

# ScienceScope

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SOUTH AFRICA'S COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

## CSIR CAREERS

IN SCIENCE, TECHNOLOGY,  
ENGINEERING AND MATHEMATICS



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*our future through science*

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# INVESTING IN PEOPLE

Innovation is a key economic driver for any country. To create wealth and to better people's lives require an ability to create and exploit knowledge. That ability is directly linked to people and their inherent and acquired skills.

**THE CSIR IS KEENLY AWARE** of the importance of its human capital – it is without a doubt its most valuable asset. Our strength lies in the quality of scientists, researchers and support staff we attract, the opportunities we create for career development, our commitment to excellence and working together to create a better future through science. Human capital development is therefore one of the organisation's strategic priorities: Ensuring that the organisation has a human capital base that is adequately equipped with the right skills to meet organisational objectives.

However, the commitment is about more than the organisation's own operational needs. It is also about a response to a national concern. The CSIR is committed to the aim expressed in the National Development Plan, which is to grow the national pool of researchers to help improve South Africa's innovation capability. The Human Resource Development Strategy for South Africa 2010 – 2030 makes key commitments towards the development of key innovation skills, also specifically to the improvement of the technological and innovation capability and outcomes within the public and private sectors to enhance the country's competitiveness in the global economy.

The CSIR is also aiming to increase the percentage of our PhD qualified staff and to continue to transform the demographic composition of our researchers and research leaders. We will continue to invest in pipeline development programmes such as bursaries, studentships and internships. The CSIR also has a science outreach programme as part of which we participate at science festivals and visit different communities around the country to promote the value of science and to get more young people interested in science.

This edition of *ScienceScope* aims to showcase CSIR careers in science, technology, engineering and mathematics (STEM). We hope that by featuring these exciting career options and how others have succeeded (sometimes against all odds) to become professionals who are making a difference, young people will be inspired to choose STEM subjects. We hope that students at tertiary education institutions, who are already studying in these fields, will be excited about the options for specialisation and consider the CSIR as a future employer.

We feature career types in natural sciences, engineering and technology, as well as social sciences. The individuals featured are researchers who are highly specialised in their respective fields: enzymologists, protein biochemists, statisticians, oceanographers, software engineers, roboticists, transport economists and more. And while we have aimed to show diverse skills, it is but a small selection of careers at the CSIR.

Visit our website at [www.csir.co.za](http://www.csir.co.za) to learn more about careers at the CSIR.

DR THULANI DLAMINI  
CSIR CEO

“The single most important investment any country can make is in its people.”

— The National Development Plan 2030

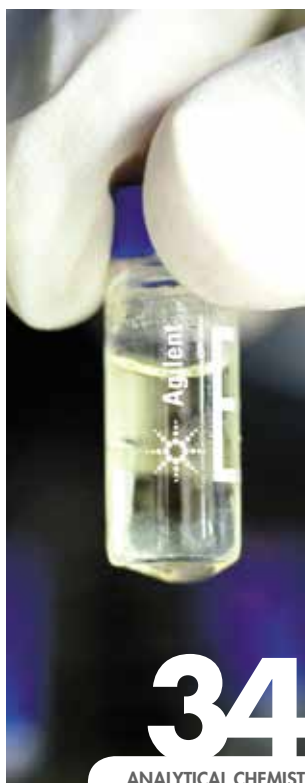
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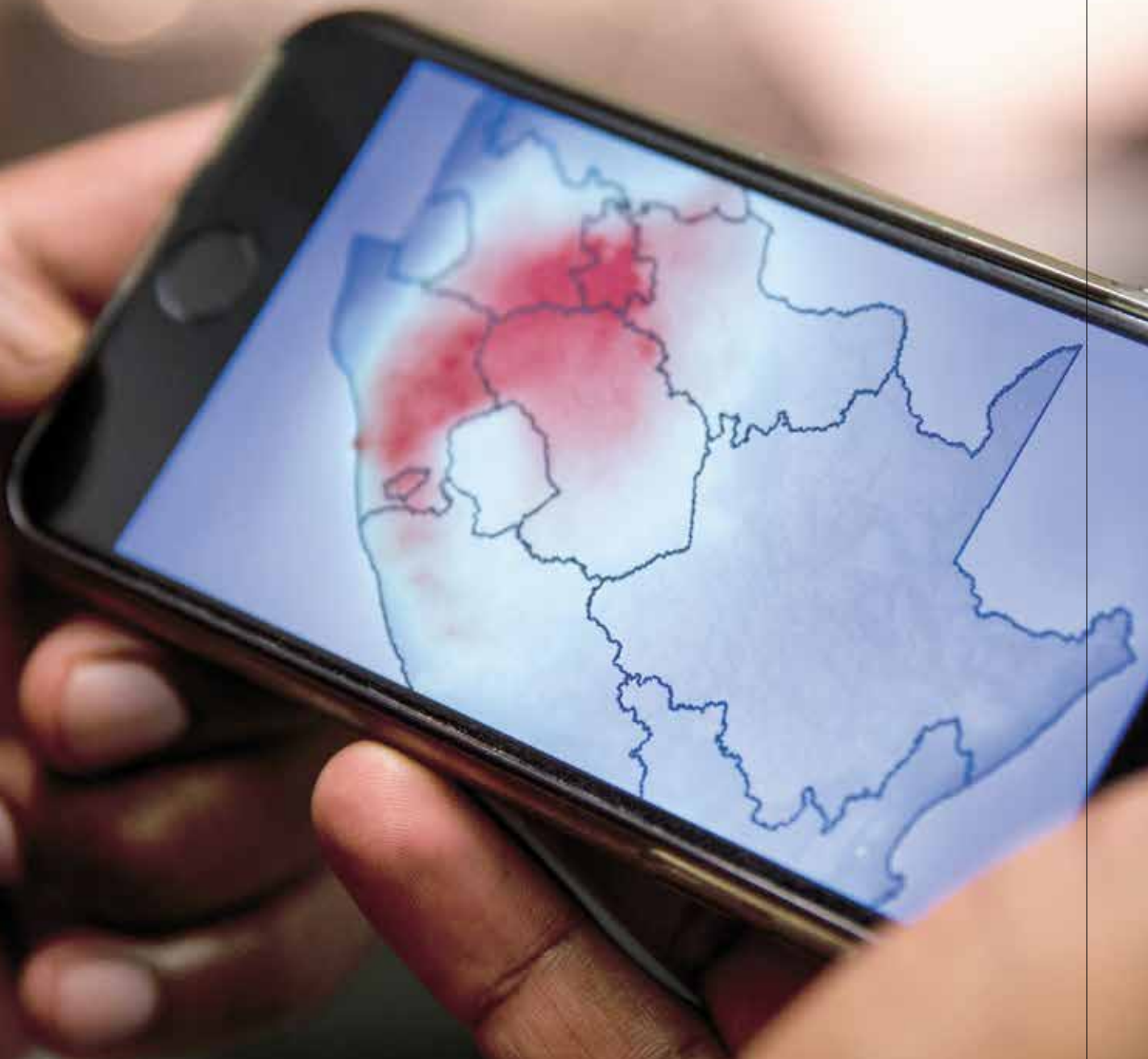
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**CAREERS IN**

# Natural Sciences





Careers in natural sciences generally include the study of physical sciences, chemical sciences and biology. It also includes the areas of mathematics, earth and related environmental sciences, and computer and information science.

The CSIR has extensive expertise in all of these fields of science and technology. These capabilities are drawn on to make an impact in almost all of the CSIR's focus areas, including energy, health, industry, the natural and built environments, as well as defence and security.

Careers featured in this section:

- Oceanographer
- Statistician
- Statistician
- Numerical modeller
- Roboticist
- Data scientist
- Information security engineer
- Software engineer
- Computer scientist
- Physicist
- Optical physicist
- Chemical scientist
- Chemist
- Medicinal chemist
- Analytical chemist
- Structural biologist
- Biochemist
- Microscopist
- Meteorologist
- GIS specialist
- Urban and regional planner



# OBSERVING THE OCEAN, ONE DATA SET AT A TIME





A keen interest in mathematics and science, coupled with a dislike for biology, led CSIR oceanographer Dr Björn Backeberg to follow a career in oceanography, which he says, “has little to do with biology, and instead looks at the processes underlying biology.”

**OCEANOGRAPHY IS A BRANCH** of earth science that studies the ocean and includes ecosystem dynamics, ocean currents, waves, the geology of the sea floor and the physical properties within the ocean.

While a lot of time is spent out at sea deploying and collecting instruments that collect information aiding in understanding the properties of the ocean, Backeberg says that only 5% of his time is spent in a wetsuit in the ocean, “if you exclude the hours I spend surfing,” he quips. “Sometimes we go out on big vessels, other times we are on speedboats.”

As an oceanographer with expertise in numerical modelling and satellite remote sensing, Backeberg explains that he deals with a lot of data. “A high level of numerical proficiency is required as I spend most of my time doing data analyses and running numerical models.”

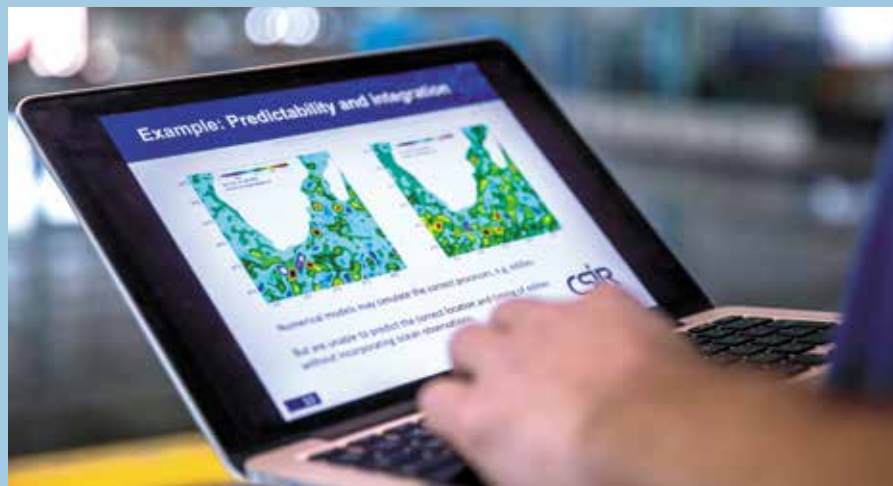
“Every day is different,” he says. “My day-to-day activities range from being a geek and fiddling with the computer, to engaging with people and working with students.”

Backeberg is currently part of the team working on developing high-resolution

predictive and observational capabilities to support decision-making in South African territorial seas and the exclusive economic zone (the area of coastal water within a certain distance of the country's coastline to which the country claims exclusive rights for fishing, drilling and other economic activities). The development of new technologies in this domain is set to benefit the rest of Africa, with extensive human capital development to build a strong regional coastal and ocean forecasting and monitoring centre.

South Africa is not home to many oceanographers and there is a definite need for the skills set in the country, says Backeberg. “We do not have people who have the technical skills to deal with a lot of data,” he says. His advice to aspiring oceanographers is to “pick a topic you can identify with and love about the ocean and try to learn as much as possible about it so that you become an expert.”

He says, “There are a lot of gaps in oceanography and with anything you choose you are likely to make an impact.”



Current models used to predict oceanic processes have too low a resolution to provide accurate enough information in support of risk and disaster management in South Africa's oceans. Backeberg's research seeks to fill this gap by providing high-resolution, usable information of South Africa's exclusive economic zone and territorial seas.



Backeberg's research over the past 10 years has been geared towards developing the tools and methodologies to advance the quantitative understanding of the ocean environment in the greater Agulhas Current region.



## CHARACTERISTICS AND APTITUDE

Backeberg says that an individual should have a love for the ocean and be interested in science.

A sense of curiosity about the earth system and how the land and ocean interact, is imperative; “being able to swim is not.”



## WHAT AND WHERE TO STUDY

Backeberg completed a BSc (Physical Oceanography) at the University of Cape Town (UCT) and completed his Master's at the University of Bergen, Norway. He later returned to UCT to obtain a PhD (Physical Oceanography). He says that Nelson Mandela Metropolitan University is the only other university offering studies in the field of physical oceanography.



## RELATED CAREERS

Marine biologist, chemical oceanographer, marine physicist and climatologist.



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# Collecting and organising data to support research

Almost every research field requires the collection, organisation, analysis, interpretation and presentation of data, which is why the discipline of statistics is one of the most valued subjects for those considering a career in science.

**PROF SONALI DAS**, a statistician who joined the CSIR in 2007, says what she enjoys most about her career is the fact that her expertise can be applied to a wide variety of domains.

"Statistics is one of the few subjects that allows you to collaborate with almost anybody who works with quantitative data. That is obviously almost everybody in the world of science, for example geologists, climate scientists, those who work in finance and economics, and even sports scientists. The more uncertainty about the data generating process, the more likely it is that a scientist will request the services of an expert statistician to help them with the interpretation."

Das was born in India and graduated with an MSc in statistics from the University of Calcutta in 1994. Thereafter, she joined the Indian Statistical Institute as a computer programmer.

"I was surrounded by peers doing their PhDs, teaching me things and encouraging me to pursue new opportunities. I built close relationships with people who later moved to great academic positions abroad. I am still in

contact with them for advice. This taught me that you learn from all of your experiences and it is better to be someone small surrounded by people who are more intelligent than you, than being a king amongst mediocre minds."

In her free time, Das completed extra training in computer applications to better her technical programming skills and then moved to New Delhi to work in the government sector.

"I soon realised that to climb the career ladder, I needed a PhD and this sent me back to my core subject of statistics."

Das was accepted at the University of Connecticut in the USA where she completed her PhD in statistics in 2006, focusing on Bayesian statistics, which has also been one of her major research focus areas since she joined the CSIR.

The Bayesian statistical approach allows a researcher to update their confidence or belief (in terms of probability) in the initial assumptions of their model with new data as it becomes available. In the game of heads and tails for example, this would mean that the result is not the number of times that heads will show up if the coin

is tossed repeatedly, but rather a measure of confidence that a head will show up on the next toss.

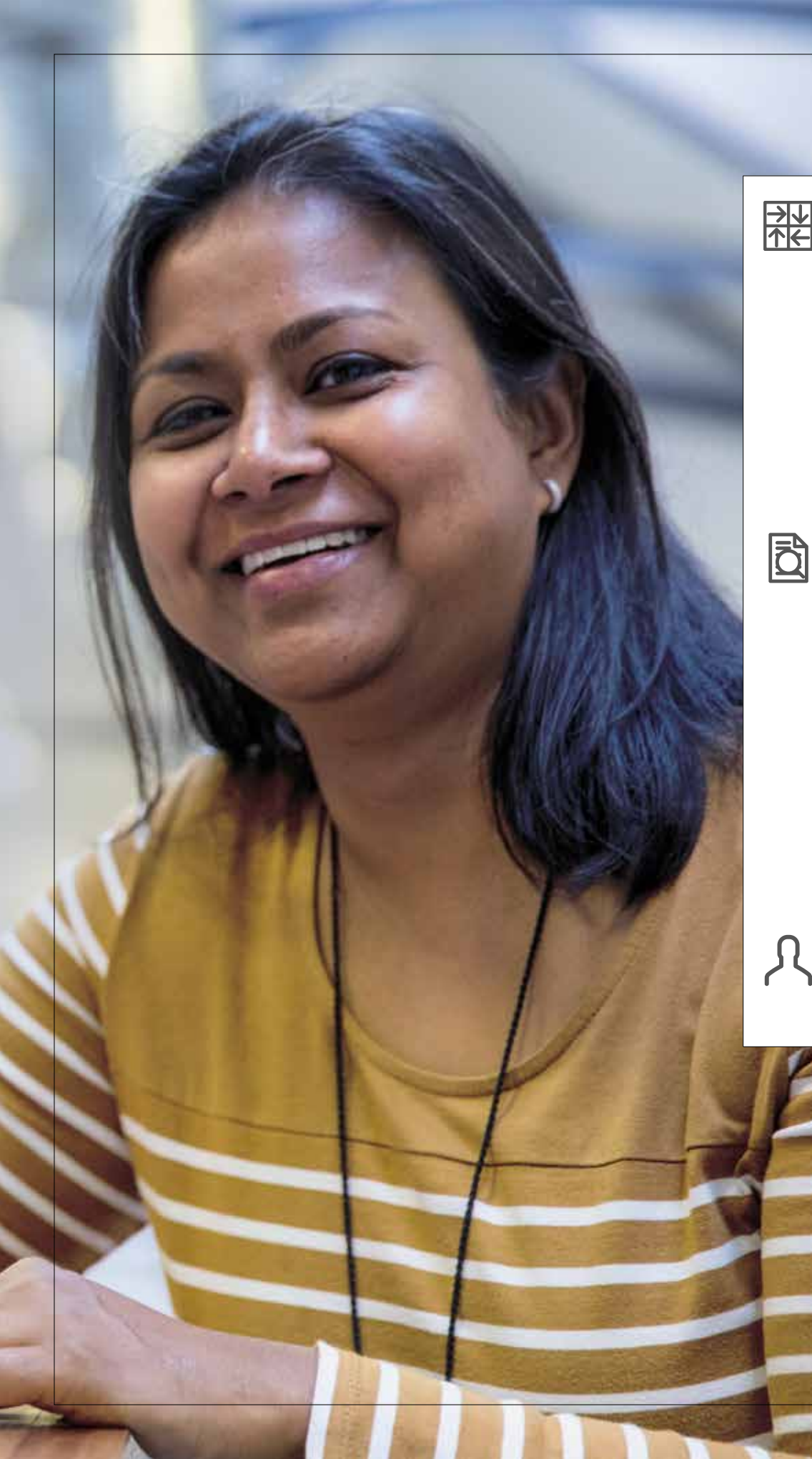
Das has worked on a variety of projects in different domains. These included doing risk analysis for climate change – helping researchers to quantify the carbon dioxide in the Southern Ocean with a higher degree of certainty. For this, she needed to understand the biology and chemistry of the carbon cycle.

She also uses her modelling capabilities for sector-specific skills forecasting and to investigate how novel data modelling techniques could be applied to human movement analysis research that can help researchers to develop better treatment methods for people with disabilities and injuries.

"I greatly appreciate the fact that the CSIR provides me with opportunities to understand and contribute towards the science landscape with some of the best people in the field," she says.

Prof Sonali Das





## CHARACTERISTICS AND APTITUDE

Das says statisticians have to excel in mathematics and be able to persevere and adapt. They should also have the willingness to make an effort to understand the various domains in which their input is needed. She says the field of statistics is becoming increasingly sophisticated, and one should be willing to learn the emerging areas within statistics if one wants to be in a research career.



## WHAT AND WHERE TO STUDY

Das has a BSc Honours (Statistics) from the Presidency College in India, an MSc (Statistics) from the University of Calcutta and a PhD (Statistics) from the University of Connecticut in the USA.

Most South African universities offer degrees in statistics. Das advises that students do as many of the foundation courses as possible and that they should only embark on their PhD studies when they have a sound knowledge of the foundation of statistical theory and methods.



## RELATED CAREERS

Lecturer in statistics, statistician in the banking and insurance industry and actuary.



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# STATISTICIANS APPLYING THEIR TRADE FOR SPATIAL PLANNING

Statisticians use statistical methods to collect and analyse data to help solve real-world problems in business, engineering, healthcare and other fields. They decide what data are needed to answer specific questions or problems, determine methods for finding or collecting, as well as analysing and interpreting the data.

Dr Pravesh Debba and Sibusisiwe Makhanya



## THE CORE RESEARCH INTERESTS

of CSIR statistician Sibusisiwe Makhanya are spatial statistics and statistical approaches to risk analysis. In terms of her studies, she's deepening her knowledge in these areas by focusing her research on statistical mapping of air quality in relation to urban population exposure and health risks.

Makhanya says statistical science is a dynamic discipline that often plays a supportive role in other disciplines and it is this opportunity of life-long learning in various areas of interest that she appreciates the most.

"I view statistics as the art and science of discerning patterns from usually imperfect data. A story from the emerging patterns is formed and communicated (often graphically), enabling a better understanding of the problem for which the data was collected," she says.

"I am particularly excited to be a statistician at this time of data abundance because challenges of data quality, spurious relationships, extreme and unusual values and sampling bias, remain.

"It is a call to our profession to not only re-assess and develop methodologies to meet the current demands, but to also advise against the inappropriate use of statistical methods – an easy sin to commit given easier access to data and data analysis software."

