplinary research, incorporating genetics, biochemistry, psychology, phytomedicine, pharmacology, exercise science and many more through collaborations nationally and internationally.



A major focus is the study of inflammation and oxidative stress-related accelerated ageing, which is a hallmark of many chronic diseases with an inflammatory component, such as Type II diabetes, cardiovascular disease, anxiety disorders, cancer and auto-immune diseases such as rheumatoid arthritis. Our aim is to uncover strategies with which to prevent accelerated ageing and transition of maladaptation into chronic disease.

Cardio-metabolic research

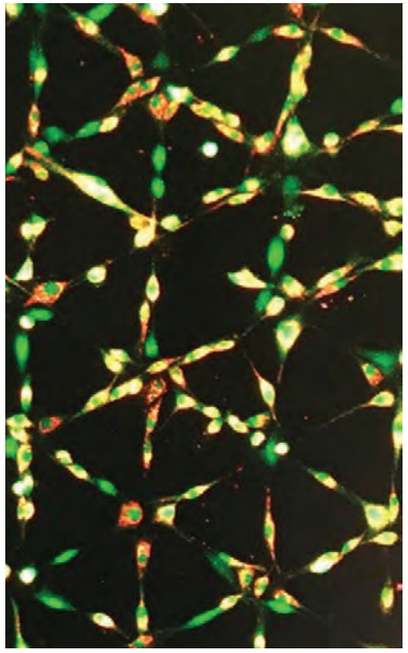
Future projections indicate that Type 2 diabetes and heart diseases will be the major cause of death in developing countries within the next few decades. Our research efforts are focused on tackling this problem in order to better understand its origin and progression, and to then drive innovation to ultimately ensure improved human health and well-being.

Muscle Physiology research

Our research focuses on stem cell biology and regenerative medicine. Under the auspices of the South African research chair (SARChi) in Integrative Skeletal Muscle Physiology, Biology and Biotechnology, we acquired the second device for nanoparticle tracking in South Africa. We are now able to assess vesicles in the nanoparticle size range that are released by humans after exercise – these vesicles are called exosomes and add another level of complexity in the study of intercellular communication and adaptation brought about via modulation of the extracellular milieu. As a biological entity, the exosomes are potentially important for whole body adaptation, but until now the field of exercise science was unaware of their existence.

Neuro research

Our research combines cell biology, cell physiology, microscopy and biochemistry approaches to dissect and investigate the relationship and role of protein degradation through macroautophagy and cell death susceptibility in neurodegeneration and gliomas. The fine balance of proteostasis control, protein aggregation and proteotoxicity is the main focus point, due to its role in the onset and progression of diseases such as



neurodegenerative diseases and cancer. In this regard, we focus on macroautophagy, chaperone mediated autophagy, cellular metabolism, mitochondrial morphology and function, tubulin and transport systems, the cytoskeleton and ATP consumption.

Metabolic Physiology and Health

According to the World Health Organization (WHO) non-communicable diseases (NCDs) kill 41 million people annually, with more than 85% of these deaths occurring in low- and middle-income countries. In South Africa, NCDs account for almost 40% of total deaths. We work in a farm workers community in a peri-urban setting to investigate and understand how obesity contributes towards the development of NCDs and inflammatory metabolic diseases such as diabetes, and hypertension and cardiovascular diseases.

Clinical Haemorheology and Coagulation research

Many diseases are accompanied by chronic inflammation, but the origin of this inflammation remains mostly unclear. Hallmarks of inflammation are both a chronic hypercoagulability and upregulated inflammatory marker profile, accompanied by a changed blood rheology. Inflammation is therefore synonymous with a pathophysiological haematological and coagulation system. Our research has led to a better understanding of the coagulation system during inflammation and how rheology is affected. We have provided extensive evidence that inflammation in chronic conditions is caused by the presence of bacterial wall components that act as potent inflammagens, with origins from bacteria entering via gut dysbioses and in the presence of low immunity. This knowledge has great implications for the treatment of a host of inflammatory conditions which include Type II diabetes, cancer, Alzheimer and Parkinson's disease, and other systemic inflammatory conditions. We use this knowledge to develop early detection modalities such as nano-biosensors, and study novel circulating biomarker molecules to both identify and track inflammatory conditions.

Please contact us

Prof. Resia Pretorius, Head: Department of Physiological Sciences
T: +27 (012) 808-3143 | E: resiap@sun.ac.za
http://www0.sun.ac.za/physiologicalsci/eng/index.php

Prof. Louise Warnich
Dean: Faculty of Science
A.I. Perold Building, Merriman Avenue
Stellenbosch University
T: +27 021 808-3072 I E: lw@sun.ac.za
http://www.sun.ac.za/english/faculty/science/