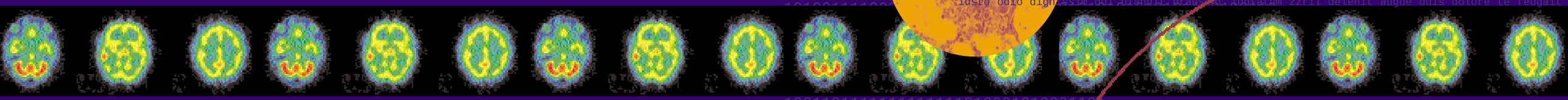
Research @ Stellenbosch

GROUND-BREAKING RESEARCH BEING UNDERTAKEN AT STELLENBOSCH UNIVERSITY



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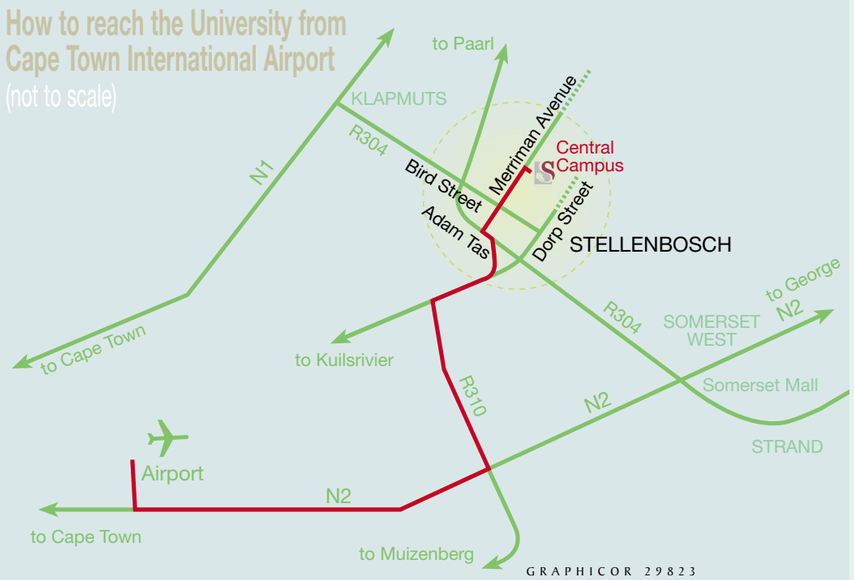
"A university is not a lecture theatre, or a library, or a laboratory; it is not a building or a place at all; its essence is a frame of mind."

Professor Samuel James Shand, Department of Geology 1911-1937

How to find us



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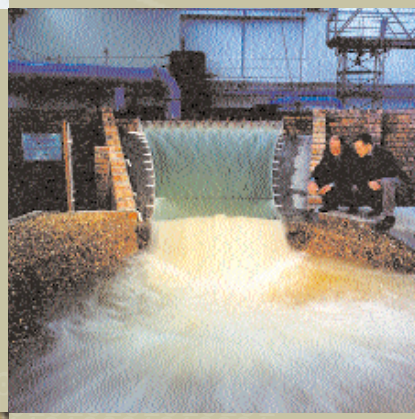
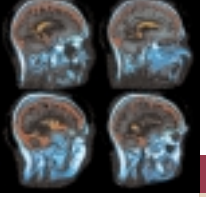
Sybelle Albrecht, Mike Cherry and Annamia van den Heever for their editing and co-ordinating role

Excelling in research

Stellenbosch University is at the forefront of basic and applied research and through partnering with industry and government has become a benchmark for research excellence.





Our mission . . .

The raison d'être of Stellenbosch University is – to create and sustain, in commitment to the universitarian ideal of excellent scholarly and scientific practice, an environment within which knowledge can be discovered, can be shared, and can be applied to the benefit of the community.

. . . and vision

In a spirit of academic freedom, and of the universal quest for truth and knowledge, the University as an academic institution sets itself the aim, through critical and rational thought,

- of pursuing excellence and remaining at the forefront of its chosen focal areas;
- of gaining national and international standing by means of:
  - its research output; and
  - its production of graduates who are sought-after for their well-roundedness and for their creative, critical thinking;
- of being relevant to the needs of the community, taking into consideration the needs of South Africa in particular and of Africa and the world in general; and
- of being enterprising, innovative and self-renewing.

COMMITMENTS

The University acknowledges its historical ties with the people and communities from which it arose.

- With a view to the future, the University commits itself to apply its capacities, expertise and resources for the benefit of the broad South African community; and
- therefore the University commits itself to be language-friendly, with Afrikaans as a point of departure.

VALUES

Equity • Participation • Transparency
• Readiness to serve • Dedication • Scholarship
• Tolerance and mutual respect • Responsibility

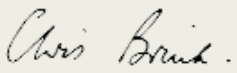
Introduction by the Vice-Chancellor

Stellenbosch is a research-intensive university, with a long history of pure and applied research, across a large range of disciplines. It is fair to say, however, that over the past two decades there has been a particular thrust in building up to world standard our science research portfolio. In this brochure we would like to showcase the result.

We understand that doing good science must go hand in hand with putting science to work for the benefit of society. In this regard I am pleased to say that we have been particularly successful. Over the past five years Stellenbosch has consistently been a national leader in such benchmark funding schemes as THRIP (Technology and Human Resources in Industry Programme) and in the National Innovation Fund. In these programmes, government funding is made available on the basis of matching funding from business and industry. It is an excellent record of living up to the promise made in our motto "Your Knowledge Partner".

We also understand that, more and more, doing good science is a matter of collaboration and networking. This brochure is therefore also intended to introduce our capabilities to other universities and research institutions, nationally and internationally. I would like to extend an invitation to potential research partners to contact our Division of Research Development to explore the possibilities of collaboration.

Finally, none of what we report on would have been possible without hard-working and committed people: researchers, research students, technicians and support staff. Stellenbosch has been singularly fortunate in the quality and stability of its staff and students. This brochure, therefore, is perhaps best regarded as a tribute to their achievements.



Prof Chris Brink
Rector and Vice-Chancellor

We understand that doing good science must go hand in hand with putting science to work for the benefit of society.

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Stellenbosch University: Excelling in research

A history of growth

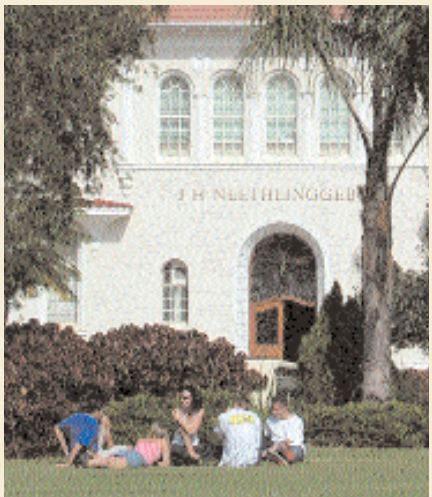
Stellenbosch University is widely regarded as one of the top research universities in Africa. This is evident in the extensive – and growing – involvement of its researchers in probing issues of great importance not only to the African continent, but also the world.

Stellenbosch has been a centre of education in South Africa since 1685 when the Dutch Reformed Church established a parish school in the then tiny town. From this small beginning evolved various educational initiatives, which by 1866 had grown into what was known as the Stellenbosch Gymnasium. As it steadily improved its standards and extended its scope, the Gymnasium set up a professorial division, known as the Arts Department in 1874. This could be regarded as the origin of the present faculties of Arts and Science. Seven years later the Arts Department was incorporated as the Stellenbosch College. This, in turn, was renamed the Victoria College of Stellenbosch in 1887 in celebration of Queen Victoria's 50 years of rule. As the College grew, new disciplines, including agriculture and education, were introduced and more buildings and laboratories added. The Victoria College became Stellenbosch University by Act of Parliament in 1918.

Recent history

The period since 1975 has brought extensive development on all the University's campuses at Stellenbosch, Bellville, Tygerberg and Saldanha. Black students were admitted to the University in 1979, and since then the numbers of Coloured, Indian and African students have risen steadily to almost 30% of total numbers. About 45% of our postgraduate students are black. The proportion of women students on the campus has also improved to more than 50%. *Refer to graphs A and B.*

The eighties saw the University taking strong measures to improve its postgraduate training and its research capacity. A fund in support of this move was set up and substantially backed by alumni and industry. Sound further decisions and actions have enabled Stellenbosch University to grow into a comprehensive research university.



Positioned for better role

Since the democratic elections of 1994, the South African higher education system has undergone significant changes. Many of these relate to improving equity and effectiveness, and positioning the institution to play a more meaningful role in developing the country and the continent as well as finding solutions for pressing international development challenges.

Stellenbosch University has been proactive in its responses to new government policies. It embarked upon a comprehensive and extensive planning process in which the whole University community participated, resulting in a Strategic Plan accepted by the Institutional Forum and by the Council early in 2000. This Strategic Plan resulted in a number of new policy and implementation initiatives. All faculties have thoroughly revised their teaching/learning programmes to align them with national and institutional priorities.

The period from 1995 to 2003 has also been characterised by a strong and continuous growth in research activities. Numerous scholars of high standing joined the University, and young scholars, in particular, were supported and developed to take their place amongst the leaders in their fields. New laboratory facilities of the highest quality were developed, new institutes came into being and extensive research support from

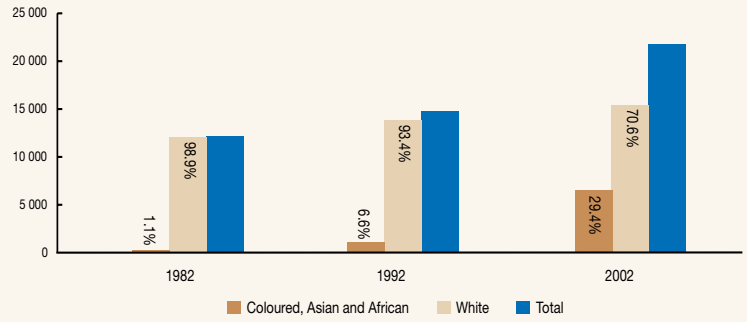
outside the University was obtained. This strategy appears to have paid off, as accepted research indicators show the University has performed exceptionally well in recent years (see Research achievements, page 7).

Positive political change in South Africa has led to increased institutional interaction with bodies abroad. Today the University has thriving international contacts at an institutional level and many staff members also have personal contacts with colleagues in other countries. Our International Office provides invaluable support for faculty to collaborate with colleagues abroad.

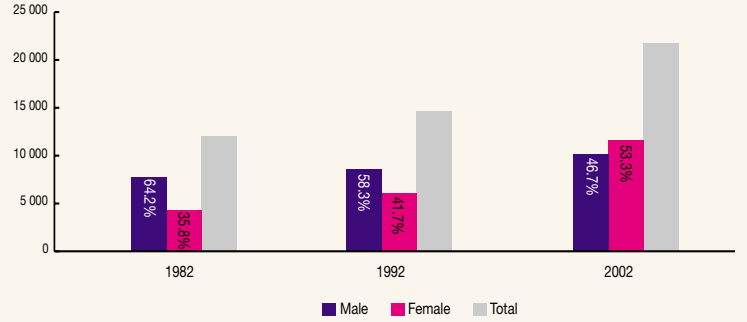
The future

From 500 students and 39 teachers in 1918, Stellenbosch University has grown to about 22 000 students (including about 2 300 distance education enrolments) and over 800 teachers, and includes some 50 research and service bodies. The future looks bright as Stellenbosch University builds upon successes of the past, while positioning itself to exploit the opportunities of the future.

Graph A: Growth in student numbers by race



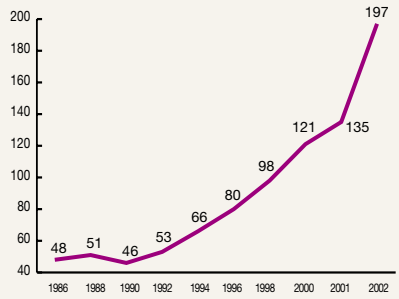
Graph B: Student numbers by gender



Stellenbosch University's research strategy: Aligned with national priorities

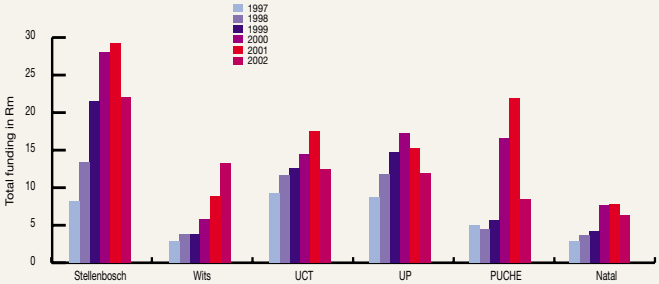
Stellenbosch University is well placed to play a significant role as a partner in the development of South Africa and our continent.

Evaluated researchers at Stellenbosch University



The NRF (National Research Foundation) manages a system of the evaluation and rating of researchers to ensure that resources are invested in those with the capacity and track record to utilise these funds effectively and efficiently.

Performance of universities most successful in obtaining THRIP funding



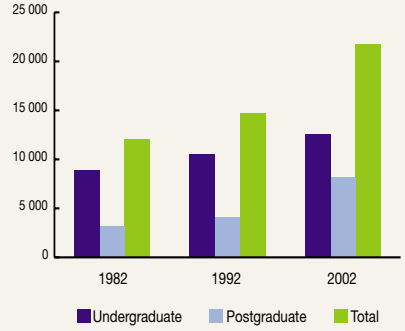
The performance of Stellenbosch in obtaining THRIP funding in comparison to other top institutions in South Africa.

THRIP: The Technology and Human Resources for Industry Programme (THRIP) is a joint venture between industry, research and education institutions and government. The programme supports the development of technology and appropriately skilled people for industry to improve South Africa's global competitiveness.
http://www.nrf.ac.za/programmeareas/thrip/

Research productivity (publications output)

Stellenbosch University is amongst the top four (out of more than 30) higher education institutions in South Africa in terms of its research productivity.

Student numbers by study level



South Africa's Research and Development Strategy

In recent times South Africa has been recognised as a leader on the African continent in determining and acting on the agenda for sustainable development. It has recognised that its research and development strategy must be a key enabler of economic growth and development.

The South African government has, in partnership with industry, higher education institutions and other agencies, developed a national research and development (R&D) strategy based on:

- Innovation
- Science, engineering and technology human resources and transformation
- Creating an effective government science and technology (S&T) system

In this context, areas that have been put forward as R&D priorities for the country are:

- Biotechnology
- The exploitation of South Africa's unique resources, e.g. in astronomy, human paleontology and indigenous knowledge
- Wealth creation through innovation
- Promoting R&D centres of excellence
- Transformation of the research workforce by developing more young researchers, women and black scientists

Stellenbosch University's role

Stellenbosch University is well placed to play a significant role as a partner in the development of South Africa and our continent. It is a comprehensive research university with strong leadership in numerous fields of human, natural and health sciences.

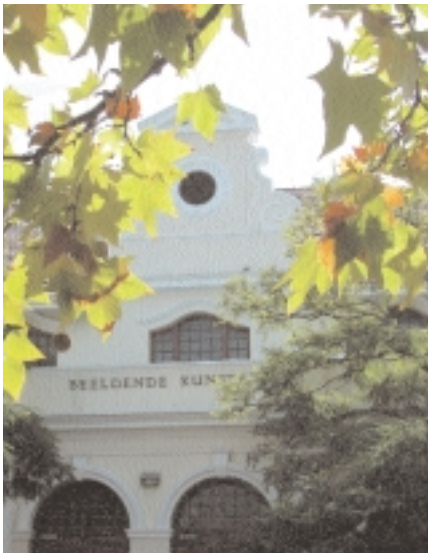
At Stellenbosch we

- work hard to develop a strong research ethos
- use our own and carefully leveraged external resources to continuously improve our infrastructure and technology
- encourage strategic alliances and partnerships
- place a premium on our staff's research capability
- promote knowledge entrepreneurship
- try to maintain a balance between fundamental and applied research

Stellenbosch University's research focus areas

Taking into account national needs and priorities, as well as our own expertise, the following focus areas are currently being developed with substantial financial support from the University:

- Language and culture in a multilingual and multicultural society
- The "knowledge economy"
- Building a new society
- Competitive economy
- Biotechnology
- Sustainable biodiversity and the environment
- The production and provision of food
- The struggle against disease and the promotion of health
- Technology for industry
- Fundamental theory, mathematics and complexity



Research achievements

Stellenbosch University is recognised as one of the top research universities in South Africa. Evidence for this includes:

- Nearly 200 of our staff members have been rated by the National Research Foundation. Only one other university (the University of Cape Town) shares this top position with us. (See graph on page 6)
- We have the highest number of NRF-rated researchers in the human and social sciences.
- Compared to our competitors, we have a greater proportion of NRF-rated researchers in the "young scientist" (Y and P) categories.
- In 2003 our researchers from "designated groups" (i.e. women, blacks and people with disabilities) received more support from the NRF's Thuthuka programme than any other institution.
- Our success in securing research funding from government agencies and industry.
- More than a third of our students are enrolled in postgraduate programmes. (See graph on page 6)
- The quality and range of our research outputs are amongst the best in the country. (See graph on page 6)
- We are the forerunner in South Africa in establishing partnerships with industry through the government-supported THRIP programme. (See graph on page 6)
- Our success at knowledge and technology transfer is reflected in the large number of commercial research contracts and the establishment of spin-off companies.
- Amongst the prestigious awards received by our researchers the past year are:
  - Gold Medal of the Chemical Institute
  - Gold Medal of the Microbiological Society
  - Gold Medal of the Zoological Society
  - De Beers Medal of the Physics Society
  - Akademie's Havenga Prize for Botany
  - Harry Oppenheimer Award
  - Bill Venter Altron Literary Award

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Stellenbosch University: Excelling in research

Nurturing research talent

Research and researchers are at the top of the agenda at Stellenbosch University and the University has a number of special initiatives aimed at nurturing and attracting talent.

Promising young scientists benefit from early career support which positions them to apply with confidence for evaluation by the National Research Foundation. Over the last number of years the University has also attracted many senior researchers from South Africa and abroad. Their success in research is enabled with an establishment fund, directed at the refurbishment of laboratories and the acquisition of research equipment.

Expert research services

Research at Stellenbosch greatly benefits from expert services provided by the Centre for Statistical Consultation and the Central Analytical Facility (CAF). The CAF's routine services include:

- Measurement of major and trace element concentrations in inorganic samples
- Measurement of major element compositions of micro-spots in polished sections
- Measurement of the concentration of inorganic elements in solutions to low parts per billion level
- Determination of the crystal structure of powdered specimens
- Generation of secondary electron images with enhanced depth of field to view almost any solid sample to magnifications of up to 50 000 times
- Determination of crystal structure in single crystal of organic compounds
- DNA sequencing and Genotyping
- The generation of mass spectra of labile, non-volatile polar molecules
- Identification of amino acids from a wide variety of biological sources
- Elucidation of structure and conformational analysis of molecules, including drug binding
- High-resolution mass spectrometric analyses of organic compounds

Rating of scientists in SA

Researchers in South Africa undergo a process of international and national peer evaluation, which is managed by the National Research Foundation.

Our A-rated scientists

The honour of being placed in category A is bestowed only on world leaders in their specific fields of research at South African tertiary training institutions.