The ability to analyse and synthesise data, especially for planning, is important because the insights generated from the data provide a starting point or basis for the decision-making process, she says.

"When I first started at the CSIR, I was fortunate to get involved in global change risk analysis and took a keen interest in the application of statistics to problems that focus on the interaction between society and the natural environment," she says.

For such problems, geographic location is important; hence she

naturally developed an interest in spatial statistics and probabilistic risk analysis. For her MSc, she focused on spatiotemporal extreme value analysis, with the modelling of heavy rainfall over the Western Cape as her case study.

"I am using and further honing these skills in a project in which we are looking at the use of data collected by satellites to support planning and monitoring of features at the interface of the built and natural environments.

"I am content that I will never reach a point where I know all there is to know in statistics for spatiotemporal data and risk analysis, hence my continued interest in these areas of specialisation in statistics," she says.

Makhanya is based in the CSIR's group for spatial planning and systems, which is headed by Dr Pravesh Debba, who is also a statistician. Debba was a co-supervisor for Makhanya's MSc and is currently her PhD co-supervisor.

Debba's research area is in the application of statistics to remote sensing data. He designed optimal sampling schemes to target specific minerals during his PhD studies. He is currently leading a project in which he is exploring the selection and integration of remote sensing technologies and algorithms to better detect, identify and assess national and man-made features and structures in urban and peri-urban landscapes. The project intends to enhance understanding of our environment and therefore aid planners in their ability to monitor the environment.

Debba says the challenges of having the appropriate data for modelling and monitoring still exist. Hence, researchers aim to find ways to overcome this challenge and to use remote sensing data to develop information tools and indicators that can help planners and decision-makers.



## CHARACTERISTICS AND APTITUDE

Statisticians should have strong analytical and mathematical skills to enable them to understand problems, identify possible solutions and gather the tools (materials and methods) required to get to those solutions.



## WHAT AND WHERE TO STUDY

Makhanya has a BSc in statistics and applied mathematics from the University of KwaZulu-Natal and a BSc Honours degree in statistics from the same university. She has an MSc degree in mathematical statistics from the University of the Witwatersrand and is currently pursuing her PhD in spatial statistics at the University of Twente in the Netherlands.

Debba has a BSc in statistics and mathematics, and a BSc Honours degree in statistics from the University of Durban-Westville. He was then awarded a bursary from the Flemish Ministry of Education and completed his MSc degree in biostatistics at the University of Hasselt in Belgium. In 2006 he completed his PhD in spatial statistics from the International Institute of Geo-Information Sciences and Earth Observation and Wageningen University in the Netherlands.

At most South African universities, students will start with a BSc course. In addition to statistics and mathematics, students can also take courses in other disciplines such as chemistry or economics if, for example, their interests are careers in the pharmaceutical or finance industries respectively. Courses in computer science are also important and universities differ in how these are offered. Students then specialise in statistics when doing their Honours, Master's and PhDs, supplemented by reading in various other fields to broaden contextual understanding. Courses in the social sciences are beneficial for most application areas and are important for those interested in psychometrics, demography, official statistics and other areas of statistics in the social sciences.



## RELATED CAREERS

Actuary, econometrician, market research analyst, applied mathematician, operations research analyst, financial analyst, biometrician, demographer, environmental scientist and data scientist.



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# Combining geography, chemistry and computer programming for photochemical modelling

South Africa's only practicing photochemical modeller, Mogesh Naidoo, says the country desperately needs expertise in this field, especially because the country faces significant challenges in meeting the World Health Organization's (WHO) guidelines for ambient air quality.

**WITH HIS INTEREST IN ENVIRONMENTAL SCIENCE** piqued during his studies at the University of KwaZulu-Natal, Naidoo went on to become the only practicing photochemical modeller in the country. He is currently pursuing his PhD at North-West University, as part of a partnership between the CSIR and Eskom. In his PhD, Naidoo looks at how coal-fired power stations affect air quality in the Waterberg area of Limpopo.

Photochemical modelling is a rare and fairly new science application in South Africa. It demands a unique combination of skills, including computer programming, geography and chemistry, says Naidoo.

Photochemistry modelling essentially simulates how atmospheric pollutants interact through chemistry involving radiation from the sun, and how these are dispersed in space over time to affect air quality. Naidoo is part of a small group of regional air quality modellers at the CSIR whose research focuses on local variations in biomass burning and biogenic emissions, vehicle emissions, the effect of emissions on climate change and the looming issue of fracking-related emissions.

With the goal to grow South Africa's expertise on natural emissions data and models, Naidoo enjoys helping and mentoring junior staff on projects and equipping his peers with new technical skills. "We want to generate emissions data and refine air quality models, and make them public. If we can provide this kind of baseline emissions data to the Department of Environmental Affairs, officials will be better equipped to regulate and manage, through modelling studies, industrial and other man-made emissions."

Naidoo is also working on an air quality management plan for the City of Johannesburg. This entails building the emission inventory for the city; undertaking air quality modelling to inform the placement of monitoring stations at hot spots and testing different emission scenarios, "for example, looking at the Bus Rapid Transit system and where and how air pollution is likely to change due to the system," he says.

Naidoo deals with a lot of data on a daily basis, from the public sector as well as private sector industrial activity, analysing the data and making sense of it. Naidoo says data gathering and analysis is a resource-intensive process that presents a common barrier to generating accurate,

high-resolution emissions data. And, obtaining reliable data from industries, especially smaller facilities, is equally challenging.

Naidoo spends a lot of time creating, modifying, refining and running models using the data gathered. "In South Africa, it is difficult to get any emissions data, never mind good data, and it is also often up to the scientist to help industries report data and to generate emissions inventories," says Naidoo.

Although South Africa may struggle to reach WHO standards, with some scientists questioning whether the guidelines are actually attainable, increasing research capacity and skills in this area will undoubtedly help to improve the country's air quality situation.





Expanding the CSIR's air quality research, particularly in the area of photochemistry modelling, will help South Africa better manage and regulate emissions.



## CHARACTERISTICS AND APTITUDE

Naidoo says one needs to be able to grasp computer programming because a lot of time is spent working with data and developing models.



## WHAT AND WHERE TO STUDY

Aspiring photochemical modellers should take chemistry as part of a BSc degree. Naidoo completed his BSc and MSc (Environmental Science) at the University of KwaZulu-Natal and is working on his PhD at North-West University. These qualifications can be obtained at most universities in South Africa.



## RELATED CAREERS

Air quality modeller and atmospheric scientist.



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# THE UNCONVENTIONAL ROUTE TO ROBOTICS ENGINEERING

Shortly after she matriculated with standard grade mathematics, no science and average marks for the rest of her subjects, a future career as a robotics engineer was probably the last thing anyone predicted for the hard-headed young Ashley Kleinhans.

**KLEINHANS SPENT THE FIRST** few years of her life on a yacht travelling the world. "My mother home-schooled me, and when we eventually settled in Cape Town I struggled to fit into the school system. Authority was unfamiliar and I was disruptive and seen as rebellious," she says.

"I was eventually sent to a boarding school in Franschhoek. In those years, girls were taught home economics, but I chose woodwork because I enjoyed working with my hands."

She matriculated from Bergvliet High School and with a memory of a deep hatred for school in general, she packed her bags and left to travel the world, mostly doing menial work in the yachting industry.

"I woke up in Spain one morning after years of living life day to day and was struck by the thought that there had to be more to life."

Kleinhans returned to Cape Town, got a full-time administrative job in the film industry and over weekends started to attend two-hour lessons at a maths and science centre in Cape

Town, basically redoing the high school curriculum.

Two years later she rewrote her matric, passed and was accepted into mechatronics engineering at the University of Cape Town. "It was the most incredible feeling getting that acceptance letter. I got a student loan and worked as an au pair and bar tender to repay the interest."

After her first year, she was on the Dean's list for academic achievement and in 2008 Kleinhans graduated with honours. She joined Volkswagen South Africa in Port Elizabeth as a project engineer and completed her Master's part time while there.

Kleinhans joined the CSIR in 2013 to work in its mobile intelligent autonomous systems (robotics) laboratory. She and her colleagues design and develop intelligent ways for robots that operate in real-world environments, unlike conventional robots that operate in controlled environments such as manufacturing.

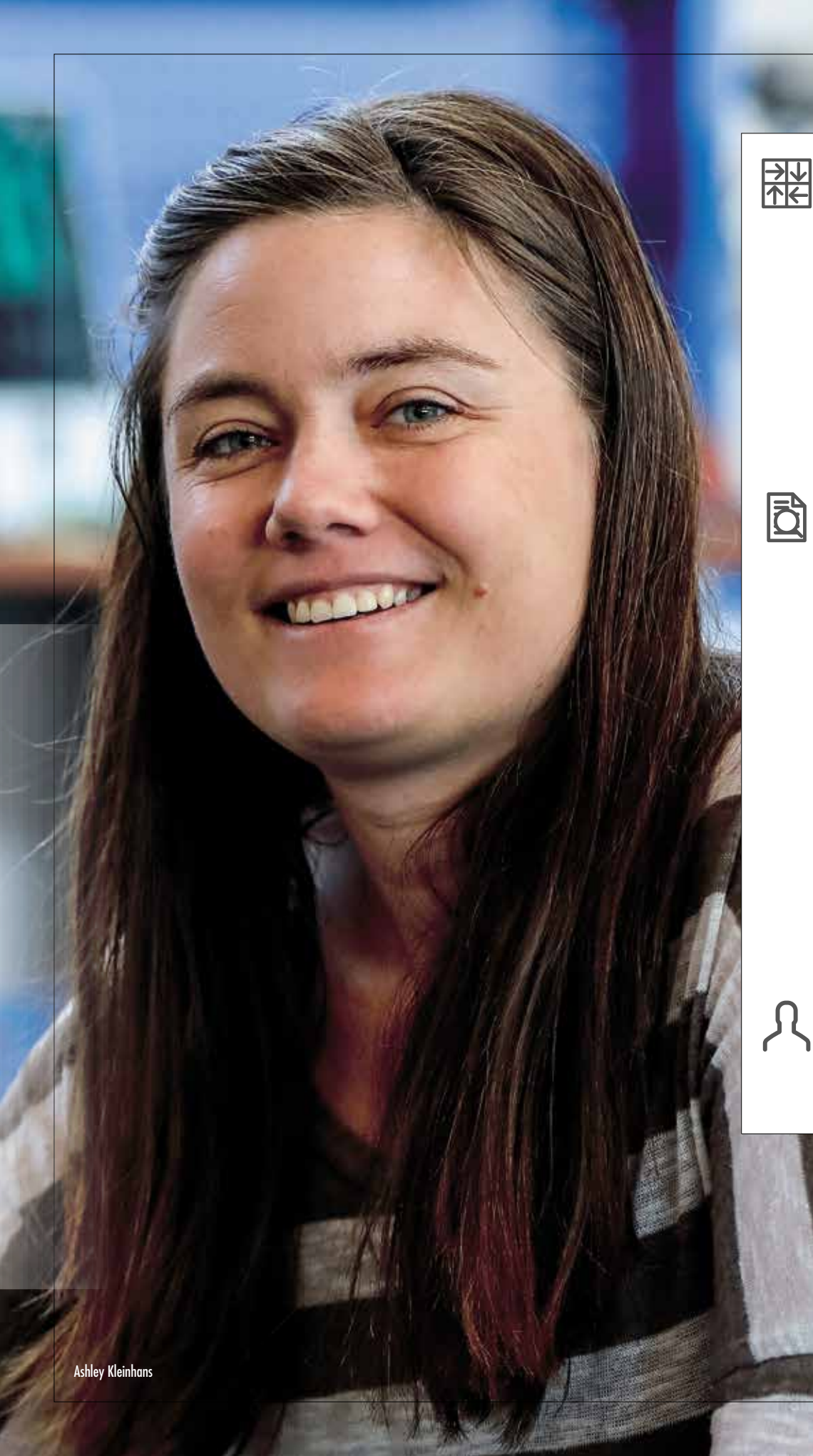
"My specific interest is in intelligence. I try to understand how humans do

simple tasks and apply that knowledge to robotics. For example, when someone picks up a mug, it is not regarded as a higher reasoning skill, yet it is something that requires several brain processes. The eyes are sensors and the brain regions calculate depth information, judge the distance, shape and size of the object, which directs how your hand is going to move.

"A robot gathers similar data using sensors, for example, lasers give depth information. The idea is to find out how to use this sensory data to control the robotic hand. I work mainly with simulation to gather data and train machine learning models that will hopefully be used on a real robot."

Kleinhans recently moved to the United States of America from where she works remotely for the CSIR. She also continues working on a PhD in robotics and computational neuroscience through the Mechanical Engineering Department of the University of Johannesburg. She says that the CSIR has been instrumental in her growth as a researcher and a person.





## CHARACTERISTICS AND APTITUDE

Engineers who work in the field of robotics constantly attempt to break new ground. Therefore they often face difficult or seemingly insurmountable challenges in their work. To cope with this, they need to be resilient, with an ability to solve problems and a willingness to continuously improve the specialist skills needed for their focus area through reading and communication with their peers.



## WHAT AND WHERE TO STUDY

Kleinhans completed a BSc Honours in mechatronics engineering followed by an MSc in neuromorphic engineering, both through the Electrical Engineering Department of the University of Cape Town.

Kleinhans suggests that students who are interested in robotics start with a degree in mechanical engineering, which is offered by most South African universities. "In your Honours (fourth) year, choose your project topic in robotics and add computer programming and mathematical studies during your degree. Learn how to learn because you will always be upskilling post your degree."



## RELATED CAREERS

Computer scientist, mechanical engineer, electrical engineer, mechatronics engineer and computational neuroscientist.

Ashley Kleinhans



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# Using data science to predict trends and plan for a better future

The successful monitoring and prediction of trends in society help us to plan optimally for the future. Government and civil society try to find optimal interventions for health challenges, unemployment and other scourges that impact on the well-being of people, while businesses formulate their strategies to improve their competitiveness. To do this monitoring and forecasting, they need data scientists, people who use their analytical skills to find and merge different data sources, to analyse and visualise these in such a way that people understand their results.

Nyalleng Moorosi



**NYALLENG MOOROSI'S DECISION** to take computer science as part of a Bachelor of Art degree at Macalester College in St. Paul in Minnesota in the United States of America was driven by her dream of becoming an economist. "I was always fascinated by the reasons that lead people to make certain decisions and believed that economics provided some of the more convincing models. However, I realised that to do that I'd have to be proficient in computing and therefore took an introductory course. Though the first course was a challenge, being at a small liberal arts college, I developed solid foundations and soon realised how simple the logic in computing was. I ended up choosing to major in computer science and minored in economics and biology."

After her graduation in 2006, Moorosi took a year off and worked as a software engineer at Thomson Reuters. She then applied for a PhD in computer science at the University of Minnesota specialising in machine learning. In 2010, due to personal and family circumstances, Moorosi decided to put the PhD on hold and leave the USA.

Ten years after having left Lesotho, Moorosi returned to South Africa in 2010. She worked privately for some months and lectured computer science at the University of Fort Hare for three years before being approached to join the CSIR in June 2014.

"In my capacity as a data scientist at the CSIR, I have worked on diverse problems. Recently, I led a project for the SABC to analyse social media conversations around the municipal elections. In another project, I am working on optimising the allocation of resources for human capital development initiatives by performing career trajectory modelling. From this we wish to highlight points in career progression that can best benefit from supportive interventions and provide a tool for developing professionals to better understand likely career progression paths given their current state. I have also worked on projects in predictive policing and rhino poaching modelling, as well as a twelve-week programme that places students into multidisciplinary teams to work on real-world problems in ICT-related fields – guided by CSIR data science practitioners."

"To become a good data scientist, one needs strong technical skills such as mathematical modelling and algorithm design, but it is just as important to step outside the computer science, mathematics or engineering department and look at an application area. This area may be either natural sciences or social sciences. So if one wants to solve real-world problems such as the ones I have mentioned, one needs social science to understand how people live, because that is where the models that describe life, live."



Nyalleng Moorosi finished her last two years of high school in Norway, thanks to a scholarship. She went on to obtain a Master's in computer science.



## CHARACTERISTICS AND APTITUDE

You need to be curious and willing to continuously learn and change with society if you want to stay relevant, says Moorosi.



## WHAT AND WHERE TO STUDY

Moorosi has an MSc (Computer Science) from the University of Minnesota in the USA and a BA degree with computer science and biology from the Macalester College in the USA.

Most South African universities offer degrees in computer science, with Honours and Master's degrees in data science or related disciplines such as machine learning, data mining and artificial intelligence. The Sol Plaatje University in Kimberley in the Northern Cape offers an undergraduate programme in data science.



## RELATED CAREERS

Quantitative banker, risk analyst (banking and insurance), scientific informaticist (biological patterns, chemical structure modelling), entrepreneur and academic or researcher.



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# THE DIGITAL GATEKEEPERS

An information security engineer develops, monitors, evaluates and maintains systems and procedures to protect identified networks and systems from unauthorised access. Simply put, they are digital doorkeepers stationed to protect what they have been entrusted with.

**ZAMA DLAMINI** forms part of a team that develops security measures to ensure information security. They create and maintain technical controls that safeguard organisational data. To do this effectively, they ensure continuous, reliable and secure access to critical systems through the identification, design, implementation, maintenance and effective communication of proper security controls. Her work includes the overseeing and monitoring of security systems

and authentication systems, the development of antivirus software, maintaining firewalls, preventing data leaks, developing encryption, securing file transfer and web content filters that ensure users are not confronted with offensive material.

Dlamini was born in Newcastle and grew up in Nongoma, Richards Bay and Durban, all towns in KwaZulu-Natal. Because of her father's work, the family moved around a lot. She says, "I enjoyed changing schools and

Zama Dlamini



meeting different teachers and classmates from different backgrounds and races. The constant movement added an element of adventure to my otherwise introverted personality and left me open-minded and streetwise. It further contributed to my easy-going nature when it comes to building networks.”

She is the eldest of four sisters and tried her best to act as a role model to them. “I took it as a challenge to keep on being the best I can be, and in a way, it enhanced my leadership skills from family, social, educational and professional perspectives. I remain the best big sister anyone could ever ask for!”

Dlamini maintained the top student position throughout her school and varsity years, receiving her computer science degrees with distinctions. “After my first university qualification, I started assisting learners and students with general guidance relating to their higher education choices; where they can get relevant information and on settling in and adjusting to varsity life.”

Her natural leadership skills have benefitted her greatly in her professional career. She has led various large projects, most notably the cybersecurity awareness project, which was a course on cyber self-

defence, designed to educate the average Internet user on how to safely and smartly use the Internet. She now works as the Operations Manager at the Department of Telecommunications and Postal Services’ National Cybersecurity Hub, which is hosted by the CSIR. The hub responds to cybersecurity incidents affecting South African citizens and local industry.

“My background to date focused on preparing myself to become one of the best leaders and information security engineers I could possibly be. I am aware that I have set quite a challenge for myself considering the borderless nature of this field, but in essence, that is what I am aspiring to. I would like to make this field so interesting for other people from other disciplines, that they will also want to have a piece of this domain.”

Dlamini says today’s technology is intrinsically linked to ‘our daily bread’, “All our duties at home and work revolve around it. In most cases, the security of our devices is the last thing we think about, as long as they are functioning and if there has not been an incident, we continue to ignore it. I do what I do to be able to respond to the ever-changing challenges of cybersecurity in our interconnected world.”



## CHARACTERISTICS AND APTITUDE

Dlamini says that to be an effective information security engineer, you need to have a passion for the development of security measures. You must have the patience to educate people on how to protect themselves against cyber criminals who employ tactics that have not previously been thought of.



## WHAT AND WHERE TO STUDY

Dlamini holds Bachelor’s and Honours degrees in computer science from the University of Zululand, and she is studying towards her Master’s in computer science at the University of Pretoria.

Information security engineering can be studied at various South African universities, such as the universities of Pretoria, Johannesburg and Cape Town, as well as the Cape Peninsula University of Technology, Stellenbosch University and the Nelson Mandela Metropolitan University.



## RELATED CAREERS

Security architect, incident responder, security consultant, security analyst, computer forensics expert, security specialist and malware analyst.



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## BEING A PART OF THE BIGGER PICTURE

"The reason I enjoy working at the CSIR is the fact that you get to work within amazing teams of brilliant people who share your passion and vision. You have the opportunity to be part of something bigger."

