HUMAN CAPITAL:
THE ULTIMATE INVESTMENT FOR INNOVATION

Successfully meeting its mandate to improve the quality of life of South Africans requires the CSIR to rely on its most important asset – its people. The ultimate investment for the organisation remains the men and women who apply their specialist knowledge in the scientific and technological research and development they undertake.

THE CSIR'S multidisciplinary nature perfectly positions the organisation to help solve the increasingly complex problems of our time. Our multidisciplinarity ensures that we leverage the best skills from a variety of disciplines and fields, and makes for a stimulating and rewarding work environment.

Some 65% of CSIR employees work in the science, engineering and technology (SET) base, with support professionals making up the remaining percentage. While the SET base is broadly classified as researchers or engineers, these individuals are highly specialised in their respective fields. They are geneticists, virologists, software developers, polymer chemists, applied mathematicians, industrial engineers and more. In profiling some of these different careers, we hope that young South Africans who are on the verge of making choices and decisions about their field of study and future careers, will be inspired to consider science as a career. To those who have already made that choice and are building their skills at a tertiary education institution or in the research sector, regard this as an invitation to consider the CSIR as an employer of choice.

In fact, a global certification company, the Top Employers Institute, has certified the CSIR as a 'Top Employer' based on independent research and international benchmarking of employee conditions of work. Our high standing as an employer is also recognised by university science students, who voted the CSIR as an 'Ideal Employer' in the national 2012/13 Student Survey conducted by global employer branding company Universum.

In addition to the dynamic work environment and access to state-of-the-art research facilities, the CSIR provides researchers with opportunities to collaborate with local and international experts. This facilitates the exchange of ideas and knowledge; it builds relationships between research teams and it keeps the CSIR research community abreast of the latest developments in the various fields.

The professional growth and development of our employees is of critical importance and is supported by an extensive suite of programmes that is aimed at advancing their careers from undergraduate to doctoral level and beyond. Transformation and diversity remain high on the CSIR agenda and recruitment strategies focus on groups that were historically under-represented in science, engineering and technology.

The potential of science and technology to improve the lives of people is an excellent motivator. At the CSIR, what we do is informed by our country's socioeconomic priorities.

Our work is relevant, as is evident from the career profiles in this edition of *ScienceScope*.

Read about our contribution to the understanding of disease and the development of relevant interventions for prevention and treatment (page 6); or about how we work towards mitigating the effects of pollution on our natural environment (page 28); and the creation of sustainable enterprises to provide communities with decent employment (page 94). There are also concerted efforts to address the challenges we face in the digital age, such as cybercrime, by providing relevant defence strategies (page 90), in addition to bridging the digital divide by increasing access to information and communications technologies (page 92).

Over and above the benefits to individuals and their communities, CSIR research also goes a long way in improving the competitiveness of industry through modelling (page 42), improved energy management (page 66) and the provision of technology assistance packages (page 74).

We trust that this edition will provide you with insight into the range and diversity of SET careers at the CSIR and a glimpse of the passion and commitment of our most valuable assets: our people.

Dr Sibusiso Sibisi,
CSIR CEO

CONT

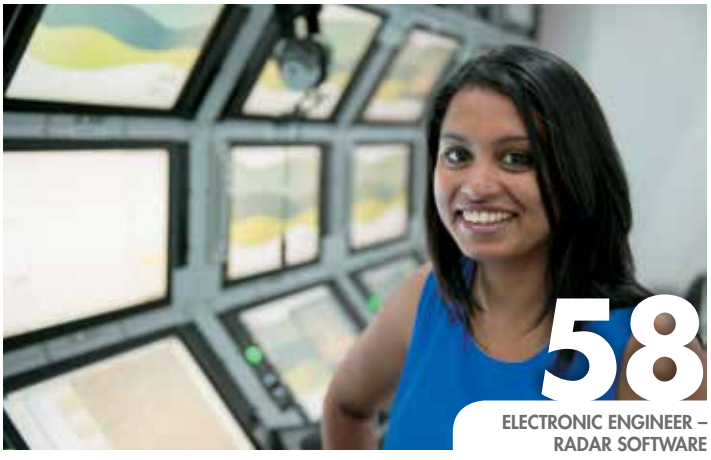
CAREERS ROOTED IN: NATURAL SCIENCES 4

View career video clips online

bit.ly/1haloNi

TENTS

CAREERS ROOTED IN: ENGINEERING, THE BUILT ENVIRONMENT AND ICT 50



CHEMICAL ENGINEER 52

CIVIL ENGINEER 70

SOFTWARE DEVELOPER – CYBER DEFENCE 90


Careers rooted in:
NATU

RAL SCIENCES

Biological sciences, mathematical sciences, physical sciences

UNDERSTANDING THE BUILDING BLOCKS OF HUMAN LIFE

The CSIR's Dr Janine Scholefield became inspired to study genetics during a high-school biology lesson when she was taught how the laws of inheritance were derived from experiments performed by Austrian monk Gregor Mendel on more than 5 000 pea plants in the late nineteenth century. At the time, Mendel was not taken that seriously, but his hybridisation experiments eventually contributed to what we understand about genetics today.

Explaining disease

Humankind has sequenced the human genome and scientists are using this to explain several diseases of which the causes have been elusive for centuries.

"A geneticist studies the way genes control cells, particularly how gene mutations can adversely affect the cell and cause disease," Scholefield explains.

"For example, if you understand which gene mutation causes heart disease, you can understand the role proteins play in the cells and better target research into treatment."

Scholefield completed her BSc and BSc (Honours) at the University of Cape Town, but then left science to teach children with autism in the United Kingdom.

Witnessing the human side

Working with special needs children led her to witness and experience the utter exhaustion and desperation caregivers and parents experience when dealing with yet unexplained human conditions.

After three years, Scholefield returned to science and to South Africa to complete an MSc in human genetics, specialising in neurodegenerative disorders.

Dr Janine Scholefield

Treatment for an African disease

"I stumbled across ribonucleic acid (RNA) interference and thought it would be great to develop a gene therapy for spinocerebellar ataxia 7, a degenerative genetic movement disorder, which, in South Africa, exclusively affects black people."

RNA is a family of biological molecules that play a role in the way genes work and cells communicate. RNA interference is a process whereby RNA molecules inhibit gene expression and can be used in medical treatment to silence mutated genes that cause disease.

Scholefield completed her PhD on developing a molecule to use in such gene therapy and was then awarded an Oxford Nuffield Medical Fellowship for post-doctoral studies in the UK. There she established technology using induced pluripotent stem cells (IPSCs) – discovered just two years before in Japan – to test the molecule.

"You can take a skin biopsy and reprogramme the skin cells into stem cells. Once they are stem cells, you can differentiate them to become neurons to be used in research to see if a treatment molecule works."

Setting up at the CSIR

Others continued with this research when Scholefield went to Pretoria to set up IPSC technology at the CSIR, specialising in the field of stem cell research.

"At the CSIR, we are using IPSC cell models to study other African diseases, for example those caused by HIV, by looking at people with different susceptibility to the virus, including elite controllers. These are people who seem to have natural immunity against HIV and do not become ill when infected.

"I work with the best team of scientists at the CSIR's gene expression and biophysics laboratory. The work is extremely rewarding. I witness how extraordinary genes are. The tools we have in molecular biology these days, are awesome."

– Antoinette Oosthuizen

Enquiries:
Dr Janine Scholefield
jscholefield@csir.co.za

WHAT DR JANINE SCHOLEFIELD STUDIED

She completed a BSc degree, majoring in microbiology and biochemistry followed by a BSc (Hons) in human genetics at the University of Cape Town. Scholefield then completed an MSc in human genetics specialising in neurodegenerative disorders, followed by a PhD on spinocerebellar ataxia 7, a degenerative genetic disease.

WHERE TO STUDY

Most South African universities offer BSc courses after which a student can specialise in human genetics at postgraduate level.

Dr Janine Scholefield works on the STORM-scope, a custom-designed microscope that can generate super-resolution images. Its lasers enable researchers to see down to 20nm, a fraction of the diameter of a human hair.

GENETICIST

CHARACTERISTICS

Geneticists must have an aptitude for maths, science and biology and a passion for their chosen specialisation field, combined with a love for biology. They should also be inquisitive and have the patience to deal with the constant challenges and set-backs of the research environment.

RELATED CAREERS

Systems biologist, molecular biologist, molecular pathologist.

"Viruses emerge and mutate to the extent that they will always have to be studied for humankind to remain a step ahead."

– Dr Hazel Mufhandu

VIROLOGIST

CHARACTERISTICS

Virologists who work in the research environment need to multitask and must be willing to put in extra hours in the laboratory. They need to collaborate with other researchers and must display strong academic ability in the fields of maths, physics and biology.

RELATED CAREERS

Microbiologist, epidemiologist, pathologist.

HIV research performed in a CSIR high-containment facility.

UNDERSTANDING VIRUSES TO HEAL AND PREVENT COMMUNICABLE DISEASES

During the early 1990s, few could foresee the extent of the scourge of HIV/Aids on the African continent. Dr Hazel Mufhandu, a CSIR virologist and HIV expert, was a teenager at the time, unaware of the fact that she would eventually devote a career to unravelling the secrets of a virus that would infect more than 10% of the South African population and annually kill thousands. In high school, Mufhandu dreamt of becoming a medical doctor, the obvious choice for a youngster who fared well in maths, biology and physical sciences.

"AT THE TIME, we simply did not know about all the career options in medical science. My marks were good but I was very disappointed when I did not qualify for admission to a medical school. I was advised to complete a BSc and reapply to medical school, but the magic of the research environment eventually drew me onto a different career path."

Discovering the laboratory

Mufhandu enrolled for a BSc at the University of Limpopo and majored in physiology and microbiology. "After those three years, the idea of another six to seven years at a medical school had lost its appeal. During my final year, I was exposed to laboratories led by doctoral scientists and I was fascinated by the research environment."

She enrolled for a BSc (Honours) at the then Medunsa, which is now a campus of the University of Limpopo.

"It was in 1996 and HIV/Aids was all over the news. It was this 'new' disease, there were no antiretroviral medicines available and I wanted to understand how the virus was transmitted and why it was so detrimental."

The HIV/Aids projects had, however, been taken and therefore Mufhandu initially focused on hepatitis B research, which also taught her the basics of virology.

Gaining experience

During a visit to the National Institute of Communicable Diseases (NICD), she learnt of a hepatitis laboratory and MSc scholarships. She joined the NICD and pursued her Master's focusing on hepatitis. For an extra income, she joined the NICD's HIV immunology laboratory as a research assistant and worked on HIV research for seven years.

Working with aptamers

"I then reached a phase where I had to make decisions regarding my personal life. I moved back to Pretoria where I joined the CSIR aptamer laboratory on a PhD scholarship. Aptamers are short, artificial, single-stranded DNA or RNA molecules that bind specifically to target molecules with antibody-like properties. The advantage is that they are smaller and more stable than antibodies and therefore can penetrate targets more easily. They are produced chemically and their production is not prone to viral or bacterial contamination. They can be used for many different applications, including ways to block HIV infection or to diagnose tuberculosis.

Mufhandu's PhD focused on the use of aptamers to prevent HIV infection. "Viruses emerge and mutate to the extent that they will always have to be studied for humankind to remain a step ahead. Some become more infectious, more deadly and even resistant to existing treatment. We need to understand how they function to develop new medicine and target optimal infection control measures. The work of virologists often forms the basis of public health interventions and medical breakthroughs needed to fight infectious diseases such as HIV/Aids," says Mufhandu.

Finding your calling

"The CSIR gave me the necessary support to advance to the pinnacle of my career. My work got exposed not only locally, but also internationally."

– Antoinette Oosthuizen

Enquiries:
Dr Hazel Mufhandu
hmufhandu@csir.co.za

Dr Hazel Mufhandu does aptamer research in a specialised CSIR laboratory.

WHAT DR HAZEL MUFHANDU STUDIED

She completed BSc in physiology and microbiology as well as BSc (Hons) degrees at the University of Limpopo. Her MSc and PhD degrees – both in virology – were done at the University of the Witwatersrand.

WHERE TO STUDY

Most South African universities offer BSc courses after which students can decide to specialise in virology during their postgraduate years.

UNRAVELLING THE SECRETS OF ORGANISMS CAUSING DISEASE

According to the latest estimates by the World Health Organisation, about 219 million malaria cases were reported in 2010. Ninety percent of the estimated 660 000 deaths occurred in Africa, mostly among children. Internationally, researchers like the CSIR's Dr Dalu Mancama are doing cutting-edge research in a continuous effort to stay one step ahead of the Plasmodium parasites, which have managed to outsmart medicine by developing resistance to existing treatment.

SYSTEMS BIOLOGIST

CHARACTERISTICS

For this career you should have an analytical mind, be willing to adapt to a fast-changing research environment, have perseverance and strong skills in maths, science and statistics.

RELATED CAREERS

Microbiologist, virologist, geneticist.

Dr Dalu Mancama

THE LATEST SETBACK in the fight against malaria was when the first cases of resistance to artemisinin-combination therapies, which was hailed as a breakthrough treatment some years ago, were recorded.

Mancama, who was trained in biochemistry and genetics, now works in a field called systems biology, where experts pull together a holistic picture of interactions within biological systems to uncover novel methods to stop disease.

"Systems biology is an inter-disciplinary field of study where researchers focus on complex interactions within biological systems rather than focusing on a part of it," Mancama explains.

These researchers look at how cells, organelles and molecules interact to determine how an organism functions and behaves. This includes the role of genes, enzymes and metabolites in metabolic networks and the study of cell signalling. Researchers do not simply study the organism and its parts in a laboratory. They also use other methods, such as computer and mathematical modelling to propose hypotheses about biological processes and systems which they can then test.

According to Mancama, this makes the CSIR the ideal place to work in this field.

"The CSIR enables us to do such multidisciplinary research, as we have access to various experts, for example in high-performance computing, laser technology and nanomedicine," he says.

Mancama has his roots in Zimbabwe and South Africa, but completed his high school years in Surrey in the UK.

"I found subjects such as chemistry, biology and physical sciences very interesting and it was a natural progression to enrol for a BSc followed by a BSc (Honours) at Brunel University in London where I majored in applied biochemistry. One advantage was that we had to work at research organisations for practical experience."

By the middle of the 1990s, Mancama had developed a keen interest in genetics. "The sequencing of the human genome was happening and I was attracted to this up-and-coming field which led me to complete an MSc in human molecular genetics at Imperial College at the University of London."

This was followed by a PhD in genetics, focusing on neuroscience and neurological disease, also in the UK.

Dr Mancama joined the CSIR in 2005 where he now heads the organisation's biomedical technologies research group. His research team formed a consortium with experts at the Universities of Pretoria and Witwatersrand to look at specific compounds which could play a role in blocking malaria transmission between mosquitoes and humans.

"We have developed models in vitro which allow us to rapidly identify drugs that have the most potential for further development. The idea is to develop drugs that work on different metabolic and biological processes in the gametocyte (when the parasite is at its sexual reproductive stage), to minimise the potential for future drug resistance," Mancama says.