In 2003 our
A-rated researchers are:
Prof J-HS Hofmeyr, Biochemistry: Winner of the Harry Oppenheimer Award, the most sought-after tribute in the South African research community. He will use the award on a project named "The Metabolic Marketplace" to produce an integrated view of how "the components of life" all work together as a system.
Prof DG Kröger, Mechanical Engineering: Winner of the prestigious Bill Venter Altron Literary Award
Prof DE Rawlings, Microbiology
Prof PJF Sandra, Chemistry
Prof MJ Samways, Entomology and Nematology
Prof AJ van der Walt, Public Law

Our P-rated scientists

The awards in Category P ("Presidential") are made annually to a select few top researchers, younger than 35, with exceptional potential, who are recognised by the international community as prospective leaders in their fields.

P-rated scientists at the University are:
Prof MG Lamprechts, Viticulture and Oenology
Prof JM Rohwer, Biochemistry
Prof JE du Plessis, Private Law
Dr I Swart, Practical Theology

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Stellenbosch University: Excelling in research

Partnerships

At Stellenbosch University we actively seek partners with whom we can achieve more for society than we can on our own.

Universities accept that they do not have a sole right to – or responsibility for – discovery, synthesis, application and transfer of knowledge. If universities are to be engines of growth and development, active engagement with society through partnerships is essential. At Stellenbosch University we therefore actively seek partners with whom we can achieve more for society than we can on our own.

Interaction with business and industry

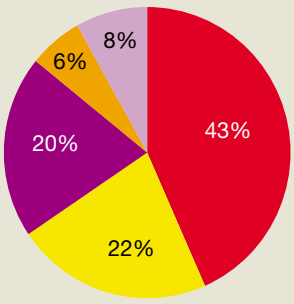
When it comes to interaction with business and industry, Stellenbosch University is leading the higher education sector in South Africa. We have a remarkable record regarding THRIP – the Technology and Human Resources for Industry Programme of the Department of Trade and Industry – having gained more funding than any other university for the past five years in a row. In 2002 the University's THRIP grants totalled almost R22 million, the largest in the country (see graph on page 6). If we add the grants and the industry contributions over the past five years, the total comes to R245 million. We have done extremely well in securing awards from the Innovation Fund: in the past year four of our research groups obtained grants with a total value of more than R30 million in aquaculture, satellite technology, plant genetics and telemedicine.

Financial management

The University has established a set of guiding principles for financial management at the University. This is in addition to the statutory requirements of Government. We have also undertaken a comprehensive study of the cost-effectiveness of all our activities, academic and non-academic.

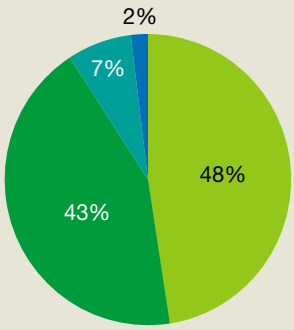
We believe that we can and must manage the University in terms of healthy business principles. Our Business Plan is the financial mirror image of our annual Institutional Plan, and both will be included in a cyclic manner in our annual management and control processes.

Total income 2002, R'000

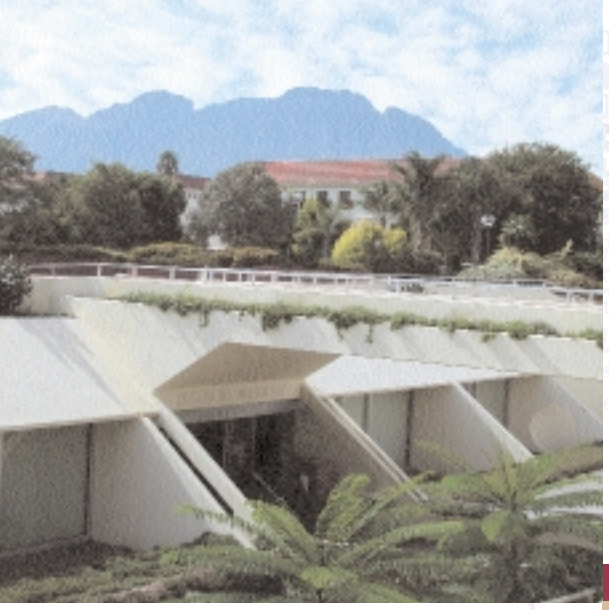


Government allocations	504 000	(43%)
Tuition and other fees	257 000	(22%)
Private donations, allocations and contracts	236 000	(20%)
Sales of services and products	70 000	(6%)
Investment and dividends	94 000	(8%)

Total expenditure 2002, R'000



Staff costs	488 000	(48%)
Other operating expenditure	444 000	(43%)
Depreciation	75 000	(7%)
Financial charges	20 000	(2%)



Building on their legacy . . .

Although many fine people served to build Stellenbosch University, four stand out as having made a particularly important contribution to the growth and reputation of the institution.

Robert Broom

Robert Broom, professor of both Zoology and Geology at the university from 1903 until 1910, gained international recognition for his research in vertebrate palaeontology. He was a man of extraordinary energy and, at the age of 70, described Australopithecus africanus, an adult man ape discovered in the Sterkfontein cave near Johannesburg. While at Stellenbosch, he explored his interest in the origin of mammals from mammal like reptiles and identified the suborder Therocephalia amongst the fossils of the South African Karoo. The Therocephalia includes the ancestors of a later group of mammal-like reptiles – the Cynodontia – the immediate predecessors of mammals. Broom published more than 90 scientific papers during his relatively short time at the University.

Regional co-operation

Stellenbosch University is a founding member of the Cape Higher Education Consortium (CHEC), together with the Universities of Cape Town and the Western Cape, and the Cape and Peninsula technikons. The aim of the CHEC is to strengthen the Western Cape as a higher education resource and to maximise the benefits of quality and cost-effectiveness, not only to the region, but also to the country as a whole.

Samuel James Shand

Shand is often regarded as the real founder of the Geology Department at Stellenbosch where he remained for 26 years. During that period he accrued a substantial number of publications in international journals and also wrote several valuable geology textbooks on igneous petrology. He exerted a lasting influence on South African geology through his students and was an inspiring teacher. His pronouncements in a public lecture of 1916 on what constitutes a University are still quoted in University circles today: "A university is not a lecture theatre, or a library, or a laboratory; it is not a building or a place at all; its essence is a frame of mind."

JC de Wet

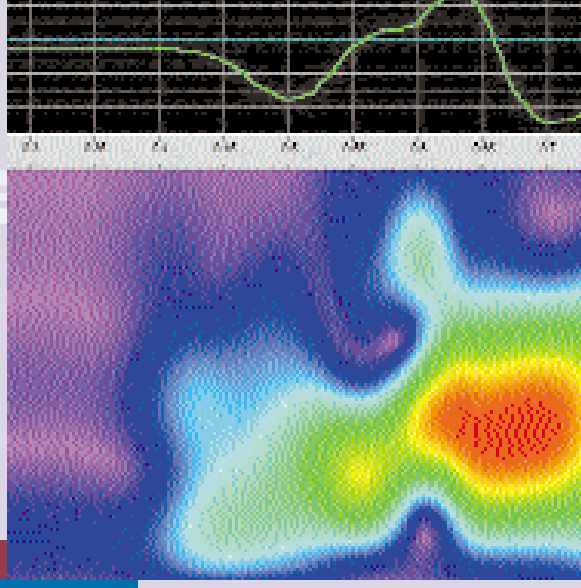
Johannes Christiaan (JC) de Wet, Professor of Law at Stellenbosch University from 1942 to 1972, is generally regarded as the most influential academic jurist in South African legal history. After obtaining doctorates from the universities of Stellenbosch (1938) and Leiden (1940), de Wet laid the foundations of Private and Criminal Law in the present day South Africa.

He revolutionised South African legal thinking by superseding the casuistic treatment of the case law with a rigorously critical analysis of precedents-based legal principles drawn from historical and comparative sources.

De Wet virtually single-handedly established Afrikaans as a legal language, exercised a profound and positive influence on a generation of students through his teaching, and played a leading role in the administration of Stellenbosch University. After his retirement de Wet continued his work as WP Schreiner Professor of Roman and Comparative Law at the University of Cape Town from 1976 to 1981.

PJ van der Merwe

PJ van der Merwe was one of the most brilliant historians South Africa has produced. Between the ages of 25 and 34 (1937 to 1944), he produced a trilogy of works on the migrant farmers and the land question in the seventeenth and eighteenth centuries. These works were based on a rigorous examination of archival sources, extensive field research and collected oral traditions. In the methods he used and the questions he addressed, van der Merwe was far ahead of many of his contemporaries. Although he was not free from the white racial prejudices of the 1930s and 1940s, his books are remarkably free of the partisan history of the colonial and Afrikaner Nationalist schools of history. He was prolific in the publication of perceptive articles in the popular press, thus raising the historical consciousness of readers. Today he is still regarded as the leading authority on white expansion and the land question in early South African history.



Innovative approaches

Stellenbosch Institute for Advanced Study

In 1999 it was decided to develop a Stellenbosch Institute for Advanced Study (STIAS) – the first of its kind on the African continent. STIAS is a high-level research facility dedicated to keeping South Africa at the forefront of international academic developments. Among the first projects undertaken by STIAS since its foundation in 2001 are:

- Merging the Layers of Life: a model that integrates different levels of biological research
- String Theory and Quantum Gravity
- Dealing with the Past: Historical Memory
- The Philosophy of Engineering Sciences
- The Future of Young Democracies
- Good Governance and Poverty Relief
- Socio-economic Rights and Constitutional Jurisprudence

Innovation and commercialisation

Stellenbosch University was one of the first in South Africa to take concrete steps to harness its intellectual capital in the interests of job and wealth creation and technology transfer. In 1999 it adopted a consolidated policy on intellectual property (IP) and established an office to manage all matters relating to IP, making innovation and commercialisation an executive portfolio at the University.

Commercialisation has taken place through the Unistel Group of companies, which is wholly owned by the University, while the formation of innovative spin-off companies is encouraged. Cutting-edge research is thus applied to the advantage of the community, industry and the University. Successful companies have been established in the fields of information technology, automotive engineering, medicine, aquaculture, public management, space technology, human genetics and boat design.

Among the private companies already doing well are:

- Attrahent Campus Innovations (e-commerce)
- Unistel Consultus (management training)
- Unistel Medical Laboratories (advanced DNA testing)
- SunSpace and Information Systems (the development of small space satellites)
- Sedation Medical Services (non-invasive sedation techniques)
- Centre for Automotive Engineering (research development and testing services to the automotive industry)
- Aquastel (freshwater fish farming)

Stellenbosch is a university where knowledge is discovered, shared and applied in a wide range of disciplines in human, health and natural sciences. The following pages highlight only some of the research projects being undertaken by the University, often in partnership with others.

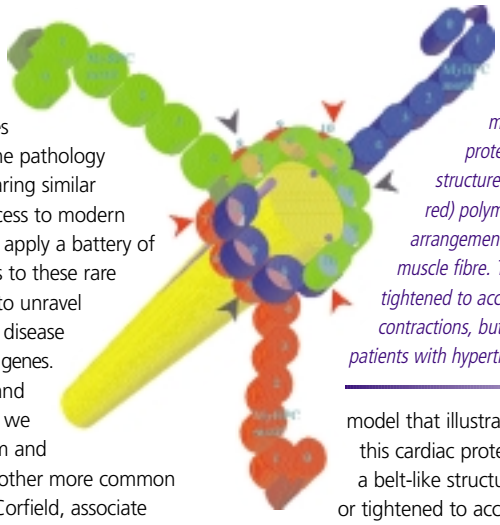
www.sun.ac.za/med_biochem/index.html

Identifying the genes that cause familial heart disease

The rhythm of life is a powerful beat, produced by the mechanical pulsing of a heart that starts fluttering in the human embryo barely five weeks after conception. In most people, the same embryonic heart will continue its mechanical pulsing some three billion times in man's allotted three-score-years-and-ten, without maintenance or a major overhaul. But hearts can be broken in more ways than by love's cruel sting. Many people suffer the consequences of their heart losing pumping power (heart failure) or having faulty electrics (conduction and rhythm disturbances). The outcome of such failures may be slow, debilitating and ultimately fatal, or the failure may be unexpected and without warning, killing even young, apparently fit people in the prime of life.

What causes these cardiac catastrophes and what can be done to prevent them? Undoubtedly, for many, nurture, in the form of a sluggish lifestyle, smoking and overindulgence in food and alcohol, plays a role in damaging the mechanical precision of this finely-tuned organ, causing the so-called 'diseases of lifestyle'. Yet, for some people, even balanced diets and daily workouts will not save them from nature and heredity. Rogue genes run in their families and half of their relatives will be at risk of serious cardiac disease. Although of enormous consequence to afflicted families, many of these inherited disorders are extremely rare. This may beg the question, 'why care and why study them?'.

Heeding the wisdom of the 17th century physician, William Harvey, a group of scientists at the University of Stellenbosch Faculty of Health Sciences believe that 'in her mistakes, nature shows tracings of her workings', and that knowledge of the 'workings' of rare diseases may well shed light on the pathology of common disorders sharing similar clinical features. With access to modern technology, the scientists apply a battery of molecular biological tools to these rare 'experiments of nature', to unravel the complexities of heart disease and to pinpoint the culprit genes. "Only when we understand what is going wrong will we be able to fix the problem and apply this knowledge to other more common afflictions," says Valerie Corfield, associate professor of molecular and cellular biology.



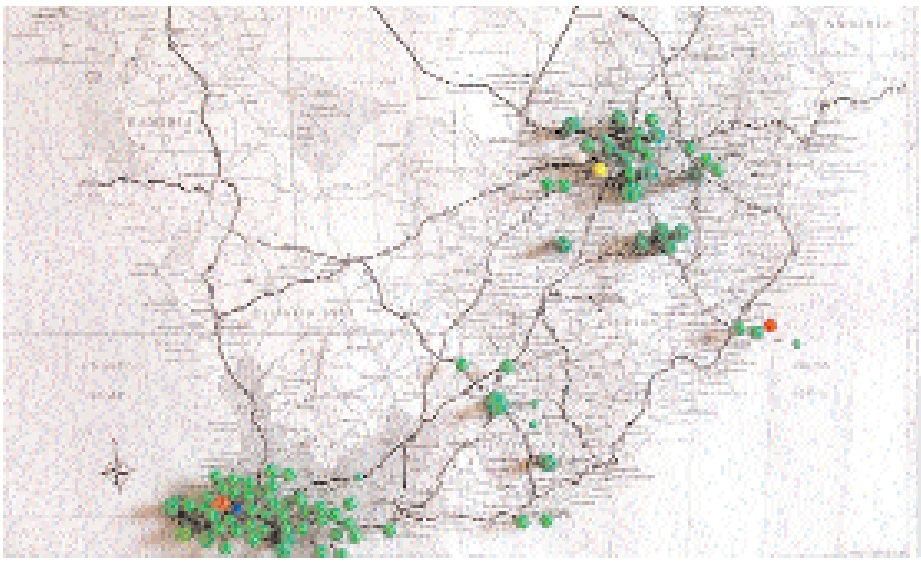
Pieces of the puzzle: a model showing how three molecules of a particular heart protein (the bicycle chain-like structures shown in blue, green and red) polymerise into a belt-like arrangement around the backbone of muscle fibre. This "belt" is loosened or tightened to accommodate the pulsing heart's contractions, but cannot do so appropriately in patients with hypertrophic cardiomyopathy.

Corfield and Hanlie Moolman Smook – both of the US and the MRC Centre for Molecular and Cellular Biology – and Paul Brink of the Department of Internal Medicine, have access to a large group of South African families who suffer from several inherited heart diseases, including hypertrophic cardiomyopathy (HCM) and long QT syndrome (LQTS). They have already identified several defective versions of the genes responsible for the life-threatening diseases in these families. They are now using these findings to probe how products from these genes disturb the heart's normal performance, and why some of the people at risk seem to suffer no ill effects and live long and healthy lives, while their less fortunate relatives die suddenly at a young age.

Going on a molecular 'fishing' expedition, the Stellenbosch team took apart a faulty heart muscle protein component that is made by a gene causing HCM. Working with scientists in the United Kingdom, they have described a new model that illustrates how the parts of this cardiac protein fit together to form a belt-like structure, which is loosened or tightened to accommodate the pulsing heart's contractions. They can also predict how glitches in the belt's structure can result in its malfunctioning, thereby causing HCM.

The Stellenbosch team has also found that many LQTS-affected families have inherited the same genetic defect from a common ancestor. This has offered the team, and their Italian and American collaborators, a unique opportunity to look for the genetic amulet that protects some relatives in the risk group from suffering symptoms of LQTS, or sudden death. Of special interest to the scientists is the balance struck between the body's adrenaline-generating system, known as the 'flight or fight' drive, and its opposing partner, the vagal system, which dampens down the body's reflex reaction to perceived danger. They are trying to find out if genetically-determined disturbances in this equilibrium destine the clinical response of an individual who harbours a defective LQTS gene.

The research has already allowed the Stellenbosch University scientists to develop blood-based diagnostic tests that support clinical diagnosis and identify those at risk, but who may not be showing symptoms of the condition. The investigation is also likely to shed more light on the prognosis associated with prevalent heart diseases, such as hypertension, heart failure and ischaemic heart disease, which lead to heart attacks. They believe that understanding the underlying mechanisms of these disorders will ultimately lead to the development of new forms of treatment, and ensure that the heart keeps up its powerful and rhythmic beat throughout its lifetime.



Tracing ancestral links: the green pins represent members of families who have inherited the same genetic defect that causes long QT syndrome from a common ancestor, who probably came to the Cape from Europe 300 to 400 years ago.

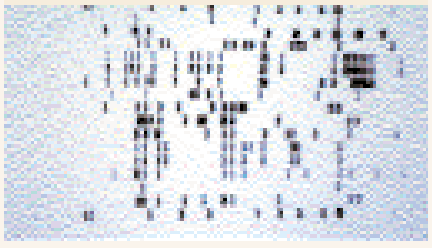
New biotechnology tools utilised to combat the ravages of an old disease

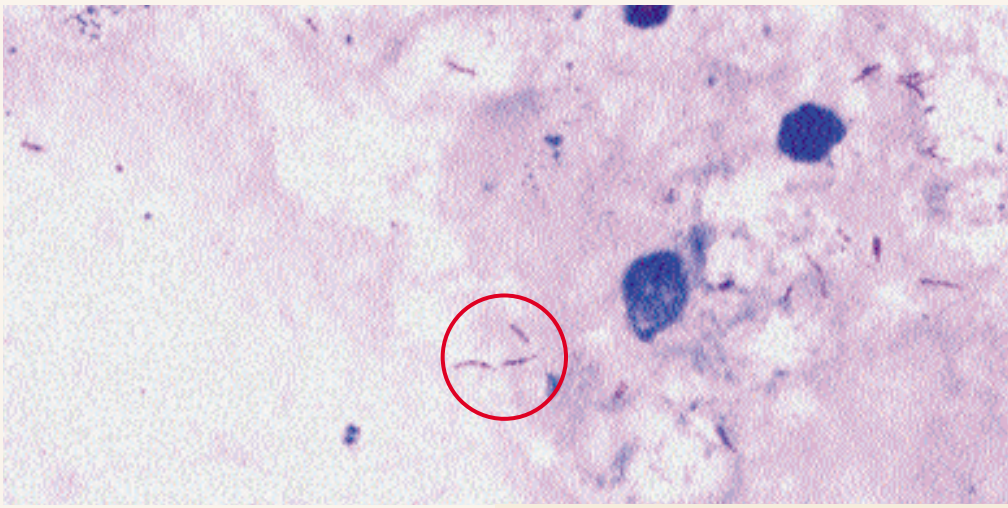
Hardly in the consciousness of the general public in wealthy, industrialised countries, the causative agent of TB, Mycobacterium tuberculosis, is probably the most successful pathogen of all time. Waves of TB epidemics have swept various continents and civilisations, affecting among others the ancient Egyptians, the Americas in pre-colonial times, and industrialised Europe in the eighteenth century. With an estimated two billion people – one third of the world's population – now infected, the World Health Organisation has now declared the TB epidemic a global emergency.