Priash Ramadeen



Priaash Ramadeen works as a software engineer at the CSIR. He is part of the team that is responsible for the creation of the Cmore system, a digital collaboration platform that brings various sensors and human intelligence together to offer commanders in the armed forces, as well as community policing and wildlife protection units, a holistic view of what is happening during an operation. Cmore has been rolled out to various southern African nature reserves to aid in counter-poaching initiatives.

**A SOFTWARE ENGINEER** is someone who applies engineering principles within a digital space. "I believe the true nature of a software engineer lies in a combination of art, science, logic, creativity and wanting to really get your hands dirty with code," says Ramadeen. His work involves design, conceptualisation, creation, innovation and engineering development.

Ramadeen grew up in Durban, South Africa. He says, "My childhood was a combination of playing soccer, running around the neighbourhood and taking a keen interest in radios and electronics." From a young age, he was interested in working with computer software. He took mathematics and science throughout high school and went on to complete a Bachelor of Science degree in electronic engineering at the (then) University of Natal. "I then joined the CSIR as an opportunity arose that allowed me to focus on software specifically."

The CSIR encourages employees to continue their studies, which allowed Ramadeen to complete a BEng in computer engineering at the University of Pretoria. "It is important to note that in the information age we currently live in, there is an abundance of amazing resources online that I encourage anyone who wants to work in the software space to make use of as supplementary to their tertiary studies."

CSIR software engineers and researchers work across various domains, performing innovative multidisciplinary research. Ramadeen says that there is something for everyone in the software space at the CSIR, "The work is fulfilling and one of the main reasons I enjoy working here is the fact that the CSIR's mandate and multidisciplinary nature allow me to contribute to solutions that aim to solve global challenges in crime, wildlife management and conservation, as well as various military scenarios."

## FAST FACT

Cmore allows different users to communicate and share information. In the environmental asset management environment, this capability has helped counter-poaching groups to collaborate and consolidate their efforts. Notifications of events, tracks discovered, comments, images and other types of information are received in real time, eliminating delays, misunderstandings or missed opportunities, typically caused by outdated information. Real-time voice, video, text and geographical information shared between, for example, counter-poaching teams, assist groups to direct scarce resources to where they are most effective.

Ramadeen believes that working with software is an essential component in today's world. At the lowest level of implementation, being able to create software and visually see the result of code is "an amazing feeling."

He says, "I often find that people are hesitant or even fearful to get their hands dirty, but I would like to encourage anyone thinking about a career to look at software holistically and use it as a tool to create great things that can make a huge difference in the world."



The Cmore platform can be accessed via multiple devices, such as smartphones, laptop or desktop computers.



## CHARACTERISTICS AND APTITUDE

To be a great software engineer, one needs to be passionate, patient and a problem-solver. You should always strive to improve your work, be open-minded, creative, innovative, curious and driven.



## WHAT AND WHERE TO STUDY

Ramadeen has a degree in electronic engineering from the (then) University of Natal and a BEng (Computer Engineering) from the University of Pretoria. These courses can be studied at many universities across South Africa.



## RELATED CAREERS

Computer scientist, mathematician, physicist, programmer and systems engineer.



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COMPUTER SCIENTIST

# TOWARDS SMART CITIES – engineering the Internet of Things



The exponential growth of smart and low-cost technologies, big data and connectivity is linking people and objects in the real world with the virtual world, where they are constantly sharing information in a system known as the Internet of Things. The CSIR's Lindelweyizizwe Manqele, a computer scientist, is doing a PhD focusing on this field.

#### RESEARCH INTO THE INTERNET

**OF THINGS (IoT)** is fast-paced and the challenges that need to be addressed are complex. To keep up, we need interoperable technologies, more sophisticated and robust algorithms and secure networks. The fact that Manqele was at university when she saw a computer for the first time, makes her achievements in this field remarkable.

She hails from Nongoma, a small town in Zululand, KwaZulu-Natal.

"I was one of the first from my village to go to university. I loved mathematics and did well in it, so my teachers suggested that I look into careers that are related to mathematics. They suggested computer science, but I had never worked on a computer before, even though it was 2003. I thought I was going to learn basic computer literacy.

"When I arrived at the University of Zululand, I was astounded to see how much more computer science entailed. The course was challenging and of about 35 students in my first year, only five of us completed the degree within three years."

Manqele also completed her Honours degree, but faced challenges with her Master's. "At one stage my computer and its external back-up drive were stolen and I had to start from scratch. I was forced to abandon my studies and go home because the university's period of grace had elapsed."

Her breakthrough came when the CSIR offered her a studentship in 2013. "I had to go to Pretoria, but had never flown in an aeroplane before. I felt like an actress in someone else's movie, but embraced the experience."

With support from the CSIR, Manqele completed a Master's degree in electrical engineering through the University of Cape Town and she is currently doing her PhD while working in the CSIR's IoT research group.

This group helps to develop IoT-based decision-making systems to create smart cities. These are cities of the future where assets and services, such as buildings, water infrastructure and waste removal will be managed with information and communication systems and smart devices.

One of the projects is the development of a sensor-based waste removal system.

"The idea is to put sensors on refuse bins, which send their load levels to a decision-making IoT platform. Instead of removing rubbish on allocated days, more efficient removal, based on bin-load levels in an area, would be possible. We are developing algorithms to develop systems that would be sufficiently robust to operate in environments with data challenges related to streaming or faulty sensors or network constraints, for example.

"I hope that this work will one day contribute to more effective service delivery to improve the health and lives of South Africans while also protecting the environment for the next generation," says Manqele.



## CHARACTERISTICS AND APTITUDE

A computer scientist/engineer in the IoT field needs to be creative and innovative with strong problem-solving skills. They need to have strong skills in mathematics and computer engineering.



## WHAT AND WHERE TO STUDY

Manqele completed a BSc and a BSc Honours (Computer Science) at the University of Zululand and later completed an MEng (Electrical Engineering) at the University of Cape Town. She is currently enrolled for a PhD in engineering at the University of Cape Town. These courses are offered at most South African universities.



## RELATED CAREERS

Software developer, system analyst, system architect, web developer, mathematician, statistician, engineer and business analyst.



An Internet of Things-based smart city decision-making model.



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Studying physics opens doors to a myriad of careers in many sectors. However, his inquisitiveness and problem-solving nature took Dr Darryl Naidoo to a lesser travelled road in the South African context, namely that of laser physics, and even more exclusively, laser beam shaping through building novel lasers.

## SHEDDING LIGHT ON BUILDING LASERS

**DR DARRYL NAIDOO** is a senior researcher in the CSIR's novel lasers group. The group designs innovative laser systems for a variety of applications in sectors ranging from industry, to medicine, defence and communications.

Naidoo focuses on the design of lasers – he looks at shaping the light inside a laser and characterises the output – the laser beam. His research requires him to construct various optical experiments, which range from solid-state lasers, to microchip lasers and extra-cavity beam shaping experiments through the use of a spatial light modulator. This has allowed him to spend time in France at the Centre de recherche sur les Ions, les Matériaux et la Photonique, called CiMAP, and the Friedrich Schiller University in Jena, Germany.

"The industry and defence sectors, for example, require high-power lasers with some desired beam shape at the output; but the medical sector requires a different laser output – not as high powered but more stable with very precise specifications," he explains.

Naidoo and his team know that in a number of laser-based applications, beam shape, stability and power are the key concerns. They have demonstrated a number of lasers with different output shapes, thus allowing for the use of a specific shape of light that is better suited for the application at hand.

"Therefore, in a more controlled manner, you can deliver a certain shape of light to the target. And by being able to vary or change the shape, you can increase the efficiency of the process. One can use the analogy of an adjustable showerhead or garden hose where the water pressure can be changed depending on the need."

Two types of laser beam shaping techniques are explored at the CSIR. The first involves opening the laser system and adding specialised elements inside the system to control the shape directly at the source. One example is adding a diffractive mirror to select a flat top beam from the laser that can be used for cutting, welding or stripping paint.

The second is to shape the light that comes out of the laser by looking at the required output and

designing the elements needed for changing the existing shape into the desired shape by using a spatial light modulator or static customised elements. "We can then transform the output shape of the laser to the shape suited for the application."

Naidoo's work focuses on the first kind of laser beam shaping. "It is a lot more efficient to develop a laser system that can give the required shape of light from the outset, versus doing it at some point outside the system – like integrating a turbocharger into a car engine versus adding it afterwards," he says.

Does he spend his time only in the laboratory building laser systems? "Not at all," he says. "I also write proposals, reports and do simulations to test whether the hypotheses will work in real life. Currently, I am focusing on building proof-of-concept systems that we can take to clients to demonstrate a working principle."

Naidoo has gained significant experience across the technology value chain while at the CSIR. He did his PhD in collaboration with what is now known as Airbus Optronics. His research used intra-cavity beam shaping to improve the brightness of a commercial system. He could demonstrate the proof of concept and the project, to develop this at two different wavelengths of light, is now continuing with funding from the Technology Innovation Agency. The CSIR-hosted Photonics Prototyping Facility (PPF), of which Naidoo is a core member, will be used to develop a prototype.

He says, "The PPF is a great opportunity to prototype photonics technologies. There is no other facility like it in the country and we are exploring and seeing what works; it is very exciting."

Naidoo also supervises an MSc student and co-supervises a PhD student.

Advice to share? "The time from a conceptual idea to demonstrating something that's feasible and developing it into something that can be used, can be extensive. It requires patience and enthusiasm. Funding and the actual research work do not happen overnight, so one has to be persistent. When you see your work pay-off, you realise that the time spent was worth it," he encourages.



Dr Darryl Naidoo



## CHARACTERISTICS AND APTITUDE

To become a physicist one needs to study physics at university and to specialise like Naidoo in the shaping of laser beams, one needs a good understanding of the field of photonics. Physicists are curious about how things work and why they work in a specific way. They are enthusiastic, patient and have a continuous desire to learn more.



## WHAT AND WHERE TO STUDY

Naidoo has a BSc (Physics and Applied Physics), a BSc Honours (Physics) (cum laude) and an MSc (Physics) (summa cum laude) from the University of KwaZulu-Natal, which was followed by a PhD, with specialisation in optical physics, from Stellenbosch University.

Stellenbosch University and the universities of the Witwatersrand and KwaZulu-Natal offer courses that specialise in photonics.



## RELATED CAREERS

Optical engineer, fundamental scientist, computational physicist and optical physicist.



Dr Darryl Naidoo designs innovative laser systems.



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# WHEN PHYSICS COMES NATURALLY

Patricia Moodley works as an optical physicist in the CSIR's optronic sensor systems group. The group studies all things optic, from camouflage and surveillance equipment to satellite sensors.

**MOODLEY GREW UP** in Pietermaritzburg in KwaZulu-Natal. Her introverted nature never stood in the way of some good old-fashioned fun. "I loved playing with my friends. We performed entire rock and pop albums for imaginary crowds, we climbed trees, grew plants, caught tadpoles and swam for hours during the hot and humid summers KwaZulu-Natal is so famous for. We even dressed up as superheroes or cartoon characters for fun," she says.

At school she enjoyed solving equations and figuring out the problems mathematics and physics presented her with. "Quite frankly, there was a lot less theory in those subjects, so it was easy for me to understand the concepts and rules and apply those to solving the problems. I decided to study computational physics at university because it presented the best of three worlds – physics, mathematics and computer programming," she says.

Computational physics is not a degree pursued by many. What came naturally for Moodley, is difficult for most. After the first year, there were less than ten people left in her class. "I enjoyed university very much. I got to meet people from different backgrounds and started playing computer strategy games with classmates."

She became a CSIR bursar and used the funds to complete her Honours degree and her Master's degree in physics (optics). "I did experimental work for my Honours and Master's degrees, which was great since it was practical work that allowed me to be inquisitive and answer all my questions through experimentation. To me it was akin to a child at play."

After completing her studies, Moodley started working at the CSIR as an intern on the testing and evaluation of optronic sensors and systems to, for example, determine if the test object is suitable for its intended purpose.

"We compare tested objects to determine the best option, for example, which night vision goggles are best suited for specific military applications. We also try and gain a better understanding of the optical properties of objects. As an experimental physicist, I use various procedures, methods and equipment to test the imaging quality of optical devices and optronic sensors and measure the optical characteristics of targets and sources."

"Saying you work for the CSIR in its safety and security research area adds some pizzazz to the job title! I find it fulfilling to add value by contributing to defence, industry and science. I believe I have been, and remain, very fortunate to be where I am."

Patricia Moodley





## CHARACTERISTICS AND APTITUDE

Experimental physicists characteristically have analytical minds. They enjoy programming and are comfortable working with different software and equipment. They are hands-on, especially with experimental work. They thrive on thinking outside of the box to solve difficult problems.



## WHAT AND WHERE TO STUDY

Students interested in this career can study computational physics specialising in optics at the University of KwaZulu-Natal or physics specialising in optics at most South African universities. They should ensure that they study mathematics, physics and computer science at school.



## RELATED CAREERS

Data analyst, information technologist and software developer.

### FAST FACT

The CSIR optically characterises camouflage patterns used for uniforms, aircraft, vehicles and netting to ensure it is suited for the environment it will be used in. It develops and tests sensors used for long-range surveillance in areas such as the Kruger National Park. Researchers also develop image processing software that enhances images received from sensors.



(Front) A lens system with a central obscuration that is typically used with a camera to perform observations during the day. This is tested by using a large optically flat mirror (back) and an interferometer (not pictured) to test the optical quality of the lens.



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# COMBINING A LOVE FOR CHEMISTRY WITH A WILL TO IMPROVE LIVES

Dr Peter Ramashadi Makgwane opted to study chemistry after discovering that chemistry offers opportunities for exploring and developing new material products that could significantly improve people's quality of life. His desire to make a positive contribution to society and the CSIR's excellent technology platforms, allow him and other researchers to transform their ideas into society-orientated, impact-focused solutions.

**MAKGWANE IS A SENIOR RESEARCH SCIENTIST** and group leader in nanocatalysis and biorenewable chemicals at the Department of Science and Technology (DST)-funded and CSIR-hosted National Centre for Nanostructured Materials. His main research interests include manufacturing metal oxide composite materials that are engineered at the nanoscale. The materials, which comprise different structures, shapes and sizes, have enhanced performance as catalysts in the chemical conversion of biomass-derived raw materials to a variety of biofuels for alternative energy sources.

"I am passionate about breaking and making new chemical bonds to produce chemical products using conventional heterogeneous catalysis and photocatalytic chemical reaction processes that mimic those of nature, such as visible-light photosynthesis.

"The chemicals are known in literature and some are commercially produced by petroleum-based fossils, but not from sustainable and renewable biomass. We are attempting to develop and entrench new chemical industry practices in response to the DST's national bioeconomy strategy.

"The increasing climate change experienced globally in the past two to three decades, including the recent unusual summer temperatures in South Africa, emphasises the need to remediate the sources that have caused this problem for the past century," he says.

He explains that it is not only the high rate of greenhouse gas emissions resulting from the use of coal, natural gas and crude oil refinery that is of concern, but also their continued usage without replacement. "This presents uncertainties for humankind with its dependence on chemicals and chemical energy."

As part of providing alternative and economically viable solutions, the CSIR's nanocatalysis group, pioneered and led by Makgwane, conducts intensive fundamental and applied research to develop alternative catalytic processes. The group aims to produce chemicals and biofuel chemical energy from renewable and sustainable biomass feedstocks (raw material such as furfural, derived from agricultural by-products, typically from corncoobs, oat, wheat, bran and sawdust) using the concept of nanocatalysis material design.

Makgwane's work has not gone unnoticed. He lists one of his career highlights being awarded funding of R12 million to enable the CSIR to develop South African industrially viable nanocatalysis chemical conversion processes, to convert biomass to alternative chemicals, biopolymers and biofuel chemical derivatives.

To prospective chemical scientists, he says, "A career in chemical sciences offers endless opportunities in various sectors. These include the petrochemical, pharmaceutical, agro-chemical processing, food, cosmetic, and water sanitation sectors. One can also become a lecturer or professor, as well as join government's science and energy agencies."

He advises that chemistry, physics and mathematics are crucial companions on the road to becoming a chemical scientist. "Developing advanced skills in verbal and written communication, as well as networking, form the backbone of career success as a chemical scientist," he says.





A close-up portrait of Dr Peter Makgwane, a Black man with a shaved head, wearing a white lab coat over a blue patterned shirt. He is looking slightly to the right with a gentle smile.

Dr Peter Makgwane

“Chemicals give birth to life; for example, chemicals support biology, and biology supports medicine; chemicals also support energy – actually everything you can see. After mathematics comes chemistry. Chemistry is the basis of everything; one can say mathematics is the father of everything, but chemistry is the mother.”



## CHARACTERISTICS AND APTITUDE

You require a high level of multidisciplinary thinking and an understanding of organic and inorganic chemistry, as well as materials design and surface chemistry. You need to have an aptitude for mathematics and a sound understanding of how nature operates, says Makgwane.



## WHAT AND WHERE TO STUDY

Makgwane has an MSc in chemistry from the University of Pretoria and a PhD in chemistry, specialising in heterogeneous catalysis for chemical synthesis, from the Nelson Mandela Metropolitan University. He completed his postdoctoral fellowship at the University of Johannesburg and the CSIR.

Specialising in chemical technology process development requires further studies after completion of a BSc and BSc Honours in chemistry, up to PhD level. An additional two years of international postdoctoral fellowship tenure is advisable.

All South African universities offer a Bachelor of Science degree as the foundation for a career as a chemical scientist. Makgwane says it is important to choose a university with an internationally acclaimed reputation in postgraduate studies. This will expose the undergraduate student to the practical industrial application of chemistry at an early career level.



## RELATED CAREERS

Chemical engineer, biotechnologist, pharmacist, material scientist and physicist.



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CHEMISTRY:  
The key to making  
more of the pulp and  
paper industry's waste

“There is only a small group of scientists in the country with expertise in chemical cellulose.”





Day-to-day out-of-the-box thinking and constantly improving your clients' products sound like a fulfilling and rewarding career. Attaining this is possible, says CSIR chemist Dr Viren Chunilall, who is part of a national research and development effort to make more of the waste produced by South Africa's paper and pulp industry.

**CHUNILALL IS A CHEMIST** in the CSIR Biorefinery Industry Development Facility. Biorefinery is a new technology practiced in South Africa's pulp and paper industry. Analogous to oil refinery technologies used to produce multiple chemicals and products from crude oil, the principle of biorefinery is to similarly convert biomass into chemicals, biomaterials and fuels, in addition to traditional wood, pulp and paper products.

Currently, the forest products industry is extracting about 47% value from trees. This is not environmentally friendly as it results in the generation of large amounts of waste that have to be disposed of. Researchers are developing technologies that create new value chains from these wastes to help revitalise the industry.

Chunilall is working on a project that involves the extraction of high-value chemicals from sawdust – a by-product of the sawmilling industry. "Our aim is to obtain xylitol and pine-oil as final products from the extraction and derivatisation processes," says Chunilall.

He has always had an interest in the environment. "As an early postgraduate student at the University of KwaZulu-Natal I worked on a project that involved the purification of wastewater using seawater. I had to work after hours and on weekends to complete the experiment. Ultimately this experiment is what led to my very first publication in the *Journal of Environmental Science and Health* and paved the way for my research career at the CSIR," he says.

Chunilall says within his field, new products and techniques of analysis are constantly being developed and there is only a small group of scientists in the country with expertise in chemical cellulose.



The CSIR is conducting experiments to obtain xylitol and pine-oil from sawdust.



## CHARACTERISTICS AND APTITUDE

One should be able to confidently engage in an open dialogue and consider different or unorthodox methods and views. Chunilall says patience is also an important characteristic as the goals of experiments and projects are not accomplished overnight.



## WHAT AND WHERE TO STUDY

Chunilall completed his BSc, MSc (cum laude) and PhD in chemistry at the University of KwaZulu-Natal (UKZN). Many South African universities offer degrees in chemistry, including the University of Pretoria, Stellenbosch University and UKZN.



## RELATED CAREERS

Analytical chemist, process chemist and mill chemist.



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# AT THE INTERFACE OF BIOLOGY AND CHEMISTRY

Medicinal chemistry is the application of biology and chemistry to the design of new drugs for treating disease. A medicinal chemist such as the CSIR's Dr Jenny-Lee Panayides applies knowledge related to chemistry, biochemistry and microbiology to generate solutions to health-related problems.