– Antoinette Oosthuizen

WHAT DR DALU MANCAMA STUDIED

He completed a BSc degree and BSc (Hons) in applied biochemistry at the Brunel University in the UK, an MSc in human molecular genetics at the University of London's Imperial College and a PhD in genetics at King's College, also in the UK.

WHERE TO STUDY

While institutes such as the Harvard Medical School have a Department of Systems Biology, at most South African universities, students will start with a BSc course, and then specialise when doing their Honours, Master's and PhDs in various different fields to equip them to work as systems biologists. Many of these courses are offered by departments of biochemistry. An increasing number of departments also offer degrees in bioinformatics or computational biology, which is a critical aspect of systems biology.

Enquiries:
Dr Dalu Mancama
dmancama@csir.co.za

Using a pipette to transfer blood onto a plate.

A blood sample on a plate ready for viewing under a microscope.

UNDERSTANDING THE PROCESS OF DISEASE

Dr Makobetsa Khati

MOLECULAR PATHOLOGIST

CHARACTERISTICS

You need to have a passion for science and be analytical, inquisitive and curious to find out how things work. Creativity and tenacity to thrive in the research environment are also required.

RELATED CAREERS

Laboratory pathologist; clinical pathologist.

Almost every medical treatment, diagnosis or prevention of a disease to improve public health has its roots in medical science. While these scientists might never consult with patients, they spend long hours in laboratories unravelling the secrets of diseases that afflict mankind.

DR MAKOBETSA KHATI, a CSIR molecular pathologist, says as a youngster he did not initially know what to study. Reaching university was a challenge in itself due to the volatile circumstances in the township where he grew up during the 1980s.

"I lived and went to school in Sebokeng in the Vaal Triangle and did well in mathematics, biology and physical sciences. In those days, it was the norm to guide top students into these subjects," Khati remembers.

"I used to read a lot, but our schooling was often disrupted by uprisings and detention of students. For instance, during the 1984 Vaal uprisings, schools were closed for almost a year and most of us were merely promoted to the next class the following year. Notwithstanding, I had a passion for knowledge and luckily found it easy to learn."

Yet, after finishing matric, there was not enough money for Khati to immediately further his studies. He worked as a queue marshal at the taxi ranks for a year or so, but then got a scholarship from the Kagiso Trust.

"I went to the University of Cape Town (UCT) where I completed a BSc and BSc Medicine (Hons) in human anatomy and cell biology. Thereafter, I worked as an intern at the Groote Schuur Hospital in Cape Town in a position jointly sponsored by the Medical Research Council."

Khati got a scholarship and enrolled for an MSc in molecular medicine at the Imperial College School of Medicine in London, which was followed by a PhD in molecular pathology at the University of Oxford.

There are different fields of pathology and people often associate the term with anatomical or forensic pathology which involves autopsies on human bodies in order to diagnose disease or find evidence of an unnatural cause of death. Clinical pathology involves the laboratory analysis of bodily fluids and tissue to diagnose disease, while a molecular pathologist focuses on the diagnosis of disease through the examination of molecules in organs, tissue and fluids. There is a lot of overlap between these disciplines.

Dr Khati was invited to start aptamer technology research at the CSIR in 2006.

"Aptamers are artificial nucleic acid molecules that have antibody-like properties. We can use them to understand diseases better, as analytical or diagnostic tools. We test ways to block HIV infection, to diagnose tuberculosis and to research targeted delivery of drugs to specific cells."

Khati says students need to be honest with themselves about what attracts them to studies in the medical field. For example, if they want interaction with patients, it might be a good idea to study medicine and become a doctor.

"A molecular pathologist is a medical scientist who is interested in understanding the root of diseases at a molecular level and mostly does laboratory work. Some people follow the traditional route and first become a medical doctor before specialising in pathology. While this allows them to register as medical specialists and gives them a clinical perspective, the basic science route is much more focused for those who want to be pure scientists," Khati says.

– *Antoinette Oosthuizen*

Enquiries:
Dr Makobetsa Khati
mkhati@csir.co.za

WHAT DR MAKOBETSA KHATI STUDIED

He completed a BSc and BSc Medicine (Hons) in human anatomy and cell biology; and a Master's in public health at UCT. In addition, he also completed an MSc in molecular medicine at the Imperial College School of Medicine in London and a PhD in molecular pathology at the Sir William Dunn School of Pathology at the University of Oxford.

WHERE TO STUDY

Dr Khati's advice is to study at a reputable university with a world-class medical school and research culture and to get international exposure and experience.

Dr Makobetsa Khati oversees an experiment which is conducted by Boitumelo Fanampe (front) and Judith Mzyece (back), students in molecular medicine from the University of Cape Town.

BACTERIA, VIRUSES AND DNA

The work of molecular biologists concerns microscopic life forms that are not visible to the naked eye. Typically, they focus on how biological aspects of life forms get passed from generation to generation. One such researcher is Dr Yolandy Lemmer, who realised her dream of becoming a scientist.

Dr Yolandy Lemmer prepares a microscope for live cell imaging of human macrophage cells.

"I STRIVE TOWARDS making a real contribution in science that would benefit the African continent and my home country, South Africa, both in terms of its reputation in science and its ability to solve problems related to poverty and disease," says Dr Yolandy Lemmer.

The young molecular biologist began her postgraduate studies in the Department of Biochemistry at the University of Pretoria in 2004. She joined the group, led by Prof Jan Verschoor, who was responsible for inventing a new tuberculosis diagnostic for those infected with HIV in Africa, thereby addressing real and relevant needs coupled to one of the medical challenges of our country. Lemmer's projects centred on the investigation of biological systems or processes at cellular level.

Like Lemmer, a molecular biologist's academic background must include doctoral studies in either molecular biology, genetics or biochemistry. In addition to this, they must possess excellent analytical skills, pay attention to detail and have natural organisational skills. The ability to handle stress, follow directions and do tasks in a precise manner is important in this career path. The skills acquired have many applications in fields as diverse as materials science, the natural environment and even the built environment.

Usually, molecular biologists work in settings such as universities, hospitals, industrial laboratories, agricultural companies, biotechnology companies, food or beverage manufacturers, oil companies and government. Their career trajectory depends on the extent of their education. Some become quality control professionals, clinical technicians, bioremediation professionals, molecular biology professors, or physicians.

For Lemmer, the CSIR was her employer of choice. "The CSIR is a multidisciplinary institution with a large active network. It provides me with the opportunity to interact with various scientists from a broad range of scientific fields both locally and internationally. I am also able to interact and work with the industry because the CSIR involves itself, through partnering, with product development and commercialisation processes in an effort to ensure that technology is transferred to industry and society.

"Every pharmaceutical product starts with an investigation into basic biology and the need to understand how cellular processes function and interact with external stimuli. Therefore any vitamin or chemotherapeutic you use, was at some stage investigated by a biologist. Deoxyribonucleic acid (DNA) is of special interest to molecular biologists. DNA has a prominent role in matters of heredity. Also, DNA plays a role in determining the occurrence of illness," says Lemmer.

Molecular biologists study bacteria and viruses. They investigate the properties of these microscopic life forms and their function in the production of antibiotics, alcohol, sugar, and amino acids. The outcomes of this research have not only contributed to major gains in medical knowledge, but also benefitted agriculture, industry and other fields.

– Lionel Jean Michel

Enquiries:
Dr Yolandy Lemmer
ylemmer@csir.co.za

WHAT DR YOLANDY LEMMER STUDIED

She completed her PhD in biochemistry at the University of Pretoria. Prior to that she completed her BSc, BSc (Hons) and MSc in biochemistry, also at the University of Pretoria.

WHERE TO STUDY

Many South African universities offer Bachelor's degrees in science, alternatively you can study at an international university that offers a degree in biology.

MOLECULAR BIOLOGIST

CHARACTERISTICS

A molecular biologist must possess excellent analytical skills, pay attention to detail and have natural organisational skills.

RELATED CAREERS

Biochemist, geneticist, microbiologist.

Dr Yolandy Lemmer

Dr Koni Rashamuse analysing the separation of recombinant proteins on polyacrylamide gel.

COMBATING DEBILITATING AND RARE DISEASES WITH MODERN BIOTECHNOLOGY

Many biotechnological techniques, such as selective breeding to optimise crops and livestock, and fermentation to produce bread, cheese, beer, wine and yoghurt, have been in use since ancient times. These techniques often enable products to be manufactured more efficiently at lower cost, using less energy or smaller quantities of raw materials, and producing far less waste. In future, biotechnology will have an increasingly important role to play in making the world more sustainable, especially in improving human and animal health, and in raising the quality of life for people globally.

BIOTECHNOLOGISTS LIKE DR KONI RASHAMUSE, a CSIR researcher, make use of recombinant DNA technology to transfer and/or combine genetic information from one organism to another.

"This works because all living things are made up of the same type of genetic material. Widespread application of biotechnology is a critical factor in ensuring health and prosperity for mankind, and making the world more sustainable," says Rashamuse.

To qualify as a biotechnologist one needs to obtain good symbols in both mathematics and physical science 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 honest, it was not my doing that I ended up studying science at school. From standard 6 to 8 (now known as Grade 8 to 10), I studied accounting and business economics and I was doing well in those subjects. When I passed Grade 10, my father enrolled me in a different school and chose physical science and mathematics for me. He did not even bother to consult me. He believed that these were the only subjects that would unlock the future," explains Rashamuse.

"After completing Grade 12, my goal was to study medicine at Wits. Like most of my peers from disadvantaged communities, medicine was the only career of note associated with physical science and mathematics. When I got a D symbol instead of the required C symbol, I settled for a BSc in microbiology and biochemistry as a bridging mechanism."

Since his Honours degree years, Rashamuse's research activities have encompassed several disparate areas of biotechnology, all linked by the subject of enzyme applications.

"Enzymes are proteins that speed up chemical reactions. These proteins play a role similar to that of a teaspoon. They facilitate the mixing of the coffee, sugar and milk, without themselves being part of the coffee. Like a teaspoon, you can reuse these proteins," he says.

His first research project at the CSIR focused on the development of biocatalytic technology for the production of anti-retroviral intermediates.

The technology was later patented and led to the establishment of a small-medium biotech start-up enterprise.

"I am currently part of a European Union Framework Programme 7 project on biowaste that includes 16 research partners from Africa, Europe and Asia. The project is aimed at developing environmentally appropriate and socioeconomically sustainable biotechnological processes for converting biodegradable fractions of the biowaste streams into a number of value-added products, such as biochemicals, biogas and organic based fertiliser, as well as biowaste-derived nutraceuticals," says Rashamuse.

– Sibusiso Ralarala

Enquiries:
Dr Koni Rashamuse
krashamuse@csir.co.za

BIOTECHNOLOGIST

CHARACTERISTICS

Biotechnologists share a sense of curiosity about how the world works, a desire to help people and make the world a better place, an aptitude for working with their hands and an inclination to pay attention to detail.

RELATED CAREERS

Bioinformatician, biotechnical scientist, protein chemistry researcher.

WHAT DR KONI RASHAMUSE STUDIED

Dr Rashamuse completed a BSc in biochemistry and microbiology at the University of Venda. In 2000, he was awarded the HB Gift Webb Postgraduate Scholarship and the NRF Prestigious Scholarship to complete his BSc (Hons) at Rhodes University. Thereafter he received the Deutscher Akademischer Austausch Dienst (DAAD), otherwise known as the German Academic Exchange Service Scholarship, to study for his Master's degree in biochemistry at Rhodes University, which he completed in 2002. In 2003, he was awarded the CSIR Prestigious Scholarship to enrol for a PhD in biotechnology at the University of the Western Cape, which he completed in 2005. Dr Rashamuse was offered a postdoctoral fellowship by the CSIR in 2006 and joined the CSIR permanently as a researcher later in the same year.

WHERE TO STUDY

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

Dr Koni Rashamuse selecting worker termites for DNA isolation.

A fish sample being prepared for mercury testing.

CHEMICAL ANALYSIS TO PROTECT THE CONSUMER

André Munian

The reality of urban life includes having to purchase food from supermarkets and other outlets rather than farming your own. Chemical analysts play an important role in the process to ensure that this food is fresh and uncontaminated. For the same reason, they also test air, water and soil in our environment to protect people from toxins and pollution.

WHAT ANDRÉ MUNIAN STUDIED

He obtained a BSc in microbiology and biochemistry at the University of the Western Cape; completed a diploma in business management through Damelin College; a BSc (Hons) through Unisa and an MSc through the University of Cape Town.

WHERE TO STUDY

A diploma in analytical chemistry at a university of technology is the most direct way to find employment in a laboratory as opposed to a BSc which is not necessarily trade-specific.
For those opting for a BSc, it is advisable to complete a BSc (Hons) and a Master's in microbiology and biochemistry offered by most South African universities.

ANDRÉ MUNIAN started at the CSIR as a chemical analyst, but later moved to managing roles in the organisation's laboratories. These days, he is the national manager of CSIR laboratories that offer chemical and analytical services to test food, beverages, water, air as well as workplace and environmental dust.

Encouraged from a young age

"At high school, I wanted to study in the science field and chose subjects that would allow me to pursue a BSc. Education was strongly valued in our home. It was never an option to settle for noncareer-oriented studies or a gap year, for example," says Munian.

"We simply had to do our subjects at higher grade and if we struggled, we would get help. I was never a top student, but worked hard."

Practical experience

After completing his BSc at the University of the Western Cape, Munian found it difficult to find employment. "For a humble job in a laboratory, someone with a BSc degree can be regarded as over-qualified, with not enough practical experience, which is why I think that universities and students should consider developing more avenues to get practical experience."

Munian completed a higher education diploma and taught at a school for three months. "I wanted to help children who struggled academically, but it demanded a lot of energy and commitment. Teaching is a calling if you want to be good at it."

He then spent some time at the food technology department of the Cape Peninsula University of Technology where he gained valuable in-service training after which he joined the CSIR.

Furthering his studies

"It was a hard time to find employment and I worked at the CSIR laboratory as a junior analyst doing everything from sampling to cleaning. Experts in the laboratory went out of their way to support me and I learned a lot from them."

During this time, Munian completed his BSc (Honours) majoring in microbiology and biochemistry at Unisa, as well as a diploma in management at Damelin College, where he learned more about accounting and project management.

The CSIR identified a waste beneficiation project in the pineapple industry. At the time, the Eastern Cape provided about 5% of pineapple juice globally, but the industry was on the decline and needed to explore alternative products related to this fruit.

Munian based his MSc on methods to produce a viable dietary fibre from the pineapple waste material, a method which was thereafter used at a facility in the Eastern Cape.

Safeguarding the consumer

Munian later joined CSIR laboratories where food such as shellfish and fish is tested for spoilage or contamination. Spoiled fish can test positive for certain allergens and heavy metals in seafood indicate contamination. Food manufacturers and large fish factories are their typical clients.