In parts of South Africa today, tuberculosis rates are similar to those found in London in 1800, despite the availability of antibiotics and a national effort to control this disease. Part of the problem is poverty, with associated overcrowding and malnutrition, but the other part lies in the nature of the bacterium itself. Unlike most other bacterial infections, which can be cured by an antibiotic course of five to seven days, TB requires a course of multiple antibiotics, taken over a period of six months, as patients do not cure quickly. The reasons for this are not clear, but medical scientists suspect that the slow growth rate of the bacterium makes it less susceptible to antibiotics. It can therefore hide away inside cells in the human body and resist the host's efforts to kill it.

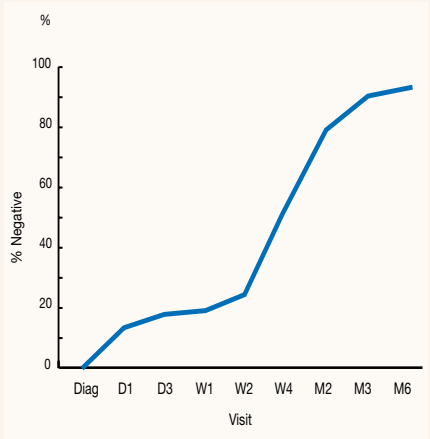
Much of the early research that underpins TB treatment and control programmes, originated in industrialised nations with a waning epidemic. Using the new tools of biotechnology, molecular scientists at the University's Faculty of Health Sciences are re-examining many ideas of the past. This is particularly important in countries such as South Africa where the epidemic is still growing. The most basic of the techniques they use, involve "fingerprinting" a culture of bacteria from each TB patient. Each patient harbours a bacterial strain with a unique genome, and a comparison of the genome

Genetic fingerprints of Mycobacterium tuberculosis strains





ZN stained section of lung tissue infected with Mycobacterium tuberculosis. The bacteria are circled in red.



The percentage of TB patients testing negative at various time points during treatment

fingerprints between different patients has revealed that there is much greater strain diversity than earlier thought, suggesting that TB has been in South Africa for quite a long time.

"It also suggests that TB has been introduced into our society from many different sources. We can quantify the relative proportion of individuals harbouring the same strain to estimate whether active transmission of disease or reactivation of latent disease from earlier infections is the most important cause of illness," says team leader Paul van Helden. The results show that most of the TB in the country is caused by recent transmission. Unlike evidence from other parts of the world, multiple infections are common, and considerable transmission of antibiotic-resistant strains exists, a source of great concern. This information could have a direct impact on the way our health authorities approach the control of this disease.

An interesting characteristic of TB is that, in the absence of immune suppression, the majority of infected people do not develop active disease. This is partly due to individual variation in terms of genetic susceptibility, and van Helden's group has identified some of the alleles – alternative forms of the same gene – involved. These genes affect immune function, so the group is studying the response of the immune system, both at the level of the organism and at the sight of infection. They are attempting to relate these results to the genomic and functional information that they have accumulated about the bacterium. This approach may provide clues leading to the development of an improved vaccine; and tools and targets for the development of new diagnostics, new drugs and faster ways to evaluate drug candidates.

In parts of South Africa today, tuberculosis rates are similar to those found in London in 1800, despite the availability of antibiotics and a national effort to control this disease.

Reservoir sedimentation

Sedimentation impacts on reservoirs are generally most severe in semi-arid regions where sediment yields are relatively high and dam catchments large, as is the case over large parts of Africa.

Reservoir sedimentation has long been identified as a major problem in South Africa. Sediment deposition occurs as a river enters a reservoir, and its sediment-transporting capacity decreases as the flow velocity declines. The mean annual sediment load of South African rivers is more than 120 million m^3, resulting in the loss of total storage capacity equivalent to that of the Hartbeespoort Dam (near Pretoria) every year. Sedimentation impacts on reservoirs are generally most severe in semi-arid regions where sediment yields are relatively high and dam catchments large, as is the case over large parts of Africa. Agriculture, afforestation, deforestation of natural forests, and overgrazing can all lead to the release of sediment particles into rivers.

Apart from the obvious fact that sediment build-up within a reservoir leads to decreasing storage capacity, sediments are deposited upstream of the reservoir, forming a delta which can become vegetated, further stimulating sediment deposition and increasing flooding levels. Within a reservoir, sediment build-up can have serious impacts on diversion and extraction facilities including turbines and pump stations.

Both sedimentation and evaporation losses can be minimised by building dams high up in river catchments, but this is not always feasible. The ideal solution, according to Gerrit Basson of the Stellenbosch University (SU) Department of Civil Engineering, is to construct only relatively small dams on rivers that carry substantial sediment loads. These dams should have low-level gates to sluice incoming sediments through during floods; and to divert the water to secondary dams away from the river course. These sluicing operations can be simulated by mathematical models developed at the SU.

An alternative solution – which can be applied under certain topographical conditions – is to bypass incoming sediment-laden floodwaters around reservoirs via tunnels or canals. Sediment removal by dredging should be seen as a last resort as the removal of existing deposits is extremely expensive and it is very difficult to get rid of the dredged materials.

While it would be wonderful if catchment management policies could improve soil conservation and serve to limit reservoir sedimentation at the same time, success in this regard has been very limited. To date, the recorded decreases in sediment loads in various southern African rivers have been due largely to the depletion of erodible topsoils, rather than successes with soil conservation measures. It is very difficult to get governments to apply strong soil conservation measures as these are generally expensive and often unpopular among farmers.

Mbashe Reservoir sedimentation, South Africa

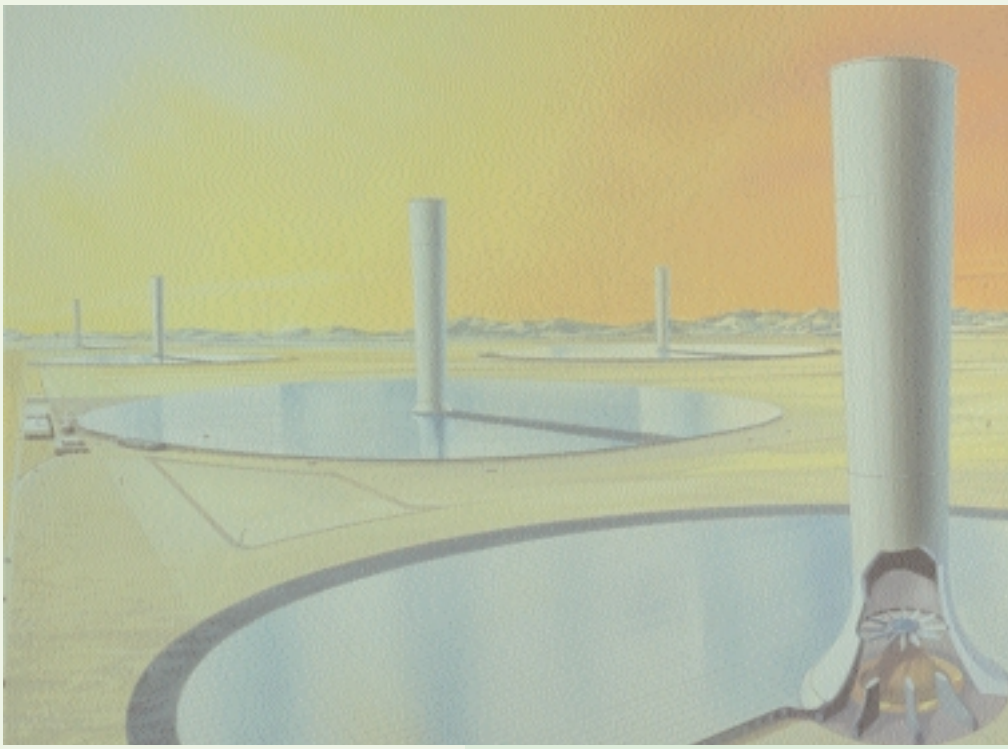
Large dams also have impacts on rivers downstream as they disrupt the sediment supply and cause the flow patterns to change, leading to deformation of river channels and associated ecological damage. Research at the University has resulted in a reservoir classification system that specifies how they should be operated in order to minimise the impacts of sedimentation under various climatic conditions. This system has also been incorporated in an economic model used by the World Bank. Another focus has been the development of a procedure to design managed environmental flood releases from dams, in order to limit the impacts of a dam on the river morphology.

The research performed by Gerrit Basson and his predecessor, Albert Rooseboom, has led to their guidelines on dealing with reservoir sedimentation having been adopted as the official guidelines of the International Commission on Large Dams.

Pongola Dam managed flood release, 2001.

Dry-cooling systems and solar power plants

A typical cooling tower might evaporate one million litres of water per hour – the equivalent of the water contained in ten swimming pools!



Solar chimney power plants

To operate effectively, power plants have to release relatively large amounts of heat to the environment. Cooling can be achieved by releasing heat to the ocean (as is the case at the Koeberg nuclear power plant) or through evaporation of water in large concrete natural-draught cooling towers. A typical cooling tower might evaporate one million litres of water per hour – the equivalent of the water contained in ten swimming pools! Because of South Africa's limited water resources, large electricity utility Eskom and other industries are installing dry-cooling systems. Prof Detlev Kröger and colleagues in the SU Department of Mechanical Engineering are involved in a series of research projects related to the development of such systems for conventional power plants, and for the petrochemical and processing industries, both in South Africa and in the USA.

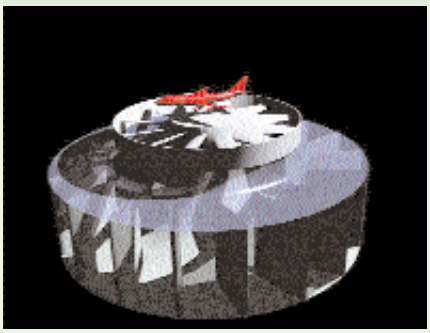
The world's largest dry-cooled power plant, Matimba, is located near Lapelele (Ellisras) in the dry Limpopo province, and was developed in consultation with Kröger's group. This plant has no wet-cooling towers and requires no cooling water, but instead has an air-cooled steam condenser. This steam condenser is similar to a car radiator in which hot water is cooled inside externally finned tubes across which air is blown by means of a fan. At the Matimba plant, 288 fans, each having a diameter of 9,1 metres, 180 tonnes of air per second flow over 2 500 kilometres of finned tubes inside which turbine exhaust steam condenses.

In view of the need for clean power in the future, the group is also involved in research and development related to solar chimney power plants. Currently in South Africa, solar power panels are used mostly to supplement domestic electricity needs, but the Northern Cape provincial government is considering the construction of such plants in the Kalahari desert to generate clean power on a large scale.

A solar chimney power plant consists of a central concrete chimney that may have a diameter of 150 m and be up to 1 500 m high – almost four times the height of the Empire State Building in New York. A glass canopy about 4 metres above the ground – but with a diameter of up to 7 kilometres – surrounds the central chimney. During the day solar radiation heats the ground under the glass canopy, collecting heat from the sun. This heat is transferred from the ground to the adjacent air, which becomes less dense and flows up the chimney due to buoyancy effects. A turbine is connected to a generator located at the base of the chimney. As heat is stored in the ground during the day, it is possible to operate this plant throughout the night as well, despite the lack of sun.

Because of South Africa's limited water resources large electricity utility Eskom and other industries are installing dry-cooling systems.

Size of solar chimney turbine compared to a Boeing 747



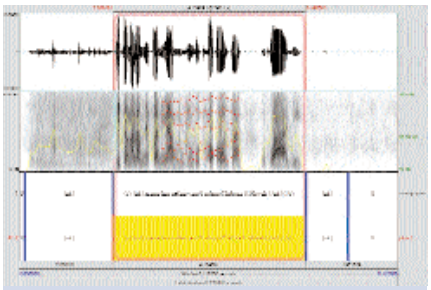
Language and speech technology for Africa

Deployment of innovative technology will greatly enhance the access to information for different language groups in the country.

The emergence of Human Language Technologies (HLTs) is gradually changing the manner in which humans communicate with computers in everyday situations. It is currently possible that a computer may answer your telephone call in a normal sounding voice and engage in an intelligent dialogue imparting information on, for instance, train, bus or flight schedules, and even make a booking on your behalf. These interactive voice systems present the potential user with information through natural language and speech – in a language of your choice!

The **African Speech Technology project** is headed by Justus Roux who is involved in developing a system that will be able to communicate in five of the most spoken languages in South Africa. The system will be able to handle a wide variety of variations of, respectively, South African English, Afrikaans, Xhosa, Zulu and Sesotho. The system comprises an automatic speech recognition module, as well as natural language understanding and speech synthesis modules. The development of these types of systems is furthermore highly dependent on the availability of extremely large electronic text and speech databases, which have to capture the wide variety of speech variations in order to develop appropriate acoustic models for speech recognition to take place automatically. The speech variations that need to be accounted for relate, inter alia, to gender, age and accent, whilst the influence of background noise, and transmission channels (a fixed telephone line or mobile phone) also need to be accounted for. A strong interdisciplinary team, comprising linguists and electronic engineers (staff as well as students), is therefore involved in this research and development project. A number of co-workers from five other South African universities are also involved. This project plays an important role in empowering mother tongue speakers of the indigenous languages to become part of the information society.

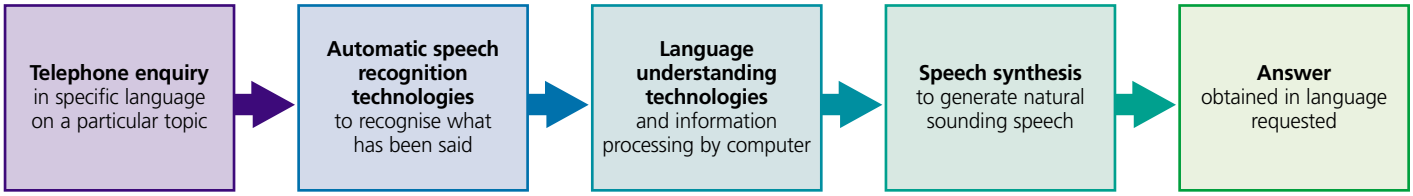
An automated multilingual hotel reservation system is currently being developed as a prototype in order to demonstrate that these systems could be applicable in the South African context. This system will allow the caller to obtain any kind of information on facilities available at a particular hotel in a particular city, up to the point where a reservation is made and confirmed by the system. When deployed, such a system will be accessible 24 hours a day, seven days of the week without any human intervention. Annotated reusable speech databases and software tools will also be available once the project ends to allow developers set up other applications in, for example, call centres. This is the first time that African languages have been integrated into automated information systems. As these systems are speech based, they have the tremendous advantage of allowing access to information to a large portion of the population that is illiterate.



An annotated Xhosa speech signal

The mixing of languages in everyday conversation remains a big challenge to this project, but various techniques are currently being developed to address this issue. The first usability tests have been conducted and the results are very promising. Eventual deployment of these and related systems will greatly enhance the access to information for different language groups in the country. It is expected to have an impact in fields such as e-health, e-commerce, e-learning and e-government, where an individual will be able to converse with a computer speaking his/her own mother tongue!

This is an attempt to bridge the digital divide and promote the use of local languages in modern communication systems, which is extremely important in a multilingual country such as South Africa, with eleven official languages. This project is funded by the Innovation Fund of the Department of Science and Technology and has already led to the establishment of a spin-off company, CatchWord: Language and Speech Technologies, Pty Ltd.



The Bureau for Economic Research financial services sector survey

At the beginning of 2002, the Bureau for Economic Research expanded the reach of its business surveys to the financial sector, under the direction of senior economist George Kershoff. South Africa is only the third country in the world to conduct such a survey – a fact that reflects the sophistication of our financial system.

Trends regarding income, expenditure, the willingness to extend credit and profitability of financial institutions are calculated. At first, the new financial survey covered only South African banks, but since the beginning of 2003, life insurers and fund managers have also been included. The contribution of the financial sector to the GDP has increased from 11% in the 1960s to 18% in the 1990s – yet its performance was not measured regularly and consistently until the Bureau's financial services sector survey filled this gap.

The Bureau's financial services survey is based on those in the United Kingdom and Switzerland. The survey results provide the most up-to-date information on how industry leaders experienced the quarter just ended, and their expectations for the next quarter regarding business volumes, premium income, funds under management etc. They also serve as a reliable benchmark for the industry. Furthermore, the survey results of successive quarters enable one to track cyclical movements, pinpoint trend changes and establish forecasts. It also provides unique information, such as business confidence, credit standards, Aids-related claims, and expectations for the next quarter, for which no figures existed previously. It is now widely recognised that these subjective individual perceptions and expectations play a key role in the future course of events.

For more than three decades, the Bureau has been conducting quarterly surveys among

senior business leaders in the manufacturing, retail and building sectors. Started at Stellenbosch University in 1944, the Bureau is one of the oldest economic research institutes in the country, and focuses on the South African macroeconomy. The Bureau monitors economic trends, and identifies and analyses factors – both local and international – that affect South African businesses. It prides itself on its extensive historical data, which is statistically sound and based on tested models. This data is collected and analysed using a variety of widely-accepted methodologies, as well as ones developed specifically for the South African environment.

The results of the survey were released for the first time on 8 October 2002 in Johannesburg. The international audit firm Ernst & Young sponsors the financial services survey, and also contributes towards its development. According to Rakesh Garach, a senior partner at the firm, the survey fills an important gap in the market and provides valuable information to senior managers, analysts and other interested parties on the state of affairs in the financial sector.

The contribution of the financial sector to the GDP has increased from 11% in the 1960s to 18% in the 1990s – yet its performance was not measured regularly and consistently until the Bureau's financial services sector survey filled this gap.

Fun with pheromones

Kheper lamarcki *on a dung ball. The male is inspecting the dung ball to see whether the female is still rolling along and to make sure that another male has not joined the party.*

Pachylomerus femoralis. *This dung beetle species is unique in that it also rolls the seeds of the yellow monkey orange tree,* ***Strychnos madagascariensis,*** *thereby spreading the seeds of the tree.*

A male bontebok, ***Damaliscus pygargus pygargus***

The bontebok marks its territory with secretion from the interdigital glands, situated between the animal's front toes.

Game farming could be seen – a little cynically perhaps – as a hobby in which some wealthy landowners can afford to dabble, affording wildlife viewing for tourists and trophies for hunters. But its popularity has been a tremendous boon for conservation, as it has resulted in large tracts of agriculturally marginal land either being conserved in its natural state, or being restored to its original state. These new reserves can be restocked with game from other nature reserves, but capture operations can be extremely expensive, especially if several days of helicopter time is required to catch only a few antelope. An alternative approach is to use the chemical compounds, or pheromones, which animals use to mark their territories, to lure them into being captured.