**PANAYIDES IS A SENIOR RESEARCHER** in biosciences. She has a PhD that was co-supervised in both synthetic organic chemistry and microbiology from the University of the Witwatersrand. "After completing my PhD, I undertook two post-doctoral research periods – the first was with the Medical Research Council, using my synthetic chemistry knowledge in a drug discovery programme that focused on identifying novel compounds for the treatment of drug-resistant tuberculosis; the second was at the CSIR, where I applied my microbiology experience to identify novel compounds that are active against various drug-resistant strains of malaria," she says.

Panayides works in the CSIR's bioassays and high-throughput screening group with her day-to-day duties being in the screening facility, where researchers screen thousands of compounds to find new therapeutic drugs; while at the same time managing synthetic chemistry projects. "In this position, I contribute to driving some of the medicinal chemistry research efforts in the CSIR – by working at the interface of biology and chemistry," she adds.

Panayides says it is important for any person interested in pursuing this career to have a thirst for knowledge, a passion for science and the ability to work in a team.

"The job is very rewarding," says Panayides. "The feeling of knowing that you contribute in a small way to the discovery of new treatments for a disease is really quite exciting; but the job can also be taxing, as synthetic chemistry rarely works in the way you hoped the first time. You need to be resilient to solve problems you encounter on a day-to-day basis – in this field knowledge really is the key."

Panayides is involved in a number of research projects at the CSIR.

"The first is in the area of malaria research, where CSIR researchers form part of a larger team called the South African Malaria Transmission-blocking Consortium (SAMTC). The team is currently working on a large project for the Medicines for Malaria Venture (MMV) and the SA Medical Research Council Strategic Health Innovation Partnership in collaboration with groups at the universities of Pretoria and the Witwatersrand, the National Health Laboratory Services and the University of Cape Town Drug Discovery and Development Centre (H3D).

"In this project, we are currently using the CSIR's high-throughput screening capabilities to assay 25 000 compounds for activity against the sexual stages of the malaria parasite, called gametocytes. The idea is that if the SAMTC can identify compounds that inhibit the gametocytes, the

chemistry team at H3D will use their know-how to optimise lead compounds and these can then be developed by the MMV into drugs that will be able to block transmission of the parasite, aiding global malaria eradication efforts," she says.

The other main project that Panayides is involved in is a collaborative research effort with the University of Pretoria's departments of chemistry and pharmacology. The project focuses on identifying novel drugs for the treatment of Alzheimer's disease through target-based research. The synthetic work on this project is undertaken at the university and the CSIR assists with structure-aided drug discovery by visualising the docking of compounds into the active site of the enzyme and then correlating this back to the biological data obtained *in vitro*.

In addition, Panayides is also involved in a project that aims to synthesise novel catalysts for use in the manufacture of active pharmaceutical ingredients.

"For this project we rely on synthetic organic chemistry and organometallic chemistry knowledge to prepare catalyst systems that are supported on CSIR proprietary scaffolds and to then validate the use of these scaffolds under various conditions that could be applied to pharmaceutical manufacturing," adds Panayides.





Dr Jenny-Lee Panayides



Testing catalyst activity on multiple substrates using the Carousel reactor.



## CHARACTERISTICS AND APTITUDE

Thirst for knowledge is important; so is a passion for science and the ability to work in larger teams. You need to be resilient to solve the problems you encounter on a day-to-day basis.



## WHAT AND WHERE TO STUDY

Panayides completed her BSc in chemistry, microbiology and biotechnology and an Honours in pure chemistry. This was followed by an MSc in synthetic organic chemistry, which she completed cum laude. She obtained her PhD co-supervised in synthetic organic chemistry and microbiology at the University of the Witwatersrand – the same university as all her other degrees. Many universities in South Africa offer courses in chemistry.



## RELATED CAREERS

Organic chemist, process chemist, medical scientist, pharmacologist and consultant.



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# INVESTIGATING THE CHEMICAL NATURE OF COMPOUNDS

Analytical chemists perform tests and other procedures on compounds to discern their nature. They typically do this work in laboratories, where they operate and maintain instruments such as spectrometers and chromatography instruments.

Kgama Mathiba chose the CSIR to hone his skills as an analytical chemist.

**“ANALYTICAL CHEMISTS** often work in service-related jobs and are employed in industry, academia and government. We conduct basic laboratory research, develop processes and products and operate high-technology instruments used in analysis,” says Mathiba.

Mathiba is currently involved in three projects at the CSIR. In the first, Mathiba and his colleagues are working on the scale-up of a green production process for the commercial production of (-) ambrifuran to 50 litre or more.

“(-) Ambrifuran is a highly fragrant compound used as a fixative agent to stabilise perfumes by reducing the rate of evaporation of volatile substances. A two-step process for the production of (-) ambrifuran starting from sclareol has been developed at the CSIR for an industrial partner, Teubes cc. Teubes supplies flavours and fragrances, aromatics, essential oils and natural extracts. The current commercial

production of (-) ambrifuran entails a chemical process consisting of at least eight steps and requires very harsh chemicals and elevated temperatures,” says Mathiba.

In another project, Mathiba and his colleagues are developing protein and enzymes reagents from indigenous microbes. He says the main aim of the project is to develop bioprocesses and products for commercialisation.

“The goal is to research and develop cost-effective biomanufacturing technologies for ribonucleic acid and deoxyribonucleic acid manipulating enzymes such as polymerases, ligases and endonucleases, as well as protein conjugation enzymes,” he says.

Mathiba is also involved in the plant-based production of antibodies for passive vaccination against HIV. The aim of this work is to advance the development of a cost-effective plant-based biomanufacturing process of antibodies in tobacco plants.





Kgama Mathiba



A vial containing a protein sample.



## CHARACTERISTICS AND APTITUDE

To be an analytical chemist, one needs to have an inquisitive mind and be keen to explore and solve problems. You need to be organised, communicative and have an acute interest in technology. Good spoken and written communication will ensure that you can record and share your findings.



## WHAT AND WHERE TO STUDY

Mathiba completed his BSc in chemistry and biochemistry and BSc Honours in biochemistry at the University of Zululand. He obtained an MSc in biochemistry at Rhodes University. In addition, he also has a diploma in sorghum brewing technology from the University of Pretoria.

The majority of South African tertiary education institutions offer qualifications in chemistry or analytical chemistry.



## RELATED CAREERS

Research scientist, forensic scientist, food scientist, quality assurance manager, laboratory manager and environmental officer.



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Dr Asongwe Tantoh



# SCREENING COMPOUNDS TO FIND NEW DRUGS FOR DIFFERENT DISEASES

The world of 'screening' is vast, with most pharmaceutical companies taking part in the race to find new therapeutic drugs and ways to combat the hundreds of thousands of different forms of diseases that are plaguing the world. Structural biologist Dr Asongwe Tantoh is one of many researchers around the world who is searching for new therapeutic drugs to combat these conditions.

**STRUCTURAL BIOLOGY** is a branch of molecular biology, biochemistry and biophysics concerned with the molecular structure of biological macromolecules, especially proteins and nucleic acids, how they acquire the structures they have and how alterations in their structures affect their function.

Tantoh leads the CSIR high-throughput screening platform.

"My job is to look for new therapeutic drugs or repurposing – looking for new uses of already existing drugs – by screening their effective activities against different biological targets or disease models," he explains.

Tantoh uses a CSIR-developed high-throughput printing technology that is fast, easy to operate and capable of screening hundreds of thousands of drugs or compounds simultaneously against different targets. Microarray screening platforms, in which multiple biological experiments can be conducted in parallel, are becoming an increasingly popular approach. Traditional screening methods, such as systematic well-plate based screening using robotic or manual handling of samples and low-density arrays of printed small interfering ribonucleic acid, can be time consuming and resource intensive.

"I impregnate the different drugs or compounds into a polymer matrix and using a custom-made printer, print them onto a glass surface. Each printed spot is a disc of approximately 500  $\mu\text{m}$  in diameter and 1 000  $\mu\text{m}$  apart from each other. Once spots are dried, I then screen them against different biological targets," says Tantoh.

Tantoh joined the CSIR in 2009 as an intern and has risen through the ranks to be named the principal investigator of the CSIR's high-throughput screening platform. He was actively involved in setting up the first high-throughput screening platform in Africa and his doctoral thesis is on the development and use of the technology at the CSIR and the University of Cape Town.

"At school in Cameroon, I found subjects such as biology, chemistry, mathematics and physics very interesting and I wanted to be a medical doctor. However, because of financial constraints I decided to pursue a career that is still closely related to medicine and also has an impact on people's daily lives," says Tantoh. "I enrolled for a BSc in structural biochemistry focusing on human anatomy and physiology at the University of Buea in Cameroon. I then obtained a BSc Honours and MSc in molecular biochemistry from Stellenbosch University. I completed my PhD in clinical sciences and immunology at the University of Cape Town," he adds.



A high-throughput microarray printer is used to screen compounds.



## CHARACTERISTICS AND APTITUDE

This career requires inquisitiveness and dedication. Moreover, you have to be nimble with your hands as high-throughput micro-arraying is somewhat of an art, says Tantoh.



## WHAT AND WHERE TO STUDY

Tantoh has a BSc (Honours) and MSc in molecular biochemistry from Stellenbosch University and a PhD in clinical sciences and immunology from the University of Cape Town.

At most South African universities, students will start with a BSc degree and then specialise when doing their Honours, Master's and PhDs in various different fields to equip them to work as structural biologists. Many of these courses are offered by departments of biochemistry.



## RELATED CAREERS

Molecular biologist and biochemist.



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# EXPLORING THE CHEMICAL PROCESSES IN LIVING ORGANISMS

Biochemistry is a branch of science that explores the chemical processes within, and related to, living organisms. It is a laboratory-based science that brings together biology and chemistry. Biochemists such as Dr Previn Naicker, a CSIR senior researcher, apply biochemistry knowledge to solve problems in the biotechnology and related fields through technology development.

## NAICKER IS PART OF THE CSIR

molecular diagnostic group that uses molecular biology techniques to detect and characterise pathogens at point of care.

"Problems in this field are typically solved by designing and conducting laboratory experiments and analysis, as well as contextualising the results. Initial experimentation is followed by a series of further experiments, depending on the scale and end-use of the technology being developed," says Naicker.

"We are currently developing diagnostic methods for the early detection and control of livestock diseases, as well as novel methods for determining vaccine efficacy and aiding vaccine design for livestock diseases and automated technologies – magnetic microspheres – for high-throughput proteomics research and proteomics research related to major human and animal diseases," says Naicker.

He says the diagnostic instruments that they are developing for infectious diseases such as foot-and-mouth disease, avian influenza and brucellosis supply real-time results in the field to enable immediate decision-making around containment strategies. It is important for the health of the animals and contributes to export opportunities and the financial sustainability of rural areas.

Outlining how he chose this career, Naicker says, "By the end of high school, I was captivated by human biology and the complexity of life. I did not know what I wanted to specialise in, but I knew that

I wanted to discover more and solve health problems in society."

Naicker matriculated in 2005 at the age of 14, thanks to an accelerated school programme for gifted students. In grade six, he was offered a scholarship to Star College in Westville in Durban, KwaZulu-Natal, where he and several other pupils underwent an accelerated learning programme.

He completed a BSc in biomedical science and pursued an Honours degree in medical biochemistry, both at the University of KwaZulu-Natal. After taking a gap year, he enrolled for his Master's degree, which was later converted to a PhD in protein biochemistry and structural biology at the School of Molecular and Cell Biology at the University of the Witwatersrand.

Naicker says students pursuing or hoping to pursue a science career path should familiarise themselves with all the industries they may be interested in.

"Conduct your background research early. Look at current opportunities, the scope of the career, time required for relevant education and salary," he adds. "Speak to experienced professionals in the relevant field and try to job-shadow or tour workplaces and attend careers days. Gain exposure to a variety of job types and be flexible with your career interests, especially when opportunities are limited. Network as much as possible; who you know is important, irrespective of the field you are in. Let people know that you are enthusiastic and have the right skills or are willing to learn."





Dr Previn Naicker



A CSIR researcher uses a pipette to draw a sample for testing.



## CHARACTERISTICS AND APTITUDE

To qualify as a biochemist, one needs to obtain good symbols in mathematics, as well as physical and life sciences in Grade 12. For undergraduate studies, one needs to take at least one of the following subjects as a major: Biology, microbiology or biochemistry.

"To be able to do this job, you must have a passion for the science at large and the positive impact it can have on society. Perseverance in your research, including the day-to-day challenges, is vital and having the ability to generally see the positives and not get too despondent by failure is a great advantage," says Naicker.



## WHAT AND WHERE TO STUDY

The majority of South African tertiary education institutions offer science degrees.

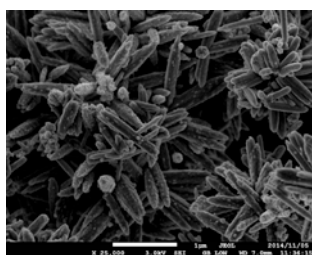
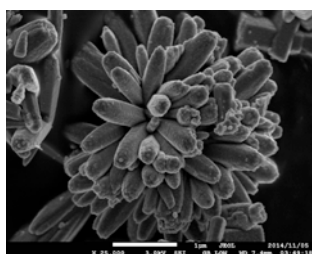


## RELATED CAREERS

Structural biologist, biotechnologist, medical biochemist, protein biochemist, technician in biotechnology/chemical/agriculture/environmental industries, application specialist for equipment or consumable supplies and laboratory manager.



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Zinc oxide nanoparticles arranged in a flower-like structure as observed through an electron microscope. What appears as a white powder, can only be identified as a nanomaterial by using an electron microscope.



# PEEKING INTO A HIDDEN WORLD – Using microscopy to support science

In the last century, advances in microscopy have opened a window into the hidden world of particles hitherto invisible to the human eye.

CSIR microscopist Charity Maepa provides crucial support to scientific research from the back-end, but she also sees her job as a form of art.

**MICROSCOPISTS** support almost every field of science. In the healthcare industry, they may identify abnormal cells or disease-causing pathogens in tissue, while those who support environmental science may seek toxins or small organisms in water samples.

Maepa works in the CSIR's nanomaterials characterisation facility where researchers study structures of materials on the scale of nanometres to develop new materials and industry processes.

"I love my job, but would never have predicted this career path. At school, I was interested in mathematics, science, biology and accounting and I had wonderful mentors who guided me in these subjects. Yet, my knowledge of career options was limited to becoming a medical doctor," she says.

"Today, more than a decade later, I realise I am not suitable for clinical practice. I belong in the laboratory where I support science from behind the scenes."

Maepa provides research support analysis with a scanning electron microscope, which scans the surface of a specimen using a focused beam of electrons that are reflected to form an image. These electrons are much smaller than light particles and allow her to see materials at a nanoscale level. The microscope provides structural information about materials, such as particle size, type, shape and arrangement. Maepa helps researchers to understand the characteristics and behaviour of the material that they study, enabling them to publish new scientific findings and to register patents for product development.

She also uses transmission electron microscopy; atomic force microscopy and

Fourier transform infrared spectroscopy for imaging in conjunction with the scanning electron microscope to give optimum results.

"Throughout the research process, CSIR nanoscientists synthesise and modify nanomaterials for various applications and often need to verify them using the microscope. We focus on applications such as polymers, catalysis, sensors and water purification," she says.

Maepa likes her support role and says the three microscopes in her facility are often booked months in advance.

"Some researchers are very competitive and strive to publish in high-impact journals to build their scientific careers. When they publish or receive prestigious awards for their work, I find tremendous satisfaction in the fact that I supported them with crucial microscopic analysis."

Maepa is also conducting her own research by doing a Master's on using waste materials from plants to remove industrial toxins from water. "These materials are cheap, abundantly available, and usually found in landfill dumps. My research seeks to find an economically viable way to address the country's water shortage and the high cost of water purification."

To her, microscopy is also a form of art.

"It is like doing photography on a nanoscale. In this world of small particles, you take images from samples and they tell a story about the quality of the material that the researcher wants to develop, whether the particles are the right shape and size, pure and optimally distributed. Therefore I make sure I get the best images to tell the best stories."



A sample stage with various samples prior to examination using scanning electron microscopy. Using this instrumentation, seemingly uninformative details to the naked eyes are translated into valuable information about the nanostructure of materials.



## CHARACTERISTICS AND APTITUDE

A microscopist is familiar with laboratory equipment and analytical software and has an in-depth understanding of electron and light microscopes and material analysis. These professionals pay attention to detail and have a genuine interest in science and a strong commitment to customer satisfaction, collaboration and team work. They have good communication skills and the ability to work in a fast-paced environment. Good eyesight is an added benefit.



## WHAT AND WHERE TO STUDY

Maepa completed a BTech in chemistry at the Tshwane University of Technology, but says that any degree in natural sciences or engineering from universities and universities of technology can provide the basic background needed to become a microscopist.



## RELATED CAREERS

Material scientist, physicist, chemical and metallurgical engineer, polymer technologist and biologist.



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# Understanding how our climate changes

Most economic activities depend on the weather and climate. This is a truth often taken for granted, together with the fact that the climate underpins our very survival as a species.

**THE SHEER COMPLEXITIES** of the many earth systems that interact to provide for a stable climate are by-and-large of little concern to ordinary people as they go about their daily business. But for a handful of researchers, understanding these complexities, have become their livelihoods – accurately modelling and simulating how these systems impact and change our climate. Dr Mary-Jane Bopape is such an individual.

Bopape is a CSIR research meteorologist specialising in atmospheric modelling. Her research focuses on developing and improving numerical models used for predicting weather and climate, and using the same models to understand atmospheric processes. “We know that the climate is constantly changing. We are concerned with understanding the nature of this change over a long period in order to inform policy-makers charged with long-term sustainability planning, the agriculture sector and the health sector, amongst others,” she says.

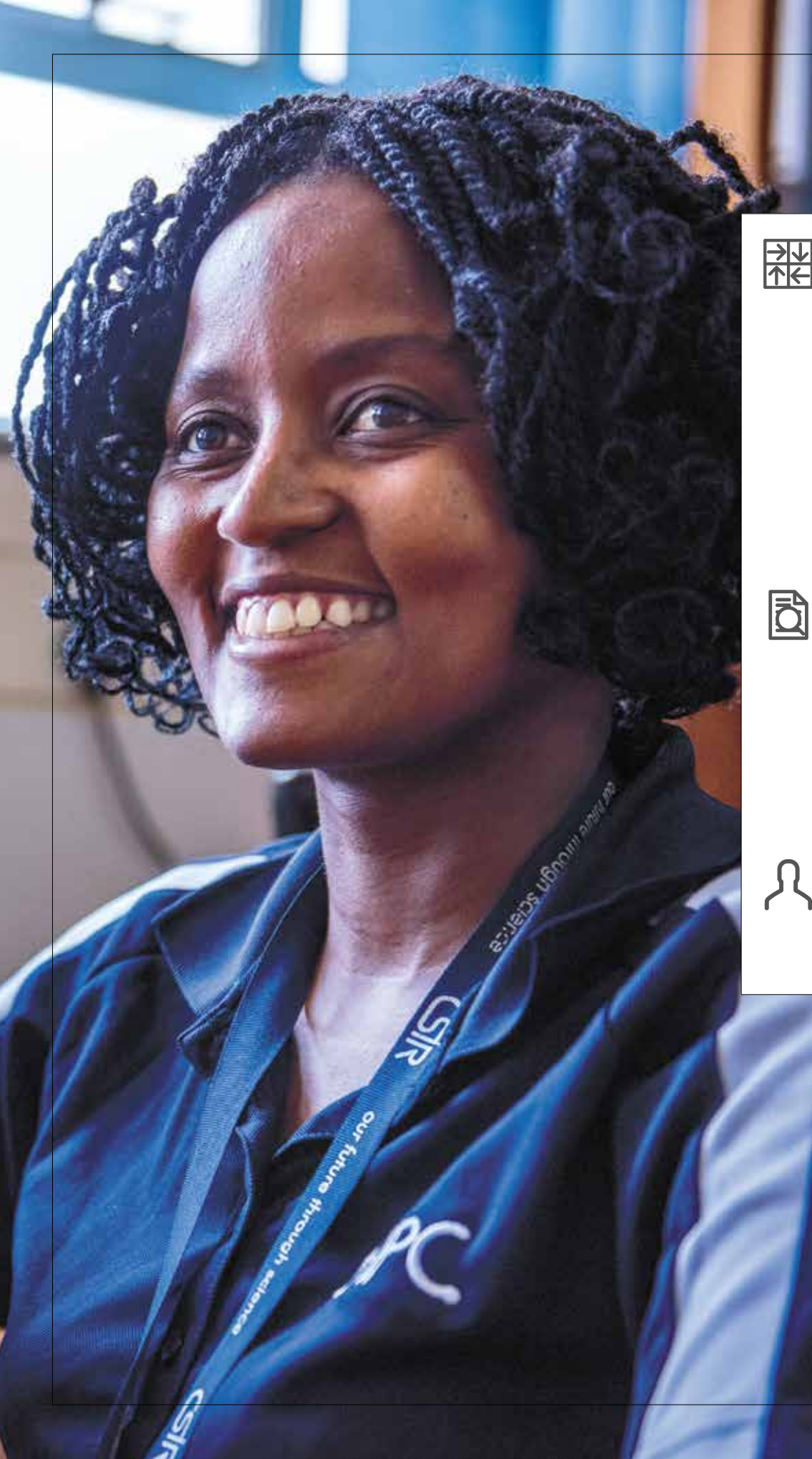
Weather and climate models require the use of very large computers in order for them to be able to produce simulations with a high resolution. Bopape works for the Centre for High Performance Computing (CHPC), which is funded by the Department of Science and Technology and managed by the CSIR. The CHPC houses the fastest computer in

Africa. It is used by researchers in different fields such as materials science, astronomy, biosciences and earth sciences.