"A chemical analyst plays a pivotal role to make sure that industry is honest, that good manufacturing practice is being adhered to and that food and beverages are safe for humans to consume.

"If contaminants are not picked up in food and the environment, it can have a negative impact on consumer health. Companies also rely on accredited laboratories to monitor the safety of their products to adhere to legal requirements that regulate the food industry."

Advice

According to Munian, someone who looks to become a chemical analyst needs to enjoy subjects such as physical sciences, mathematics and biology. "I also found that geography helped me to see the bigger picture of countries' agricultural and economic activity.

– Antoinette Oosthuizen

Enquiries:
André Munian
amunian@csir.co.za

CHEMICAL ANALYST

CHARACTERISTICS

Chemical analysts do a lot of routine laboratory work. You need to be hard-working and adhere to high standards of ethics and professional integrity as the precision of your results could have an impact on public health, the accreditation of your laboratory and the legal risks that your clients face.

RELATED CAREERS

Quality assurance manager in the food industry, production line manager in the petrochemical industry.

USING MASS SPECTROMETRY TO SPEED UP DRUG DISCOVERY

With the usage of mass spectrometry continually expanding, an increasing number of scientists, technicians, students, and physicians are coming into contact with this valuable technique.

MASS SPECTROMETRY has many uses, both qualitative and quantitative, from analysing simple gases to environmental contaminants, pharmaceuticals and complex biopolymers. The extraordinary versatility can make mass spectrometers daunting to novices. Senior scientist Dr Stoyan Stoychev, who specialises in mass spectrometry, provides a candid explanation of what this discipline is about.

"Mass spectrometry (MS) is a mature technology predicated on a premise demonstrated almost a century ago. It is widely used in most scientific disciplines involving basic research or industrial endeavours that require accurate and precise measurement of elemental and molecular components. More recently, in the past 20 years or so, MS is being applied to study biomolecules such as proteins, peptides, enzymes and antibodies," says Stoychev.

Separating ions of differing masses

Mass spectrometry is an analytical technique used to measure the mass-to-charge ratio of ions. It is generally used to determine the composition of a physical sample by generating a mass spectrum representing the masses of sample components. Put simply, it is a powerful analytical technique that is used to identify unknown compounds; to quantify known materials and to interpret the structure and chemical properties of molecules. This is achieved by ionising the sample and separating ions of differing masses, and recording their relative abundance by measuring intensities of ion flux. Scientists make use of an instrument known as a mass spectrometer to identify molecules present in solids, liquids and gases; determine the quantity of each type of molecule, as well as determine which atoms comprise a molecule and how they are arranged.

"Typically one would do an analytical chemistry course and then specialise in MS by doing a related MSc/PhD. Alternatively, as in my case, you could do a biological or chemistry degree and later start applying MS during post-graduate research," says Stoychev.

"MS is a very powerful tool that has traditionally been used to characterise small molecules, but its more recent application to bio-molecules such as proteins, peptides, enzymes and antibodies drew my interest. MS, through its sensitivity, resolution and accuracy is the perfect technique to study proteins, and in particular protein structure-function relationships, which is my other research interest.

Stoychev continues, "In the past two years we've worked on the implementation of a very powerful MS-based technique referred to as Deuterium exchange measured via mass spectrometry (DXMS). This workflow allows for in-depth characterisation of protein dynamics, structure, and conformational changes which in turn can be used to advance knowledge of human disease and guide pharmaceutical drug design. Most recently, through collaboration with the University of the Witwatersrand, we published the first peer-reviewed article that uses a locally performed DXMS study on a protein. To my knowledge this is a first for South Africa/Africa.

"Since the technology is evolving at a very fast pace, there are always new applications and approaches becoming available, which makes it exciting. The workflows and applications being developed in our lab are subsequently used to support CSIR-wide research as well as external research (mostly at universities). Hence, we provide solutions that scientists can apply to answer their research questions. There are a range of projects that all come with their own set of unique challenges. This keeps one interested in the work and allows expanding knowledge and experience, since one is always trying new approaches," says Stoychev.

– Sibusiso Ralarala

Enquiries:
Dr Stoyan Stoychev
sstoychev@csir.co.za

MASS SPECTROMETRIST

CHARACTERISTICS

Some of the characteristics required in this field include the need to be methodical and precise and pay attention to detail, while patience and out-of-the-box thinking, are also required.

RELATED CAREERS

Analytical scientist/chemist, research and development chemist, research scientist.

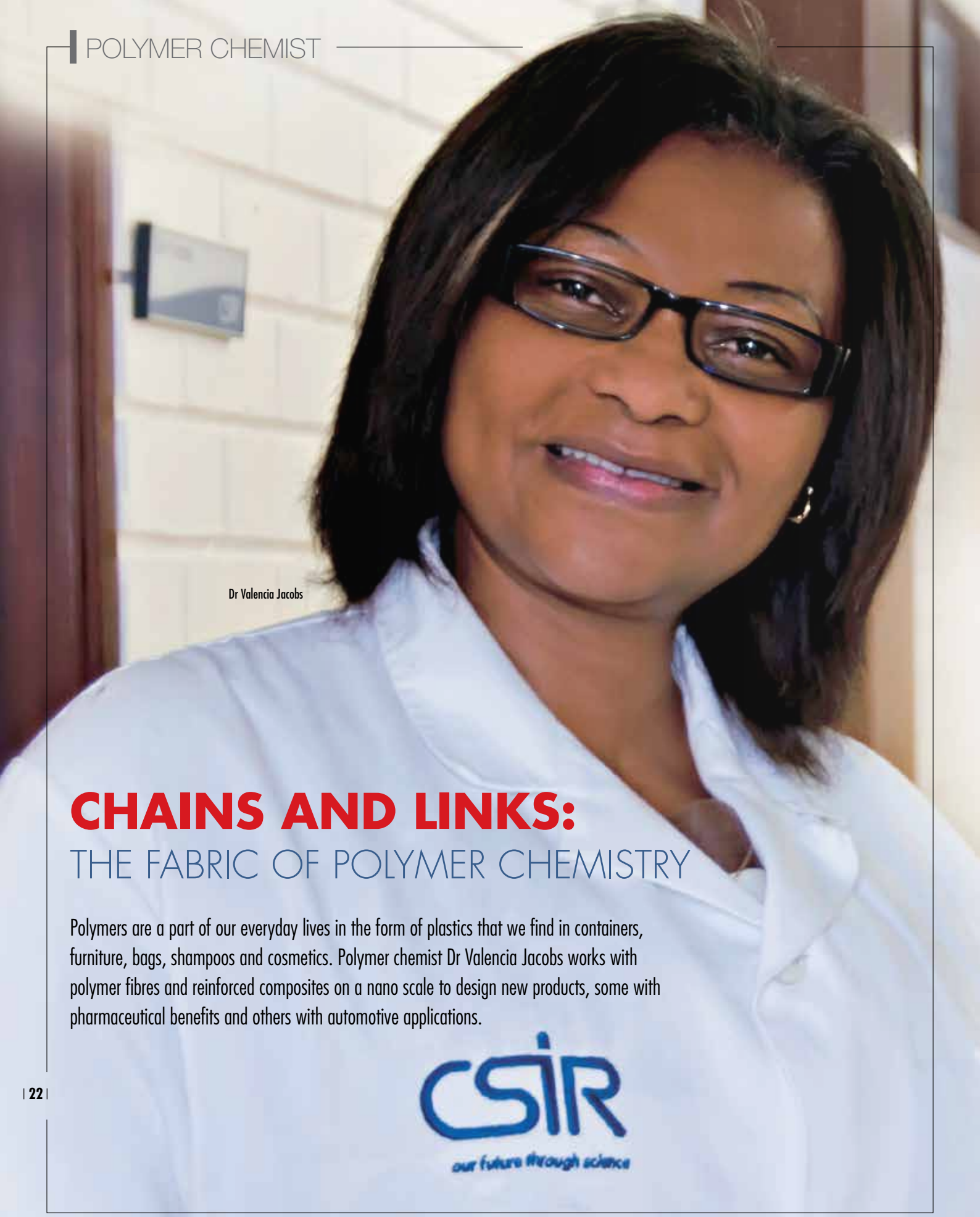
Dr Stoyan Stoychev

WHAT DR STOYAN STOYCHEV STUDIED

He studied a PhD in structural biology at the University of the Witwatersrand and for his undergraduate (BSc) studies he majored in biochemistry, with supplementary subjects such as chemistry, physics, mathematics and statistics. During his PhD studies he was introduced to mass spectrometry (MS). The novelty as well as power of MS as a tool for protein analysis, prompted him to focus his interest on the field of MS-based protein research.

WHERE TO STUDY

Many South African universities offer degrees in analytical chemistry.



Dr Valencia Jacobs

CHAINS AND LINKS:
THE FABRIC OF POLYMER CHEMISTRY

Polymers are a part of our everyday lives in the form of plastics that we find in containers, furniture, bags, shampoos and cosmetics. Polymer chemist Dr Valencia Jacobs works with polymer fibres and reinforced composites on a nano scale to design new products, some with pharmaceutical benefits and others with automotive applications.

CSIR
our future through science

Above: Dr Valencia Jacobs uses an Environmental Scanning Electron Microscope, one of the tools used to determine the characteristics of electrospun nanofibres.

Left: Nanofibrous material (web) of which the individual fibres have a diameter in the nano range. These fibres were electrospun directly onto a nonwoven mat for filtration purposes.

POLYMER CHEMIST

CHARACTERISTICS

"I am patient, methodical and precise with attention to detail. This is my strength as a polymer chemist," says Jacobs.

RELATED CAREERS

Research chemist or engineer, development chemist, process chemist.

Endless opportunities

"I was attracted to this career because of the endless opportunities for growth in your career as well as in research and development. Polymer science is a multidisciplinary field. As a polymer chemist, I often work with engineers, physicists, biologists and other scientists to conduct research. My skills can also be applied in various fields including biomedical, environmental protection and protective clothing," says Jacobs.

Most polymer chemists spend their day planning and conducting experiments, supervising production of new polymer materials, managing laboratories and performing tasks required in the research and development process.

Making a difference

Polymer chemistry and polymer science can be used in many ways to offer innovative solutions, such as water purification, medical diagnostics, tissue engineering and drug development, to address pressing problems facing our country.

Jacobs' day-to-day projects are based on researching applications and the design of end-products offering optimum cost-effective solutions.

She believes that determination and hard work are important drivers of success as a polymer chemist. So too, is teamwork.

"Communication and working as a team are key. A polymer chemist must possess the ability to clearly communicate complicated scientific findings or concepts," says Jacobs. "Although a polymer chemist can work independently, very often they are a part of a team of chemists and other scientists."

A career highlight

Jacobs describes one of the highlights of her research as a collaboration between the CSIR and Lulea University in Sweden. "In this project we successfully fabricate reinforced chitosan-based nanofibres with antibacterial properties by utilising the electrospinning technique."

She explains: "This is a highly technical way of saying that we use chitosan, a product derived from crab shells, to create antibacterial wound dressings. We do this by spinning extremely small (nano-sized) fibres from the chitosan and a polymer solution. These nanofibres are a thousand times thinner than a single human hair, have antibacterial properties and the ability to rapidly clot blood. It can also be used as nanofilters."

Jacobs encourages young professionals in her field to choose the CSIR as an employer. "The environment at the CSIR is diversified in terms of disciplines and there is great potential within the CSIR for career growth," she says.

– Lionel Jean Michel

Enquiries:
Dr Valencia Jacobs
vjacobs@csir.co.za

WHAT DR VALENCIA JACOBS STUDIED

She completed a BSc in chemistry and biochemistry and an Honours in chemistry at the University of Fort Hare. Her MTech in chemistry and PhD in textile science were done at the Nelson Mandela Metropolitan University.

WHERE TO STUDY

Polymer chemistry can be studied at any tertiary institution that offers courses or research related to polymers. These courses are offered at Departments of Chemistry, Textile Science/Engineering, Nanotechnology and Nanosciences, Polymer Science and Engineering, and Materials Science and Engineering.

Dr Sally Archibald

ECOLOGIST

CHARACTERISTICS

An ecosystem scientist should have a love for nature and the outdoors. The individual should also be creative and unafraid of working with numbers. Archibald says that a passion for research is key, so that the reward lies in the job itself.

RELATED CAREERS

Environmental impact assessor, fire ecologist, conservationist.

HELPING ECOSYSTEMS ADAPT TO A CHANGING WORLD

Dr Sally Archibald has dabbled in mathematics, languages, zoology and botany, even trying her hand at journalism. Her path to ecosystem researcher at the CSIR was hence not direct or typical, but she says it's often better to take the scenic route.

"For me it was worth trying out a few different things until I found what I liked. Even though it might have seemed undirected at the time, I ended up with some really useful skills," she says.

Room to grow

Archibald explains that scientists with diverse backgrounds flourish at the CSIR exactly because the organisation believes in making a multitude of skills available within research teams and across its different research units.

"The CSIR is also a supportive, mentoring environment where you feel relevant and have the freedom and independence to seek answers to important questions," adds Archibald. "And, as an established institution, it has systems in place that enable scientists to pursue new ideas, even if the immediate benefits of the research are not yet obvious."

She says the CSIR encourages scientists to decide how their time is spent, as long as they consistently produce results.

Out in nature

Archibald's own research looks into how climate, fire, vegetation and people affect the environment and biodiversity, and how to better manage and mitigate potentially negative changes.

"My research helps create and maintain the landscapes and environments that support us," she explains.

Much of her work is geared towards informing policies around land management, sustainability, conservation and climate change. For instance, one of her projects looks at how to use fire as a tool to increase the grazing quality of vegetation for animals in the Kruger National Park. Another focuses on how water resources can be improved by removing alien invasive plants.

These projects involve field experimentation, and thus travelling, all over South Africa.

"There is a lot of scrambling around outdoors, so a love for nature is important," says Archibald. She does quite a bit of number crunching in front of the computer as well, and her aptitude for statistics comes in very handy.

The art of science

But what attracted her to research most of all was something many people would not associate with science: creativity.

"Being creative is a huge part of being a good scientist. You need to find new ways to look at old problems and you must be able to design experiments that reveal new information," she says. "In other words, a scientist needs a vision."

Enquiries:
Dr Sally Archibald
sarchibald@csir.co.za

Above and background: Dr Sally Archibald tests the water potential of savannah trees using a Scholander Pressure Device. This is a simple, reliable method for assessing the water stress of a plant.

WHAT DR SALLY ARCHIBALD STUDIED

During her undergraduate studies at the University of the Witwatersrand (Wits), she took both BA and BSc subjects, while deciding what she really wanted to do. She became very interested in evolutionary biology, which led her to botany and then on to plant ecology. During her MSc at the University of Cape Town, Archibald was exposed to the use of remote sensing, in the form of satellites, to obtain environmental data. She later went on to complete her PhD on African fire regimes, jointly at Wits and Princeton University in the USA.