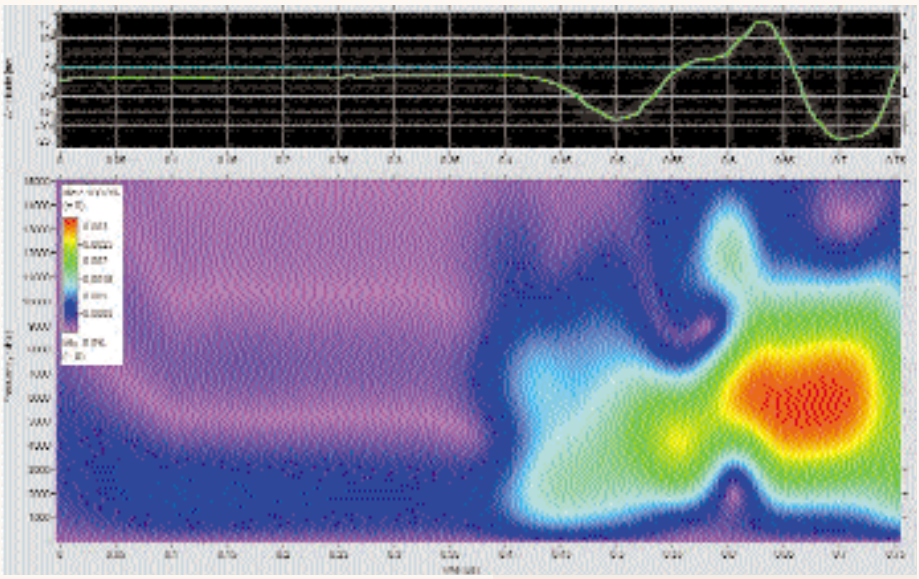
An alternative approach is to use the chemical compounds, or pheromones, which animals use to mark their territories, to lure them into being captured.

Ben Burger and his collaborators of the Stellenbosch University Laboratory for Ecological Research have been doing research for more than 30 years on these and other antelope pheromones. One of their primary aims is to synthesise pheromone analogues for exactly this purpose. Although not applicable to all species, in both the bontebok and blesbok, for example, it could be both a cheaper and a more humane method of capture, and the group is currently developing a cocktail of the active constituents of the interdigital secretions of these two species. The development of this method will be an enormous breakthrough in game farming. As soon as the synthesis of 3 g of one last constituent is completed, Burger will have synthetic material equivalent to the secretions of 300 million bontebok, and field trials can be performed.

Research is also being undertaken on the pheromones of birds, reptiles and other mammals. In one of the most exciting recent projects it was discovered that the cheetah secretes elemental sulphur in its urine, a unique phenomenon in the animal world. This species can reach speeds of more than 110 km/h in short bursts, but is not very powerful and cannot defend itself effectively against other carnivores such as lions and hyaenas. This may be the reason why – in order not to advertise its presence – cheetah urine is practically odourless. Besides sulphur, the urine contains only a few volatile organic compounds in such low concentrations that they are barely detectable by the human nose. One plausible explanation for the presence of sulphur in the urine is that the sulphur-containing amino-acids present in the proteins of the animal's diet, instead of being converted into the strongly odorous organic sulphur compounds that are present in the urine of other feline species, are metabolised to sulphur, which does not have such a strong odour. The possibility that sulphur could even serve as a unique species-specific pheromone in the cheetah, is currently being investigated.

Few people know that there are more than 4 000 dung beetle species in Africa alone. Dung beetles play a crucial role in the ecology of rural areas: by burying herbivore dung, they improve soil fertility, promote the spreading of plant seeds, and destroy the habitat of dung-breeding flies. Scarcely a single fly can be found during the summer months in nature reserves in South Africa with a normal dung beetle population, whereas the indigenous people only a few kilometres outside of these areas are often covered in flies; not to mention the well-known problem of dung-breeding flies in Australia. Burger has been researching the identification of sex-attracting pheromones of dung beetles for almost two decades, and they appear to have highly complex pheromone dissemination and detection techniques. Some species, for example, release the pheromones 'packed' in tiny protein particles – almost as though the message is sent off to the opposite sex in an envelope to ensure its integrity! Others use so little material that it cannot be detected by the most modern analytical instruments, in which case an antenna of the insect has to be connected to an amplifier to construct a 'living detector' with which the pheromone can be detected.

Products from polymers



Looking at a membrane used for treating industrial effluent with a new ultrasonic imaging technique that can see both the membrane and any layers of deposit that form on top of it

Novel uses of polymers now apply nanotechnology, involving objects that are too small to see with the human eye.

Polymers are large molecules, consisting of repeated chemical units joined together, usually in a line like beads on a string. They can be natural: they comprise 57% of the earth's material, including rock-forming minerals, the tissues of animals and plants, sand and glass; or synthetic, for example the organic materials that make life comfortable, such as your mattress and pillow, discardable nappies, contact lenses, hip joints, medicinal capsules, cosmetics and hair sprays. Most of the plastics that make up the paraphernalia that fill our lives are made of polymers!

So, unsurprisingly, polymer science is an interdisciplinary field. Ron Sanderson and his team of researchers at the SU Institute of Polymer Science are working on a wide range of applications of polymers as coatings, including those for decorative paints; for paper that must remain recyclable yet perform like a plastic laminate; for making insecticidal mosquito nets to fight malaria; and for steel in an attempt to remove the hexavalent chromium that can contaminate water supplies, such as those which were the subject of the lawsuit filed by Erin Brokovich in the movie with the same name.

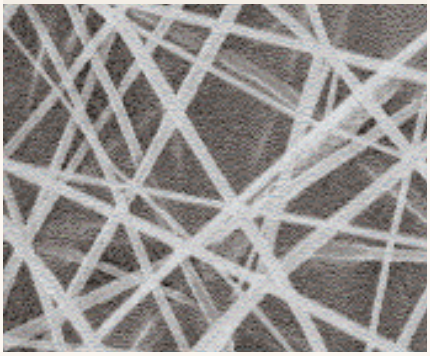
Sanderson's group has been investigating ways of using by-products from Sasol's plants to produce new useful polymers, especially paint binders and adhesives for the export market. They characterise commercial polymers, blend them with other substances, study the effect that these additives may have, and derive their structural morphology and properties, all of which can improve their export potential.

In collaboration with other universities, they have been synthesising the materials for producing membranes, especially those that can desalinate water; strip out colour for drinking water from dams and rivers; and purify industrial effluents by recycling water so that rivers and the sea are less polluted.

Other projects on the go include the development of "green" recyclable technology for the packaging industry, printing papers and board for ink jet printers to make hard copies of, for instance, digital camera photos.

Novel uses of polymers now apply nanotechnology, involving objects that are too small to see with the human eye. Here product development for the health industry is focused on three projects. The first, in collaboration with the Chris Barnard Clinic for Thoracic Surgery at the University of Cape Town, aims to produce minute hydrogels and scaffolds for heart bypass prostheses. The second, in collaboration with the SU Biochemistry Department, aims to mimic natural anti-tumour agents, which may help as a new agent in health care. The third involves improved materials for wound dressings and treating skin blemishes.

Nano-electrospun fibres in cloths for antiseptic wound or burn dressing



www.mrc.ac.za/anxiety/anxiety.htm and www.mentalhealthsa.co.za

False alarm! The neuroscience of anxiety

Anxiety is a crucial aspect of human experience, and descriptions of anxiety date back to the beginning of history. At the same time, anxiety is one of the newest of fields. Advances in a range of disciplines and technologies, including brain imaging and genetics, have provided novel insights into brain mechanisms that underlie anxiety and promise to lead to new treatments for people who suffer from anxiety disorders (see box).

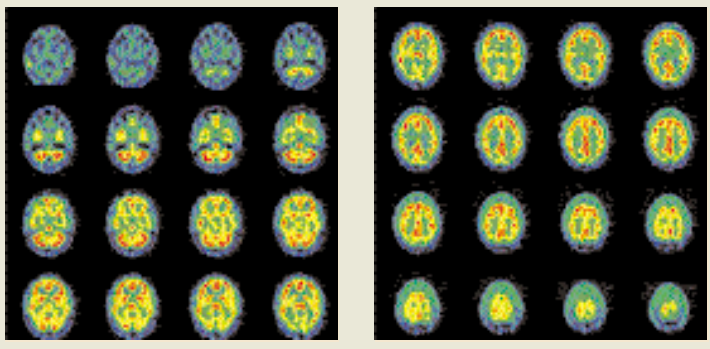
"Much of our work begins with the hypothesis that each of the anxiety disorders represents a kind of false alarm," say co-directors of the SU/MRC Unit on Anxiety Disorders, Dan Stein and Soraya Seedat. "During the course of evolution, humans have developed a range of normal alarms, such as a fear of strangers in infants. Anxiety disorders develop when there is excessive triggering of such responses." This hypothesis represents a radical shift in psychiatry. Until fairly recently, for example, obsessive-compulsive disorder (OCD), an anxiety disorder that is characterised by excessive hand washing and other repetitive responses, was conceptualised as a rare condition originating from unconscious conflict. Today, it is recognised as one of the most common neuropsychiatric disorders, and the tenth most disabling of all medical conditions.

To explore the false alarm hypothesis of anxiety disorders, the multidisciplinary team of researchers in the Unit focuses on understanding the underpinnings of these conditions, using a range of different methods. One approach is to determine whether pathological behavioural patterns in animals are associated with particular kinds of biological changes. A recent study found that monkeys with stereotypic symptoms reminiscent of OCD respond to medications that act on the serotonin neurotransmitter system. A second exciting area of research, conducted in collaboration with the SU Nuclear Medicine Department, involves the use of functional brain imaging. One such study indicated that when particular medications are used to treat people with post-traumatic stress and other anxiety disorders, this leads to deactivation of the limbic system, which is important in mediating fear.

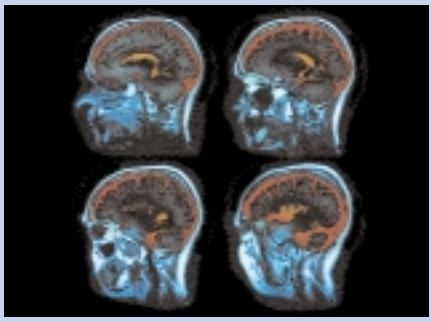
The international human genome project has led to greater understanding of how nature and nurture interact to influence behaviour. In collaboration with the SU/MRC Centre for Molecular Biology, two young researchers from the Unit are searching for normally-occurring gene variants that predispose people to develop OCD. They have found that early onset OCD is associated with specific variants in a neurotransmitter system known as dopamine. This might help explain why early onset OCD is often associated with tics, which are thought to be mediated by the dopamine system.

The Unit also undertakes clinical trials of new medications for the treatment of anxiety disorders. Its members recently published the first open label trial showing that certain kinds of medication can be useful for treating adolescents suffering from post-traumatic stress disorder (PTSD), and it has also made contributions to the pharmacotherapy of OCD, social anxiety disorder, and trichotillomania.

Stein and Seedat emphasise that the Unit's researchers are committed to translating basic neuroscience into clinical and community benefits. Many of its projects are therefore community oriented – for example, a recent study examined whether participation in the Truth and Reconciliation Commission provided protection against the development of PTSD. In addition, the Unit has established a mental health information centre to liaise with the public and help destigmatise psychiatric disorders.



This SPECT scan of a patient with obsessive compulsive disorder (OCD) demonstrates markedly increased perfusion in ventral cortico-striatal circuitry, a finding that is characteristic of this condition.



Anxiety disorders comprise various different conditions, including:

- Obsessive-compulsive disorder, characterised by obsessions such as recurrent intrusive thoughts or images that increase anxiety, and compulsions such as repetitive patterns of behaviour or mental acts employed to neutralise obsessions.
- Panic disorder, characterised by panic attacks – surges of anxiety with physical symptoms, e.g. a racing pulse, feeling short of breath, chest pain, sweating, or trembling, and accompanying thoughts such as the urge to flee, that affect patients out of the blue.
- Phobias are marked by an intense fear of specific things or situations such as animals or insects, natural situations such as heights or closed space, blood, needles or injury, with associated subsequent avoidance of these.
- Post-traumatic stress disorder, comprising anxiety symptoms after a traumatic event, e.g. assault, rape or a natural disaster. These symptoms include thoughts and memories of the trauma, avoidance of places and people associated with the trauma, and being very aroused.
- Social anxiety disorder is characterised by fear of embarrassing or humiliating oneself in social situations that involve performance, e.g. speaking in public, eating, drinking or writing in public, or interactions such as dating or being the centre of attention.
- Trichotillomania is a condition that compels people to pull out their hair. Although not classified as an anxiety disorder, it has some overlap with obsessive-compulsive disorder in that it is characterised by repetitive, stereotyped behavioural patterns.

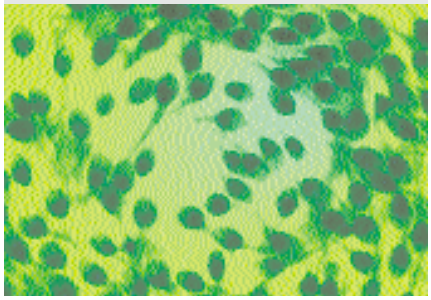
Exploring infertility in men and women

Historically, women have always carried the responsibility for infertility, but with the development of the science of sperm morphology, it has become increasingly clear that men are responsible in about 40% of all cases. These result from both genetic and environmental factors, including stress. Reports of declining sperm counts, an increasing incidence of urogenital abnormalities and testicular cancer in some regions, and evidence of the role of environmental pollutants in male reproductive function have focused the research spotlight in reproductive medicine on subfertile males. Recognising the importance of sperm morphology as a predictor of infertility, Thinus Kruger, Danie Franken and a team from the SU Obstetrics and Gynaecology Department and the Tygerberg tertiary hospital are studying sperm quality, by comparing the semen profiles of fertile and subfertile males.

They are currently evaluating the quality of sperm throughout the world (South America, Europe and Africa) using a set of strict criteria for the evaluation of human sperm morphology. "Such comparisons enable researchers to determine the threshold between fertility and subfertility more accurately," says Kruger. Tests are used to analyse the number of sperm in semen, how many are moving and how many are of the uniform oval shape. The quality of sperm cells is determined by their shape: the typical normal human spermatozoa consist of a smooth oval or acorn head with an intact mid-piece and tail section, such as the example shown below. Men with this type of cell are unlikely to have problems producing children.

The SU team described the first thresholds to distinguish between fertile and subfertile males as long ago as 1986. These thresholds were accepted by the World Health Organisation as an international standard for the evaluation of male fertilty, specifically to assist clinicians in the area of in vitro fertilisation. The thresholds are known as the 'Tygerberg strict criteria' and they have played a key role in the management of infertile couples in countries all over the world.

Human sperm firmly bound to the zona pellucida

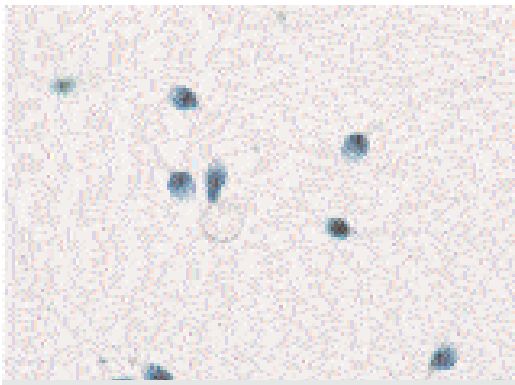


Kruger emphasises the importance setting reliable standards for estimating the likelihood of a man's fertility. To ensure the reliability of the standard measurements of fertility and subfertility, sperm profiles are constantly being refined to supply the clinician with prognostic criteria to council patients more effectively, not only in the area of assisted reproduction, but also to determine if a couple could conceive naturally.

With sperm morphology as the reference point, the Tygerberg team has studied the clinical significance and fundamental physiological aspects of human gamete interaction, in particular how human sperm binds to the zona pellucida – a clear coating or layer that surrounds the human oocyte (egg cell), rather like the white of a chicken egg. This results in the physiologic induction of what is known as the acrosome reaction. The acrosome is the membrane that surrounds the sperm head, and which is shed when the sperm prepares itself to enter the oocyte. Since the mid-1980s, Franken and his team have been using specialised in vitro bioassays, developed in the Stellenbosch/Tygerberg laboratories, to record these interactions. One provides information on the sperm-zona pellucida binding capacity of a specific sperm sample. A second supplies data on subtle changes in the acrosome reactivity of the human sperm.

Both tests are employed as techniques to measure changes in sperm populations that occur after exposure to specific compounds, and both facilitate environmental toxicology studies on human reproduction by evaluating changes in sperm function among a population that is exposed to environmental waste. Other studies are evaluating the role of DNA disorders among men diagnosed with subfertile semen characteristics. "The unveiling of the basic mechanisms involved in human gamete interaction will ultimately allow for the development of new male reproductive diagnostic capabilities, as well as the design of improved and safer therapies aiding conception in childless couples where male infertility is a factor," says Franken.

Another revolutionary new intervention has been the use of assisted reproductive technology (ART) to manage infertility, which resulted in the birth of the world's first test tube baby in Britain in 1978. The SU Reproductive Biology Unit has been at the forefront of research in this field since the beginning of the revolution in reproductive medicine, and in 1984, its members were instrumental in the birth of the first test tube baby in Africa. Subsequently, the SU team of clinicians and researchers pioneered the country's first frozen embryo pregnancy, and performed the first successful micro-injection procedure, called intracytoplasmic sperm injection. By injecting a single spermatozoon into the cytoplasm of the oocyte, fertilisation can be stimulated and development of an embryo can occur which can result in a pregnancy. This research underpinned the successful clinical management of hundreds of couples from Africa, and many other parts of the world, who were previously unable to conceive.



Human spermatozoa

At present, the team is developing semen thresholds for in vivo fertilisation, which should enable clinicians to predict a couple's pregnancy chances at home, without ART interventions. Under the jurisdiction of the Stellenbosch group, an ongoing international study is also looking at semen profiles of fertile men in Argentina, Turkey, Switzerland and South Africa. "It is possible that a sperm with DNA damage can still fertilise eggs, but the embryo will have poor potential. This aspect of a male's contribution is being studied to attempt to select better quality sperm with no DNA fragmentation to use in assisted reproduction. Since this is a prospective study, data will be available only within the next two years," says Kruger.

www.sun.ac.za/wine_biotechnology/

Biotechnology and wine

The South African wine industry is currently facing new challenges. Not only has globalisation of the wine market resulted in increased competition, but the focus of this market is no longer solely directed towards quality. The emphasis has shifted in two directions: maintaining consistency while favouring the expression of typical characteristics, i.e. wines that reflect their geographic origins; and environmentally friendly production.

How can biotechnology contribute towards these ends? Wine may in fact be the oldest documented biotechnological invention, with archaeological evidence suggesting the existence of specific winemaking equipment some 10 000 years ago. The modern buzzword 'biotechnology' is not often associated with this ancient process, which is frequently perceived as shrouded in mystery and even as belonging more to the world of arts than to the one of brute technology. Yet, the transformation of grape juice by micro-organisms within specifically designed containers certainly fits the definition, and the fundamental principles of vineyard cultivation and vinification have remained largely unchanged for centuries. But during the last two decades, second-generation biotechnological products – including purified enzymes and specifically selected yeast strains – have been incorporated into the winemaking process, and have led, together with changes in viticultural practices and cellar technology, to improvements in both production processes and wine quality.