Hailing from Limpopo, Dr Bopape completed her matric in 1998. She then obtained her BSc and BSc Honours (Meteorology) at the University of Pretoria (UP). After joining the South African Weather Service in 2003, she completed her MSc (Meteorology) in 2006. She then joined the CSIR in 2008, completing her PhD (Meteorology) at UP in 2013. After her PhD, Dr Bopape worked as a postdoctoral research fellow at the University of Reading in the United Kingdom for a two-year period, while on a sabbatical from the CSIR.

Dr Bopape became the first South African to receive the World Meteorological Organisation Research Award for Young Scientists for her co-authored work titled ‘The Internal Variability of a Regional Climate Model over South Africa’. The paper was published in the *International Journal of Climatology* in 2008. She is the Vice President of the South African Society for Atmospheric Sciences (2016/17 to 2017/18). She co-supervises Master's students at the University of Venda and lectures a BSc Honours module at UP on a part-time basis. Her work has made it possible for her to travel to a number of countries such as the USA, Australia, China, Japan, Italy, Egypt and Ethiopia for conferences and meetings.





## CHARACTERISTICS AND APTITUDE

To work as a meteorologist in general, you need to love the natural environment, understand how it works and have an aptitude for working with large datasets. To qualify as a meteorologist, you need to take mathematics and physics at university. To specialise in numerical modelling, you need to love working with equations, solving problems, programming, working with large datasets and spending a lot of time indoors.



## WHAT AND WHERE TO STUDY

The University of Pretoria offers a degree in meteorology, while the University of Cape Town offers degrees in ocean and atmosphere sciences. The universities of the Witwatersrand and Venda, as well as the North-West University offer postgraduate degrees that include meteorology-related topics.



## RELATED CAREERS

Weather forecaster, climatologist, oceanographer, agrometeorologist, air quality specialist, researcher, academic.



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# Applying geographic information systems to allocate resources and solve crime

The field of geographic information systems (GIS) allows experts to visualise, analyse and interpret data to understand relationships, patterns and trends.

## CSIR PRINCIPAL RESEARCHER

Dr Peter Schmitz works with software and computer programs to create and maintain data and maps that can be combined with geographically referenced data. These datasets are used in a myriad of applications, from crime analysis, location-allocation modelling and environmental impact assessments, to surveying, urban planning and road maintenance.

The application of GIS in crime is one that has made many a headline. To build watertight cases, police investigators require more than just a spreadsheet with addresses and call times proving that the suspect was in a particular area; they need detailed information, such as a map displaying the location of the cell towers, the time of the phone calls, and the direction from where the calls were made.

Investigators acquire cell phone records of perpetrators to pinpoint that the suspect was in the area where the crime took place and at the time it occurred. The phone records are key evidence, since they are able to identify usage of the suspect's cell phone, before and after the crime took place. In 2008, the testimony of Schmitz as a technical expert helped secure the conviction of the killers of Taliep Petersen.

As the use of GIS continues to increase, specialists like Schmitz are able to assist local governments in providing transportation, health and infrastructure management to an ever-growing population, using data acquired through

GIS. Since most of the decisions they make are related to location, geographic information is one of the most important and valuable factors in the areas of planning, public safety, urban renewal and economic development issues facing local governments.

Schmitz says the discipline offers a wide range of opportunities from surveying to advanced geospatial statistics.

In addition to the many projects in forensic GIS, he also does allocation analysis to place schools, fire stations, offices and businesses at optimal locations. "I work on a range of projects, ranging from crime analysis and climate-related studies to bulk infrastructure modelling for private and state-owned entities, mostly in a supportive role to other analysts," he says.

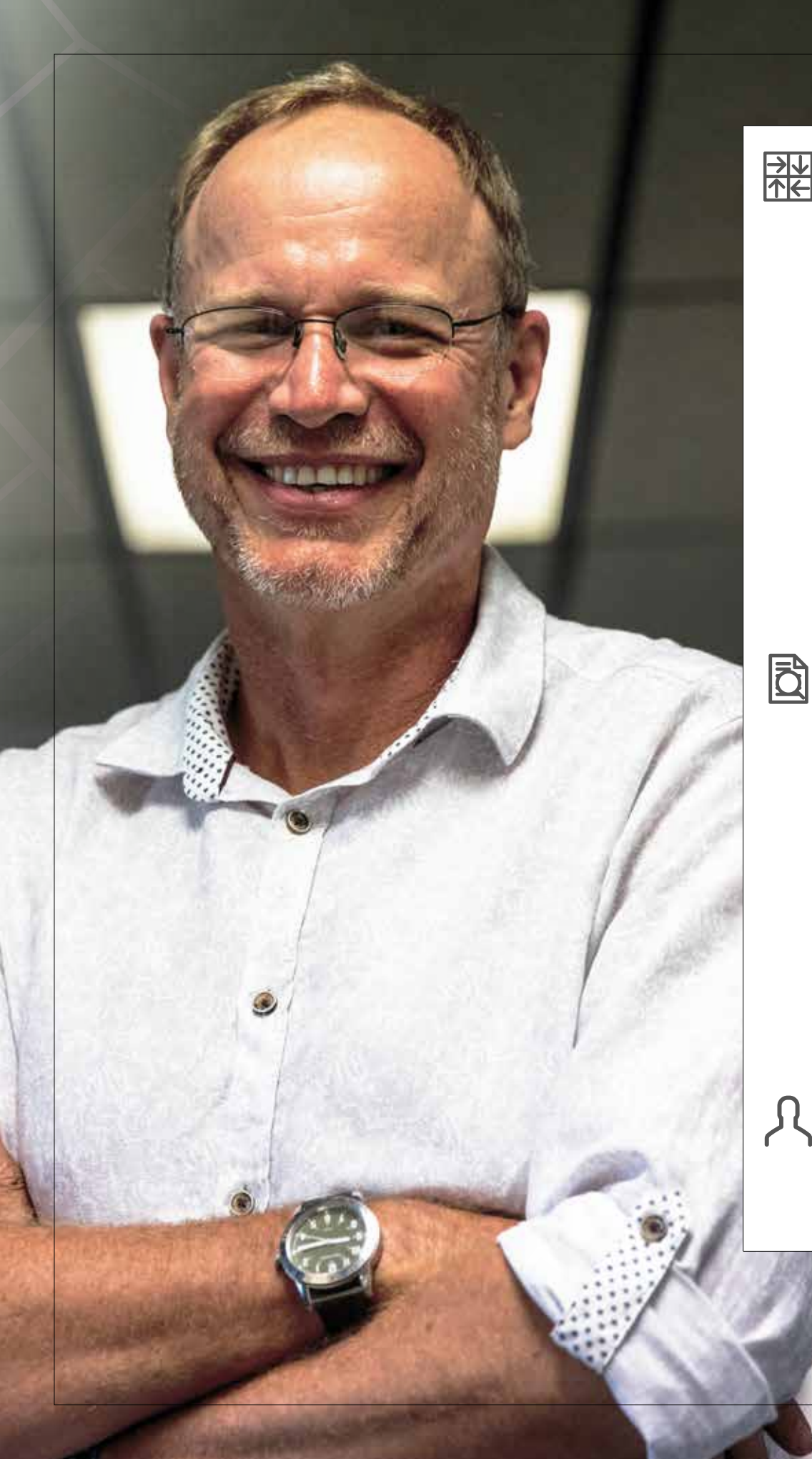
Schmitz leads the CSIR election forecasting team. This team undertakes forecasting for national and municipal elections. In the case of the 2016 municipal elections, Schmitz and his team were able to accurately predict the outcome of the election using a CSIR forecasting model. The CSIR was able to identify major trends and the overall results of the election. "This is done by aligning previous election voting districts to current voting districts as input to the election prediction model," he says.

Schmitz lectures GIS on a part-time basis at the University of Pretoria and applied sciences at the University of Applied Sciences, Stuttgart, Germany.

"You name it, we map it."

Dr Peter Schmitz





## CHARACTERISTICS AND APTITUDE

A GIS specialist must have a good understanding of geography, mathematics, physics and statistics. Other subjects/disciplines such as computer programming, surveying, biology, medicine, remote sensing, oceanography, criminology, engineering, geology, meteorology, environmental sciences, forestry and hydrology are all added advantages. Most GIS specialists come from these fields and have added GIS to their specific skills package by formally registering at the South African Geomatics Council as a GIS Technician (NQF Level 6), GIS Technologist (NQF Level 7) or as Professional GIS Practitioner (NQF Level 8).



## WHAT AND WHERE TO STUDY

Schmitz studied geography and mathematics at the University of Johannesburg and hydrology at the University of KwaZulu-Natal. He read geographic profiling of serial criminals at the British Columbia Institute of Technology in Canada. His PhD was in geography at the University of Johannesburg and he completed a BSc Honours in geoinformatics at the University of Pretoria.

Learners can study at any university in South Africa. Some universities offer GIS as part of geography, surveying or environmental sciences.



## RELATED CAREERS

A GIS specialist can work for government departments, local authorities, state-owned entities, private companies, mining houses and academia.



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# PLANNING: SHAPING OUR COLLECTIVE FUTURE

Cities and regions are faced with complex challenges of transformation, service delivery and sustainable development in contexts that are becoming increasingly dynamic, uncertain and volatile. Professionals such as Elsona van Huyssteen, a CSIR urban and regional planner, contribute by supporting decision-makers to find coherence, manage tensions and develop high-impact interventions.

## The scope of urban and regional planning

Urban and regional planning as a profession is often described as a science and an art. In a science context, this implies engaging in complex adaptive systems, where knowledge is value laden and relational.

Urban and regional planners are involved in a wide range of fields, ranging from contributing to land or infrastructure development, to longer term spatial and integrated planning processes aimed at ensuring co-ordinated and timeous investment by stakeholders.

"Planners often lead and contribute to the development of policies and plans to achieve more equitable, sustainable and productive cities or thriving rural regions," Van Huyssteen says.

"They also provide decision-makers with support to enhance the investment impact and consider intended and unintended consequences of housing, land development and public transport interventions.

Van Huyssteen describes urban and regional planning as an integrative, action and future orientated discipline that supports the longer term development and management of cities, towns, settlements and regions in ways that address the current challenges, as well as contribute towards a sustainable future in those spaces and the world at large.

## Urban and regional planning in South Africa

"Whilst many challenges remain, democratic and integrated spatial planning has actively contributed to enhancing living conditions in South African cities and towns over the last decade," she says.

Planning plays a key role in guiding government infrastructure investment and land development in ways that can increase access to social and economic opportunities and improve the quality of life of communities in marginalised areas, she says.

The challenge, however, is to facilitate development processes relating to housing, land and infrastructure in ways that consider community needs as well as taking cognisance of dynamic influences of (and impact on) the economy, technology, transport, the environment and the multiplicity of role players in urban areas.

"One of the critical aspects to consider in service delivery and forward planning for development in cities and towns is to not only focus on backlogs and existing needs, but to consider potential demographic changes and resource dynamics influenced by high levels of mobility and interdependencies within inter-regional social and economic networks and socio-ecological systems.

One of the biggest challenges facing the planning profession in South Africa and in Africa is the rate at which cities and towns are growing and vulnerabilities are increasing," she says.

## The CSIR emphasis: Spatial planning support to decision-makers

The CSIR's work focuses on spatial planning decision-support to policy-makers, government and other stakeholders.

Van Huyssteen is a researcher in the CSIR urban and regional planning group. Her group has been involved in various initiatives to support smart city and regional planning, urban and rural policy development, as well as infrastructure investment in South Africa. Research and development includes developing technology and spatial indicator technologies to support spatial analyses, track growth trends and simulate future growth in cities and settlements. A large part of her work focuses on raising awareness on fast-changing dynamics and critical considerations in different regions and towns across South Africa to enhance the impact of government policies, enable differentiated investment and facilitate better service delivery collaboration between local and district municipalities, as well as different provincial and national departments.

By identifying growth implications and spatial change trends, planners and geo-spatial specialists in her group have recently made valuable contributions to discourses in South Africa's *Integrated Urban Development Framework* and in providing a spatial perspective on change over the last two decades in South Africa's biggest cities, for *The State of South African Cities Report, 2016*.

They are also involved in the development of tools to maximise the impact of government investment, considering the diversity of the South African social, economic and resource landscape. One such example is the recent tools developed for the Department of Rural Development and Land Reform to support rural infrastructure and social facility investment, and ongoing support to the Department of Justice in re-demarcation of service boundaries for magisterial courts to increase accessibility, especially for people in highly dense, remote and marginalised areas.

Within metropolitan areas and cities, a major focus in the group is building the capability to simulate future growth implications of cities, and compare implications and costs of alternative investment proposals, especially for poor households. Together with a multidisciplinary team of international and local collaborators, planners in the group are also exploring possible risks of potential climate change associated hazards on cities and towns in South Africa.

Given the complexity of urban and regional planning, planners are often contributing to or leading multidisciplinary teams and work with communities as well as a range of stakeholders. Even though direct short-term impact is often challenging to measure, Van Huyssteen says she finds satisfaction in being constantly challenged to find creative ways to contribute to the unfolding future.



“A desire and commitment to make a contribution to the future is imperative.”



## CHARACTERISTICS AND APTITUDE

Van Huyssteen says making sense and bringing about change in emergent conditions requires being willing to connect and collaborate with others, the courage to be challenged, a belief in the future, and a commitment to personal growth.



## WHAT AND WHERE TO STUDY

Van Huyssteen holds a Master's degree in town and regional planning from the University of Pretoria. She completed a Bachelor's degree in town and regional planning at the same university. She says there are options for accredited undergraduate or postgraduate qualifications at many local universities that will qualify one for professional registration with the South African Council for Planners.



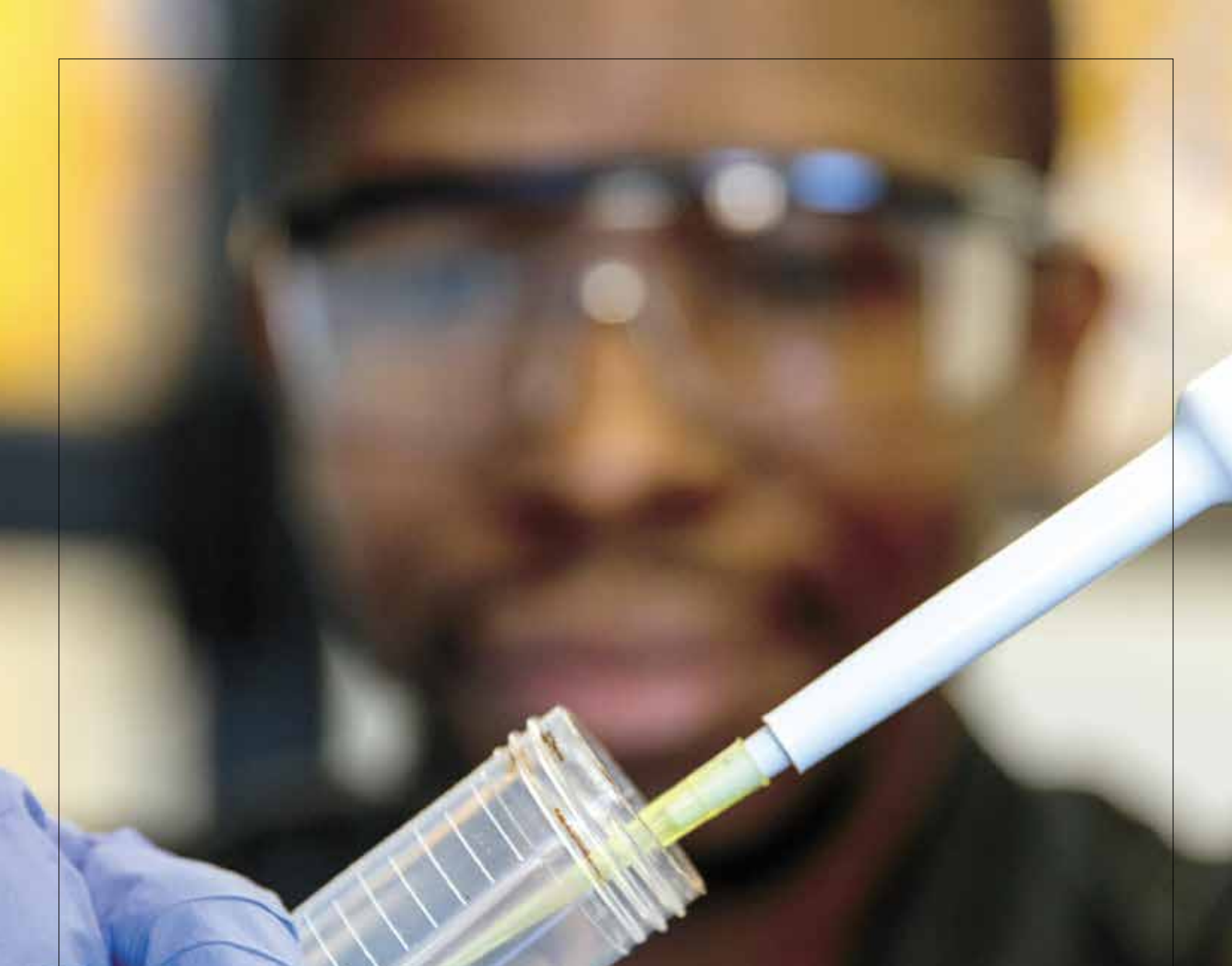
## RELATED CAREERS

Environmental scientist, civil engineer, urban designer, public policy analyst and property developer.

Elsona van Huyssteen



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**CAREERS IN**  
Engineering and  
Technology





Careers in engineering and technology are typically rooted in the fields of civil engineering, electrical and electronic engineering, mechanical engineering, chemical engineering, materials engineering, environmental engineering, environmental biotechnology, industrial biotechnology and nanotechnology. The CSIR has a strong skills base in engineering and technology.

Careers featured in this section:

- Aeronautical engineer
- Coastal and port engineer
- Civil engineer
- Mechanical engineer
- Electrical engineer
- Materials engineer
- Pavement engineer
- Bioprocess engineer
- Protein biochemist for industrial biotechnology
- Enzymologist for industrial biotechnology
- Bioengineer
- Research chemist



# Aeronautical engineering offers variety

Aeronautical engineers are typically involved in the research, design and development of aircraft and spacecraft.

**AERONAUTICAL ENGINEERS** perform fundamental research that relates to aerodynamics, aircraft structures and related materials. They investigate propulsion by designing, developing or optimising aircraft engines and propellers. Aeronautical engineers may also be involved in the design and optimisation of aircraft and aircraft components, such as wings, engine inlets, tail sections and fuselages. They also work on missiles, bombs, external fuel tanks and other aircraft systems.

The CSIR is home to leading aeronautical research and development with a strong track record in technological advances and achievements. Work in this domain includes wind tunnel testing and analysis using a suite of wind tunnels that include low, medium and high-speed tunnels, as well as a seven-meter wind tunnel where, for example, unmanned aerial vehicles (UAVs) can be tested. The CSIR designs and tests UAV engines and offers a range of evaluation services to clients in the civil and military environments. Other aeronautical research at the CSIR includes computational fluid dynamics, flutter testing and analysis that determine the safe carriage and release of a store.