WHERE TO STUDY

"I like the cross-disciplinary approach," says Archibald, "so if you are good at different things, try to combine them into a degree that is unique to you." She suggests taking courses in biology at any South African university and adding subjects like economics, statistics or geography.

Dr Mary-Jane Bopape's career took off when the CSIR recruited her to its Centre for High Performance Computing where she assisted Earth scientists with modelling research.

Dr Mary-Jane Bopape

METEOROLOGIST

CHARACTERISTICS

These professionals need to be precise, analytical and methodical with an aptitude for maths, physics and computer skills.

RELATED CAREERS

Atmospheric modeller, weather forecaster.

DECODING THE WEATHER TO PREDICT ITS FUTURE

SHE WAS IN MATRIC at Hwiti High School in Mankweng, Limpopo, when her mother brought home a pamphlet from the South African Weather Bureau (now called the South African Weather Service).

Little did Dr Mary-Jane Bopape realise the extent to which that day would dictate the course of her life. Today, she is a meteorologist specialising in atmospheric modelling at the CSIR. Atmospheric modelling is a specialist field of meteorology and these models are used to forecast weather and to predict climate variability and change.

Early interest in the field

It was her high school geography teacher who instilled Bopape's love for meteorology and the chapter on climatology was her favourite.

"The pamphlet contained information on where to study meteorology and what the requirements were. My uncle encouraged me to go to university, going against the advice of others in the community who felt that it was easier to enter the job market with a more technical qualification."

Bopape's keen interest in geography and good marks for physical sciences and mathematics landed her a space at the University of Pretoria where she completed a BSc in meteorology in 1999. She completed her BSc (Honours) in 2002 and joined the South African Weather Service for five years while completing her MSc.

Joining the CSIR

Her career took off when the CSIR recruited her to its Centre For High Performance Computing where she assisted Earth scientists with climate modelling research. Bopape then moved to a unit which specialises in natural resources and the environment and completed her PhD, which she was awarded in September 2013.

"I worked on the development of a new atmospheric model for my PhD. In a research environment, the simulations produced with an atmospheric model produced on a computer can be used to study the response of certain weather phenomena to changes in the composition of the atmosphere, or changes to the sea and land surfaces," Bopape explains.

"When studying climate change, atmospheric scientists include the predicted changes in greenhouse gas concentrations and study how climate is going to change as a result of these concentrations. The models are made up of basic equations that describe motion, energy and conservation of mass. The equations are written in programming language so that they can be understood by a computer."

Current work

Bopape says that researchers are continuing to work on the model with the ultimate goal to develop a cloud resolving model in South Africa, which can be used to study atmospheric processes and perhaps be used for operational forecasting.

"I am currently also studying how the diurnal cycle and intensity of rainfall is likely to change because of global warming."

Her work requires that she spends most of her days behind a computer doing updates in code to further develop a model, running it or analysing its output. "As climate scientists, we also participate in projects such as those that look at the effect of climate change on health and water quality."

Meteorologists collect and analyse atmospheric data such as wind, air pressure and humidity to predict weather patterns. Many industries and the public rely on this information to plan their days and protect themselves against natural disasters.

– Antoinette Oosthuizen

Enquiries:
Dr Mary-Jane Bopape
mbopape@csir.co.za

WHAT DR MARY-JANE BOPAPE STUDIED

She completed a BSc in meteorology followed by a BSc (Hons) in the same discipline at the University of Pretoria and joined the South African Weather Service for practical training. She then completed her MSc and PhD.

WHERE TO STUDY

Various degree courses can be taken at South African universities. While a BSc in meteorology is offered at the University of Pretoria, at other universities there are options to study degrees in environmental and geographical sciences or a BSc with subjects such as mathematics, statistics, applied mathematics and physics, and to then specialise in meteorology from the Honours level.

TO SAVE A RIVER, DAM OR WETLAND

Dr Paul Oberholster is one of only a handful of limnologists in South Africa. Yet, it is a discipline that is alive and well the world over and, given the increasing importance of water resources in a changing climate, one for which the demand is fairly high.

LIMNOLOGY IS THE STUDY of life in fresh water such as rivers and wetland systems.

"My job is to understand how a water system functions and what is preventing it from functioning as it should. The projects that I'm involved in almost all have to do with detecting pollutants in our water resources," says Oberholster. "I would go to a specific water system, such as a river, and put monitoring programmes in place to detect chemical, physical, biological and environmental indicators linked to pollution of the system. These could include anything from heavy metals and acid mine drainage to nutrients from sewage systems."

Once enough data have been gathered through the monitoring programmes for Oberholster and his team to form a baseline, ways are suggested in which to restore the river or wetland system. They usually remain involved until after the restoration in order to monitor the results thereof.

It is an out-in-the-field kind of job

Oberholster is currently involved in 11 different projects, including one with the African Union that spans six countries. Another project in the Upper Olifants River involves more than 30 researchers from several disciplines and organisations.

"What I love about my job is that each river, dam or wetland has its own system – no two systems are the same and there is no 'one-size-fits-all' solution to their problems. Every time you go to a new project, you discover something different. I also love being in the field. About 80% of what I do happens out in the field, with the remaining 20% keeping me in the lab."

Based at the CSIR in Stellenbosch, Oberholster is the organisation's only limnologist. He does, however, continuously work across disciplines with other researchers such as hydrologists and chemists.

"Our projects are multi-disciplinary in nature," he says. "Within the CSIR, you are especially encouraged to work with other disciplines to help solve problems. In so doing, you gain the kind of practical knowledge that is hard to come by in most other environments."

Study overseas

One of the biggest factors that make limnologists such an endangered species in South Africa, is the fact that none of the local universities offer it as a major subject. When Oberholster started studying towards his BSc degree, he had limnology as one of his subjects. He took the subject further into his postgraduate studies and completed his PhD in water resource management at Colorado State University in the USA.

– Petro Lowies

Dr Paul Oberholster and colleagues collect data from monitoring systems in the Waterberg (left) and physical samples from the Upper Olifants River (middle), and the Waterberg (right).

Enquiries:
Dr Paul Oberholster
poberholster@csir.co.za

Dr Paul Oberholster

LIMNOLOGIST

CHARACTERISTICS

Limnologists have to be analytical thinkers, driven by curiosity and a need to solve problems. You must have a passion for nature conservation and love being outdoors. You should also be able to keep the big picture in mind at all times.

RELATED CAREERS

Conservation biologist, hydrologist, microbiologist.

WHAT DR PAUL OBERHOLSTER STUDIED

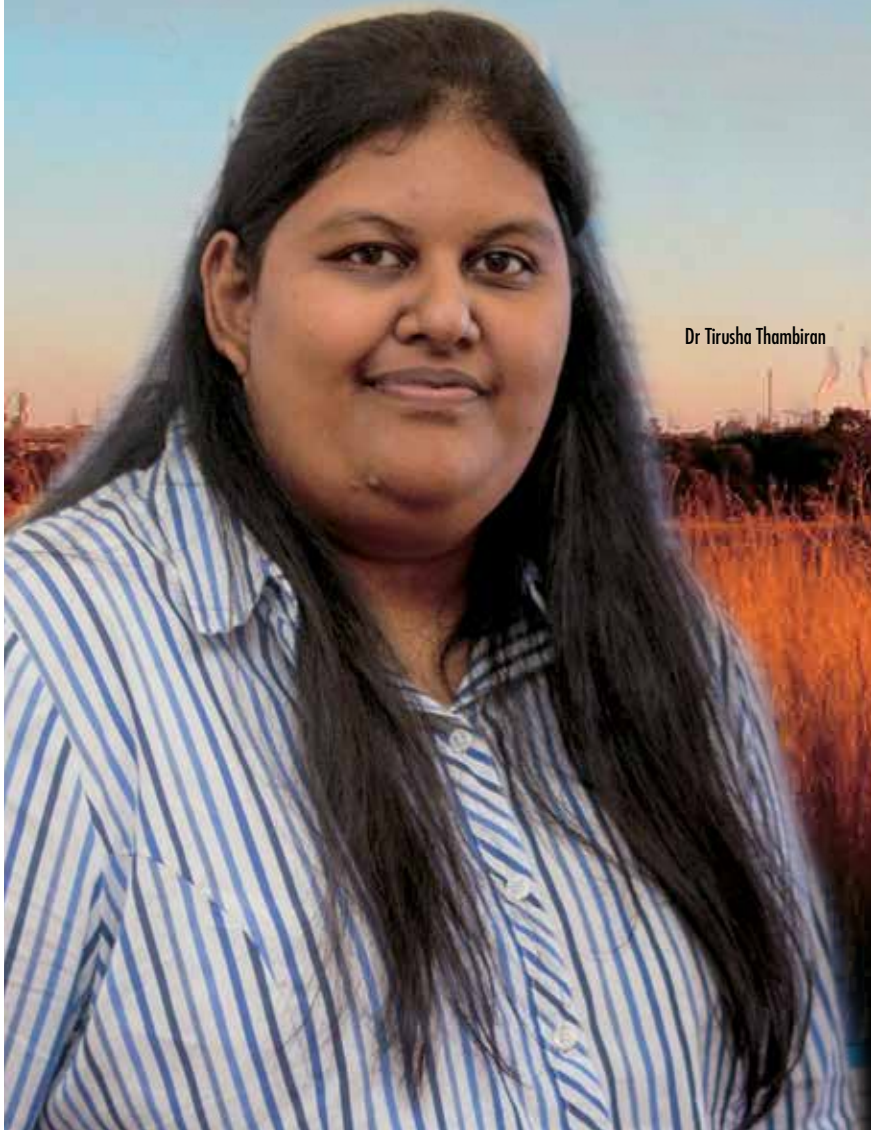
He completed a BSc, BA, MSc and a Master's degree in Environmental Management at the University of the Free State. Limnology was a major subject throughout his studies. He then continued his postgraduate studies through the University of Pretoria with a PhD in water resource management. The research for his PhD was conducted at Colorado State University in the USA.

WHERE TO STUDY

Limnology as a university subject is no longer offered at a South African university. Oberholster suggests that you do a broad BSc degree with botany, zoology and chemistry as subjects, and then do your postgraduate studies overseas. The Society of International Limnologists annually offers scholarships at overseas universities to students wanting to study this discipline. However, the applicant will compete with students from all over the world, thus their marks should be exceptional.

ON A MISSION TO HEAL THE WORLD

"The atmosphere is a key part of the Earth's life support system and it is faced with testing challenges such as climate change and air pollution. These can only be tackled by actions and policies that rely on our understanding of atmospheric science. That is why I chose this career," says Dr Tirusha Thambiran.



Dr Tirusha Thambiran

ENVIRONMENTAL SCIENTIST

CHARACTERISTICS

Environmental researchers need a keen interest in the environment, good communication skills and the ability to work well with others.

RELATED CAREERS

Environmental engineer, climate specialist, geoscientist.

DR TIRUSHA THAMBIRAN is an environmental scientist at the CSIR. Her work involves applying science to improve the understanding of the causes and drivers of air pollution, as well as the study and discovery of means to mitigate the negative effects of climate change.

"We find opportunities to mitigate air pollution and climate change. This generally involves collecting data on the sources of pollution emissions and quantifying the impacts on air quality and on people. We also investigate the impact of air pollution on climate change," she explains.

Environmental science has a large number of varying fields that contribute to the understanding of human impacts on the environment. These studies are used to provide solutions that can have multiple positive benefits for society and the environment.

Thambiran specialises in atmospheric science, particularly the fields of air quality and climate change. Her career choice was guided by a fascination of nature and science from an early age. "I was always in awe of nature; I love animals and beautiful landscapes. I knew early on that I wanted to study the environment. Seeing the destruction that occurs on land and sea, and the consequential impact on people made me want to be part of the solution from an early age."

Thambiran obtained a BSc in environmental science from the University of KwaZulu-Natal (UKZN).

"My undergraduate training gave me a very good grounding in the pressures and challenges of the environmental research world. Many of the issues I came across resonated very well with me, as these were issues that I could see unfolding in my surroundings. One such was air pollution, a big problem in my community. I then chose to focus my postgraduate studies on the field of atmospheric science," she recalls.

In her doctorate, Thambiran tackled the highly contentious issue of air pollution caused by oil refineries in the south of Durban.

"My postgraduate studies allowed me to apply more innovative thinking and to be solution-driven. Science has proven beyond any doubt that air pollution can result in a number of adverse human health impacts. These include difficulty in breathing, increases in chances of heart attacks, and increased incidences of cancer. My study focused on the co-benefits for communities and the business sector if air pollution was to be decreased. I wanted to go beyond identifying the problem, and more towards identifying workable solutions."

Her study was well received and she has become a sought-after speaker at policy-making platforms. "Knowing that my research has impact and is acknowledged as being novel and innovative has been a hugely rewarding experience," she remarks.

Thambiran believes that there is a bright future for aspiring researchers in this field at the CSIR and strongly encourages young people to consider the career, as well as joining the CSIR. "The involvement of dynamic, enthusiastic individuals who are passionate about bringing positive changes to our one and only world, is crucial. Young people who are passionate about the environment and are driven to succeed and seek to develop a research career should choose the CSIR," she concludes.

– Mandla Ndlovu

Enquiries:
Dr Tirusha Thambiran
tthambiran@csir.co.za

WHAT DR TIRUSHA THAMBIRAN STUDIED

She obtained a BSc and MSc in environmental science from UKZN, and a PhD focused on atmospheric science, from the same university.

WHERE TO STUDY

Degrees in environmental science are offered at most South African universities.

DEDICATED TO THE HEALTH OF SOUTH AFRICANS

Public health science identifies and promotes strategies to reduce the occurrences of and death from diseases. Dr Caradee Wright is a public health scientist at the CSIR. Her area of specialisation is in environmental health where she undertakes epidemiological studies on the distribution of diseases related to the environment.

"I WAS ATTRACTED TO A CAREER in public health research because I wanted to add to the existing body of knowledge and I want my contribution to be useful in making a real impact and difference to the lives of South Africans," says Dr Caradee Wright.

"In my field of work I aim to improve the health outcomes of communities through science. We conduct studies to improve our understanding of how diseases spread and how they can be prevented. At the CSIR, we go one step further as we also find ways to raise awareness to ensure preservation of health and wellbeing of communities," she says.

Public health science is very broad, with numerous fields of speciality. Wright's field of interest is solar ultraviolet radiation exposure, as well as air quality management. She obtained both her Honours and Master's degrees in environmental management and geography at the University of KwaZulu-Natal and then went to the University of Otago in New Zealand to study for her PhD at that university's School of Preventive and Social Medicine. Her PhD was on public health, specialising in personal solar ultraviolet radiation dosimetry.

"I really enjoy the study of dosimetry, which among other things measures the amount of radiation people receive from being exposed to the sun. I want to generate data and information that will lead to a reduction in the number of skin cancer cases in South Africa, as well as reduce the other adverse effects of excessive sun exposure, such as cataracts and immune suppression. My research will be used to draft sun awareness campaigns, raise levels of knowledge about skin cancer and hopefully change behaviour too," she says.