Within this context, the only way that the South African wine industry can meet its future challenges is by ongoing investment in – and the rapid adoption of – new technologies. Genetic engineering, in particular, is predicted to play an essential part in the future development of all agricultural and agro-processing practices. Although the advent of genetically modified agricultural products has encountered some resistance from customers, mainly in Europe, the tremendous potential of this technology is likely to ensure its future application on a large scale. Biotechnology promises new and sustainable solutions that could address the problems associated with the currently unsustainable way that arable land is being used to increase production. Since 1995, the Institute for Wine Biotechnology at the SU, with financial support from the local wine industry, and the South African Department of Trade and Industry, has focused its research efforts on genetic improvement of the two most important organisms required for the making of wine: grapevines and wine yeast.

Several research projects focus specifically on reducing the environmental impact of viticulture. Melane Vivier is investigating ways of improving resistance of vines to a range of pathogens which cause diseases, for example grey rot. Initial results are extremely promising, with genetically modified grapevines showing significantly increased resistance in glasshouse trials. The use of such vines has the potential to reduce greatly the harmful environmental effects associated with the current practice of spraying with pesticides.

Several projects, conducted by Florian Bauer and Pierre van Rensburg, are aiming at improving specific aspects of processing, in particular colour extraction, filtration and clarification. For this purpose, the institute is developing wine yeast strains that produce specific enzymes that either enhance colour extraction, or digest macromolecular compounds that would otherwise have to be filtered out of the wine. Some of these yeasts have been used in experimental wines produced on a small scale, and have been shown to achieve these objectives without any reduction in quality!

When a wine drinker assesses the 'nose' of a wine, he or she smells a particular combination of aromatic compounds produced by the grapes and the yeast strains which fermented the juice. Maret du Toit and Florian Bauer are researching the possibility of modifying the metabolism of specific wine yeast strains to reduce the production of unwanted by-products, while retaining or increasing the desirable delicious aromas associated with fine wines.

The benefit to human health associated with moderate wine drinking has been established empirically. In particular, compounds that are found in high concentration in red wines called antioxidants have been shown to prevent cardiovascular diseases. Maret du Toit is trying to extend the benefits that can be derived from the drinking of wine, by engineering yeast strains which produce these compounds. Her ultimate aim is to increase their concentration in both red and white wine – where they are also present – but in naturally lower concentrations on account of the skin being removed from the fruit earlier in the winemaking process.

Both the wine industry and the wine consumer stand to gain significantly from further developments of modern biotechnology. It is highly likely that the greenest and cleanest quality wines of the future will be derived from grapes and fermented by yeast that have been genetically optimised for this purpose.

A postgraduate student in the Institute assesses the growth of a yeast culture.

Microbiology of biomining

The world's first gold-bearing, arsenopyrite bio-oxidation plant built at the Fairview mine, Barberton, South Africa.

Most people do not associate microbes with mining, but micro-organisms can actually be used to extract metals from both sulphide and iron-containing ores and mineral concentrates.

Most people do not associate microbes with mining, but micro-organisms can actually be used to extract metals from both sulphide and iron-containing ores and mineral concentrates. With the help of funds from the mining company BHP-Billiton, the National Research Foundation and THRIP, Doug Rawlings and his group in the SU Department of Microbiology are trying to find out about the gene pool that is shared by microbes that live in a biomining environment, and how the conditions under which they operate can be optimised for industrial purposes.

The most important mineral decomposing microbes are the iron and sulphur-oxidising bacteria. These organisms grow by fixing carbon dioxide from the atmosphere, and their modest nutritional requirements are provided by the aeration of an iron or sulphur-containing mineral. As sulphuric acid is produced during the oxidation of inorganic sulphur, these organisms grow in low-pH environments. Aeration may take place either in a stirred tank, or during the irrigation of a mineral-containing ore that has been stacked in a specially constructed heap. Small quantities of inorganic fertiliser may be added to ensure that nitrogen, phosphate and trace element limitation does not occur.

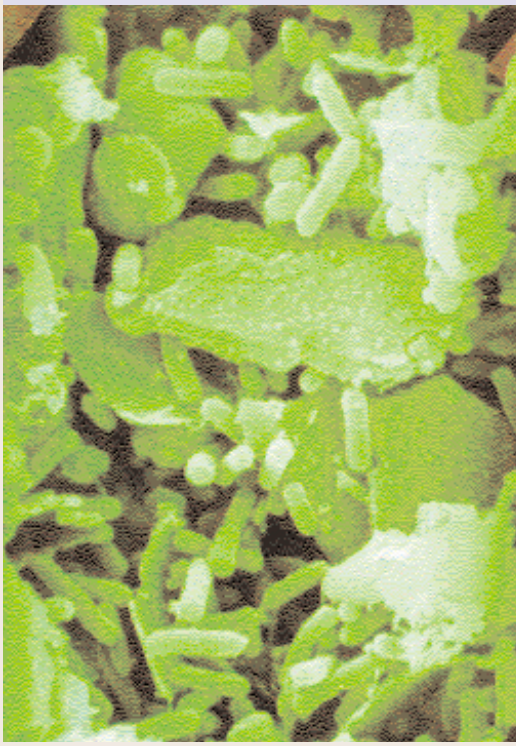
When iron and sulphide are oxidised by bacteria to produce ferric iron and sulphuric acid, these chemicals convert the insoluble sulphides of metals such as copper, nickel and zinc to soluble metal sulphates that may be readily recovered from solution. Although gold is inert to microbial action, microbes can be used to recover gold from certain types of minerals because as they oxidise the ore, they open its structure, thereby allowing chemicals in which gold is soluble (such as cyanide) to penetrate the mineral.

The types of bacteria that are present in the mineral bio-oxidation process differ depending on the temperature at which mineral decomposition takes place. The work of Rawlings's research group is currently focused on three types of bacteria, *Leptospirillum ferriphilum* (an iron-oxidiser) that grows at 40 °C and *Acidithiobacillus caldus* (a sulphur oxidiser) and *Sulfobacillus thermosulfido-oxidans* (an iron and sulphur oxidiser), both of which can grow at a temperature of up to 50 °C.

In general, the microbes involved in biomining are well adapted to growing in their inorganic, mineral-rich, acidic environment. Nevertheless, there are some areas in which they can be improved. For example, although these bacteria are highly resistant to many metals, some are sensitive to metals or ions such as chloride and two forms of arsenic – arsenite and arsenate. As part of their current research, the group is studying at least three sets of arsenic resistance genes from a highly arsenic-resistant *Acidithiobacillus caldus* isolate to try and discover how it became so resistant.

Research is also under way to investigate from which organisms the arsenic resistance genes were acquired. This is part of a more comprehensive study by this group into what sorts of genes are found in the 'horizontal' gene pool that is shared by microbes that live in a biomining environment. The gene pool is termed 'horizontal', as it is capable of being transferred between microbes and serves as a source of genes for new properties that may be recruited as required. Research into small pieces of DNA known as plasmids, many of which are capable of transferring DNA between different types of bacteria, is also a focus of this group.

Rod-shaped, iron and sulphur-oxidising bacteria growing amongst mineral particles



Research and innovation in the service of South African society

It is generally assumed that scientific research and innovation should translate into significant social and economic benefits to all the citizens of a country. There is growing evidence that national investments in research and technological innovation do in fact produce long-term sustained economic growth as well as improvements in people's quality of life. Various factors affect the science and innovation capacity of a country, but none more than its human capital resources, as countries seeking to compete effectively in the new global knowledge society require a skilled workforce. The Centre for Research on Science and Technology at SU, headed by Johann Mouton, has undertaken various studies on the South African research and innovation system over the past eight years. In a recent study, it focused on the human capital base of the system and discovered a number of very worrying trends as far as the R&D workforce of the country is concerned.

The South African scientific workforce is ageing, with few young replacements being attracted to the system. Figure 1 shows how the age of publishing scientists has shifted quite dramatically from 1990 to 2000. Whereas only 20% of those who published peer-reviewed articles in 1990 were above the age of 50, this proportion has increased to 49% in 2000. This trend – should it continue – has far-reaching implications for the knowledge base of the country. Not only does it indicate that our scientific output is likely to continue to decline, with an inevitable severe drop in the next decade, but it suggests that we are either not successful in attracting young publishing scientists into the system. These trends point to deep structural problems in our national system of innovation that require urgent attention.

The South African scientific workforce is ageing, with few young replacements being attracted to the system.

Figure 1: The ageing of the S&T workforce

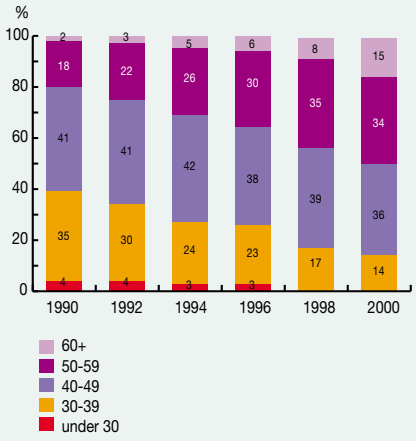
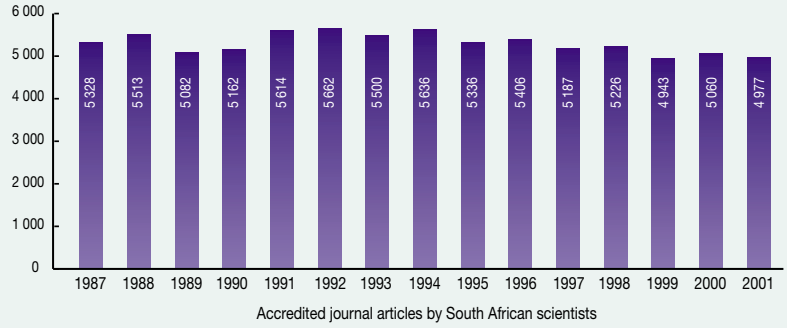


Figure 2: Scientific output: 1987 to 2001



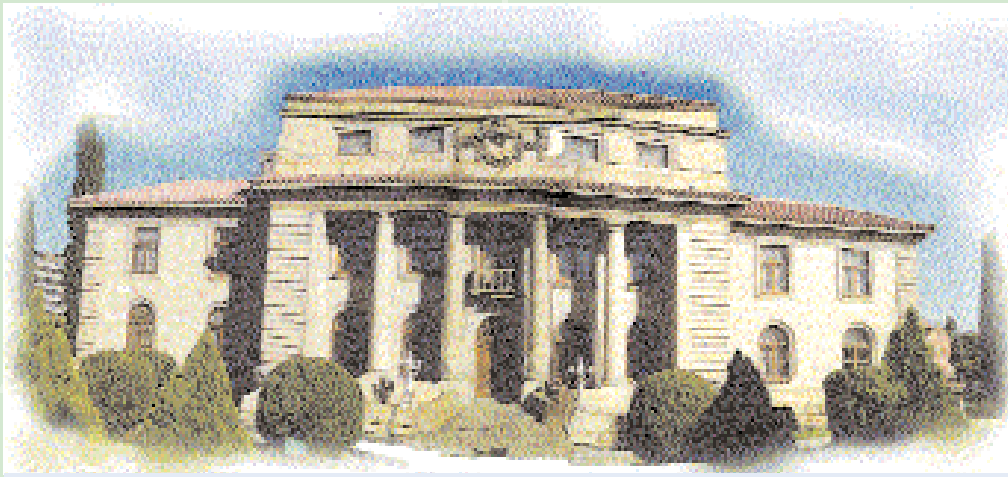
The Centre's research has also shown that there has been no significant change in the demographic profile of publishing scientists since 1990, with white male authors still dominant in this field of endeavour. The Centre's analysis shows that white scientists still produce more than 90% of all articles published by South African scientists. Similarly, men continue to dominate scientific production with more than 83% of all publications produced by male authors. This latter figure is even more significant if one keeps in mind that more than 40% of all academics in South African universities and technikons are female.

These trends in the size and shape of the science and technology (S&T) workforce in the country need to be assessed in the context of overall scientific output. When measured in terms of peer-reviewed articles in accredited scientific journals (Figure 2), the results for the past fifteen years clearly show how total scientific output has hardly increased within the past decade. It is therefore not surprising that South Africa's share of global scientific output (as measured in ISI-linked articles) is declining. Whereas we produced nearly 0,7% of all output in 1987, we have subsequently dropped to less than 0,4%.

The Centre's research on the S&T workforce has already had a significant impact on science and technology policy in the country. Its work on the ageing of the scientific workforce has informed recent policy documents of the government (the National Plan on Higher Education and the new R&D Strategy), while we assembled much of the official *S&T: Facts and Figures* document released by the National Advisory Committee on Innovation in 2002.

Constitutional interpretation

Established in 1997 as a joint venture of the universities of Stellenbosch (SU) and the Western Cape (UWC), the Research Unit for Legal and Constitutional Interpretation facilitates research on how to read and implement South Africa's new Constitution. South Africa had never had a constitution as highest law, so since our transitional and subsequently our final constitutions were enacted in 1994 and 1997, respectively, there has been a need to consider the impact of the supreme Constitution on statutory interpretation in a systematic and detailed manner.



South Africa's Supreme Court of Appeal in Bloemfontein.

Generally speaking, jurists feel comfortable when, with confidence and certainty, they can state: "This is what the law says!" When interpreting enacted texts (such as acts of parliament or regulations promulgated by an organ of the executive) the professed clarity and unambiguousness of the language of the text in question boost the said confidence and certainty. The clear and unambiguous language of a law, so the conventional belief goes, should be given effect to without ado because it is a reliable manifestation of the intention of its author, the legislature. Interpretation actually becomes an issue only when the language of a law is unclear and/or ambiguous. The interpreter, usually a judicial officer, then has to invoke recognised canons of construction or other interpretive aids in order to retrieve the intention of the legislature from the text. This, in a nutshell, is the conventional, most widely recognised, literalist-cum-intentionalist approach to the interpretation of enacted law.

South Africa's transitional Constitution ushered in a new dispensation premised on a Constitution as highest law, which is couched in all but clear and ambiguous language. Its successor, the present Constitution, is similarly a text couched in characteristically general and open-ended language. This textual style stands in contrast with the prevalent, English common-law inspired style of drafting enacted law in South Africa. In the common-law tradition enacted legal rules are most often drafted in detail, endeavouring to cater, as explicitly as possible, for numerous particular instances and to close as many loopholes as possible, lest the legislature's will be misunderstood and misapplied. This style of draughtsmanship, producing long-winded and often esoteric formulations, anticipates a literal reading of enacted law. In civil-law legal systems on the European continent the language of enacted legal norms is, by contrast, characteristically inclusive and open-ended – as is the text of South Africa's Constitution.

The Unit's researchers, under the direction of Jacques de Ville and Lourens du Plessis, have shown that the openness of the constitutional text poses a challenge rather than a threat to legal interpreters. Meaning can never be said to be fixed because it is generated through a dynamic and complex interplay of linguistic signifiers. The language of any legal text (including an enacted law text) is not retrieved from within the text, but is made and agreed on in dealing with the text. No meaning resides in the text. These insights are associated with what is also known as the *linguistic turn* in legal interpretation.

Jurists desirous of the confidence and certainty that they believe the conventional literalist-cum-intentionalist approach has to offer, are quite sceptical about the linguistic turn claiming that it is likely to promote an undisciplined attitude of 'everything goes' among legal decision-makers and that this attitude will, in the long run, undermine legal certainty. But the Unit has questioned this view, and endeavoured to show that these fears are unfounded. First, no language is clear and unambiguous and jurists interpreting enacted texts in this mistaken belief, very often hide behind the language of texts to shirk the responsibility of really engaging with these texts in order to arrive at a just interpretation in the circumstances of each particular case. Second, the insights associated with the linguistic turn are not necessarily incompatible with conventional canons of construction if the latter are re-understood and appropriately reformulated. Third, acceptance of the full consequences of the linguistic turn, far from inducing an undisciplined and irresponsible 'free for all' attitude among jurists, emphasises the huge and often awesome responsibility of legal – and, in particular, judicial – decision-makers. Under no circumstances can these decision-makers be relieved from *personal responsibility* for the decisions they make. They cannot hide behind the fictitious 'clarity and unambiguousness' of the language of the texts they are called upon to construe, because the perennial open-endedness of language always leaves them with a choice.

South Africa's transitional Constitution ushered in a new dispensation premised on a constitution as highest law, which is couched in all but clear and ambiguous language.

www.sun.ac.za/virology/dept/default.htm

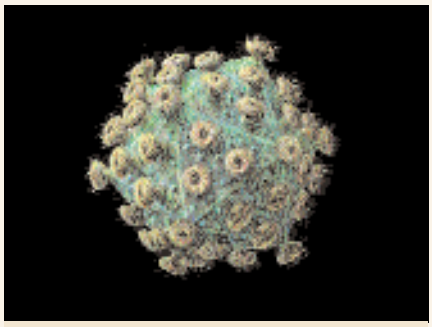
Developing an HIV vaccine for Southern Africa

Stellenbosch scientists are contributing towards the development of a vaccine to contain the HIV/Aids pandemic that is decimating communities in sub-Saharan Africa. Working in collaboration with an American biotechnology company and using recombinant DNA technology, the Stellenbosch team is working on a combination vaccine that will specifically target HIV subtype C – the strain of the virus most prevalent in Southern Africa, India and China.

Stellenbosch scientists have been at the forefront of retroviral research right from the start, by establishing the first retrovirus culture facility in the country – and on the African continent. Before the outbreak of the pandemic in the early 1980s, they were studying the newly discovered retrovirus family, of which HIV is a member, including related simian viruses occurring in African primates. Subsequently, the establishment of a molecular biology laboratory in the Faculty of Health Sciences enabled scientists to study the genetic characteristics of HIV strains circulating in South Africa, especially when it became clear that the infection was not confined to the homosexual community, but was spreading heterosexually. A collaborative study with the Primate Institute in Nairobi to characterise retroviral strains in primates from east and southern Africa, led to the first description of a simian immunodeficiency virus in the chacma baboon – one of only three simian immunodeficiency viruses discovered in baboons in Africa.

Thus the Stellenbosch scientists were particularly well placed to join a multicentre interdisciplinary programme initiated by the South African government in 1999 to produce an effective, affordable vaccine – South Africa's Aids Vaccine Initiative, run by our Medical Research Council. Although the Stellenbosch team has had access to multiple viral strains since the beginning of the epidemic, vaccine development was a new field for scientists when they embarked on the project in 1999. They therefore entered into a collaborative agreement with the Chiron Corporation of San Francisco, one of the world's leading biotechnology companies working in the field of viral vaccines. For the construction of the vaccine, the various scientists involved in the project selected a viral strain isolated in the Department of Medical Virology in 1998.

The vaccine currently under development endeavours to stimulate both arms of the immune system by making neutralising antibodies, and launching a strong cell-mediated response. Since this approach requires a combination vaccine, it is known as a prime boost strategy. The immune system is first primed with a DNA vaccine and then boosted with a second vaccine, comprising a live vector/protein. The premise of the approach is that by forewarning the immune system about the appearance of the virus, the immune system will respond with a swift, focused and suppressing counter-attack if and when HIV infection occurs.



An illustration of the human immunodeficiency virus (HIV)

Stellenbosch scientists have been at the forefront of retroviral research right from the start, by establishing the first retrovirus culture facility in the country – and on the African continent.