At home in this diverse field of aeronautics, is CSIR aeronautical engineer, Lara Nel. Nel grew up in Johannesburg where she studied towards her aeronautical engineering degree at the University of the Witwatersrand. She says that her inquisitive nature is what drew her to engineering in the first place. "I enjoy knowing why things are the way they are and how things work. My love for science and engineering lies in the fact that science explains why certain things operate the way they do and engineering allows me to use this knowledge to create something significant."

An experimentalist at heart, Nel found a place within the CSIR's aeronautical research group where she works as a junior engineer while working towards her doctoral degree. "One of the things I enjoy most about my work is the fact that there are so many knowledgeable people here to learn from. My seniors are people who are willing to share their knowledge and we have challenging and stimulating discussions all the time."

Nel's passion for learning started at a young age. "I enjoyed doing science projects and experiments at school, testing something and then figuring out why the results were the way they were. I enjoy problem-solving, and the satisfaction that comes after having solved a problem," she says. Her work at the CSIR requires a combination of physics, experimentation, computer programming, mathematics and a good measure of problem-solving. "I do the work I do because I enjoy it. I love aerodynamics, especially in the supersonic regime. I get to do a bit of everything that I enjoy, which makes my work fulfilling."

Lara Nel





When asked to give advice to people tasked to choose a career, Lara quotes Howard Thurman, "Do not ask what the world needs. Ask what makes you come alive, and go do it. Because what the world needs, is people who have come alive."



## CHARACTERISTICS AND APTITUDE

Nel says that there is a lot of overlap between aeronautical and mechanical engineering, and that the problem-solving skills you learn in engineering are valued in many different careers. It is not unusual to find aeronautical engineers working in various other fields, such as Formula One racing or wind turbine designing. "The skills acquired during your studies as an aeronautical engineer will be valued wherever aerodynamicists are required."

Aeronautical engineers typically enjoy solving complicated problems. They have an aptitude for mathematics and science and are creative. The type of work brings a fair amount of challenges, so perseverance is key.



## WHERE TO STUDY

The University of the Witwatersrand is the only institution in South Africa that offers a full aeronautical engineering undergraduate degree. Other universities, such as the University of Pretoria, offer mechanical engineering with some aeronautical subjects included in an undergraduate degree.

At postgraduate level, different universities have different areas of focus within aeronautical engineering.



## RELATED CAREERS

Mechanical engineer and industrial engineer.



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# CREATING SAFE HAVENS FOR SHIPS

Coastal engineering, a branch of civil engineering, is the study of the ongoing processes and construction within the coastal zone. The field involves aspects of nearshore oceanography, marine geology and civil engineering, often directed at combating coastal erosion or providing navigational access.

## COASTAL ENGINEERING

typically includes the development of structures, in addition to the transportation and probable stabilisation of beach sand along with other coastal sediments. Coastal engineers are responsible for conducting dredging operations to retain a secure route for the transportation of vessels into or away from waterways and harbours.

One such engineer is CSIR coastal and port engineer, Johan Kieviet, who uses his extensive knowledge of coastal processes and civil structures to mainly study two aspects; namely, the impact civil structures have on the surrounding shoreline and the coastal processes, and the impact of the sea on the structural stability of such structures.

"This discipline is about enabling the full utilisation of our coastline and its surroundings for economical and recreational reasons, while ensuring a balance between development and the environment," he says. "This often requires expertise in coastal engineering, marine engineering and oceanography."

Kieviet is working on a number of projects, including measuring the movements of container vessels

entering and exiting the Durban harbour. This requires the deployment of differential global positioning systems on incoming and outgoing vessels using the CSIR's met-ocean instrumentation unit.

"My involvement in this project is on the processing and analysis of the raw data," says Kieviet. "This requires the interpretation of the motion data to ensure it is accurate."

He says the motions are around the centre of gravity of the vessel and covers surge, heave, sway, roll, pitch and yaw motions. The motions are then used by the CSIR numerical modelling team to determine when it is safe for a vessel of a specific size and weight to enter and exit the harbour given a certain sea condition or storm.

Kieviet is also involved in the physical modelling of the foreshore protection work near the port of East London. The CSIR was approached to conduct a two-dimensional physical model study on a typical revetment (barricade) design as part of the East London foreshore protection works. The objective is to evaluate the stability of the cross-sectional profiles of the structure and assist with optimisations where possible,

as well as to quantify the rate of overtopping over the structure crest.

Kieviet is also playing a critical role in the physical modelling work on breakwater spur repair options on Cape Town's main breakwater. "The work includes alternative repair options to a damaged section on the southern side of the spur breakwater."

He says that the repair included restoring the damaged area as originally designed with 25-ton dolos armour units in two layers and adding a 5-ton rock berm and concrete blocks in front of the toe at the repaired section. It also included repairing the damaged area with three layers of 25-ton dolos armour units and placing the toe dolos units at the repaired section in a trench created in front of the toe at the repaired section. The model was at a scale of 1:54 and orientated in the wave basin to allow for waves coming from 318° north. All models studies were concluded successfully and construction repair works on the breakwater is to start in the near future.





Johan Kieviet



Left: Kieviet sets up equipment to calculate damage to a small breakwater protecting a slipway.

Above: Core-loc armour units were used in the laboratory testing to determine their suitability as a protection method for a small slipway from wave attack.



## CHARACTERISTICS AND APTITUDE

One must have problem-solving skills, be a logical thinker and have strong abilities in subjects such as mathematics, applied mathematics and physical science. Most importantly, one should have a love for the sea and being outdoors.



## WHAT AND WHERE TO STUDY

Kieviet completed a BEng (Mechatronic) and MSc Eng (Coastal and Port Engineering), both from the Stellenbosch University, the only university in South Africa offering specialisation in coastal engineering.



## RELATED CAREERS

Marine engineer and oceanographer.



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# THE 'HARD HAT' PROFESSION: Creating and maintaining our built infrastructure

Civil engineering is not only about inspiring structures – it is also about maintaining and adapting the infrastructure that people around the world depend on every day – roads, railways and bridges; energy and water supply; waste networks and flood defences. It is civil engineers, like the CSIR's Muzi Nkosi, who have to keep this infrastructure running effectively and adapt it to meet challenges such as population growth, climate change and natural disasters. Civil engineers must also find ways to deliver the infrastructure needed when budgets are constrained.



Muzi Nkosi



**CIVIL ENGINEERS** design, construct and maintain the built environment infrastructure. Nkosi says that anyone can construct a bridge or skyscraper, but that there are fundamental issues that can only be addressed by civil engineers, such as the safety of the structure, the duration of its design life, and its environmental impact. Simply put, with the implementation of most built environment projects you only have one opportunity, given the irreversible social, financial and environmental risks involved. "And that's where my profession comes in," says Nkosi.

The work Nkosi does at the CSIR seeks to better understand the choices involved in everyday trip-making and the constraints attached to those decisions for ordinary transport users. "Understanding the interaction between users and the built environment enables efficient planning, better use of limited resources and most importantly,

providing services that meet the needs of every day users," he says.

He has been involved in a number of projects such as the Gauteng household travel survey, the City of Tshwane's A Re Yeng Bus Rapid Transit and other transport planning projects. Nkosi is currently involved in a project that seeks to estimate road-based emissions for the City of Johannesburg.

"This is a multidisciplinary project involving civil engineers (transport engineers) and environmentalists," he says. "The role of the transport engineers in this project is to estimate vehicle kilometres in and around the City of Johannesburg, using a variety of travel demand models."

The estimated vehicle kilometres then serve as input into the emissions model. "This is important in terms of assessing various transport policies and their respective impacts on road-based emissions."



Transport planning is key to ensure that efficient integrated transport systems are in place for cities.



## CHARACTERISTICS AND APTITUDE

Civil engineers need to be innovative, be willing to continuously develop their skills and be able to work under stressful conditions.



## WHAT AND WHERE TO STUDY

Nkosi holds a BSc degree in civil engineering from the University of the Witwatersrand. Most South African universities and universities of technology offer civil engineering programmes.



## RELATED CAREERS

Environmental engineer, transport engineer, hydraulics engineer, geotechnical engineer and structural engineer.

"The beauty of civil engineering is not in the infrastructure itself, but in the impact it has on society."

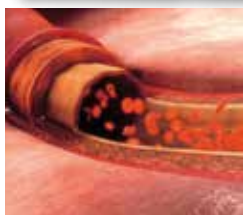


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Dr Alfred Bogaers

### FAST FACT



An example of fluid-structure interactions is blood flow through the cardio-vascular system. A pressure pulse from the heart causes artery walls to expand ever so slightly. In turn, this arterial-wall expansion causes a pressure pulse to propagate through the arterial system at enormous speeds (up to 500 cm/s), which in turn slowly forces blood to circulate through the body (at speeds below 40 cm/s). The very nature of blood flow is a strongly coupled problem between fluid flow and arterial wall deformations. The flow of blood is directly dependent on the arterial wall displacements, where these displacements are again a direct result of the interacting blood flow. To solve problems of this nature requires accounting for the highly non-linear, strongly coupled interactions between multiple physical domains.



# Using advanced mathematics for engineering excellence

When engineers design structures such as bridges or aircraft, they need to be sure that these structures will be strong enough to withstand mechanical and natural forces.

They use a combination of experiments with models and numerical simulations to ensure that the final structure is safe for people to use. CSIR mechanical engineer Dr Alfred Bogaers works on a variety of projects related to mathematical modelling in the engineering, health and natural sciences domains.

**ON A WINDY MORNING** in November 1940, a mere four months after its construction, the Tacoma Narrows Bridge in Washington started to oscillate dangerously, then broke up and tumbled into the strait between Tacoma and the Kitsap Peninsula.

The spectacle was caught on film and today it is still shown to engineering students as a cautionary tale into the dangers of designing structures without accounting for all possible unknowns. The bridge failed due to what is today known as aeroelastic flutter, a complex phenomenon which may occur due to the interaction between structures and fluids.

"When designing structures such as bridges, buildings and aircraft, engineers have to couple the laws of fluid dynamics and structural mechanics to ensure that a structure is strong enough to withstand any possible fluid-structure oscillations. These problems are often very complex and are solved with a combination of experiments and numerical simulations," says Bogaers, who also specialises in using advanced mathematical modelling in the field of fluid-structure interactions.

As a child, Bogaers dreamt of becoming a pilot, but his eyesight was not good enough. He then opted for mechanical engineering and completed his Master's at the University of Pretoria.

"While applied mathematics is part of every engineering course, I started to focus more on it in my honours year as I enjoyed the rigour of mathematics," he says.

He joined the CSIR in 2010 through a studentship and completed his PhD in mechanical engineering at the University of Cape Town.

At the CSIR, Bogaers works on a variety of projects related to mathematical modelling in

the engineering, health and natural sciences domains. One such project includes flutter analysis for aircraft design.

"Flutter is when an aircraft wing starts oscillating as a result of the structure's interaction with the airflow. The risk is often higher with military aircraft as their designs often press boundaries with what is feasible.

"In the past, when designing aircraft, engineers had to primarily rely on physical experiments, in the form of scale models to be tested in wind tunnels or ground vibration testing, but this is costly. Therefore we use numerical methods as a supplementary tool, where we can test several design iterations to minimise design faults that may lead to flutter earlier in the design process, before the construction of scale models starts."

Bogaers says that there are standard methods to calculate how fluid-structure interactions might happen, but experts are continuously improving those and developing new methods as new challenges present.

"Mathematical modelling is a powerful tool. We can use it to try and gain a deeper understanding into physical systems. For example, another problem that I am working on is sea ice modelling – how it forms and moves. This modelling is part of the CSIR's work to develop an earth system model. The formation and movement of sea ice plays an enormous role in our global climate. Despite covering only a small area of the earth's surface on the north and south poles, the reflective nature of sea ice reflects much of the incoming sunlight. This in turn means less energy is absorbed and thereby allows for these regions to remain relatively cool. Sea ice further contributes to global ocean circulation. Changes in the cyclic growth and movement of sea ice can lead to changes in global climate."



Dr Alfred Bogaers specialises in advanced mathematical modelling.



## CHARACTERISTICS AND APTITUDE

Mechanical engineers need to be detail oriented and inclined to persevere with an aptitude for mathematics and science. If they want to specialise in fluid-structure interaction analysis like Bogaers does, they will need to focus on obtaining advanced mathematical skills on a post-graduate level.



## WHAT AND WHERE TO STUDY

Bogaers obtained his BEng, BEng Honours and MSc in mechanical engineering from the University of Pretoria. He joined the CSIR in 2010 and got his PhD in mechanical engineering from the University of Cape Town in 2015. Most South African universities offer degrees in mechanical engineering and Bogaers suggests that students do a PhD in numerical methods or applied mathematics.



## RELATED CAREERS

Aeronautical engineer.



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# Using energy systems to create a sustainable future

As the world looks to discontinue the use of fossil fuels, there is a growing global trend to find cleaner and more sustainable and economic methods of producing energy. Crescent Mushwana, an electrical engineer, heads a team of CSIR engineers that does just that.

**AN ELECTRICAL ENGINEER** uses science and mathematics to design, test and implement electrical systems, with the aim of providing the best method to solve a problem for an industry or community.

“Energy supply is a topical issue in our country. It is intrinsically linked to improving the lives of South Africans. Electricity is the main driver for industrialisation, economic and social development.”

Through research and testing, Mushwana identifies the best technologies that the country can use to create an ideal energy mix for the future. This is done by creating models that look at generation capacity, grid requirements, power system operational requirements and support services to supply reliable and sustainable power to consumers; as well as various sources of energy used to supply the energy system, including solar, wind, biofuels, gas, coal and nuclear.

The core of the work involves utilising software tools to model and analyse the energy system, both on the supply side and the demand side, and looking at the economic value and feasibility of implementing these systems in the country. The research team also looks at long-term energy-system requirements and develops strategies that help the government, companies and municipalities plan their energy systems.

Mushwana says electrical engineers with an interest in the modelling of energy systems could find themselves developing into energy modellers, who create models and networks that ensure an efficient energy system. Mushwana believes that working in the right team could help any young engineer in his or her career path.

“The idea is to ensure that young researchers grow by being exposed to cutting-edge technologies and projects. At a later stage, if these researchers join industry, the country benefits. For engineers who want to develop their skills, especially in the field of energy research, the CSIR is the best place to do so.”

Mushwana says his aptitude for physics and mathematics in school was a natural introduction to the world of electrical engineering. He received his undergraduate degree at the University of Johannesburg, his postgraduate degree at the University of Pretoria and his Master's degree at the University of the Witwatersrand, and reveres each institution's educational standard.

He says that he is determined to make South Africa a leader in using renewable energy systems to drive economic development. He is working on projects that can help the country and communities create energy systems that will drive economic and social development, and create jobs that will last for many years to come.

Crescent Mushwana







This dual-axis photovoltaic plant is installed at the CSIR Pretoria campus as part of a project to use the campus as a real-world research platform for a cost-efficient future energy system based on renewable energy. The real-time digital simulator (above) is used to model the power output of the photovoltaic plant and other integrated energy sources to research the real-time behaviour of the energy system.



## CHARACTERISTICS AND APTITUDE

"I would single out an ability to communicate, as you can have the best project in the world, but if you can't share it with others, it stays yours and won't make an impact," says Mushwana.



## WHAT AND WHERE TO STUDY

Study electrical engineering at any of the South African tertiary education institutions that offer the degree, but consider adding communication, business management and leadership modules to your studies.



## RELATED CAREERS

Mechanical engineer, industrial engineer, electro-mechanical engineer and power system engineer.



# ENGINEERING A CAREER OF MATERIAL BENEFIT

Titanium is the ninth most abundant structural metal in the earth's crust. South Africa has the second-largest titanium-bearing reserves in the world. Titanium is as strong as steel, yet 45% lighter. It is twice as strong as aluminium, yet only 60% heavier. It is one of the most corrosion-resistant metals available. But, it is ten times more expensive than steel.

**THE TREMENDOUS POTENTIAL** of titanium, juxtaposed against its costs, is what motivates materials engineer Dr Christopher Machio to use his problem-solving skills and scientific expertise to design ways to make this precious metal work for industry and, in turn, establish South Africa as a world-class competitor in the manufacturing of titanium-based components.

Dr Christopher Machio joined the CSIR eight years ago. During the past three years he has honed his material engineering skills under the auspices of the Titanium Centre of Competence – a Department of Science and Technology initiative to create a titanium metal industry in South Africa.

Machio describes the two streams of titanium beneficiation, “There is the upstream side, where you move from titanium ore to titanium metal (powder), and the downstream side. My team and I focus on the downstream side where we add value to the titanium powder to develop products, typically engineering components.”

The market for titanium is broad, from aerospace, medical, oil and gas, power generation, to high-end automotive, sport and jewellery industries. Both the local and international demand for it is growing rapidly.

“Cost is a big issue when working with titanium. We aim to find

cheaper ways of making titanium products without compromising qualities such as strength and durability.

“We use a less expensive production method than what is currently used locally and internationally. Lowering the cost of titanium parts will generate new markets, especially in the automotive industry where lighter vehicles are desired for improved fuel efficiency and reduced greenhouse gas emissions,” Machio continues.

In short, Machio works with the loose titanium powder in a mould, applies pressure to it and places it in a furnace before extracting the product.

He explains, using a successfully completed prototype valve seat for the automotive sector, “Powder particles are compacted in a die of the desired shape. The particles are held together by mechanical bonding and the shapes are exposed to a high temperature in a controlled environment – usually a specialised furnace to create strong bonds throughout the body mass and increase the strength. When the component is released from the die, it is scrutinised under a number of microscopes to confirm the quality and identify any deficiencies.

“My work is to understand the interaction of the properties of the powders, the parameters

during compaction and the heat treatment, so that, in the end, we can commercialise the production techniques.”

While this might sound straightforward, the reality is more complex. “Many things can go wrong. For example, the powder could be contaminated; the powder from two different suppliers could have compositional differences; it could fail to flow, and thus fail to fill the die. During compaction, it could develop detrimental defects or miniscule fractures rendering the component unusable.”

Machio and his team generate new knowledge as they go, which can also be applied to other metal powders. In addition, they are exploring an opportunity to partner with a manufacturing company that can use the knowledge gained by the CSIR and produce components currently only available through importation from international markets.

Besides the gratification of using South Africa's abundant resources to benefit the country, Machio says, “There is also the realisation that you have been bitten by the material engineering bug when something works; when you find a solution that many have struggled with. It is challenging and immensely satisfying.”





Dr Christopher Machio



A compacted automobile valve seat insert produced using titanium powder.



## CHARACTERISTICS AND APTITUDE

An aptitude for mathematics, physics, chemistry, design and engineering is required. You need to be an analytical thinker and be system oriented.



## WHAT AND WHERE TO STUDY

Machio has a BSc in mechanical engineering from Moi University, Kenya, an MSc with specialisation in materials engineering from the University of Cape Town and a PhD in metallurgy and materials engineering from the University of the Witwatersrand.

Various South African universities offer degrees in metallurgy and materials engineering. Students can also follow a general science track by acquiring a BSc in physics or chemistry at any university and following this up with a specialisation in materials engineering at the Stellenbosch University or the University of Cape Town.



## RELATED CAREERS

Lecturer, materials consultant to industry and research manager.