Asked what her typical projects look like, Wright explains, "My assignments are mainly descriptive epidemiological projects that aim to understand prevalence of disease. I spend a lot of time conducting fieldwork to determine associations between risk factors and diseases. I also provide and present evidence from my studies. The work influences policy-makers and the public on the prevention of diseases."

Wright recently led a project sponsored by the Cancer Association of South Africa (CANSA) which investigated the knowledge, attitudes and behaviours of schoolchildren in relation to sun exposure.

"We wanted to know whether children use sun protection and if not, why not, so that we can try to support them in the future," she says.

Wright is a champion for the advancement of young scientists in South Africa. She is a member and former co-chair of the South African Young Academy of Science (SAYAS) – a body that seeks to enable young scientists achieve scientific excellence in their careers.

She sees the CSIR as a great place for a public health scientist to work. "The potential for growth and success is immense; the range of the career is very wide for aspiring scientists and researchers. There are a lot of experts in different areas who can be called upon for advice and collaboration on projects.

"To date, my biggest success on a personal level was seeing the first student whom I supervised, graduate. It takes a lot of commitment and effort to mentor and supervise students, and seeing them successfully complete their degree is extremely rewarding," she remarks.

– Mandla Ndlovu

Enquiries:
Caradee Wright
cwright@csir.co.za

WHAT DR CARADEE WRIGHT STUDIED

She completed a BSc and MSc in environmental management and geography at the University of KwaZulu-Natal, and a PhD in public health at the University of Otago in New Zealand.

WHERE TO STUDY

Most South African universities offer degrees in environmental management. Upon further studies, students can discover their key areas of interest in this broad field of study and proceed to specialise.

PUBLIC HEALTH SCIENTIST

CHARACTERISTICS

"A career in science or research requires that you have an inquiring mind, tenacity and perseverance. You have to be good at multi-tasking, extremely hardworking and committed to making a difference. Specifically, for a career in public health, you should have good statistical skills, enjoy reading and be willing to spend many hours doing fieldwork among communities," she advises.

RELATED CAREERS

Epidemiologist, biostatistician and professionals in disease control and prevention.

Dr Caradee Wright

CHARACTERISTICS

You will need proficiency in mathematics and science, an interest in nature and a love for technology.

RELATED CAREERS

Environmental engineer, atmospheric scientist, surveyor.

Dr Moses Cho

WHAT DR MOSES CHO STUDIED

He completed a BSc and MSc in botany and conservation biology before studying remote sensing at the International Institute for Geoinformation Science and Earth Observation (ITC) at the University of Wageningen, in the Netherlands.

WHERE TO STUDY

A number of major universities in South Africa offer courses in geographical information systems and applied remote sensing. These include the universities of KwaZulu-Natal, Cape Town, Fort Hare, Pretoria, Johannesburg, and the North West and Stellenbosch universities.

CUTTING-EDGE TECHNOLOGY MEETS THE NATURAL ENVIRONMENT

Dr Moses Cho's rural upbringing had a major influence on his choice of career. "I have always been fascinated by the natural diversity of plants and animals and the complex interaction between them and the physical environment. I grew up in a rural area where the community was heavily reliant on natural resources for its survival. We fetched our drinking water from the stream and we collected nuts from the forest, which provided income to the family. That is how my strong bond with nature was established," Cho remarks.

CHO IS A CSIR REMOTE SENSING SCIENTIST focusing on vegetation science. Remote sensing is the acquisition of information about an object without making direct physical contact with it. He joined the CSIR in 2007 and says that he was attracted by the organisation's research philosophy that prioritises interdisciplinary collaborations, which he believes are necessary to solve complex environmental challenges.

"I was mesmerised by the breadth of skills and the facilities available at the CSIR when I joined the organisation. My job combines the very best of modern technology with the essentials of nature. We use sensor devices such as handheld, airborne or spaceborne cameras to obtain information about the health, composition, structure and distribution of vegetation by analysing the image data which in most cases are collected by satellites that orbit the Earth.

"We produce map products of various spatial scales. They detail the current state of our vegetation resources and serve to inform policy formulation and implementation on the use and management of these resources. This science also allows us to identify endangered or stressed vegetation species, determine tree species composition in protected areas, and analyse grazing capacity of rangelands.

"The knowledge gained allows for the development of strategies to preserve our precious ecosystems. We share new knowledge through scientific publications in peer-reviewed journals, and local and international conferences," he comments.

Cho knew very early in his youth that he would pursue a career in natural resources and the environment. "I grew up seeing the resources that used to sustain our communities dwindle considerably. This intrinsically pushed me to pursue BSc and MSc degrees in botany and biodiversity conservation. I later specialised in remote sensing of vegetation at PhD level. I was motivated by the fact that by using remote sensing techniques, I would be able to make a significant contribution to the conservation of nature far beyond my locality."

Cho continues, "In this field, one never stops learning. I am a member of the Society of Conservation Biology and African Association of Remote Sensing of the Environment. This affords me continuous opportunities to develop new knowledge and skills in nature conservation and the use of remote sensing technology."

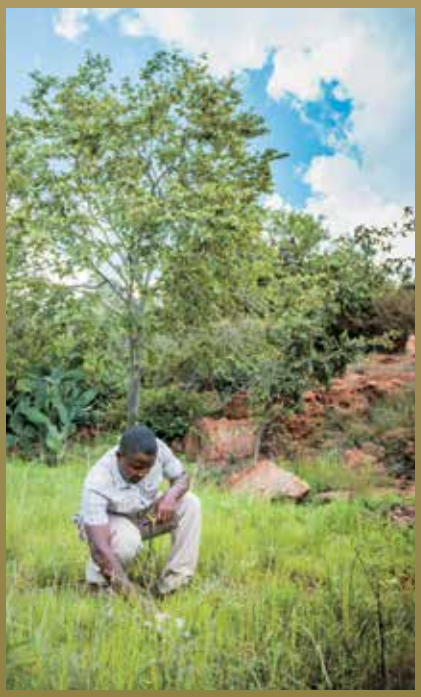
Cho regards the development of a model that provides accurate measurement of vegetation stress from remote sensing data as his biggest career success yet. The model has been successfully used to assess crop stress around the world, particularly in Asia and Europe. "We have also successfully used the model to assess the effects of acid mine drainage in South Africa," he says.

The field of natural resources and the environment requires many more dedicated scientists like Cho, and he encourages young people to seriously consider a career in this field. "I believe there is no better place in South Africa for young science professionals than the CSIR."

Cho also supervises PhD and MSc students in his field. "I take a lot of joy in seeing young people succeed in this field," he concludes.

– Mandla Ndlovu

Enquiries:
Dr Moses Cho
mcho@csir.co.za

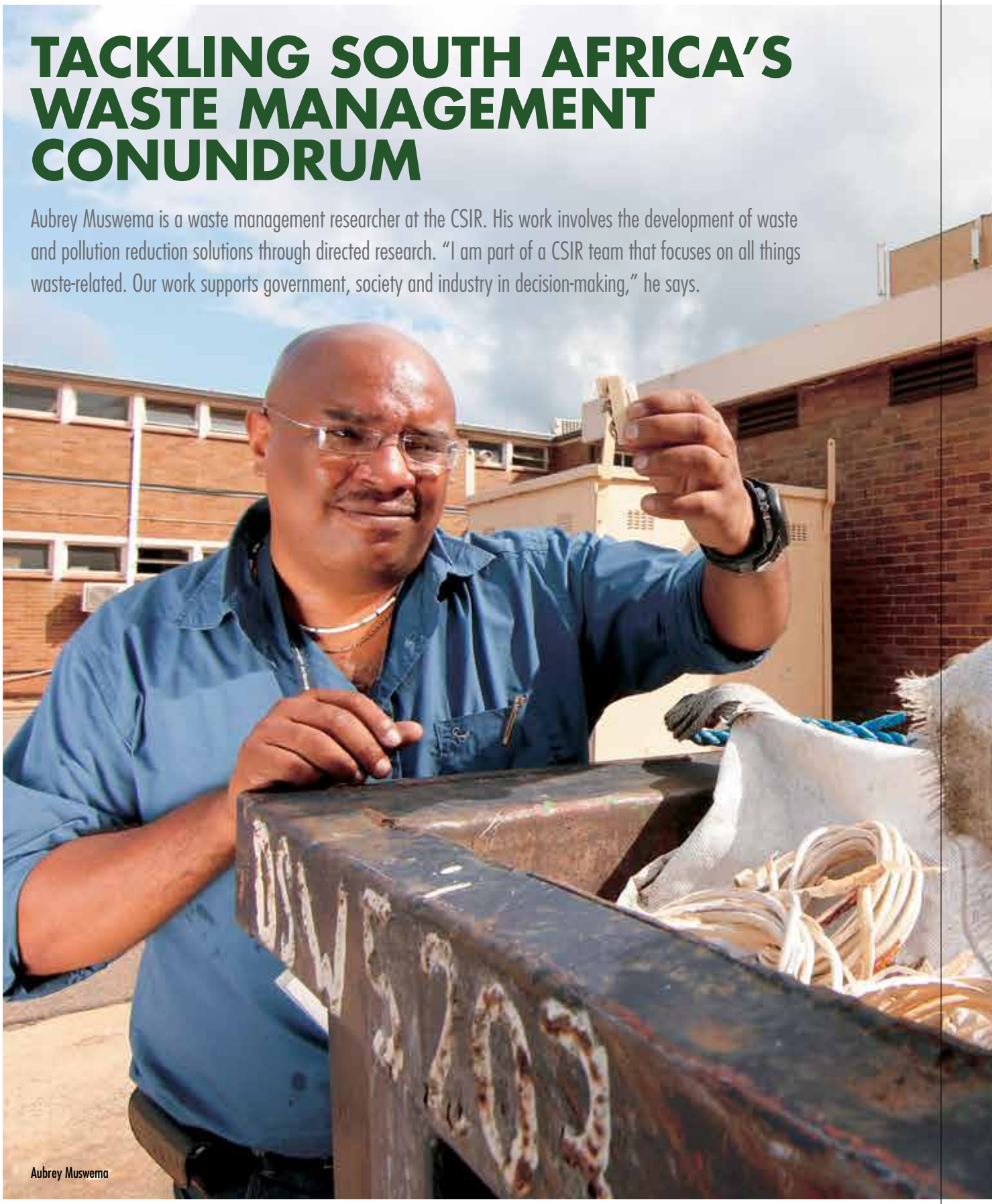


Dr Moses Cho measures the leaf area index, a key characteristic of forest productivity.

An analytical spectral device used to measure leaf reflectance.

TACKLING SOUTH AFRICA'S WASTE MANAGEMENT CONUNDRUM

Aubrey Muswema is a waste management researcher at the CSIR. His work involves the development of waste and pollution reduction solutions through directed research. "I am part of a CSIR team that focuses on all things waste-related. Our work supports government, society and industry in decision-making," he says.



Aubrey Muswema

SOUTH AFRICA IS HOME to over 50 million people. It has a vibrant and bustling economy with a wide range of industrial sectors that drive the livelihood of the country. One aspect of the country's rapid urbanisation and industrialisation is the generation of large amounts of waste. The Department of Environmental Affairs report compiled by the CSIR in 2011 showed that South Africa generated approximately 108 million tons of waste in 2011.

"Managing waste is part art and part science and has a number of facets that range from studying waste production, people and their waste-related behaviour, to understanding economics and the environment," says Muswema.

"Decision-making in waste management requires a broad understanding of all the key variables that affect waste production. We identify and promote best practice models in waste management, policy and governance. Our work also seeks to influence the waste behaviour of consumers and households," he explains.

He has built an impressive career in this field, though his career path took a sharp turn to land him here. He started his university life studying for a degree in veterinary medicine before moving into environmental impact assessment and waste management research.

"I had always had an interest in the environment; my current career in waste management grew out of a peculiar set of choices that I made more than 10 years ago. I studied for a degree in veterinary medicine and towards the middle of my studies, I began to assist lecturers in environmental impact assessment projects, which I thoroughly enjoyed. I was caught between making a choice to finish my degree and making a change in my educational direction to follow my new interest. I decided to finish the degree and then look for an opportunity to follow the new career path after I had completed my studies.

"I ended up practising as a veterinarian on the South Coast of KwaZulu-Natal for about two years. I then got a chance to follow my environmental interest and completed a Master's degree in environmental management looking at medical and veterinary waste management," he recalls.

Muswema's career in waste management research has afforded him opportunities to investigate varying waste management challenges.

"There has never been a dull moment; my first assignment in the field was to assess environmental impacts at existing cemetery and landfill sites in KwaZulu-Natal. This involved travelling to every single landfill and cemetery site in the province.

"We are currently working on a portfolio of projects that includes food waste research where we are establishing research collaboration with counterparts from Sweden, recycling of wastewater for industrial purposes for KwaZulu-Natal municipalities and the reuse of sewage sludge. My work combines office and fieldwork and requires a lot of interaction with people," he says.

The impacts of poor waste management practices and pollution are borne by every sector of society or industry, and the challenge of waste and pollution grows greater as economies and populations grow. He believes that the waste research field is therefore crucial.

"Every single development brings with it a waste management challenge; every single transaction we make has a waste footprint. We need more skilled and dedicated experts to develop this field, and I believe that the CSIR is the best place for young researchers looking to make a career in waste research. The organisation provides many opportunities to grow young researchers," he remarks.

– Mandla Ndlovu

Enquiries:
Aubrey Muswema
amuswema@csir.co.za

WASTE MANAGEMENT RESEARCHER

CHARACTERISTICS

An inquisitive mind, an eye for detail and a positive attitude are required.

RELATED CAREERS

Environmental researcher, environmental economist, waste treatment scientist.

WHAT AUBREY MUSWEMA STUDIED

He completed a Bachelor's degree in veterinary medicine at the Samora Machel School of Veterinary Medicine at the University of Zambia and clinical attachments at Onderstepoort Veterinary Academic Hospital in Pretoria. He also obtained a Master's degree in environmental management at the University of KwaZulu-Natal.

WHERE TO STUDY

Most South African universities offer degrees in environmental management. Once students develop key areas of interest in this broad field of study, they may opt to pursue specialisation.

REAPING REWARDS FROM SOUTH AFRICA'S BOTANICAL RICHES

Finding the right mix of indigenous plants, agricultural practices and agroprocessing is what makes the contribution of the CSIR's Lizandé Kellerman singular.

Lizandé Kellerman

PLANT ECOLOGIST

CHARACTERISTICS

A love of the outdoors and plants, and an interest in and understanding of agricultural requirements to cultivate indigenous species are essential. The ability to mentor is also important when introducing technology to potential beneficiaries.

RELATED CAREERS

Environmental manager, environmental impact assessment practitioner, vegetation specialist consultant.

Sceletium tortuosum, or Kougoed, is cultivated under shadehouse conditions at Nourivier in the Namaqualand region of the Northern Cape.