Emphasising the importance of the dual approach, team leader Estrelita Janse van Rensburg says it is accepted worldwide that a single vaccine will not contain the virus. "It is widely agreed that an HIV vaccine should both fight and contain the virus. Some vaccines currently being tested on humans are already outdated in terms of these new insights and initiatives."

The teams from Stellenbosch and Chiron have made rapid progress over the last three years, and the first part of the vaccine was manufactured in California and shipped to South Africa in late 2002 for testing on baboons. The team has already started with the immunisations, but the full study will take at least a year to complete.

Dr Richard Glashoff (left) and Dr Walter Liebrich (right) are both involved with assessing the immunogenicity of candidate vaccines.

Bioethics

Bioethics is both a very old and a very new discipline. In its original manifestation as medical ethics, it has been known since the time of early Greek philosophy which produced the Hippocratic Oath – still the symbol of the medical practitioner's commitment to a life of service and moral rectitude. The 1960s saw a notable rebirth of interest in – and reflection on – the moral aspects and challenges of medicine and the life sciences in general – hence the term 'bioethics'.

This rebirth was precipitated by a number of events and phenomena. Firstly, dramatic technological advances, such as renal dialysis and transplant surgery demonstrated an unprecedented expansion of medical power over disease, which generated questions about its reach and limitations. Secondly, the Second World War and its aftermath, including the rising new tide of a human rights culture in most of the world, revealed that medical and scientific practice is by no means value free, and could easily elope into morally dubious practices, such as the experiments on human subjects by the Nazis, the dropping of atom bombs on Hiroshima and Nagasaki, the Chernobil diasaster, and, closer to home, the treatment of Steve Biko by medical practitioners. Thirdly, the enormous power of medicine to control disease and relieve suffering brought, in its wake, a growing realisation of the enormous costs associated with the execution and extension of these powers.

The enormous power of medicine to control disease and relieve suffering brought, in its wake, a growing realisation of the enormous costs associated with the execution and extension of these powers.

Research in bioethics at Stellenbosch has started as a systematic programme in the early 1990s, and is undertaken by a unit led by Anton van Niekerk, which has done both theoretical and applied work in the field. Central to the Unit's research has stood the moral ramifications of one of Africa's most serious problems, HIV/Aids. Resources for health care are limited, and those limitations raise difficult questions about priorities for and access to health care, as the HIV/Aids phenomenon in Africa has demonstrated dramatically over the past decade.

Above all, what is required in South Africa to curb Aids is a national, co-ordinated and comprehensive treatment and prevention campaign that has the prevention of mother-to-child transmission (MTCT) as a core component. The fact that such a programme is as yet not fully operational, is a serious moral indictment of this country's official health care policies. The most serious impediment to the humane and effective management of MTCT is not a lack of knowledge, the unavailability of drugs, the infrastructure to make them available, or their unaffordability. It is the lack of political will and the denial of the seriousness of the problem on the part of the political leadership, particularly in South Africa.

Once this leadership assumes its rightful responsibility, all the indications are that aid from the rest of the world, both from governments and pharmaceutical companies, would be forthcoming, and a very significant reduction of MTCT could be expected. In other countries, similar programmes have been successful in reducing the number of cases of paediatric Aids caused by MTCT by an order of magnitude – from about one third to three per cent of mothers who are HIV positive.

It is also important to acknowledge that the Aids catastrophe compels us to reflect critically on the massive imbalances between

the wealth of Africa and the West, and thereby to rethink the requirements for human well-being on a global scale. Sub-Saharan Africa generates no more than 1% of the total wealth produced in the world. The buying power of all the countries south of the Sahara, except South Africa, in total just about matches that of a country such as Norway. The developed world can no longer ignore the fact that Africa is the home of 10% of the world's population, lives on 1% of the global economy, and carries 70% of the world's HIV/Aids burden. Aids shows compellingly that bioethics has to be understood and become operational on a global scale.

The situation surrounding Aids in Africa is one of many examples of the way in which women's health is threatened by inadequate social status. The social stigmatisation that threatens Aids victims is one of the most serious moral problems obstructing the pandemic's effective management. Can education in itself overcome this predicament? That remains unclear. What also has to be done is to rethink procedures of attaining informed consent that are better adapted to the communal strain in African patterns of identity formation. Of paramount importance is also the possibility of role models going public about their HIV status – a move that has been suggested for politicians in South Africa, but met with very little success. It has to be attempted on a wider scale – the crisis warrants even this possible intrusion of privacy, although such action should remain voluntary.

The situation surrounding Aids in Africa is one of many examples of the way in which women's health is threatened by inadequate social status.

The quest for the perfect pear

Blossoming orchard in the Western Cape

All over the world, the value of fresh fruit in our diet is gaining increasing recognition. Fruit is not only delicious and versatile, but also packed with essential vitamins and minerals. First-world consumers, although aware of these hidden benefits, also expect the fruit in their fruit bowls to be exceptionally attractive and free of external and internal disorders, and for this they are prepared to pay a premium.

South African-grown fresh fruit has long had a reputation for high quality, but in order to remain competitive on the international markets, only the best quality should be exported. So, improving fruit quality, and ensuring that fruit remains in good condition during its long journey to overseas consumers, is the motivation behind the research of Karen Theron and colleagues from the SU Department of Horticultural Science. These objectives are supported by the Deciduous Fruit Producers' Trust, Citrus Research International and the National Research Foundation, as well as the private sector.

External and internal fruit quality factors, such as size, colour, skin blemishes, sugar and acid content and flesh firmness, are primary determinants of the marketability of fresh deciduous fruit. Approaches used to improve fruit size include the stimulation of strong flowering buds, and achieving an optimal balance between vegetative tree growth and the number of fruits allowed to develop to maturity on each tree. The physiological bases of these interventions rest primarily on the production, net availability and preferential allocation of carbohydrates for fruit growth, which is in competition with other growing organs such as shoots and roots.

Another focus is the impact of our sunny, warm climate on fruit quality. Unsightly skin blemishes caused by sunburn, or insufficient red colour development, are major factors responsible for reductions of export-grade volumes. A recent breakthrough emerging from the doctoral project of Wiehann Steyn, is the improved understanding of red colour development and loss in blushed pear fruit, based on studies of factors influencing metabolism of anthocyanin and related enzyme activities. This showed clearly that there are cultivar-specific differences in colour stability and sensitivity to temperature fluctuations during the season. This insight will help breeders of new cultivars to select progeny which are not so susceptible to colour loss.

Similar problems with fruit quality are experienced in citrus production, and are being studied by Graham Barry and Etienne Rabe. For example, the physiology of yellow/orange pigments in the rind is being investigated in relation to the metabolism of a plant growth regulator. This should point the way to manipulations which could enhance pigment synthesis and thus fruit colour. The sugar content of citrus fruit is a prime determinant of eating quality. Previous research on the importance of light on sugar accumulation has resulted in the application of orchard pruning techniques to optimise light interception. Currently, the timing and severity of water-deficit stress on sugar accumulation, without adversely affecting fruit size, is being investigated.

An exciting new irrigation approach, the open hydroponic system, promises to increase deciduous and citrus orchard productivity and fruit quality through more effective application of water and mineral nutrients. The underlying eco-physiological responses of trees to this technology, as well as its effects on crop load and fruit quality, are being investigated, and preliminary indications are that tree responses are more complicated than expected.

Substantial losses are incurred during the period between harvest and point of sale, as a result of the deterioration of fruit quality during cold storage, shipping and distribution at overseas markets. So another strong research focus is on post-harvest quality, including chilling disorders, control of fruit ripening rates, and new developments in packaging for quality maintenance during the extended storage regimes required for export. In particular, valuable new insights have been gained regarding the ripening processes in pears and plums. Forelle pears produced in South Africa are prone to mealiness, an internal disorder characterised by poor texture and lack of juiciness. This was thought to result from insufficient post-harvest cold storage, but Elke Crouch has shown that, to the contrary, mealiness appears to be a chilling injury disorder. This research is being continued to further understand the biochemical changes involved, and to develop optimum protocols for cold storage of this variety.

Variability of red blush in Rosemarie pears

All over the world, the value of fresh fruit in our diet is gaining increasing recognition.

Meeting the global challenge of finding sustainable biofuel

In the nineteenth century, humans turned to fossil fuels – primarily crude oil and coal – for energy. These resources are not only unsustainable, but contribute to global warming. The production of biofuel from renewable plant biomass could provide a more environmentally friendly and sustainable alternative.

Man has always been dependent on plants as a source of food, fuel and protection. With the advent of industrialisation, particularly since the nineteenth century, humans turned to fossil fuels – primarily crude oil and coal – for energy. But use of these resources, which have been stowed away for millions of years, is not only unsustainable but introduces gases into the atmosphere which upset the earth's delicately balanced carbon cycle. Simultaneously, natural forests have been destroyed and the earth's capacity is yielding, with global warming being one of the consequences.

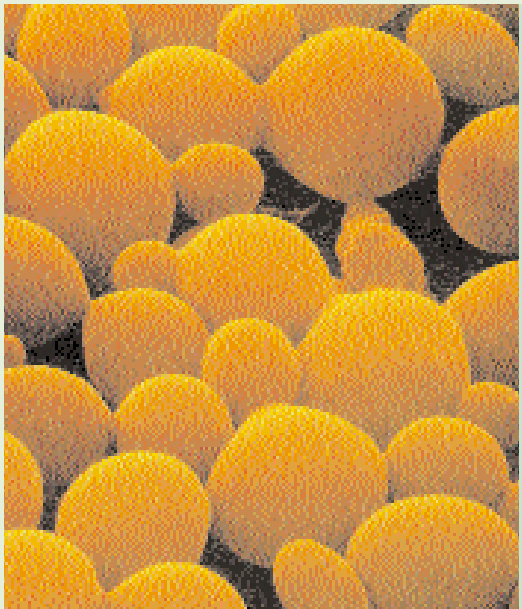
Plant material remains our most abundant renewable carbon source, with more than 4×10^9 tons available annually for conversion to energy and feedstuffs. In a similar manner to that in which yeasts are able to ferment grape and barley sugars into ethanol in wine and beer, the more adverse polymers in wood can be fermented, providing a cheap and sustainable source for the production of bioethanol as an alternative fuel. Using gene manipulation, Emile van Zyl and his collaborators in the SU Department of Microbiology, as well as in Sweden and in the USA, are developing baker's yeasts that may in future be used to produce this biofuel.

Funded by the Swedish STINT Foundation, van Zyl and collaborators at Lund are developing novel genetically manipulated yeasts that are able to metabolise and grow on xylose, the second most abundant wood sugar after glucose. Together with a newly established European consortium, van Zyl envisages the development of robust yeast that can ferment all the 6 and 5-carbon sugars present in wood to bioethanol, thus almost doubling the yield of existing technologies where only some of the 6-carbon sugars from wood are converted into ethanol.

In a second joint venture with the group of Lee Lynd at Dartmouth, USA, and funded by the SU Department of Energy, van Zyl's team is exploring the development of manipulated yeast that cannot only ferment sugars, but can degrade mildly treated wood and other agricultural by-products and simultaneously ferment the released sugars to bioethanol. This research includes prospecting for enzymes originating from microbes which naturally degrade wood and engineering these enzymes into yeast, enabling the yeast to both degrade and ferment woody material. The research is very much geared to a future generation of designer yeasts and major technological barriers still need to be overcome. But ultimately, not only should bioethanol be able to compete on price with existing fossil fuels, but its production should be sustainable. Bioethanol production would be based on agricultural by-products and biomass on land not used for conservation or food production.

Decaying tree trunk covered by white rot fungi (rack moulds)

This research is of particular relevance to South Africa as, traditionally, our agricultural industry does not process plant by-products. More than 15 million tons are wastefully discarded each year. Our landscape has also been infested with alien plants which, if left uncontrolled, contribute an estimated further 15 million tons of plant biomass annually. Both of these are potential sources of biofuel which van Zyl hopes to harness.



Electromicrograph of budding baker's yeast used for boiethanol production (left)

Yeast is engineered with enzymes from saprophytic fungi associated with plant decay (right).

Saving unborn babies from smoking and alcohol

In the last decades of the previous century, giant leaps in science and technology contributed to a significant improvement in maternal and newborn health. In most industrialised countries today, a woman can go through pregnancy and childbirth in the confident knowledge that the risk of death to herself or her baby, or even complications, is minimal and that dedicated specialists, technology and resources are available to take care of almost any eventuality.

In South Africa's Western Cape province, this reality is very different, especially in poor communities where women are often caught in a damaging cycle of disease, malnutrition and socio-economic ills such as excessive smoking and alcohol abuse. At provincial hospitals in the province, the most recent perinatal mortality rate is 18,5 for every 1 000 deliveries. This is very high when compared to the six to eight perinatal deaths per 1 000 deliveries in developed countries. In addition, the intrauterine to neonatal death ratio is 4:1, in contrast to a ratio of 1:1 in the industrialised world.

A patient being examined with the aid of the Umbiflow at the Perinatal Mortality Research Unit at Tygerberg Hospital. The device enables medical staff to detect problems without having to resort to expensive technology.

To determine why so many babies die before or during the first week after birth, the Obstetrics and Gyneacology Department in SU Faculty of Health Sciences established a Perinatal Mortality Research Unit in 1987 in collaboration with the MRC. "We also wanted to find ways of reducing perinatal deaths due to common conditions and improve the knowledge of midwives regarding perinatal care," says outgoing head of the Unit, Hein Odendaal.

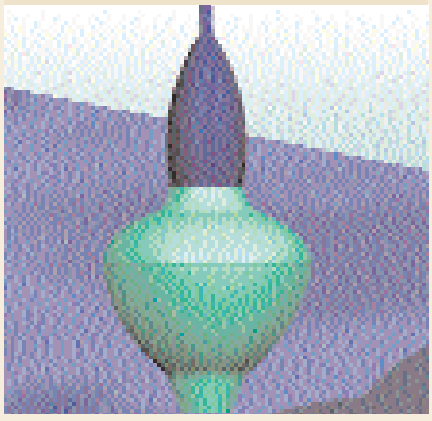
According to Odendaal, placental bleeding and pre-term labour cause almost half of perinatal deaths in Coloured women in the Western Cape. As a result of the Unit's work at the Tygerberg tertiary hospital, the perinatal mortality rate of mothers who received proper antenatal care at the hospital, improved from 35/1 000 in 1972-74 to 12,5/1 000 in 2002. "This excess of intrauterine deaths, is caused primarily by placental bleeding, but also by poor placental function," he says.

The rate of placental bleeding in Coloured mothers in the Western Cape is among the highest in the world, and indications are that cigarette smoking and alcohol use in pregnancy are probably the main causes. Both factors also increase the frequency of pre-term labour. The Unit has also reported that genital infection caused by the micro-organism *Mycoplasma hominis* is another cause of premature delivery.

Another cause of intrauterine death is poor placental function, leading to poor growth – and in some cases, death – of the fetus. However, poor fetal growth is commonly caused by less dangerous conditions. Sophisticated tests are usually recommended to confirm or exclude poor placental function. "It is essential to differentiate between the dangerous and less dangerous causes since an unnecessary premature delivery may lead to severe neonatal morbidity. On the other hand, delays in delivering may cause intrauterine death," says Odendaal.

In a developing country such as South Africa, medical staff in the public health sector do not always have access to sophisticated and expensive technology to monitor fetal growth. The SU group has found that measurement of the uterine growth with a simple tape measure and plotting it on a growth chart is a valuable screening test for poor fetal growth. Suspected cases with poor growth are then examined to determine the flow velocity in the umbilical artery. Poor flow velocity is indicative of placental insufficiency and therefore of fetal jeopardy. With the assistance of the MRC and the CSIR, members of the Unit developed a highly effective apparatus – the Umbiflow, which can be connected to a computer to measure placental function. Four prototypes of the apparatus are now in use at primary health care clinics in the Western Cape.

The ultrasound probe consists of a transmitter for the direction of the ultrasound waves to the umbilical cord of the fetus and a receiver for the waves, which have been scattered by the circulating fetal blood cells. The electronics inside the probe connect to a Pentium III computer via the USB port to analyse the degree of change of the initial sound wave.



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Our search for mammalian ancestry

In spite of the small difference in chromosome number between man and the last common ancestor of all eutherian mammals, the chromosomes are in combinations that differ radically from their present configuration in man.

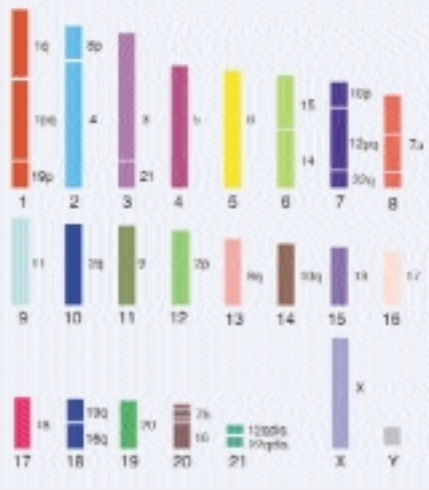
What do the aardvark, elephant, hyraxes, dugongs and manatees, tenrecs, golden moles and elephant shrews have in common? Not much, you might think, apart from all being mammals. But although there are no unique anatomical characters shared by these animals, there are many similarities in their DNA. A second common feature is their evolutionary history – all of them originated in Africa. Dubbed the Afrotherians, it has been proposed that they share a common ancestor that evolved when our continent was isolated from others when the ancient southern continent of Gondwanaland broke up about 105 million years ago.

This was the time when dinosaurs held sway on earth. Soon after their demise came the age of mammals, when the ancestors of the 18-odd different groups of mammals that exist today – including the Afrotheria – started to diverge from one another. Before the break-up of Gondwanaland, Africa and South America were contiguous and, interestingly, the nearest relatives to the Afrotheria are the Xenarthra – the sloths, anteaters and armadillos of South America. This suggests that the placental mammals (known as the Eutheria) may have originated in the south of Gondwanaland before tectonic movements of the earth's plates led to the present continents moving apart from one another.

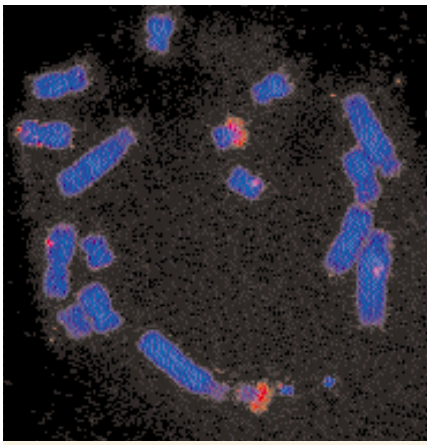
Terry Robinson of the SU Zoology Department and his collaborators here, in the UK and Russia are exploring these puzzling relationships, using an approach that tracks changes in the way the genetic material, contained in the chromosomes, has been reshuffled in the evolutionary past. By identifying these 'cytogenetic' signatures they aim to resolve the relationships among the Afrotheria, as well as place this group within the eutherian evolutionary tree.

Once these scientists have isolated single chromosomes from each Afrotherian representative, they can be used to make 'chromosome paints' to highlight regions of DNA sequence which are similar among species. Starting with the aardvark, Robinson and colleagues reciprocally 'painted' the chromosomes of the aardvark and man to assign areas of correspondence between their genomes.

They then expanded the study to include the African and Indian elephants, and their data suggest that the last common ancestor of the living mammals had 44 chromosomes, compared to our own 46. However, in spite of the small difference in chromosome number between man and the last common ancestor of all eutherian mammals, the chromosomes are in combinations that differ radically from their present configuration in man.