### FAST FACT

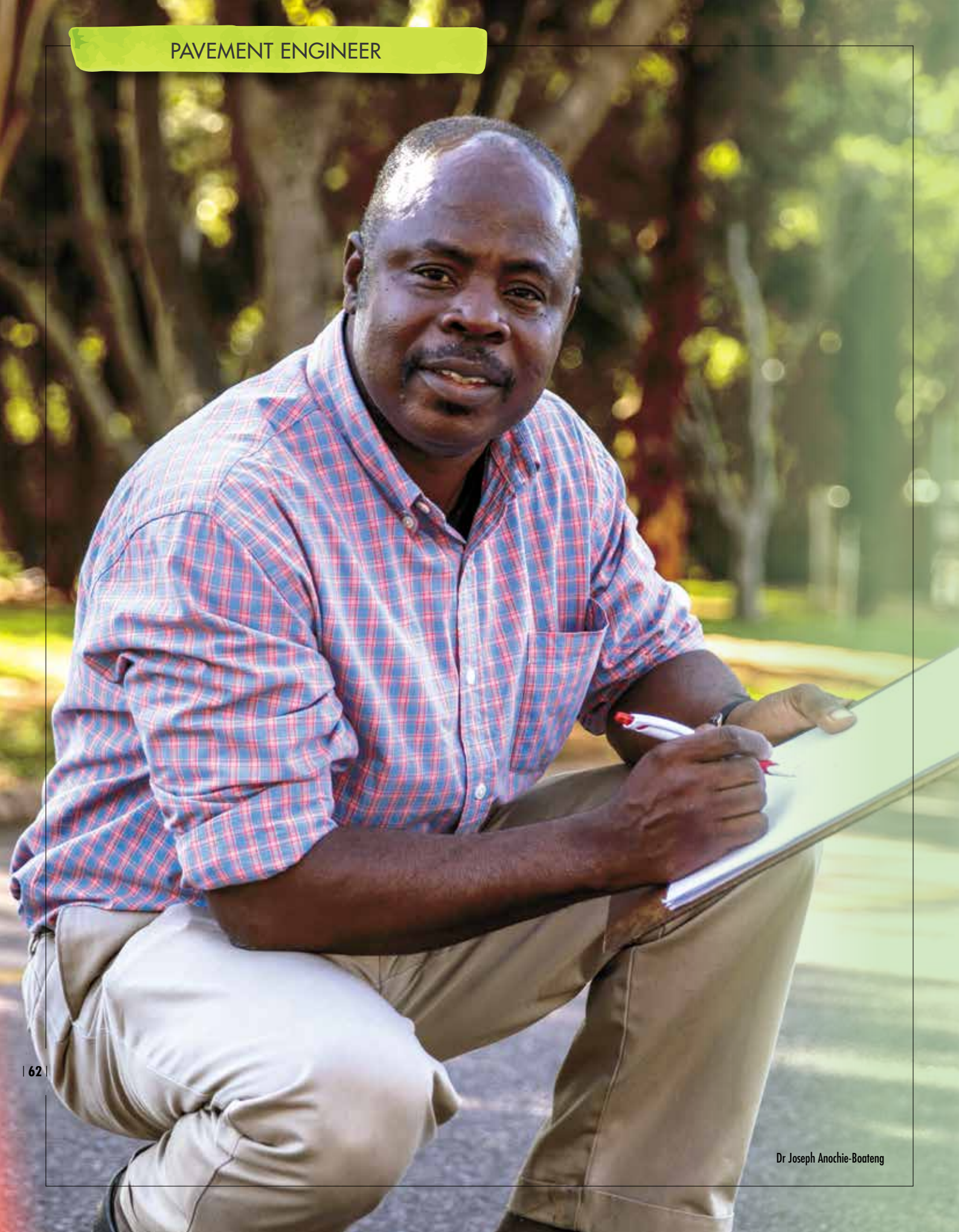
## WHAT IS A MATERIALS ENGINEER?

A materials engineer uses the huge fundamental base of knowledge on materials and materials processing to develop properties and new materials suited to specific applications, for example using titanium powder to make industrial components such as automobile valve seat inserts.



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# UNDERSTANDING HOW ROADS ARE BUILT

Pavement engineering is a branch of civil engineering that involves the planning, design, construction, operation and maintenance of roads. Engineers in this field take into account future traffic flows, design of highway intersections, geometric alignment and design, highway pavement materials and design, structural design of pavement thickness, and pavement maintenance.

## CSIR PRINCIPAL RESEARCHER

Dr Joseph Anochie-Boateng's job at the CSIR includes investigating concrete mixtures and pavement thickness, evaluating existing pavements, conducting materials testing and recommending repair or reconstruction alternatives.

Anochie-Boateng's work has taken him to many African countries. In Ghana, the rehabilitation and maintenance of low-volume roads is seen as a crucial part of the country's efforts in agricultural development and in its strategies for economic recovery and growth, poverty alleviation and food security. Therefore the identification of appropriate design options for higher risk sections of low-volume roads is seen as an important component to improving sustainable, all-season rural access. The CSIR is undertaking a two-phase study on alternative surfacing for steep slopes in Ghana. The overall aim is to establish optimal pavement solutions that provide all-season access for low-volume roads in steep terrain by identifying, defining and demonstrating appropriate bituminous or non-bituminous surfacing options as alternatives to the current gravel wearing surfacing. Anochie-Boateng is leading the research team on this project that started in 2016 and will end in 2020.

Recently, high incidences of premature failures in asphalt concrete layers of roads

have been reported in Tanzania. This has been attributed mainly to the increasing traffic volumes and loading on Tanzanian roads in urban areas and highways. The CSIR, in collaboration with the Tanzania National Roads Agency, conducted a forensic investigation of the causes of premature failures of bituminous layers in high-volume urban roads and highways in the country. The primary objective was to identify the factors that contributed to the failures and propose remedial measures to prevent similar future occurrences of rutting on roads and highways in Tanzania. Anochie-Boateng led the project team to its successful completion. Currently, he is leading the same project team to develop interim guidelines for hot-mix asphalt design in Tanzania.

Anochie-Boateng has led the development of a number of manuals, guidelines and test protocols to support the pavement and asphalt industries in South Africa and Tanzania. Through his research and development work, he developed research topics for postgraduate students from the University of Pretoria and the Tshwane University of Technology. He also manages a long-term pavement performance programme for the Western Cape Department of Transport while playing the role of research leader for advanced testing, evaluation and modelling of hot-mix asphalt.

Research and guidelines on road design, construction and maintenance, as well as the material with which roads are built, are key in ensuring roads with a long lifespan.



Dr Anochie-Boateng tests the stiffness, rutting and cracking resistance of asphalt.



## CHARACTERISTICS AND APTITUDE

In this field, an aptitude for numeracy and an appetite for problem-solving are required.



## WHAT AND WHERE TO STUDY

Anochie-Boateng holds a PhD in civil engineering, with specialisation in transport infrastructure and pavement engineering, from the University of Illinois in the United States of America. Civil engineering degree courses can be taken at most South African universities.



## RELATED CAREERS

Asphalt materials expert, structural engineer, transportation geomaterials expert and lecturer.



Dr Anochie-Boateng measures a pavement crack.



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# Merging biotechnology and engineering expertise to produce bio-products

Dheepak Maharajh fell in love with the fact that value can be extracted from something that someone thinks of as a germ or trouble-causing microorganism. He was first exposed to the commercial value that a single organism can provide when he started working in the domain of bioprocess engineering at the large-scale facilities of AECL bio-products. Today he is a CSIR principal researcher that leads the organisation's bioprocess and product development.

**"SINCE MY HIGH SCHOOL** years, I enjoyed science and I could only see myself pursuing a career in science," says Maharajh. "That does not mean that the road that led me where I am today, was straight. Having enrolled for a BSc in botany and zoology after matric, I opted to quit my studies and went to work as a laboratory assistant at AECL bio-products. I returned to studying once I had established my passion and completed an MSc in bioprocess engineering (cum laude) from Stellenbosch University in 2009.

He says bioprocess engineering is a specialisation of chemical engineering; it deals with the design and development of equipment and processes for the manufacturing of products such as agriculture, food, feed, pharmaceuticals, nutraceuticals, chemicals, polymers and paper from biological material and treatment of waste water.

"It is a marriage of biotechnology and engineering. In essence, we develop technologies in the bioprocessing space – anything that takes into account producing

a product from biological material such as yeast, fungi, bacteria, algae, viruses, mammalian cells or any type of biological single-cell process."

Maharajh says that while he was still a lab assistant, there was always conflict between scientists and engineers. Engineers design the plant, while scientists design the process or understand the actual science behind the process.

"For me, venturing into bioprocess engineering allowed me to merge the two because it allowed me to have expertise in biotechnology and engineering."

"At the CSIR, we develop technologies that can be implemented commercially through process and product development. In doing so, there are requirements for both biotechnology and engineering expertise," he says.

Maharajh explains that if one is developing a process at a 10-litre scale, it's a lot simpler to do that than on a 100 000-litre scale. "It's important to keep in mind what is likely to happen at large scale when doing small-scale development."

Much of Maharajh and his team's work is in the area of fermentation. The team works with bacteria, mainly *Bacillus*, yeast and algae.

"As far as bacteria is concerned, the main focus of our research group is *Bacillus* – a group of bacteria widely found in soil and water – for biological control. The technology is based on the concept of biomimicry. Our indigenous bacteria integrate into natural ecosystems through the principle of bio-augmentation. The products are developed with the aim of replacing the harsh chemicals and pollutants with next-generation biological and biodegradable alternatives, to improve well-being, while preserving scarce water and environmental resources. Through the technology platform that we've developed over the past decade, we've created a spin-out company, called OptimusBio. The company is essentially marketing all the technologies that we've developed," he says.





Dheepak Maharajh



## CHARACTERISTICS AND APTITUDE

You have to be mechanically minded, proactive and be prepared to get your hands dirty. You must understand engineering principles, as well as what happens at single-cell level and large-scale process level.



## WHAT AND WHERE TO STUDY

Maharajh obtained his NDip and BTech in biotechnology from the Durban University of Technology. He has an MSc in bioprocess engineering (cum laude) from Stellenbosch University.

Most South African universities offer qualifications in biotechnology and/or chemical engineering. To qualify as a bioprocess engineer, students have to specialise in bioprocess engineering at Master's level.



## RELATED CAREERS

Chemical engineer and biotechnologist.



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# CHARACTERISING THE STRUCTURE AND FUNCTION OF PROTEIN MOLECULES

Proteins are key in biological processes; they are the major driving force in living organisms. They serve various functions, such as structural support, storage, transport and catalysis in reactions. Their functioning has been markedly exploited in biotechnology. Dr Tsepo Tsekoa, CSIR principal researcher and research group leader for biomanufacturing technology demonstration, has vast experience in this field.

## PROTEIN BIOCHEMISTS

characterise the structure and function of protein molecules, which may be of interest to the enzyme and reagents industry, as well as for human and veterinary health.

"At the CSIR, protein biochemists focus mainly on the recombinant production of biologics, including reagent proteins, vaccines, as well as originator and biosimilar antibodies. In recent years, my research and development focus has been on developing production processes for biologics manufactured at bench and pilot scale. Biologics are pharmaceutical products manufactured, extracted or semi-synthesised from biological sources. My work requires that I separate these molecules, such as antibodies and enzymes, to purify them, then characterise their structure and function in relation to a market need," says Tsekoa.

As a protein biochemist, Tsekoa has expert knowledge of downstream processing, including filtration and chromatography, as applied to biomanufacturing development at bench and pilot scale. He also uses techniques like mass spectrometry,

crystallography and biophysical characterisation to study the structure of these proteins.

Tsekoa is also the champion of the CSIR biopharming platform.

"The platform makes use of plant-based expression systems to develop biologics destined for human and veterinary health, as well as industrial biotechnology at various stages of development," says Tsekoa. "The production of biopharmaceuticals in plants poses many interesting questions for the biochemist. These questions include, how to separate the target protein from the host plant proteins, what post-translational modifications the plant-produced proteins have and whether they are functionally active."

He has his roots in Lesotho, but obtained his qualifications at the universities of London, Cape Town and the Western Cape and is qualified at doctoral level in applied biotechnology.

"I found subjects such as chemistry, biology and physical sciences very interesting and it was a natural progression to enrol for a BSc in biochemistry," he notes.

Dr Tsepo Tsekoa





Dr Tsepo Tsekoa measuring the activity of a recombinant antibody.



## CHARACTERISTICS

You need to be curious, analytical, patient and have the ability to persevere.



## WHAT AND WHERE TO STUDY

Tsekoa completed a BSc and BSc (Honours) in biochemistry at the University of London followed by an MSc in biochemistry from the University of Cape Town. Thereafter he obtained his PhD in applied biochemistry from the University of the Western Cape.

The majority of South African tertiary education institutions offer science degrees. A major in biochemistry or molecular biology is a good starting point and one can specialise in protein biochemistry thereafter.



## RELATED CAREERS

Molecular biologist, biotechnologist and microbiologist.



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# MAKING THE MOST OF NATURE'S ACCELERATOR OF CHEMICAL REACTIONS

Enzymes are complex molecules that perform complex biochemical and biological functions. They can be exploited to develop new technologies, products and solutions for research, industry and health. This is the task of an enzymologist, such as CSIR senior researcher Dr Lusisizwe Kwezi.

**"MY JOB AS AN ENZYMOLOGIST** entails studying and characterising the properties of enzymes and how they function in biological systems, with an emphasis on translating these into products," says Kwezi. "In addition, we develop biomanufacturing processes to produce enzymes and antibodies of interest for use as molecular biology tools in research."

"Some of the enzymes that we aim to produce are polymerases for application in the polymerase chain reaction – a technique used in molecular biology to amplify a single or a few copies of a piece of deoxyribonucleic acid (DNA) across several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence; and restriction enzymes for cloning and genetic manipulation – these are enzymes that cut a DNA molecule at a

particular place. They are essential tools for recombinant DNA technology. The enzyme 'scans' a DNA molecule, looking for a particular sequence, usually four to six nucleotides. We also aim to produce bioconjugation enzymes for coupling enzymes to proteins and antibodies," he elaborates.

Enzymologists work in a variety of sectors in the biotechnology industry; they develop new technologies, products and solutions for research, industry and health.

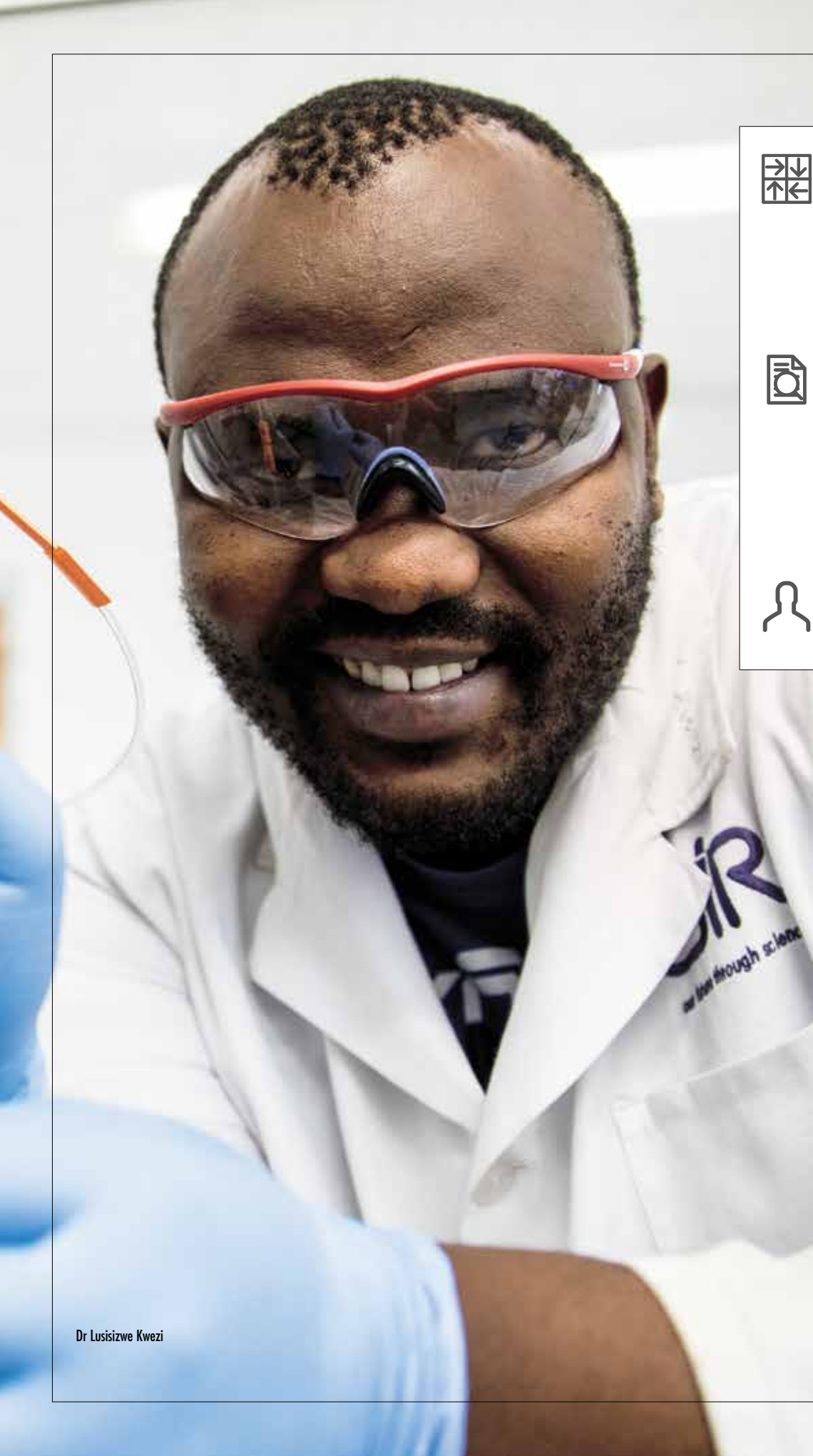
"In industrial biotechnology, enzymologists can use enzymes to produce products such as detergents, sweeteners, flavourants and fragrances. In health biotechnology, enzymologists use enzymes to produce therapeutics and treatments, for example, insulin used to treat type-1 diabetes," he says.

Kwezi holds a PhD in biotechnology, with a focus on plant biotechnology, proteomics, cell signalling and molecular biology.

He joined the CSIR in 2014 as a senior researcher to focus on his research in biopharming of HIV-neutralising antibodies for potential use as a post-exposure HIV prophylaxis. In using biopharming as a production platform, Kwezi is also investigating the production of biosimilar antibody vaccine – a biological medical product that is an almost identical copy of an original product that is manufactured by a different company – and other therapeutic antibodies.

"Enzymology is rapidly evolving, so to stay abreast in this field, one has to read and consume as much literature as possible. This will not only keep you up to date with emerging trends in the field, but help improve your understanding of fundamental principles," he adds.





## CHARACTERISTICS

"To succeed as an enzymologist you need good technical acumen in this field. You have to develop dynamic problem-solving skills to formulate solutions in response to a multitude of challenges," says Kwezi.



## WHAT AND WHERE TO STUDY

Kwezi completed a BSc at the University of the Western Cape, followed by a BSc Honours and an MSc, which was later converted to a PhD. Most universities in South Africa offer a BSc in biochemistry or biotechnology.



## RELATED CAREERS

Molecular biologist, proteomicist and protein biochemist.



Bacteria used to produce enzymes are lysed to extract soluble protein from the cells. In the downstream process, target enzymes are purified using a chromatography system.

Dr Lusizwe Kwezi



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Suzanne Smith

At the intersect of engineering, chemistry  
biotechnology and nanotechnology:  
MICROFLUIDICS FOR HEALTH



Applying the science and technology of controlling fluids that are constrained to a small (microlitre) scale for health-related applications, is the focus of CSIR senior engineer Suzanne Smith. Smith focuses on microfluidic and microsystems technologies to develop devices for point-of-care diagnostics.

**SMITH WORKS ON PROJECTS** that include a blood cell counting device, a centrifugal or CD-based microfluidic platform and a paper-based biosensors platform. Different microfluidic device formats are used for each of these systems, all with the aim of providing low-cost, disposable devices for point-of-care testing, and can be adapted for a variety of applications from medical diagnostics to environmental monitoring.

Paper-based systems are a focus of Smith's current work, where the integration of printed electronics into paper-based microfluidic devices is being explored. This allows for intelligence and automation to be built-in, making paper-based devices an attractive point-of-care diagnostic solution.

"The work is challenging as it is multidisciplinary and involves various engineering and science aspects, from electronic and mechanical to chemical and biological systems. This means that you are constantly learning

about other fields and how to combine these aspects with your area of expertise – which makes each day interesting," says Smith.

She says the work entails both research and development aspects, and thus reading up on cutting-edge technologies, as well as applying these concepts to design and create tangible devices and solutions. The career type entails hands-on laboratory work for manufacturing and testing of devices, as well as research and conceptual and engineering design.

"In South Africa, we understand first-hand the challenges associated with implementing effective point-of-care diagnostic solutions to address healthcare issues in developing countries. This positioning, combined with our capabilities in various design and manufacturing techniques, makes for the ideal environment to generate innovative diagnostic solutions, using different microsystems platforms," she says.



An example of a printed electronic device containing a printed antenna for potential integration with paper-based microfluidic devices.