Kellerman explains required cultivation and irrigation methods of Kougoed and cancer bush to project beneficiaries Mr Jacobus T Brandt (left), Mr Deon Grundman (middle) and Mr Hendrik (Jap Jap) Klaase (right).

PLANT ECOLOGY is a highly specialised field and focuses on the study of the diversity of plants in an ecosystem. A plant ecologist by training, Kellerman is part of a CSIR team that promotes the medicinal plants and essential oils sector in South Africa. She has been responsible for the planning, implementation, management and financial administration of three rural community-based projects where indigenous plants are grown for their commercial value.

"Our social impact is achieved through technology transfer to these communities, who learn the skills of cultivation, harvesting and processing of these different species. We have identified certain South African plant species that yield natural products of cosmetic, medicinal and nutritional value. Our role is to balance and support the dual imperatives of responsible commercial cultivation and use, and conservation."

Ultimately, this technology transfer and on-the-job mentoring lead to community upliftment and development, poverty alleviation, job creation and skills development and training through wild crafting. Wild crafting is the commodity beneficiation of indigenous plant species: the extraction of products or substances which make up the plant species and have cosmetic, medicinal or nutritional value.

Out in the field

Kellerman's job requires significant measures of knowledge, skill, energy and patience. "Some of my projects are based in the Northern Cape, where long distances and extreme climatic conditions make targeted technical and community interventions that more difficult," she explains.

Travelling from Pretoria to this part of South Africa is par for the course when she visits Nourivier and Witdraai, where kougoed *(Sceletium tortuosum)*, cancer bush *(Sutherlandia frutescens)*, Kalahari melon *(Citrullus lanatus)* and devil's claw *(Harpagophytum procumbens)* are cultivated. Kougoed is a natural sedative, while the Kalahari melon yields valuable seed oil and devil's claw is used to treat a range of ailments. Another project that is currently being upscaled and entails the cultivation, harvesting and processing of devil's claw, elands bean *(Elephantorrhiza elephantina)* and marama bean *(Tylosema esculentum)*, is also situated in the Northern Cape.

"The best way to tackle project site visits is through active engagement with participants," she explains. "In this way, I meet the needs for coaching and guidance, while encouraging the community to explore solutions collectively." Her communication and negotiation skills come in handy when her job requires community liaison, or stakeholder interactions with traditional or local authorities.

Her responsibilities extend to the identification of new wild-harvested cosmetic, medicinal and food plants in South Africa for investigative purposes, mapping and collection.

The bigger picture

Kellerman has extensive knowledge and experience of environmental management issues. She is responsible for the environmental reviews and legal compliance of the CSIR's enterprise development projects, as well as for other CSIR projects on request.

She explains, "I deal with the application for and management of, amongst others, environmental impact assessments, water use licences, waste management licences, ploughing rights and bioprospecting permitting." She has held a number of positions in academia and industry – the ideal training ground for acquiring and applying this valuable knowledge.

Her advice to anyone who wants to follow in her footsteps is simple, "If you love plant life and are keen to make a difference: get your hands dirty and your feet wet! It's all about finding opportunities to make a difference through applying your skills to help others. Be prepared to engage and find ways of working in different sets of circumstances."

– Biffy van Rooyen

WHAT LIZANDÉ KELLERMAN STUDIED

A BSc and BSc (Hons) in botany and an MSc also in botany *(cum laude)* from the University of Pretoria. Her PhD in plant ecology through the University of Pretoria is nearing completion. She also has a postgraduate Certificate for Higher Education and Further Training from the University of South Africa.

WHERE TO STUDY

Most universities in South Africa offer undergraduate and postgraduate courses in botany and ecology.

Enquiries:
Lizandé Kellerman
lkellerman@csir.co.za

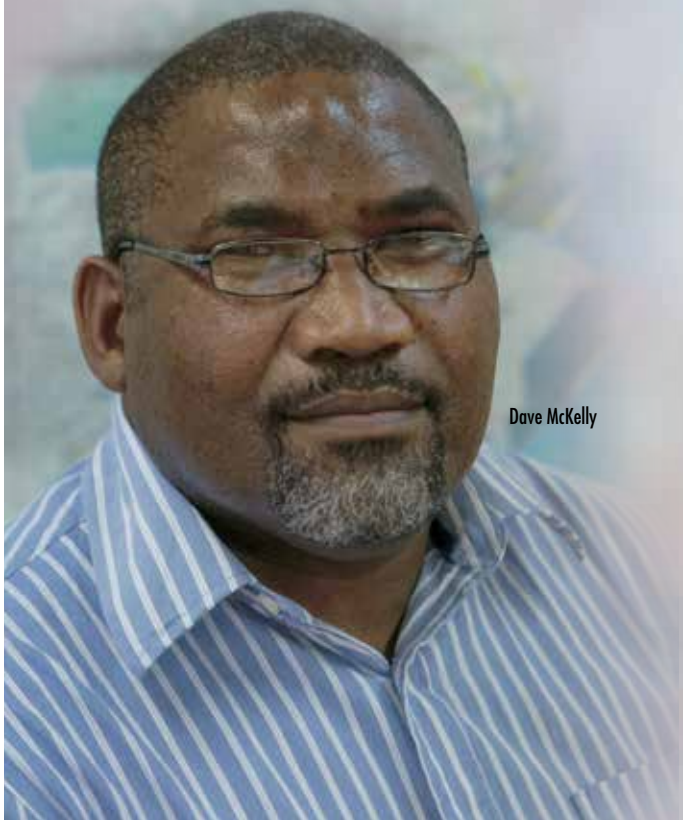
GEOGRAPHIC INFORMATION SYSTEMS TO PLAN FOR MAN AND ENVIRONMENT

Population growth places pressure on our cities and natural environment with mankind needing more safe housing, transport infrastructure and facilities to provide education, healthcare and social services. These days, city and regional planners use specialist technologists who work with advanced geographic information systems (GIS) to analyse spatial information to assist with the planning process for this infrastructure.

THE CSIR'S DAVE MCKELLY and Mawande Ngidi use specialised computer software to create geographic maps which support city planners by visually depicting data, such as demographic information about citizens, where they live and the location of existing buildings, roads, parks and fire stations.

Urban and regional planners use the outcome of the analysis to advise local or national government or developers on how and where to place or extend facilities to develop urban and regional places of high quality. Schools and clinics, must, for example, be well located with respect to the people they are intended to serve.

McKelly is an experienced GIS specialist with a computer science background, while Ngidi studied geography and environmental management, with GIS as one of his major subjects.



Dave McKelly

CSIR projects

"Some of our projects started with requests from the Department of Public Service and Administration to analyse the existing location of facilities and advise on where more facilities such as schools, courts, police stations, libraries and fire stations were required," says McKelly.

"We create maps that depict cities or regions and, for example, the whereabouts of chemical storage facilities with a high fire risk, as well as where people live. By analysing the spatial relationship between the fire stations and areas of the city, the system allows us to calculate and display the likely response times of a fire team to any area of the city."

Our experts' training

McKelly worked at the Department of Forestry after completing school and over the years obtained computer science qualifications through part-time studies. He later completed a postgraduate diploma and an MSc in GIS through an international network of universities, called UNIGIS.

"When we started to work with GIS more than a decade ago, it was regarded as a nice to have. Nowadays, it is seen as an essential tool for spatial planning," McKelly says.

Ngidi holds a Bachelor's degree in geography and environmental management and became interested in GIS, which was one of the modules in his second year.

"With GIS, you can eventually specialise in many different fields. Coming from an environmental background, I am learning a lot about city planning, while Dave's strength is the creation of data systems and algorithms, thanks to his computer science background," Ngidi says.

The difference GIS makes

"With GIS, we can overlay sets of data on a map, for example, the population of a certain area, the number of health-care facilities and even the extent to which these facilities are staffed to provide basic or more specialised medical care.

"We can depict the size and whereabouts of community halls and analyse the spatial reach of the facilities to assist planners to advise a municipality where to upgrade or build more such facilities by taking into account the demographics and transport networks of the area."

McKelly and Ngidi agree that the ability to grow and study further, as well as the support of the best experts in the field, are the biggest advantages of being GIS analysts at the CSIR.

– Antoinette Oosthuizen

Enquiries:
Dave McKelly
dmckelly@csir.co.za
Mawande Ngidi
mngidi@csir.co.za

GIS ANALYST

CHARACTERISTICS

You need to have a passion for geography, enjoy working with maps and data, have an analytical mind and have an aptitude for statistics.

RELATED CAREERS

Urban and regional planner, environmental expert, geologist, consultant in the sectors of commercial oil, mining, gas and healthcare.

Mawande Ngidi

"Without GIS technologists, city planners would have to rely on more manual and time-consuming processes to plan and develop our cities."

– Dave McKelly

WHAT MCKELLY AND NGIDI STUDIED

McKelly obtained a diploma and an MSc in GIS through the University of Salzburg (Austria). Ngidi obtained a Bachelor of Social Science and a Bachelor of Social Science (Hons) in geography and environmental management at the University of KwaZulu-Natal.

WHERE TO STUDY

Detailed information about graduate and technical training in GIS is provided by the Geo-information Society of South Africa. GIS is incorporated in undergraduate courses and postgraduate degrees in geography, computer and environmental science. GIS is applied in many fields and to excel as a GIS technologist, a good understanding of the field in which you will apply the information is critical. You should thus also carefully select your related courses such as geography, geology, spatial planning or biology.

COMPUTATIONAL FLUID DYNAMICS: MATHS IN MOTION

Dr Oliver Oxtoby, a computational fluid dynamics (CFD) developer, uses mathematics to solve real-world problems. He develops tools that engineers and industry use in their design process to create more efficient and safer designs at a lower cost.

TYPICALLY, CFD DEVELOPERS generate numerical algorithms and the computer programs based on the algorithms, which can be used as a predictive tool for design engineers. This means that engineers can test multiple possible designs for the same cost as a handful of physical prototypes done in reality. "Ultimately, mathematical modelling is about making intelligent approximations to get useful answers in a finite period of time," explains Oxtoby.

Oxtoby's biggest project is to determine the effect of the weight and movement of fuel sloshing back and forth inside aircraft wings, on the wing structure and design. Ultimately, the aim is to contribute to the internationally competitive industry of aviation by designing more efficient fuel systems. Oxtoby and his team will do physical testing of their calculation at the University of Pretoria's Centre for Asset Integrity Management.

Oxtoby explains: "Considering that over fifty percent of the Airbus A380's take-off weight is fuel alone and that much of the fuel is carried in the wings of the aircraft, one can just imagine the impact this has on the behaviour of the aircraft. The value of an accurate fuel sloshing model in the design process, speaks for itself."

CFD experts typically work on a variety of projects. They would, for instance, be able to determine at which angle an aeroplane should ditch (to do a safe emergency landing on water). CFD is used in the health industry to model the flow of blood through arteries and is also used by teams that design ventilation systems. Oxtoby explains, "We create tools for industry so that it is able to craft designs that have a higher probability of being successful from the outset. This is how we endeavour to contribute to the competitiveness of South Africa's industries."

CFD development presents a good balance between applied engineering, advanced mathematics, physics and computer programming. "I enjoy working at the CSIR, because, as a researcher, you have the freedom to come up with your own ideas and if it is a practical idea, you are given the freedom to pursue it. The CSIR also has a broad focus, which means that there are no limits to the field you can work in," says Oxtoby.

– Nicole de Kock

Enquiries:
Dr Oliver Oxtoby
ooxtoby@csir.co.za

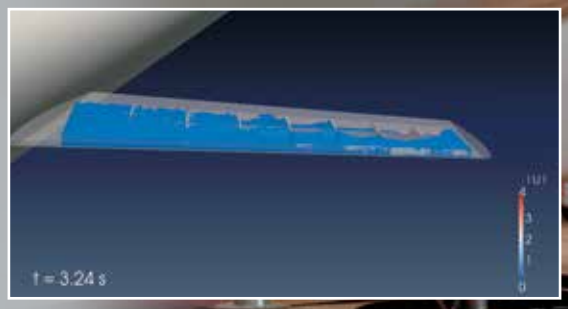
APPLIED MATHEMATICIAN

CHARACTERISTICS

An interest in mathematics, thinking creatively in order to solve problems that are out of the ordinary, applying immense attention to detail, because the slightest mistake may cause the entire algorithm to fail, as well as an interest in computer programming are required to become a CFD developer.

RELATED CAREERS

Applied mathematician, mechanical engineer, aeronautical engineer.



A computer-generated diagram of fuel sloshing back and forth in the wing of an aircraft.

WHAT DR OLIVER OXTOBY STUDIED

He studied a BSc (Hons) in applied mathematics and physics at the University of Cape Town in 2000. He then went on to do his Honours in applied mathematics as well as a PhD in applied mathematics. He graduated with a PhD in 2007.

WHERE TO STUDY

Universities that offer mechanical or aeronautical engineering, as well as applied mathematics as possible degree options would enable someone to become a CFD developer.

"Ultimately, mathematical modelling is about making intelligent approximations in order to get useful answers in a finite period of time."

– Dr Oliver Oxtoby

Dr Oliver Oxtoby

NANOMATERIALS RESEARCHER

CHARACTERISTICS

To be a good researcher, you should be able to multitask, have tenacity and be able to focus on a goal.

RELATED CAREERS

Biologist, polymer chemist, physicist, environmental scientist, engineer (chemical, metallurgical, mechanical).

Dr Gugu Mhlongo

REDEFINING OUR FUTURE: THE SCIENCE OF NANOMATERIALS

"When I began my Honours programme, one of the subjects I was introduced to was nanotechnology – the science of manipulating matter at atomic and molecular scale to form or develop novel materials and devices in different fields. It was a completely new term to me at the time, but soon grabbed my interest. I started researching the subject and attending conferences on nanotechnology. It was during one of these presentations that I decided to choose a career path focused on nanomaterials research."

DR GUGU MHLONGO was encouraged by the fact that nanotechnology is multidisciplinary, covers a wide field and can be applied to many devices, depending on the properties of the specific material used.

Nanomaterials are materials that have unique properties because of their extremely small (nano-scale) size.

Mhlongo is involved with the production of nano-sized materials for application in gas sensors and sensors for breath analysis for medical evaluation. These nano-sized materials include oxide semiconductors such as zinc oxide, titanium dioxide and tin oxide. Nanostructures based on these materials are known to exhibit excellent sensing properties, especially within nanometre range, which makes them perfect for use in sensors.

Gas sensors can be used to detect or monitor harmful and toxic volatile gases (such as methane or carbon monoxide) in the environment, for example to warn miners of a gas leak and the risk of explosion.

Her job also entails the incorporation of metals on the surface of oxide semiconductors to enhance their sensing properties. "I enjoy manipulating the size and morphology of these materials, which give them a unique sensing ability on nano scale," she says.

Mhlongo has spent the past five years focusing on research, development, knowledge generation and publishing her findings. Recently there has been a shift in her focus. As much as it is important for a researcher to publish in journals, it is also important to produce devices using nanomaterials.