The postulated mammalian ancestral chromosomal complement. This ancestor's correspondence to the human chromosomal complement is indicated to the right of each schematic likeness, and with horizontal lines indicating breakpoints. Nine chromosomes have been conserved in toto since common ancestry (numbers 5-6; 9; 11; 13, 17-18; 20 and the sex-determining X chromosome). (From Yang et al 2003: Reciprocal chromosome painting among Human, Aardvark and Elephant (Superorder Afrotheria) reveals the likely eutherian ancestral karyotype. Proc. Natl. Acad. Sci. USA 100: 1062-1066).

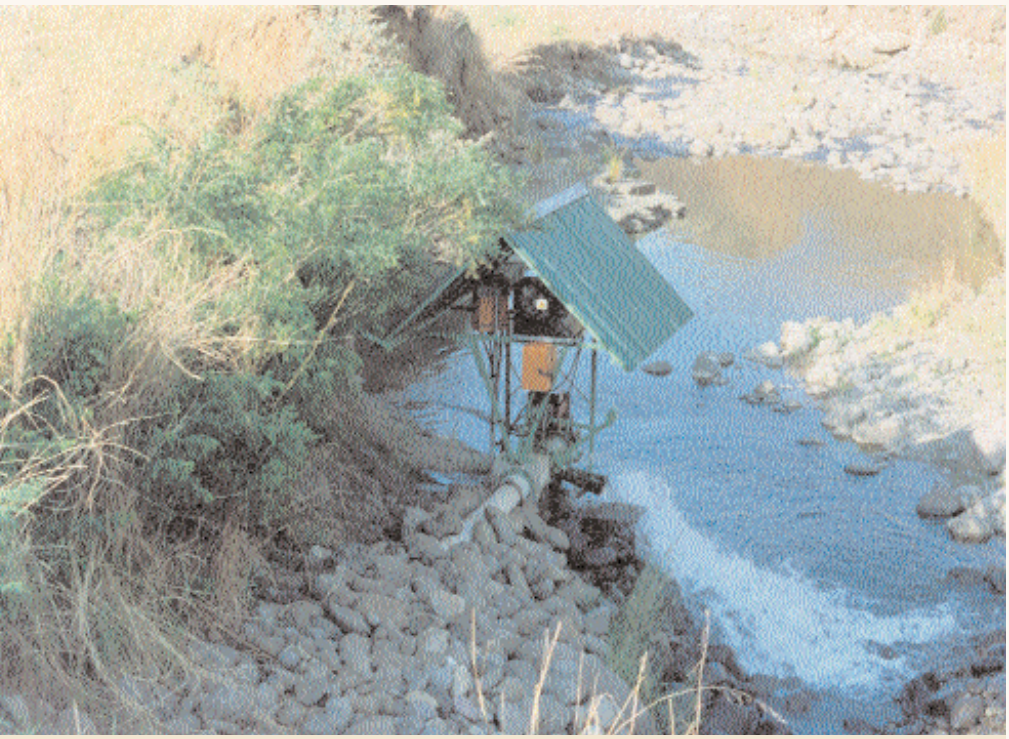


Cross-species painting using human chromosome 17 DNA showing common DNA sequences between this human chromosome (red) and the short arm of aardvark chromosome 8

These data are of intrinsic interest as they should help us to understand the role of spontaneous chromosomal rearrangements in speciation. But they may also have an applied spin-off, in testing the hypothesis that chromosome rearrangement breakpoints in human pathology and in evolution are correlated. Chromosomal rearrangements, similar to those that have 'reshuffled' the ancestral chromosomal complement, also appear to have a causal role in the genesis of tumours, with certain types of rearrangements often specifically associated with particular tumour types. Why then the difference – an evolutionary change in some instances, and in others a pathological condition?
The answer is not yet clear, but the availability of comprehensive genome sequence data for mouse and man has begun to provide some insight into the structure of the DNA sequences at these breakpoints.

This work has been supported by a grant to Robinson and his collaborator Malcolm Ferguson-Smith – of Cambridge University – by the Wellcome Trust. They are now extending comparative chromosome painting analyses to the remaining Afrotheria and the Xenarthra, which should contribute towards the development of an authentic evolutionary tree for all placental mammals.

Cost-effective energy for rural electrification



A power electronic voltage regulator connected to a micro-hydro generator

As recently as 1990, the majority of South Africans in disadvantaged communities had no electricity in their homes. At the beginning of the last decade, our national electricity utility, Eskom, together with municipalities around the country, started to address this problem seriously. Their endeavour was boosted when the government's Reconstruction and Development Programme set ambitious electrification targets in 1994, providing for 450 000 new households to be electrified per year until the turn of the century. These targets were exceeded, and electricity was installed in 2,8 million homes, improving the quality of life of approximately 20 million people and creating many jobs in the process. The challenge is to bring electricity to the rural areas, particularly in KwaZulu-Natal, and the Limpopo and Eastern Cape provinces, where two million dwellings (an estimated one third of all households nationwide) remain without electricity. Power Electronics is one of the key technologies which can provide cost-effective electrical energy to these communities.

The Power Electronics Group at the SU has been conducting research into the cost-effective electrification of remote areas since the early 1990s. The ability of power electronic converters to provide 'intelligent control' of electrical energy opens new possibilities in the generation, storage and distribution of electrical energy. Most of the power electronic systems developed by the group are based on a new type of solid-state switch (insulated gate bipolar transistors) in combination with state-of-the-art microcomputer technology.

One of the first projects undertaken in association with Eskom was the development of a universal semiconductor electrification device. This device makes it possible to convert a low-quality electricity supply to a well-regulated output voltage. The main aim of the device is to reduce the cost of conventional transmission lines by making it possible to use a low-quality transmission system. The transmission line may even be in the form of low-cost steel wire or a single-wire earth-return transmission system.

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During the last three years new electronic voltage regulators and electronic phase converters have been developed by the group. Due to the high cost of the standard three-phase transmission system currently employed, remote farms and rural communities are usually only supplied with single-phase electricity. The absence of a three-phase electrical supply makes it impossible to use high-power electrical equipment, for instance large electric motors. As a result, high-power pumps and hammer mills are usually powered by diesel engines. The converters allow cost-effective conversion of a single-phase supply to a three-phase supply, thereby providing energy which can be used by high-power agricultural equipment.

Recently a number of projects have focused on developing technology to provide electricity to informal settlements. A new voltage regulator, which does not require expensive energy storage components, has been developed. This device makes it possible to significantly reduce the cost per connection in informal settlements. Another research project has resulted in the development of a new converter that makes it possible to use direct – as opposed to alternating – current distribution in such settlements. This device enables the transmission of more power through the existing distribution system, while providing an effective method of combating the illegal use of electricity. This is achieved by making use of the fact that it is difficult to convert a DC (direct current) voltage to a usable AC (alternating current) form.

A universal semiconductor electrification device powering a pump on a farm in the Karoo

SUNSAT – Africa's first satellite

This challenge attracts graduate students, who have to master the intricacies of embedded computers and software, satellite pointing control, and communication systems.

Three – two – one – zero, we have lift off… These words on 23 February 1999 marked Stellenbosch, and Africa's entry into space as SUNSAT, a satellite developed by over 100 graduate students and technical staff of the SU Engineering Faculty, was lofted into space atop a Delta II rocket, from Vandenberg Air Force Base in California.

The billowing fumes were a final realisation of the vision of emeritus Professor Jan du Plessis, and former Vice-Rector Christo Viljoen – who in 1958 recorded signals from Explorer 1, America's first satellite. The project, undertaken in the SU Department of Electrical and Electronic Engineering, was initiated in 1992, and was led by Arnold Schoonwinkel, Garth Milne and Sias Mostert.

Microsatellites, which weigh less than 100 kg, are a challenging test for computer and control systems. This challenge attracts graduate students, who have to master the intricacies of embedded computers and software, satellite pointing control, and communication systems. Engineers with these skills – and who are accustomed to working in a team – are greatly valued by industry, as the technologies are common to many other systems.

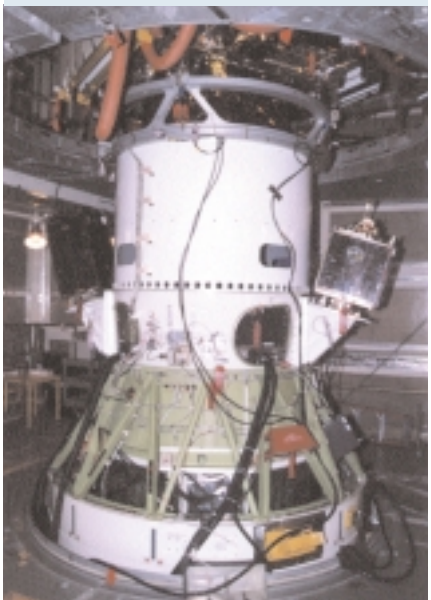
The Electronic Systems Laboratory was formed to meet the demands of SUNSAT, and has also supplied electronic and mechanical systems for overseas satellites. South Africa has a competitive advantage in such specialised products where high-level manpower dominates costs. Its skills have also been applied to non-satellite developments, including new computers, sensors, data gathering systems, flight control systems for unmanned aircraft, and even remote-control units for distance education.

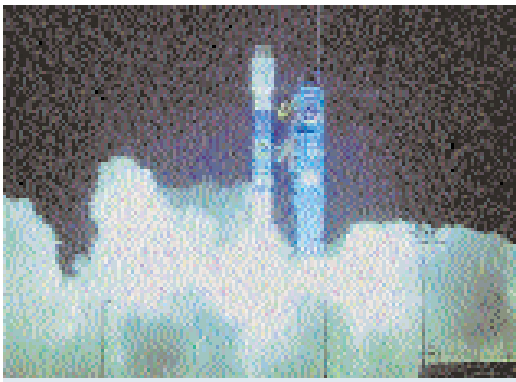
In 1992, SUNSAT's design goals were set to challenge the existing performance norms of university and small industry-class satellites. These included developing and flying a 3456 pixel-wide multispectral camera, three-axis orientation control, and a communications system that enabled hand-held amateur radios to communicate through the satellite. With the advent of SUNSAT, these innovations were all demonstrated in orbit.

In retrospect, initiating a satellite programme was a daunting task, as no support for satellite developments was forthcoming from government, and Stellenbosch had no experience in this field. But industry leaders saw long-term benefits and provided initial support, which was later augmented by the National Research Foundation and the THRIP programme of the Department of Trade and Industry. Scientists from the United States National Aeronautics and Space Administration visited the laboratory, which led to their agreeing to arrange a free launch for SUNSAT if some of their own experiments could be conducted on the flight. This turned into a very fruitful collaboration.

Many of SUNSAT's systems attracted international interest, and have been supplied to other countries. SUNSAT's camera was supplied for Korea's third satellite, Kitsat-3. In

SUNSAT attached inside the launch rocket





Lift-off of the Delta II rocket carrying SUNSAT

December 2002, an unfolding arm, as well as a star camera developed in the laboratory entered space on Australia's FEDSAT satellite. The arm is folded up during launch, but once in orbit is released by an explosive bolt to straighten out and deploy a sensor far enough from the satellite to avoid interference from its magnetic field. The star camera shoots with an exposure time of one second, which is sensitive enough to record dots of light for the stars. The dot patterns can be matched to the known star locations to determine accurately the angular orientation of the satellite.

Opportunities for international contracting later grew beyond the limits that could be handled by the University, so a commercial company, SunSpace & Information Systems (Pty) Ltd (SunSpace), was formed, and soon expanded into Stellenbosch's Techno Park. SunSpace is now a major funder of research in the laboratory, and currently supports 20 master's students.

An exciting new project recently launched in collaboration with the Catholic University of Leuven in Belgium, is the Multisensor Microsatellite Imager, which will include a medium-resolution hyperspectral imager, a high-resolution multispectral camera, and a colour TV camera. This is supported by the Department of Trade and Industry's Innovation Fund.

The laboratory has also begun studies for a new small satellite, with an aim of an early 2005 launch. It will be smaller and more manoeuvrable than SUNSAT, will carry an improved camera and use the latest electronic technology. It is expected to be the forerunner of a future South African science satellite.

The church and community research project

Training of volunteers – 31 August 2002 at United Reformed Church (URC) Zion in Paarl East

Church congregations are uniquely placed to tackle poverty-related problems, as many of them have reasonable infrastructure at their disposal, and are able to reach out to households in their community. The Unit for Religious Demographic Research at the SU, assisted by the departments of Sociology and Geography, has been attempting to use congregations both to acquire information on poverty-related issues, and to attempt to address its root causes. The four major areas of concern identified by the community were HIV/Aids, unemployment, sexual violence against women and children and substance abuse.

A pilot study was launched in 2001 in the Paarl/Mbekweni area, where all places of worship were mapped using Global Positioning System (GPS) technology; 10% of households were surveyed; and a structured interview was held with the leadership of the congregations. In conducting this research, people from the community itself were trained in research methodology and gathered the data in their communities. The survey questionnaire was developed by inviting 20 representatives of the Paarl community, and the fieldwork for the survey was done by approximately 150 members of Paarl congregations.

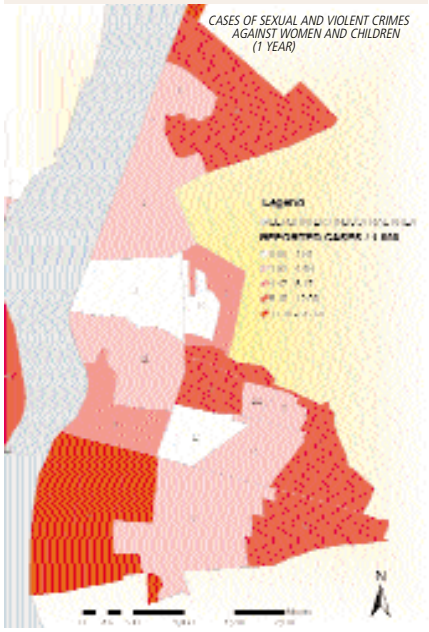
The quantified data obtained from the questionnaires were used to construct a geodatabase, implying that all data are related to a specific geographical location. This geodatabase was coupled with the Geographical Information System (GIS), which makes it possible to produce maps displaying spatial variation in the data. Data related to the location of all places of worship were also incorporated in the GIS. One of the advantages of having this database is that areas with high needs can be portrayed on a map, making it easier to visualise spatial aspects of social problems.

Secondary data from the South African police in the form of crime statistics related to sexual crimes against women and children; from state health clinics relating to the reported incidence of persons screening positive for HIV; and the 1996 national census data relating to the general demographics of the communities, have been incorporated into the database, allowing the presentation of additional layers of information on maps. This leads to more efficient communication between the different parties involved. For example, graphical representations of the spatial incidence of HIV/Aids are making it easier to motivate and mobilise communities to deal with the problem.

The spatial patterns of poverty, HIV/Aids, unemployment, sexual violence and substance abuse, can be assessed within the community, and problematic areas localised. A local network has been created in an attempt to address the problems, and apartheid divides have been bridged in congregations working together towards this goal. In doing so, there has been a realisation that existing services can be better utilised by sharing resources on a community basis. For example, Paarl's Athlone Institute, in partnership with the provincial Department of Social Services, is delivering a service to women and children in Paarl-East who are affected by sexual and/or violent crimes.

This pilot project has led to a number of communities and non-government organisations approaching the unit to conduct the same type of research in other areas, and in the process facilitate co-operation between the different stakeholders in their societies. A similar project is under way in George and several other projects with different communities and government are being negotiated at the moment.

Incidences of sexual crimes against women and children in Paarl East



Eye on the elite

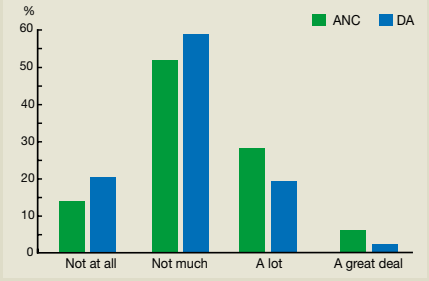
Elites have been pivotal in the process of kick-starting and driving the process of democratisation.

In South Africa the process of democratisation has opened a window of policy opportunities for the new government. By establishing a constitutional state through negotiations and the holding of democratic elections, the new regime obtained the constitutional right to restructure the relationships between the state, the economy and society, in order to address the development needs of the population. Not only in South Africa, but also in a number of recent democratic transitions, particularly in the 1980s and 1990s, elites have been pivotal in the process of kick-starting and driving the process of democratisation. Elites are those people who hold authoritative positions in powerful public and private organisations and influential movements and who therefore are able to affect strategic decisions regularly. As the 'switchmen of history', elites can be described as the social agents that define the different dimensions of public issues, and enhance the salience of some issues in contrast to others.

In this context, the Centre for International and Comparative Politics, under the directorship of Hennie Kotzé, has conducted an analysis of elite perspectives in South Africa, based on interviews with identified members of the elite. Six surveys of leadership opinions since 1990 have allowed the Centre to build up an extensive database on South African elite perspectives. An understanding of the attitudes and value patterns of the elite allows policy makers to gain insight into how important policy decisions are shaped. In a longitudinal study such as this, which spans over ten years, analysts are able to discern particular trends which can serve a predictive function in the policy arena in both the public and private spheres, allowing the course of the transition process to be traced. Apart from the theoretical insights, this analysis also provides inputs into public policy making in South Africa. One of the most important assumptions in this trend study has been that for successful transition – and eventually consolidation of – democracy, a relative measure of attitudinal unity amongst the elite is required. Such a condition points to the acceptance of political institutions and the general 'rules of the game' amongst the elite.

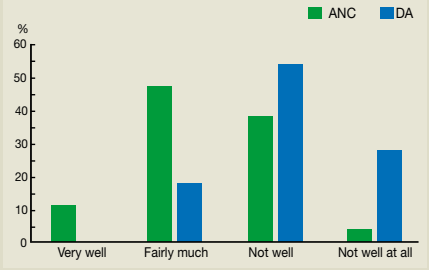
But the most recent elite survey, conducted in 2000, shows that in certain areas, elites display a slight divergence of attitudes. One of the areas that shows less convergence of attitudes concerns the capacity of the state to deliver public goods. From some of the attitudinal patterns related to the capacity of the state, it is clear that the elite supporters of both the governing African National Congress (ANC) and the opposition Democratic Alliance (DA) perceived significant capacity losses in important state agencies, such as the police, the courts and the civil service (Figure 1).

Figure 1: Confidence index in legal system, police and civil service



Similarly, when asked to indicate levels of satisfaction with respect to state service delivery in education, basic services and the distribution

Figure 2: Index of satisfaction with service delivery

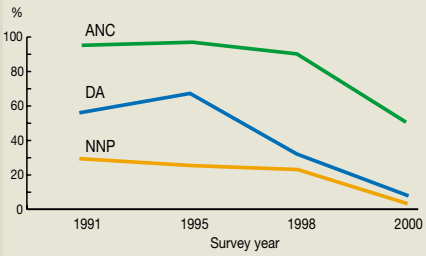


of welfare payments, DA supporters displayed far less satisfaction than their ANC counterparts (Figure 2).

This relatively large discrepancy between the ANC and the DA respondents could have been expected. However, what is surprising is that 42% of the ANC respondents are of the opinion that government is not delivering according to expectations. In the same category, DA supporters recorded 82%.