## CHARACTERISTICS AND APTITUDE

Strong abilities in mathematics and science are required. Subjects such as computer science and biology are also useful, but not essential.



## WHAT AND WHERE TO STUDY

Smith has a BEng degree in electronic engineering and a Master's in bioengineering, both from the University of Pretoria. "Choose a university with a strong engineering faculty that allows for specialisation in bioengineering," she says.



## RELATED CAREERS

Electronic engineer, biomedical scientist and medical doctor.



A microfluidic cartridge device for blood cell counting applications.



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# FINDING NANOTECHNOLOGY SOLUTIONS TO WATER QUALITY CHALLENGES

Water is a vital resource, but globally and in South Africa, we are faced with a dire shortage, exacerbated by pollution and global warming. CSIR research chemist Dr Phumelele Kleyi is using modified nanomaterials to develop water purification technologies that may in future help communities to clean their own water.

Dr Phumelele Kleyi

**MILLIONS OF SOUTH AFRICANS** still do not have easy access to safe drinking water, many of them in rural communities where there is limited or no water infrastructure. Kleyi is part of a CSIR water research group that develops nanomaterials for the removal of contaminants from water. These contaminants include organic substances such as dyes, inorganics such as ions and harmful microorganisms such as bacteria or viruses.

"To get where I am today was not plain sailing," says Kleyi, who has a PhD in chemistry. "I want to encourage students who face financial and academic challenges, to not give up on finding their niche."

After finishing matric in 1994, Kleyi enrolled at the Nelson Mandela Metropolitan University (University of Port Elizabeth at the time) to study a Bachelor of Pharmacy degree.

"I passed mathematics and physics, but failed the other pharmacy-related subjects. I did not have money to return the following year and spent a year at home. It was painful, to realise your peers are progressing, but you are not."

In 1997, Kleyi enrolled for a BSc, but after his second year, he once again ran into financial difficulty and suspended his studies for four years.

"The irony is that I qualified for funding from the university, but due to outstanding debt, I was not allowed to register for the following academic year."

Kleyi worked several jobs, including a stint on an assembly line at Volkswagen to save money,

but then qualified for funding from the National Student Financial Aid Scheme (NSFAS).

"This time, I pushed through and completed my BSc, BSc Honours, MSc and PhD with no further interruptions. When I ran into financial difficulty the first time, I should have asked for help to find funding opportunities within the institution. Because I was young and the first from my family to go to university, I had no-one to give me that advice. I only heard later, from my peers who had similar difficulties, about the NSFAS. My advice to young people in a similar situation would be to not wait, but to communicate with the university as soon as problems arise. Information is now more readily available than back then – there are always options."

Kleyi joined the CSIR in 2014 and his research focuses on the development of nanostructured materials for water disinfection.

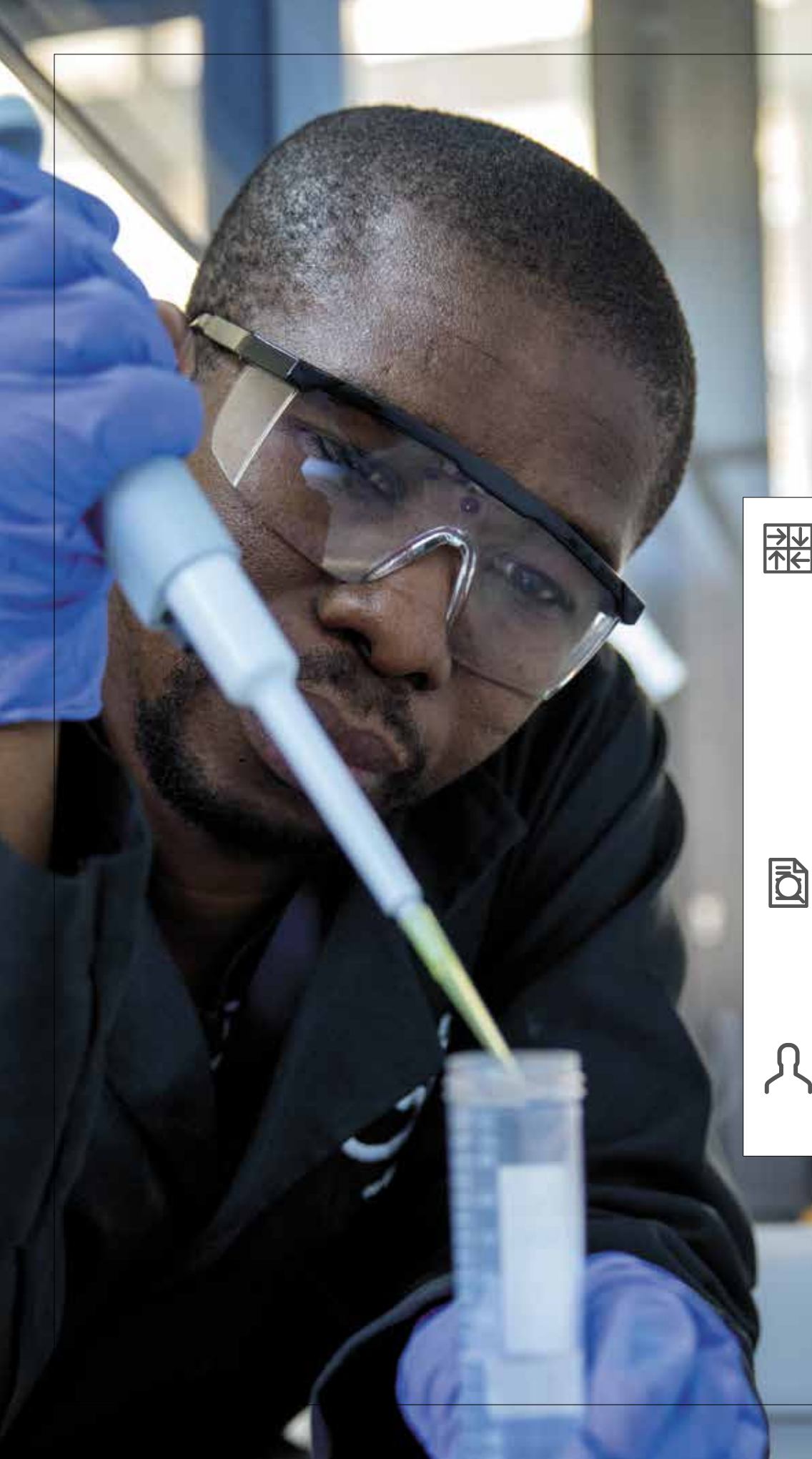
"We want people to have a device that helps them to purify their own water, so that they don't drink water that makes them sick. Such a device could be connected to a tap, or be a portable pot that filters water through modified nanomaterials. We use nanoclays, a very fine type of soil and often a by-product of mining, which are modified to remove contaminants and to add disinfection properties."

Kleyi's research results have been published in a peer-reviewed journal, while an application for invention disclosure for another nanomaterial has been submitted.

"We are currently negotiating to partner with a key water treatment industry player, hoping to eventually commercialise this product."







A sample of the antimicrobial clay material used for water disinfection.



## CHARACTERISTICS AND APTITUDE

A research chemist must have passion for scientific research and an academic background in chemistry. Other requirements include the ability to work independently, problem-solving skills and attention to detail. These scientists work in laboratories to develop new chemical compounds that are typically needed in medicine and other scientific innovations.



## WHAT AND WHERE TO STUDY

Kleyi completed a BSc in chemistry and applied mathematics, followed by a BSc Honours, an MSc and a PhD in chemistry, which are offered at most South African universities.



## RELATED CAREERS

Material scientist, chemical engineer, forensic scientist and process chemist.



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# CAREERS IN Social Sciences and Economics







Careers in the social sciences are typically rooted in fields such as psychology, economics and business, sociology, law and political sciences. While these skills sets do not make up the biggest proportion of the CSIR workforce, they remain an important part of the multidisciplinary that is at the core of the organisation's ability to make an impact.

Careers featured in this section:

- Behavioural scientist
- Political scientist
- Transport economist

# OPTIMISING HUMAN BEHAVIOUR AND TEAM WORK

The field of behavioural science is about human actions and interactions within a certain context.

Behavioural science can refer to all fields of study that analyse and draw actionable conclusions about how people think, act and react to a wide variety of situations in various fields such as the military, police, business organisations and many more to enable optimal individual, group and organisational functioning.

## THE CSIR'S TEAM OF BEHAVIOURAL SCIENTISTS

relies on processes that have a solid foundation in empirical research to provide psychological research support in specialised fields within the safety and security environment.

Scientific research on human behaviour generates knowledge and insight on how individual soldiers and groups of soldiers can function most effectively. Researching what motivates people within specific groups and deploying informed, testable interventions on the ground, is central to managing modern conflict on the African continent. CSIR research results in methods that help the defence force to identify candidates who show potential to succeed as soldiers early on in their training.

Adelai van Heerden has always been interested in human behaviour. When other girls her age read magazines, Adelai studied psychology handbooks. "Child and cultural psychology were of particular interest to me. I was completely absorbed in gaining as much insight into the human mind as possible during my studies." Van Heerden studied a Bachelor of Arts degree, majoring in psychology and sociology at the Nelson Mandela Metropolitan University. After completing her undergraduate studies, she joined the CSIR as a human resources (HR) practitioner. "I worked in HR for a decade, which gave me a thorough insight into workings of organisational culture and the importance of maintaining a productive, healthy, diverse and passionate workforce."

Van Heerden's career took a turn when a CSIR military client requested

that a military behavioural science project be initiated. She says, "When the request came, my career aligned with my passion. The fields of organisational psychology and human resource management are very closely related and I immediately registered for a Master's degree in human resource management through the University of London. I also wrote the international Project Management Professional (PMP) exam and obtained my PMP certification through the USA Project Management Institute." She became the first female behavioural scientist at the CSIR and now manages a behavioural sciences research group in the safety and security research area.

## CSIR behavioural science grows

Ishreen Rawoot joined the CSIR's behavioural sciences team in 2015 and is a registered research psychologist, currently studying towards her doctoral degree in psychology. She says, "A career in psychology is more demanding than it is made out to be. Many school learners are under the impression that a three-year undergraduate psychology degree allows you to work as a psychologist. I too was under this impression when I began my studies, however, I quickly learnt that to obtain a professional registration with the board of psychology takes approximately six years; a minimum of three years for an undergraduate degree, another year of Honours studies and then at least one more year of studying towards a Master's degree. To be able to register as a psychologist you must then complete a supervised

internship for another year after which you must achieve at least 70% in the final board examination for psychologists – not an easy task."

## A tough, but versatile career

The nature of behavioural science requires an ability to look through a different lens and a willingness to immerse yourself into the realities of different individuals from various backgrounds and cultures to enable true appreciation and understanding of human behaviour and motives. Laaiqah Parker, a CSIR research psychologist and doctoral candidate, and a member of the behavioural sciences team says, "I am inquisitive and have always been a 'people's person'. Because of this, it was natural for me to enter a career where I get to work with people. To be a good behavioural scientist, I work hard and try to be adaptable."

Van Heerden, Rawoot and Parker chose a career that has allowed them to make a contribution to behavioural science research within the South African military context. "Behavioural science research is applicable in all areas of an organisation because human beings are at the heart of all organisations. Research is normally conducted by qualified psychologists, sociologists, anthropologists, human resource specialists and experienced practitioners and can be applied in organisational settings such as the military, police, health sector, corporate environments, government, the media and many more. The options are limitless," concludes Van Heerden.



"Honours and Master's degree selections are tough because space in the programmes is extremely limited. Students interested in psychology as a career should, therefore, ensure that they are up for the challenge and are willing to work hard throughout their degrees to secure a place in the postgraduate programmes." — Ishreen Rawoot



Adelai van Heerden, head of the CSIR's behavioural sciences group.



Ishreen Rawoot, CSIR research psychologist.



CSIR research psychologist and doctoral candidate, Laaiqah Parker.

## BEHAVIOURAL

Focussing on Military & that supports Africa

The CSIR established expertise in this domain in 2004 to support unique Behavioural Science requirements in Specialised Military Contexts.

Current Research Areas include:

- Psychometrics
- Recruitment and Selection
- Training. Research on the selection of personnel is linked to training, as occurs before training, and the effect of selection procedures on the performance of personnel in training.

- Psychological
- Motivation and
- Leadership
- Communication
- Organizational
- Organizational
- Group
- Social



## CHARACTERISTICS AND APTITUDE

To work as a behavioural scientist one must get along well with people from diverse backgrounds. You must also have a lot of patience, determination and the ability to make tough calls.



## WHAT AND WHERE TO STUDY

Most South African universities offer degrees in psychology, sociology and anthropology.



## RELATED CAREERS

Human resource practitioner, corporate psychologist, sociologist and anthropologist.



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# A chance encounter with the water sector becomes a lifelong passion

"I stumbled into the water sector," CSIR research group leader, Dr Inga Jacobs-Mata admits with a laugh. But that was years ago and today Jacobs-Mata has become a specialist in transboundary water governance and particularly enjoys the study of power in the politics of water.

Dr Inga Jacobs-Mata





"SOCIAL SCIENTISTS do not necessarily think of a career in the water sector," says Jacobs-Mata, who was encouraged to follow a career in the water sector by her supervisor while completing her Master's at Stellenbosch University. "My professor did a short module on the political debate around water wars and after doing a small assignment on the topic, I was encouraged to do my Master's and later PhD in water governance."

Armed with a degree in international relations with a specialisation in transboundary water governance, there are various aspects one can focus on, she says. "The ways in which countries share water can be a focus. Gauteng gets most of its water from Lesotho, so how are those inter-state negotiations between South Africa and Lesotho managed?"

Another aspect is to focus on how water is placed on the global agenda. Do policymakers and heads of state know that water is a global security issue? One can also look at it from a regional point of view, she explains. Water is strategic for a particular country so how is it used as a strategic resource in a regional setting?

Jacobs-Mata is currently reviewing the Deutsche Gesellschaft für Internationale Zusammenarbeit International Water Stewardship Programme (IWaSP) that has been set up in various countries. "IWaSP is an international water security programme which combines global best practices in water stewardship with local know-how."

The six-year programme (2013-2018) facilitates partnerships between the public sector, the private sector and civil society. It addresses shared water risks on a catchment scale, while improving stakeholders' use and management of water and building their capacity to develop their own solutions. "My job is to review the impact of this programme and look at how it has contributed to achieving water security in the different countries."

It is often reported that the next world war will be about water. Jacobs-Mata is of the view that while that is a sensationalist headline the media often uses, it does draw people to the topic of water. She says there have been far more cases of cooperation than of conflict in the international discourse of water. But lower down the

scale, at the very local level, she explains, is where one finds conflict. "Countries will not go to war due to water, they will find other cooperative or diplomatic mechanisms to get what they want, but one farmer will likely fight another for depleting the water resources in the area."

Jacobs-Mata's advice to aspiring political scientists is to have a working knowledge of other disciplines, "because the types of water challenges we are faced with today are very complex and require adaptive and courageous responses. This often means working outside the box and outside the confines of a specific discipline."

She says that there are many opportunities for social scientists wishing to pursue a career in the water sector. "If you can be creative in your thinking and the application of your science to real-world examples, there is a place for you in the water sector."



As part of the CSIR's Nelson Mandela Day 2016 celebrations, Jacobs-Mata encouraged the youth in Groblersdal to pursue careers in science.



## CHARACTERISTICS AND APTITUDE

"As a political scientist, it is essential to be able to see the bigger picture in issues and have a sense of curiosity, particularly about people, power and governance systems," says Jacobs-Mata.



## WHAT AND WHERE TO STUDY

You should study a degree majoring in international relations, political science or public policy. Most South African universities offer such degrees.



## RELATED CAREERS

Public administrator, diplomat, international trader, international law expert and political science researcher.



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# Applying economics to deal with the allocation of resources in the transport sector

Transport economics is the study of the movement of people and goods over space and time. CSIR researcher Shaun Mhlanga is a transport economist who deals with issues pertaining to how scarce resources are expedited and allocated in the transport sector.

## AS TRANSPORT ECONOMIST,

Mhlanga has to respond to questions that relate to how government should prioritise financial support for various sub-sectors in the transport industry; particularly in reference to the need for public subsidies, and what regulatory or policy instruments should be used to achieve government objectives and goals as stated in policy prescriptions.

"Transport economists are consulted on how to deal with the development of appropriate instruments and policies to guide the effective governance and management of various transport systems," says Mhlanga.

He is also equipped to address pricing issues related to the cost of transport services and transport infrastructure, concerns on how shortfalls in the system should be supported and circumvented and assessing the impact of transport activities on society, the environment, as well as the economy.

"Transport economics is renowned to be of crosscutting nature and have strong links with transport engineering and traditional economics. But increasingly, you find transport specialists in urban spatial planning, built environment management, logistics and supply chain management.

"For instance, my experience and areas of expertise include macro-sectorial and transport economic analysis, public policy, statistical analysis, public finance reform, transport finance, sustainable development, environmental and transport governance, public financial management, transport policy and analysis."

He has been involved in projects to develop an integrated freight logistics plan and a freight flow model for the Durban-Free State-Gauteng Corridor. He has also worked with the World Bank to measure the cost of doing business in South Africa through exports and imports at various borders – land, sea and air.

Due to his extensive expertise and experience in the transport sector and particularly transport public finance, Mhlanga also worked on the gap analysis for the Rail Safety Regulator with specific emphasis on identifying and prescribing appropriate funding frameworks based on those used by regulatory agencies across the world. Additionally, he has led a flagship project that sought to map the analytical architecture for the country's pipeline supply chain system to identify salient bottlenecks in the provision of liquefied products to the economy. Pipeline logistics deals with the movement of petroleum and other liquefied content from source to consumption. The project was mainly about identifying factors

that could potentially constrain or influence the supply and demand of such liquefied products.

Mhlanga led a project that investigated and identified industrial sectors that can be considered for the expansion phase of Gauteng's Industrial Development Zone (IDZ).

"The main objective of the project was to conduct an in-depth technical analysis, including a value chain analysis, to identify and recommend mineral beneficiation projects and prospective sectors in the Gauteng IDZ that could potentially increase domestic air-freight using the OR Tambo International Airport," he says, adding, "This entailed the identification of existing and future potential investment opportunities for export that will address government's macro-economic policies in line with key national and provincial policies and strategic frameworks."

He has also played a role in a team that supported the Department of Transport to establish dedicated funding for road infrastructure maintenance and road asset management systems.

Mhlanga developed an interest in the transport field when he signed up for first-year studies. At the time, the Department of Transport had embarked on an awareness campaign to launch and introduce Transport Economics and Business Logistics Management as a

qualification at the North-West University in 2003.

At the time, there was a demand for young professionals in the field. Mhlanga was contemplating a career as a chartered accountant. Upon reading more about transportation, logistics processes, economics and the fundamental role that transportation plays to bridge prominent spatial disparities and facilitate attainment of socioeconomic imperatives in all economies, he began to take a keen interests in transport studies and have actively pursued a career within the fraternity as a result. He has never looked back.

He is currently involved in a project aimed at improving the regulation and the organisational setting in the minibus taxi industry.

"This project aims to highlight evidence of functional integration of transport services or modes that are not governed by any formal obligations and the role of the industry in alleviating issues of accessibility and migration, which cause pressures to the road system. The project aims to identify whether incentives should be used as a 'carrot' to induce the desired outcomes in the industry or a 'stick' in terms of strict legal action and enforcement of the law to achieve government's predetermined outcomes."



Shaun Mhlanga



## CHARACTERISTICS AND APTITUDE

According to Mhlanga, South Africa needs more quantitative transport economists with a strong econometric background. The country is still developing its data repository capabilities to improve knowledge and evidence regarding unit cost of transport services, operations, as well as infrastructure in seeking to inform the development of sustainable and affordable transport systems and services.



## WHAT AND WHERE TO STUDY

Mhlanga studied transport economics as a major for his undergraduate and Honours degrees at the North-West University and University of South Africa, respectively. He went on to pursue his Master's in sustainability (transport) at Leeds University in the United Kingdom. Domestically, transport studies are included at courses at the universities of Johannesburg, South Africa and Cape Town, as well as the Stellenbosch and North-West universities.



## RELATED CAREERS

Public sector analyst, policy analyst, transport manager, public transport specialist, fleet controller, transport regulator, transport policy specialist, business logistics practitioner, as well as careers in the aviation, roads, maritime, pipeline and rail sector.



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