Mhlongo is thrilled to be an integral member of team CSIR. "As a young, ambitious researcher in search of experience, the CSIR is the perfect place for me. In my field, we have world-class facilities with unlimited opportunities for career advancement."

Through collaborations between the CSIR and other international laboratories, young researchers are given opportunities to visit nanoscience laboratories around the world, not only to grow their skills, but also to interact with other experienced nanomaterials researchers. Young researchers are also encouraged to attend conferences locally and internationally.

"Nanotechnology has been hailed as the technology of the future. In my opinion it is the single most exciting and expansive area of research that can lead to great technological breakthroughs," says Mhlongo.

Nanomaterials research can be applied in biosciences, to treat water and to develop new energy devices such as batteries and solar cells.

– Lionel Jean Michel

Enquiries:
Dr Gugu Mhlongo
gmhlongo@csir.co.za

WHAT DR GUGU MHLONGO STUDIED

She completed her BSc, majoring in physics and mathematics in 2004. Thereafter she pursued an Honours degree in physics under the MANUS/MATSCI programme between the universities of Zululand and the Western Cape and iThemba LABS. She completed an MSc in physics at the University of Zululand, still under the MANUS/MATSCI programme where she conducted research on titanium oxide nanostructured materials for application in solar cells. In 2007, Mhlongo joined the CSIR studentship programme and began her PhD. Her dissertation focused on nano-sized phosphor materials for application in light emitting devices.

WHERE TO STUDY

Most South African universities offer research in nanotechnology or nanomaterials at postgraduate level. Others introduce courses in this field at either second- or third-year level as part of their existing curriculums. The extent to which universities offer these courses depends on the research focus of the university. South African universities such as the University of Pretoria, the North West University and the University of Zululand are now providing postgraduate degrees in research projects in nanomaterials. These universities partner with industry players such as Sasol, Eskom and Element 6 as well as research institutions such as the CSIR, Mintek and the South African Nuclear Energy Corporation.

Dr Hermann Uys

ONE ION TRAPPED FOR CSIR PHYSICIST: A QUANTUM LEAP FOR TECHNOLOGY

CSIR physicist Dr Hermann Uys specialises in quantum optics – the so-called final frontier. He currently leads CSIR research into the quantum control of atoms and molecules, developing quantum control applications of trapped ions and ultrafast pulsed lasers.

QUANTUM PHYSICS is a branch of science that deals with discrete, indivisible units of energy called quanta.

"Physicists are trained in understanding the fundamental laws of nature. At the most basic level, these laws underpin the workings of all modern technological innovations spanning the medical, engineering, chemical, computational, electronic and even biological disciplines," says Uys. "Typically, physicists use their knowledge of these laws to further their understanding of nature, or they apply their knowledge to develop new technological innovations. This can be done either in an academic, or more applied research or engineering environment."

Uys says, in physics there is always the thrill of discovering new things. "I think the urge to explore and navigate uncharted territory is intrinsic to human nature," he says. "Physics allows one to explore nature at a very deep level."

Uys studies methods for controlling nature at the level of individual atoms. In this regime, nature is described by the laws of quantum mechanics.

His projects usually include three broad steps. First the project is conceived by imagining a new control technique. Secondly, all aspects of implementation of this technique are studied theoretically using mathematical and computational methods. Finally, the project is implemented in a laboratory. During this implementation phase one draws on a very diverse set of skills and knowledge of many sub-disciplines in physics and engineering.

These include quantum mechanics, atomic physics, radio-frequency engineering, vacuum technologies, laser physics and classical optics, computer control of instruments, feedback control and so on. "The diversity of knowledge that you employ ensures that you never get bored," he says.

"Outside of the laboratory a physicist's skills can be useful in any environment where detailed analysis of complex problems is required, including systems design, project management, or in the capacity of management of science," he notes.

The CSIR is a stimulating and vibrant environment for any scientist whose research interests overlap with the CSIR mandate. Broadly speaking, Uys says, "Physicists make a difference in two ways. Firstly, technological advances all rely on the understanding of the way nature works. Name any technological advance you can think of and you can be assured that it is in some way based on some aspect of physics or the manifestation of physics through chemistry, biochemistry or one of the biological sciences. It is the job of physicists to expand our knowledge of nature, which will ultimately underscore the technological inventions of the future. Secondly, a big part of a physicist's work entails transferring knowledge to the next generation of physicists. This contribution to human capital development ensures that we have highly skilled individuals to maintain South Africa's growth in a knowledge-based world, for generations to come."

What keeps Uys going is the high level of technical expertise in physics and mathematics, discipline and patience, good project management skills, a respect for ethical conduct, ability to work well with people on all levels of the career hierarchy, from students to executives; but above all, a never-ending spirit of exploration.

– Mzimasi Gcukumana

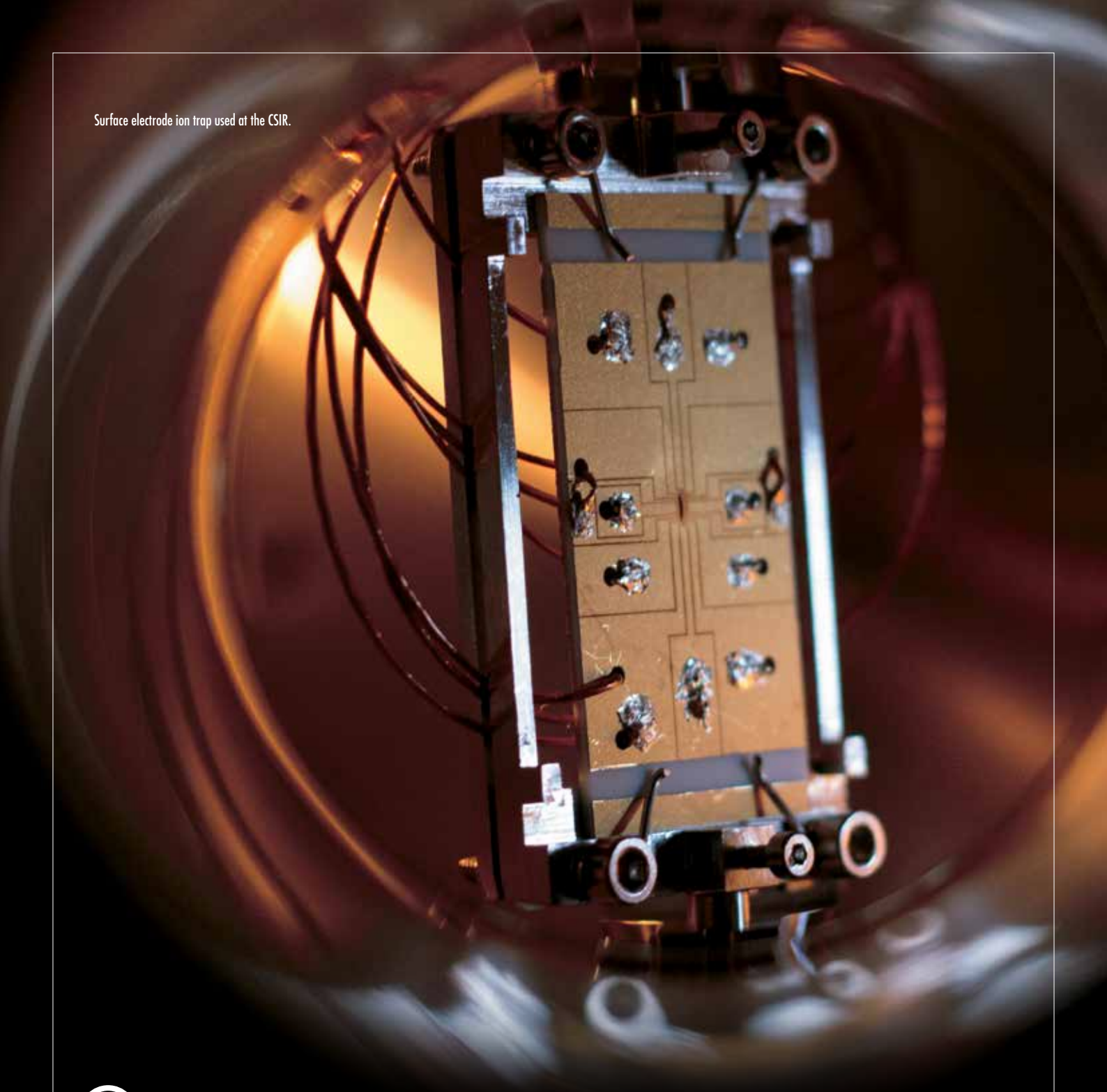
PHYSICIST

CHARACTERISTICS

Physicists must be driven by a curiosity about the forces of nature and how it works, believe in the spirit of exploration, and have patience, coupled with discipline.

RELATED CAREERS

Astrophysicist, photonics researcher, nuclear engineer.



Surface electrode ion trap used at the CSIR.

WHAT DR HERMANN UYS STUDIED

He obtained a BSc and an MSc in physics at the University of Pretoria. He majored in physics from BSc through to PhD, with courses in chemistry as an undergraduate. He obtained his PhD at the University of Arizona in Tucson, Arizona in the USA.

WHERE TO STUDY

Most universities in South Africa offer both undergraduate courses and postgraduate degrees in physics.

Enquiries:
Dr Hermann Uys
huys@csir.co.za

BEAMING ABOUT LASERS

Only a few years ago, on the taxi into Pietermaritzburg, and then during the 30-minute walk to Scottsville, Sandile Ngcobo would quietly prepare his mind for the daily challenges of tertiary education. At that time, he was in his first semester at the University of KwaZulu-Natal, studying mathematics, physics and programming, and he had never used a computer before.

"IF YOU DIDN'T SUFFER sometimes, you could easily think the world is yours," says the laser physicist now, just as the world's first digital laser makes international headlines. The digital laser, developed by CSIR laser scientists, uses a type of liquid-crystal display (LCD) technology to change the shape of a laser beam dynamically and instantly – a feat scientists have been working towards for a long time and one that could have limitless applications in the modern world.

Maths and physics open doors

Ngcobo is a researcher at the CSIR, where his work forms part of his PhD.

"It is quite a normal route for students to work at the CSIR while enrolled for studies at a South African university and there are a lot of funding opportunities here," he says. "It seems like everyone wants to work here – the world-class facilities are well looked after and I get to do what interests me. I have the freedom to explore research ideas and to solve problems."

He explains that a background in maths and physics has opened up a broad range of career paths for him and that he could apply his digital modelling and programming skills in almost any of the fields in which the CSIR works.

"There was a time when I wanted to study pharmacy, but as it turns out, my work with lasers will have many applications in the medical field." For example, scientists can use the digital laser as an 'optical tweezer' to manipulate microscopic objects, like cells and cellular components.

Be your own role model

"I could fill whole shoe boxes with rejection letters from companies and organisations that I applied to for sponsorships and work opportunities. But I never gave up." Eventually, Ngcobo got his opportunity at the Hartebeesthoek Radio Astronomy Observatory, where he helped build a laser that could measure how the distance between the moon and the Earth changed.

He says his success is the product of self-discipline, planning and taking responsibility for his own life.

"Don't hold yourself back. Decide where you want to go, otherwise someone else will decide for you."

Enquiries:
Sandile Ngcobo
sngcobo@csir.co.za

WHAT SANDILE NGCOBO STUDIED

He completed his undergraduate studies and Honours degree in computational physics at the University of KwaZulu-Natal (UKZN) and his MSc in physics at Stellenbosch University. His MSc supervisor brought him along to the CSIR in 2006 and a year later he started working here permanently. Currently, he also is enrolled at UKZN for his PhD.

WHERE TO STUDY

Ngcobo says areas like maths and computational physics provide a good basis for a number of careers that need digital simulation and programming skills. Many South African universities can be considered for such studies.

Sandile Ngcobo

PHYSICIST

CHARACTERISTICS

"A laser physicist should be well-rounded to be able to solve problems by applying the laws of physics," says Ngcobo. "It is also important to have a passion for understanding how things work and to be willing to give more than 100% in terms of hard work. Science is not only for 'clever' people. It is about opportunities and exposure to new things."

RELATED CAREERS

Computer programmer, astronomer, mathematical modeller.

Careers rooted in:

ENGIN

THE BUILT ENVI

EERING

RONMENT & ICT

Engineering, architecture, information technology, computer science

CHEMICAL ENGINEER

CHARACTERISTICS

Chemical engineers should have high doses of curiosity coupled with a healthy interest in how processes work and products are developed. Excelling in mathematics, physics and chemistry is a must.

RELATED CAREERS

Chemist, process designer, materials scientist.

WHAT KERSCH NAIDOO STUDIED

He completed a BSc in chemical engineering at the University of KwaZulu-Natal and then obtained an MEng in chemical engineering at the University of Pretoria.

WHERE TO STUDY

Chemical engineering is offered at most universities in the country, as well as some universities of technology.

Kersch Naidoo

Naidoo places capsules into the production line.

Natural products undergo a quality inspection.

CHEMICAL ENGINEERING FOR THE CURIOUS OF MIND

A healthy dose of curiosity seems to be the recurring theme for those wanting to become chemical engineers. At least, that is what Kersch Naidoo, a chemical engineer at the CSIR, believes.

FOR HIM, it started at primary school where his natural interest in chemistry and physics was driven further by a curiosity to know how things are made. "I liked the practical side of chemistry, especially when it is used to make products, and my passion for chemistry and physics eventually led me to chemical engineering," says Naidoo.

Chemical engineering is all about chemistry and related processes used in making desired products or chemicals. These engineers concern themselves with the practical design and operation of equipment used in making new products as well as streamlining existing production processes. Where chemists typically develop chemical processes in a laboratory environment, chemical engineers are the ones who take the processes out of the laboratory and apply them in a commercially feasible manner.

It is about the process

Naidoo explains the difference between chemical engineers and other types of engineers: "We specialise in the process and what it takes to get the 'ingredients' working together to form something useful. That is why you will find chemical engineers in a wide range of industries, from paper and pulp to pharmaceutical and biomedical, agroprocessing, petrochemicals, mineral processing, food processing and many more."

Most of Naidoo's current projects have to do with either pharmaceutical or food/feed products. He works with a team that searches for indigenous plants with pharmaceutical benefits. They try to produce beneficial natural medicinal products from these local indigenous plants that can be used by consumers for various ailments.

The question he asks daily is: "Can we improve the current processes?" For instance, one of his projects involves optimising the entire process of putting African Ginger on the market – from harvesting, extracting and purifying the active ingredients to encapsulating it in various dosage formulations such as capsules, tablets, lotions, creams, etc. as dictated by the particular purpose for which it is required.

Multiple products, multiple fields

Being able to explore the whole value chain of a product and not only the product or process development is one of the reasons why Naidoo loves working at the CSIR. "The CSIR is a diverse organisation where you will not just work on a single product or in a single field. Here, you will be able to explore multiple product developments in multiple industries. What is more, you get to work with a wide selection of equipment and other skilled people in various disciplines that you won't find in any one industry. If you have a curious mind and love solving problems, this is where you need to be."