The data further suggests that Mbeki's job is hampered by the fractured sympathy patterns for the President as indicated by the elite. There is not much sympathy from supporters of the opposition for Mbeki, and by examining a cross-section of opinion leaders supporting the largest parties in South Africa, including the ANC, Mbeki clearly does not enjoy nearly the same levels of sympathy and support as Mandela (Figure 3).

Figure 3: Opinion-leaders of largest parties feeling 'very sympathetic' towards current President



The possibility of comparing elite perspectives with public opinions and perceptions is an interesting one, which is currently being investigated by the Centre. The issue is whether the values of these leaders coincide with those of the general populace, whose opinions are currently being solicited as part of the World Values Survey, of which Kotzé is one of the principal investigators in South Africa. If this is not the case, it could be asked whose values ultimately find bearing in national policy.

In 2002 the South African elite survey was extended to Nigeria, Algeria, Senegal, Uganda, Kenya and Zimbabwe, focusing on the the level of acceptance of the New Economic Partnership for Africa's Development (NEPAD). The significant findings on key policy elements of the NEPAD and value patterns among the opinion leaders of these African states will be of considerable benefit to policy makers in Africa, and allow valuable country comparisons on key aspects of values.

Since 1994 there has been an explosion of survey data on political attitudes in South Africa, including especially data on the attitudes and motivations of voters. There are fewer data for the years prior to 1994, and very few data that allow for a comparison of sociopolitical values across both periods. These surveys together can provide invaluable insights into elite and public perceptions and opinions, thereby enabling increased discourse regarding the consolidation of democracy in South Africa and elsewhere in Africa, and a greater understanding as to how South Africa fits global trends.

The theory of physics

Theoretical physics, as the theory of physics, seeks to address questions ranging from fundamental research topics – such as the origin and composition of the universe – to applied physics, which impacts directly on our everyday lives through technology. For example, quantum mechanics and statistical physics, which are two of the theoretical cornerstones of modern physics, play a fundamental role in our understanding and design of modern materials such as polymer networks (such as rubbers and gels) and materials used in modern electronic devices.

At Stellenbosch a particular research focus falls on statistical physics and quantum many-body techniques, viz. the study of many interacting quantum particles – or particles which are of the same order as the electron's mass. Due to the many-body nature of these systems they can exhibit very complex behaviour, which requires novel and advanced mathematical tools in order to describe their properties successfully. In any fabrication process, one cannot control all parameters and thus ends up with what is commonly known as disordered condensed matter systems. For example, in the preparation of a crystal there are invariably impurities at random positions in the crystal.

Imagine a crystal consisting of one type of atom. This pure system will be a conducting metal if there are free electrons – electrons not bound to a particular atom – as is the case in a metal. Disorder is now introduced by replacing the atoms at random positions by a different type of atom, which would invariably happen in the fabrication process. If the concentration of these impurities is high enough, they can trap the free electrons and the conducting metal turns into an insulator. As the trapping of the free electrons is due to a combination of their quantum properties and their repeated scattering from the impurities, this is referred to as a quantum transition. Although mathematical formulations that describe this transition exist, they are subject to several technical problems and limitations. At Stellenbosch a mathematical framework that avoids many of these problems and limitations has been developed. In particular this formalism opens up the possibility of studying the interplay between disorder and interactions, one of the areas in condensed matter physics where very little progress has been made to date.

Disorder in the soft condensed matter environment – for example polymer systems – is being studied in the context of polymer networks formed in a confined geometry, such as sandwiched between two plates. Cross-links join together different macromolecular strands and also attach some of the strands to the plates. The technological importance of these materials is clear. During instantaneous cross-linking processes any two polymers touching at the moment of formation can become cross-linked, whereas, in the models under study, the wall links can occur as grafted permanently by their ends to the walls at arbitrary positions, or linked at an arbitrary point along their length to any point on a wall.

As in the metal-insulator case discussed above, the randomness here increasingly limits the freedom of system constituents, in this case the conformations of the polymer chains. The mechanical properties of such polymers as affected by the disorder and the confinement have been calculated for certain idealised cases. We are interested in the amount of deformation which occurs when forces of given strengths are applied to the system, while taking into account the frozen disorder cross-linked into the network. In this sense, a theoretical picture of the modification of the usual elasticity of an unconfined network has emerged with respect to linking between plates. How this elasticity is altered by the walls seems dependent on which of the wall-linking processes is implemented in computations. Such calculations should enhance our understanding of how to improve the elastic properties of materials with pores or interfaces, using polymer gels.

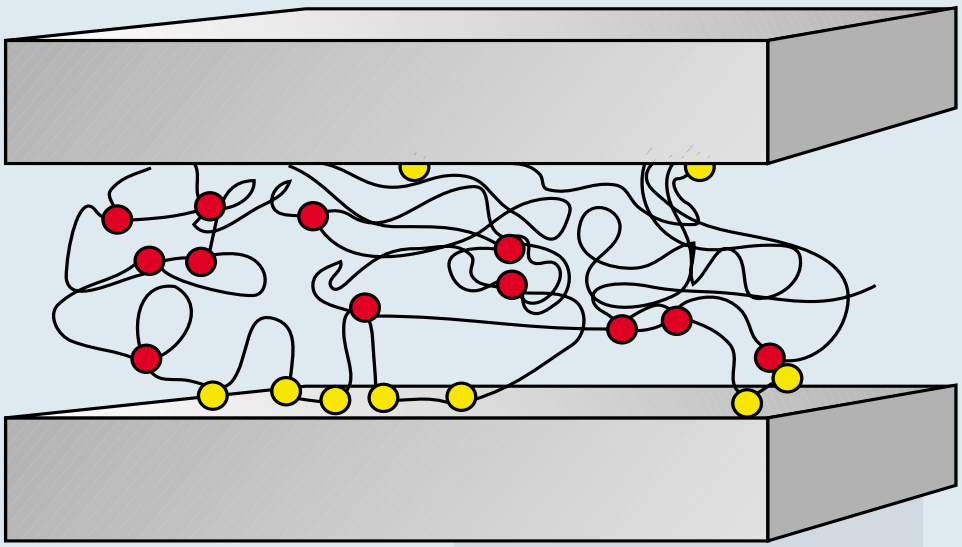


Diagram of the confined network with cross-links (red) and wall links (yellow). The elastic properties of such networks were studied theoretically under volume-preserving deformations using an idealised, non-interacting polymer chain model.

Theoretical physics, as the theory of physics, seeks to address questions ranging from fundamental research topics – such as the origin and composition of the universe – to applied physics, which impacts directly on our everyday lives through technology.

Aspiring towards inclusive education in South Africa

Inclusive education strategies should not simply be narrowed down to matters of educational organisation and practice, but should be directed towards ensuring that learners of all ages with diverse needs are empowered.

Inclusive education is generally defined as inclusive of the participation of all learners with diverse educational needs (including learning problems and disabilities) in mainstream schools and communities. In South Africa, the education system has generally failed to respond to the diverse needs of the learner population, resulting in massive numbers of dropouts and failures. Official policy has recommended the development of inclusive schools, and implementation strategies have focused mainly on the efficiency of practical matters of educational organisation and practice such as the curriculum and teaching practices. But Petra Engelbrecht of the SU Department of Educational Psychology, feels that inclusive education strategies should not simply be narrowed down to matters of educational organisation and practice, but should be directed towards ensuring that learners of all ages with diverse needs are empowered to become caring, competent and contributing citizens in a changing and diverse society. Research in this field is currently focused on three areas, all of which are related.

Research in policy development focuses on the systematic monitoring and evaluation of the implementation of policy regarding inclusive education, both nationally and internationally. Locally, this includes research on the assessment of learners with diverse needs. At present the implementation of inclusive education in various provinces in South Africa is being monitored, with the evaluation of inclusive education in 21 schools in two provinces already completed.

Research on human resource development considers and responds to existing skills, beliefs and attitudes of educators and educational psychologists; and develops the skills and knowledge necessary for the effective implementation of inclusive education in both pre-service and in-service training phases.

In-service training material for educators based on research results has been developed and has been presented in various parts of the world. Research in the period between 1997 and 1999 focused on pre-service educators and their attitudes towards disabilities, with almost 3 000 students at six universities in Queensland, Australia and the Western Cape taking part in the project. Results indicated that for all pre-service educators, increased contact with people with disabilities had a noticeable and positive impact on their level of comfort in dealing with them in inclusive classrooms. As a result, training programmes were adapted to increase understanding of individuals with disabilities, and prospective educators were exposed to training that is reflective and critical about underlying perceptions of diversity. In-service educators formed the focus of the second phase of the project, which took place between 1999 and 2001, during which educators in Gauteng and the Western Cape who already had learners with diverse needs – including disabilities – in their classrooms, were identified. The areas identified as most stressful for educators in the implementation of inclusive education were administrative issues; the behaviour of learners with diverse needs; and the educators' perceived self-competence. Based on this knowledge a support framework for educators in South Africa was developed and is in the process of being implemented.

Lastly, the experiences of parents and learners of inclusive education and options for learners with diverse needs and their parents/caregivers are being explored, for example in terms of specific needs in classrooms for learners with disabilities.

Engelbrecht's recommendations have been incorporated in policy documents by both national and provincial education authorities. Inclusive education is a dynamic process and this research programme endeavours to provide new and innovative solutions to the challenges facing learners, educators and parents in an inclusive education system.

Inclusive education in action Photo: Early Learning Resource Unit (ELRU)

Faculties, departments, institutes and centres of Stellenbosch University

Research: a primary function

Stellenbosch University takes research to be one of its primary functions. Most of the research is done by individuals and groups in departments, though with growing co-operation across the boundaries of departments and faculties. New institutes, centres, etc are set up when it becomes important to bring scattered expertise together in one place, or to give existing expertise a clear identity – for the sake of, say, interaction with the community or with clients. Institutes, centres, etc are listed here in one of two ways:

(i) The name of the institute, centre, etc is given under that of a department. This shows that in its functioning it interacts mostly with one particular department, or that it is itself the way of functioning of that department in certain of its modalities (e.g. research). Needless to say, the research and service performed by the department are not limited to the area signalled by the name of the institute or centre.

(ii) The institutes, centres, etc are mentioned at the end of the list of departments for a faculty. This shows that most of its interaction is with more than just one department in that faculty or, indeed, is with that faculty as a whole. Needless to say, again, in many cases the interaction is with departments in other faculties as well.

This document does not aim to show any formal lines of reporting.

Faculty of Arts

Dean: Prof HJ Kotzé
email: hjk@sun.ac.za
website: http://www.sun.ac.za/arts

Department of Afrikaans and Dutch
Department of African Languages
Research Unit for Experimental Phonology (RUEPUS) (NRF Unit)
Department of Ancient Studies
Centre for Bible Interpretation and Translation in Africa
Department of Drama
Centre for Theatre and Performance Studies
Department of English
Department of Fine Arts
Department of General Linguistics
Department of Geography and Environmental Studies
Centre for Geographical Analysis
Department of History
Department of Information Science
Centre for Knowledge Dynamics and Decision Making
Department of Journalism
Department of Modern Foreign Languages
Department of Music
Department of Philosophy
Centre for Applied Ethics
Department of Political Science
Centre for International and Comparative Politics
Department of Psychology
Centre for Community Psychological Services: Unit for Psychology
Department of Social Work
Department of Sociology and Social Anthropology
Centre for Research on Science and Technology (CREST)

Faculty of Agricultural and Forestry Sciences

Dean: Prof L van Huyssteen
email: lvh@sun.ac.za
website: http://www.sun.ac.za/agric

Division of Agricultural Sciences
Department of Agricultural Economics
Department of Agronomy
Department of Animal Sciences
Department of Entomology and Nematology
Department of Food Science
Department of Genetics (including Biometry)
Department of Horticultural Science
Department of Plant Pathology
Department of Soil Science
Department of Viticulture and Oenology
Institute for Wine Biotechnology

Division of Forestry Sciences
Department of Conservation Ecology
Department of Forest Science
Department of Wood Science

Faculty of Economic and Management Sciences

Acting Dean: Prof JU de Villiers
email: judv@sun.ac.za
website: http://www.sun.ac.za/economy

Department of Accountancy
Department of Business Management
Department of Economics
Department of Industrial Psychology
Centre for HIV/Aids Management in the World of Work
Department of Logistics
Department of Statistics and Actuarial Science
Centre for Statistical Consultation
Graduate School of Business
Africa Centre for Investment Analysis (ACIA)
Centre for Leadership Studies (Africa)
School for Public Management and Planning
Bureau for Economic Research (BER)
Institute for Futures Research (IFR)

Faculty of Engineering

Dean: Prof A Schoonwinkel
email: schoonwi@sun.ac.za
website: http://www.eng.sun.ac.za

Department of Applied Mathematics
Bureau for Industrial Mathematics (BIMUS)
Department of Process Engineering
Centre for Process Engineering
Institute for Minerals Processing and Intelligent Process Systems
Institute for Thermal Separation Technology
Institute for Reactive Systems and Environmental Technology
Institute for High Temperature Materials Processing
Bureau for Chemical Engineering
Unit for Continued Education
Department of Civil Engineering
Institute for Structural Engineering
Institute for Transport Technology
Institute for Hydraulic and Environmental Engineering
Department of Electrical and Electronic Engineering
Centre for Electrical and Electronic Engineering
Unit for Electrical Energy
Unit for Electromagnetics
Unit for Electronics
Unit for Computers and Control
Unit for Signal Processing
Department of Industrial Engineering
Institute for Industrial Engineering
Centre for Global Competitiveness in Engineering
Unit for Advanced Manufacturing
Department of Mechanical Engineering
Institute for Thermodynamics and Mechanics
Central Electronic Services
Central Mechanical Services
Engineering Faculty Schools Centre

Faculty of Education

Dean: Prof T Park
email: tp@sun.ac.za
website: http://www.sun.ac.za/education

Department of Didactics
Centre for Higher and Adult Education
Information Centre for Children's Literature and Media
Research Unit for Mathematics Education (RUMEUS)
Department of Education Policy Studies
Department of Educational Psychology and Specialised Education
Centre for Community Psychological Sevices:
Unit for Educational Psychology
Department of Sport Science
Institute for Sport Science
Centre for Educational Development (CENEDUS)

Faculty of Health Sciences

Dean: Prof WL van der Merwe
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http://www.sun.ac.za/healthsciences

School for Allied Health Professions

Department of Human Nutrition
Nutrition Information Centre of Stellenbosch University (NICUS)
Department of Occupational Therapy
Department of Physiotherapy
Department of Speech – Language and Hearing Therapy

School for Basic and Applied Health Sciences

Department of Anatomical Pathology
Department of Anatomy and Histology
Department of Chemical Pathology
Department of Forensic Medicine
Department of Haematological Pathology
Department of Medical Microbiology
Department of Medical Physiology and Biochemistry
MRC Centre for Molecular and Cellular Biology
Department of Medical Virology
Department of Pharmacology
Poison and Drug Information Centre
Bureau for Bio-engineering

Faculty of Health Sciences (continued)

School of Medicine

Department of Anaesthesiology
Department of Cardiothoracic Surgery
Department of Dermatology
Department of Internal Medicine
Drug Research Unit
SU Centre for Cost Effective Medicine
Department of Neurosurgery
Department of Nuclear Medicine
Department of Obstetrics and Gynaecology
MRC Perinatal Mortality Research Unit
Department of Ophthalmology
Department of Orthopaedic Surgery
Department of Otorhinolaryngology
Department of Paediatrics and Child Health
Department of Plastic and Reconstructive Surgery
Department of Psychiatry
MRC Unit on Anxiety and Stress Disorders
Mental Health Information Centre of South Africa
Department of Radiation Oncology
Department of Radiodiagnosis
Department of Surgery (General)
Department of Urology

School for Oral Health Sciences

Department of Applied Oral Health Sciences
Division of Oral Medicine and Periodontics
Division of Orthodontics
Division of Prosthodontics
Department of Conservative Dentistry
Division of Crown and Bridge Therapy
Division of Dental Materials
Division of Endodontics
Division of Paediatric Dentistry
Division of Restorative Dentistry
Department of Diagnostic Sciences
Division of Maxillo-facial Radiology
Division of Maxillo-facial and Oral Pathology and Forensic Sciences
Division of Oral Biology
Oral and Dental Research Institute (ODRI)
Department of Maxillo-facial and Oral Surgery
Division of Anaesthesiology
Division of Maxillo-facial and Oral Surgery

Faculties, departments, institutes and centres of Stellenbosch University *(continued)*

Faculty of Health Sciences
(continued)

School for Public and Primary Health Sciences
Department of Community Dentistry
Division of Oral Higiene
Division of Preventive and Public Oral Health
Department of Community Health
Division of Occupational Health
Department of Family Medicine and Primary Care
Department of Nursing
Centre for Care and Rehabilitation of the Disabled

Central
Centre for Tuberculosis Research and Education (CENTRE)
Centre for Human Genetics Research and Education (GENRED)

Faculty of Law
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Department of Mercantile Law
RAU/SU Centre for International and Comparative Labour Law (CICLA)
Department of Private and Roman Law
Centre for Child and Family Law
Department of Public Law
Research Unit for Legal and Constitutional Interpretation (RULCI) (NRF Unit; SU/UWC)
Legal Aid Clinic
Trade Law Centre for Southern Africa (TRALAC)

Faculty of Military Science
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School of Science and Technology
Aeronautical Science (Mil)
Mathematics (Mil)
Military Physics
Military Technology
Nautical Science

School for Geospatial Studies and Information Systems
Computer Information Systems (Mil)
Military Geography

School for Security and Africa Studies
Military History
Military Strategy
Political Science

School for Defence Organisation and Resource Management
Accountancy and Auditing (Mil)
Economics (Mil)
Public and Development Management (Mil)

School for Human Resource Development
Academic Development
Industrial Psychology (Mil)
Mercantile and Criminal Law (Mil)
Centre for Military Studies

Faculty of Science
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Department of Biochemistry
Department of Botany
Institute for Plant Biotechnology (IPBT)
Department of Chemistry
Institute for Polymer Science
Department of Computer Science
Institute for Applied Computer Science
Department of Consumer Sciences: Food, Clothing, Housing
Department of Geology
Gemstone Research Centre
Department of Mathematics
Department of Microbiology
Department of Physics
Institute for Theoretical Physics
Department of Physiological Sciences
Department of Zoology
John Ellerman Resource Centre for Zoology
Institute for Mathematics and Science Teaching (IMSTUS)

Faculty of Theology
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Department of Old and New Testament
Department of Practical Theology and Missiology
Department of Systematic Theology and Ecclesiology
Bureau for Continuing Theological Training and Research (BUCTER)
Beyers Naudé Centre for Public Theology

Other (of a central nature)

Stellenbosch Botanical Garden
Central Analytical Facilities
Centre for Student Counselling and Development (CSCD)
Language Centre (incl. Unit for Document Design)
Stellenbosch Institute for Advanced Study (STIAS)
Africa Institute for Mathematical Sciences (AIMS) (together with UCT and UWC)
South African Centre for Epidemiological Modelling and Analysis (CEMA)
University Museum (comprising the Sasol Art Museum and the SU Art Gallery)

Associated institutions

Bureau of the Woordeboek van die Afrikaanse Taal
(= "Dictionary of Afrikaans") (housed in the University)
Matie Community Service
USB-ED (Pty) Ltd ("ED" for "Executive Development") (functioning in close interaction with the Graduate School of Business)