Chemical engineers are found applying their trade in a variety of fields and projects within the CSIR. Naidoo started working here in biopolymers and materials science before moving on to the natural products and food/feed development that he is currently doing. His peers are scattered across projects in the fields of biotechnology, the natural environment, titanium production and materials science, to name but a few.

– Petro Lowies

Enquiries:
Kersch Naidoo
knaidoo3@csir.co.za

Broken wires and strands of a steel wire rope test piece.

MECHANICAL TESTING FOR STRENGTH AND SAFETY

When Riaan Bergh spots a car with a tow bar, he's on all fours before he can help himself, checking how the thing is designed and connected, and whether it would pass a strength test. This habit began during the formative years of Bergh's career, when he was responsible for testing a great number of tow bars. Today the science of breaking remains his focus as the business manager of three mechanical testing laboratories at the CSIR.

Safety first

The CSIR's mechanical testing laboratories provide specialised strength and safety testing services that allow mining, manufacturing, transport and construction companies and heavy industry to comply with safety requirements. In the rope testing lab for example, steel ropes used in mines are subjected to destructive tensile testing. "We pull the rope until it breaks so that we can determine the force it can handle and how much it stretches before it snaps," says Bergh.

In the self-contained self-rescuer lab, Bergh and his engineering team test devices of the same name. "If a miner finds himself in a situation where there is too little air to breathe, he can use this device to produce oxygen by means of a chemical reaction," he explains. Samples of the devices in use are regularly drawn for testing in order to minimise the number of defective units in circulation.

The third lab is the mechanical testing lab, which ensures the safety of equipment involved in lifting, like crane hooks and slings, and equipment used as support structures in mines.

Engineering is science applied

After a brief stint of wanting to be a fireman, Bergh committed to a career in engineering at the tender age of seven. He says the field is all about applying the principles of science to make people's lives better, and in his case, safer.

The CSIR itself has a similar goal, and engineers can find a stimulating environment in many of the areas in which the CSIR applies its multidisciplinary skills, from materials science and manufacturing to the built environment. Bergh adds that the CSIR also provides employees with a good balance between work and private life.

A leader

"As a young engineer, it was important for me to gain experience working in the technical arena before moving into a management position," he says. "Machines are easy to maintain, but to motivate and lead people is a big challenge."

Bergh puts a lot of emphasis on being able to interface well with those who report to him, and with customers and suppliers. He is also passionate about sharing his knowledge with younger engineers to help them succeed in their careers. "One person can only do so much, but a team of talented people can do great things."

Enquiries:
Riaan Bergh
rbergh@csir.co.za

MECHANICAL ENGINEER

CHARACTERISTICS

"A good engineer understands how things apply in the real world and how to bring theory into practice," says Bergh. "Strong academic performance is as important – if you can show technical superiority you will advance more quickly."
He adds that people skills, good communication skills and a keen eye for detail are also crucial.

RELATED CAREERS

Product development engineer, shaft engineer, design engineer.

Riaan Bergh

WHAT RIAAN BERGH STUDIED

After school Bergh studied mechanical engineering (BEng Hons) at the University of Pretoria. He then went on to complete a postgraduate qualification in engineering management while working part-time as a testing engineer for a consulting firm.

WHERE TO STUDY

"Working while studying allows you to get a foot in the door and to build your curriculum vitae," says Bergh. He advises young people to apply for postgraduate bursaries and sponsorships with work obligations, or to first work for a few years before pursuing postgraduate studies.

AUTOMATING ALL THINGS MECHANICAL WITH ELECTRONICS

When electromechanical engineer Terence Ratshidaho had to choose what he wanted to study, he let his love for mathematics and physics be the guide. He decided that mechanical engineering would be a good match, but halfway through his studies, he met the world of robotics and that changed his mind.

ELECTROMECHANICAL ENGINEER

CHARACTERISTICS

You must have an aptitude for mathematics and physics, love challenges and have a great deal of persistence.

RELATED CAREERS

Mechatronics engineer, industrial engineer, electronic engineer, mechanical engineer.

The PackBot 510 is a robotic platform equipped with a laser scanner and on-board computer which is used for safety inspection of mine stopes immediately after blasting. It is also used for urban search and rescue projects. The Packbot 510 is controlled from an operator console which is a laptop with a joystick.

The PackBot 510 inside an artificial mine stope with the operator console showing the user interface. This consists of video streams from the PackBot 510 and the map of the environment. These robots can operate autonomously, semi-autonomously (by giving it goals) and manually (using a joystick).

Terence Ratshidaho making adjustments to the PackBot 510 while sitting inside an artificial mine stope, created to simulate the environment in which the PackBot 510 will operate.

WHILE HE ENJOYED STUDYING mechanical engineering, Terence Ratshidaho wanted to follow his passion for robotics and could easily switch from mechanical to electromechanical engineering. He was a student at the University of Cape Town – the only South African tertiary institution that offers a degree in electromechanical engineering.

Bridging the gap

"Electromechanical engineers bridge the gap between two disciplines that often work together. Robotics is a good example of this collaboration because so many everyday mechanical objects are controlled through computers. Now, when I have to work on the electronics of a robotics system, it is easy to understand the mechanics that underpin the technology," he explains.

Electromechanical engineers can design, build, control, and maintain a wide range of engineering products and processes. Just think of motor cars and aeroplanes, where computers control the engines and ensure that they work efficiently, or production machine tools such as automated latches and milling machines, even artificial hearts or the humble washing machine.

Programming a major part of the work

Ratshidaho's work therefore entails a great deal of computer programming, especially with the programming language C++. He uses this language and a mathematical modelling programme called MATLAB to estimate an autonomous robot's trajectory without using obvious tools, such as GPS or cameras.

"This can get quite tricky," he explains. "The project I used to base my Master's study on was to localise an underground mine safety robot that gets sent into a mine shaft, following a blast to check the safety conditions before miners are sent down. It is dark down there, so cameras won't work, and it is too far underground to use GPS coordination." He is now working on a similar project with a search-and-rescue robot.

Within the CSIR, electro-mechanical engineers and mechatronics engineers can be found working on projects that have to do with the automation of mechanical processes, such as industrial manufacturing, robotics and aeronautics systems.

"There is no place like the CSIR," says Ratshidaho. "Being here, you get to solve problems that have not been solved before. You don't follow a normal working routine, which means that you will not get bored. You also get to work with some of the brightest minds in your field, and your career will grow with leaps and bounds."

– Petro Lowies

WHAT TERENCE RATSHIDAHO STUDIED

He completed a BSc in electromechanical engineering at the University of Cape Town and an MSc in computer engineering at the University of KwaZulu-Natal.

WHERE TO STUDY

Currently, the University of Cape Town is the only tertiary education institution to offer a degree course in electromechanical engineering in South Africa. However, mechatronics engineering is a very similar field and is widely offered at many South African universities.

Enquiries:
Terence Ratshidaho
tratshidaho@csir.co.za

KEEPING AN EYE ON THE SKY WITH RADAR

The first line of defence in a combat situation is being able to recognise a threat before having to face it. Taariqa Maharaj forms part of an elite group of software engineers that keeps an eye on the sky with radar technology.

THE CSIR HAS A TRACK RECORD in radar technology dating back to the Second World War, and continues to hold its own in this field in a style comparable to the best in the world.

A radar system is a complex combination of engineering, mathematics, programming, hardware design and signal processing. Radar is used in many different environments. In aeronautics, for example, it is used to detect and guide aircraft by emitting electromagnetic signals. These signals are bounced back from the aircraft, giving information on its speed and direction.

For a young software engineer, this might seem daunting. Not for Maharaj. Sitting in front of the control panels, she says: "I am not afraid to ask the obvious questions and in our group, no question is considered stupid. The people I work with have a wealth of knowledge that you cannot find in books, and it would be a big oversight on my part to not tap into that. I am curious by nature and the ever changing programming environment is a perfect fit."

After completing her BSc Honours in engineering, Maharaj joined the CSIR's radar and electronic warfare group. She says that she was eased into things by being given smaller tasks. This allowed her to grow her skills to a level where she can now work on the full integration of all of the subsystems.

Developing a tracking radar facility requires a group of experts from different fields. "Much of what we do comes from developing concepts obtained from user requirements. We integrate software applications for the user interface, control of the radar system and data communications," she says.

A radar system requires a control node, 'the brain', that signals the antennae to follow an aircraft, for example. This control system is made up of many subsystems, built by software engineers such as Maharaj.

Designing and prototyping form the essence of innovation in this domain. Maharaj says that the most difficult part of her work is having the patience to drive a project through when your code simply won't work. She explains: "It almost never works the first time. But little comes close to the deep sense of pride when it finally clicks."

She describes herself as someone who easily gets bored with routine tasks, but her work keeps her completely engaged. "Code can change almost daily, and it is my job to not only keep up, but keep ahead," she adds.

Radar development is a competitive space. Currently, South African radar research shares the world stage with an increasing number of countries. In order to stay ahead, the pressure is on the engineers to work faster, smarter and more cost-effectively. Maharaj designs and implements the neurons used to control the system. The greatest impact of her work is felt in border safeguarding and air traffic control.

The CSIR contributes to national safety and security which includes the sovereignty of our land, maritime and air space, by detecting and tracking entities that enter our territory. Radar is one technology field that is deployed for this purpose.

Maharaj's advice for budding young innovators is to study electronic engineering and develop their programming skills. She says, "In programming your knowledge base is never saturated, there is always something new to learn and experience and the more you know, the better you will be at it."

– Lèsa van Rooyen

Enquiries:
Taariqa Maharaj
tmaharaj@csir.co.za

WHAT TAARIQA MAHARAJ STUDIED

She obtained a BSc (Hons) in electronic engineering from the University of KwaZulu-Natal.

WHERE TO STUDY

Most universities in South Africa offer both undergraduate courses and postgraduate degrees in electronic engineering.

Taariqa Maharaj

ELECTRONIC ENGINEER

CHARACTERISTICS

You must have the drive to learn new things, have a lot of patience to see things through and have an analytical mind to work through the processes. Problem solving forms a big part of your daily work and you must enjoy figuring out new coding languages.

RELATED CAREERS

Application integration engineer, software developer, software architect.

TUNNEL TECHNOLOGIST STANDS HER GROUND IN AERONAUTICS FRATERNITY

Because of her small build, Sarah Dikgale has spent many hours working as an avionic technologist cramped in the tail section of attack helicopters during inflight system checks. "At night, I could still feel the movement of the aircraft when I climbed into bed," she says.

Sarah Dikgale

WHAT SARAH DIKGALE STUDIED

Dikgale studied at Ekurhuleni West College where she did a national diploma in electrical engineering (heavy current). She furthered her studies towards aeronautics by doing a BTech in quality and is now doing a BTech in industrial engineering.

WHERE TO STUDY

In South Africa, the BTech degree is awarded by universities of technology. A popular institution is the Tshwane University of Technology with campuses in Pretoria, Nelspruit, Polokwane, Ga-Rankuwa, Soshanguve and eMalahleni. There are several other universities of technology spread throughout the country.

DIKGALE WORKS as a wind tunnel technologist at the CSIR where she is responsible for the maintenance and calibration of instrumentation and support systems of the Medium Speed Wind Tunnel (MSWT). The tunnel has been used by the CSIR over the past 30 years for aeronautics research, testing the limitations and behaviours of aircraft such as the Rooivalk, Mirage and Cheetah, by conducting wind testing of models of these aircraft.

The complete system looks and feels like an industrial plant with subsystems that include air compressors, air cooling systems, different mechanical and electrical valves, as well as electrical and hydraulic systems. To maintain the tunnel, you need a broad knowledge base that covers all the different technologies in the subsystems. Dikgale says, "You have to have excellent problem-solving skills, because when something goes wrong during a test, time is invariably against you and you don't have the luxury of hours to ponder the issue."

Dikgale explains her role: "The responsibility for the tunnel includes maintaining the instrumentation and subsystems where data will be analysed to ensure the readiness of the tunnel before the execution of the test."

Variety, unpredictability and creativity

The job has great variety and unpredictability: "No two projects that I have worked on have been the same," Dikgale explains. "Each test is different and I have to put effort into ensuring the tunnel is ready for every different model we have to test."

When everything is prepared, Dikgale does calibrations and functional checks on the complete system, making sure that everything is exactly as it should be. There is absolutely no margin for error.

Working as a technician is not limited to aeronautics. There are career opportunities in any manufacturing or testing facility that runs on heavy machinery that uses hydraulic, mechanical or electrical systems.

Because of Dikgale's thirst for knowledge and sense of adventure, she enjoys working at the CSIR. She says, "I find it difficult to imagine working somewhere else, because at the CSIR I get to think for myself, take initiative and be creative. The long and irregular hours are a small price to pay for the creative freedom I enjoy."

"When I see an aircraft flying overhead and know that some of the systems modifications were tested in the tunnel, I am grateful that we helped to put it safely in the air."

– Lèsa van Rooyen

Enquiries:
Sarah Dikgale
sdikgale@csir.co.za

Sarah Dikgale working on the electrical set-up for a wind tunnel test.

"I find it difficult to imagine working somewhere else, because at the CSIR I get to think for myself, take initiative and be creative."

– Sarah Dikgale

WIND TUNNEL TECHNOLOGIST

CHARACTERISTICS

An ability to handle pressure is a prerequisite – "If anything goes wrong, people will look to you to get it fixed." You must be a team player, and have excellent technical problem-solving skills.

RELATED CAREERS

Aircraft technician, biomedical equipment technician, electrical technician.

ARCHITECTURE AND MUCH MORE FOR REAL BUILDINGS

For the challenging field of architecture, school subjects must include mathematics, science (for some universities) and first-language proficiency. However, a good, solid portfolio that includes creative aspects is likely to get you accepted to study this course – more so than simply scoring high marks.

THIS IS THE ADVICE of research architect Peta de Jager, who is the team leader of a group of architectural engineering researchers at the CSIR. "A degree in architecture is a generalist degree – one learns something about many different topics, from the humanities through to the sciences, including culture, history of architecture, technical aspects, design and structures," she explains. "It can thus open many doors for you, including employment in the construction field, design, working at an architectural firm and moving on to start your own firm," De Jager continues. "It is similar to being a chef – lots of different ingredients that complement one another are added and the proof of the pudding is in the actual final product.

"It can be very challenging; one has to be able to juggle many balls simultaneously. One wants to use science and research-informed design for promoting sustainable buildings, without extinguishing the creative pursuit of architecture or ignoring the special needs of people who use the buildings, e.g. hospitals," she adds.

De Jager's group enjoys the multidisciplinary working environment that includes mechanical engineers, software developers, modellers, project managers and systems engineers. The research group she leads specialises in social infrastructure, specifically healthcare and education buildings. Colleagues use scientific research and development to support service delivery, procurement, design, construction, operation, and maintenance of buildings. The work focuses on the South African context to ensure social and technical appropriateness and sustainability.

The real McCoy

De Jager's group currently conducts two large, multimillion rand, multiyear projects. The one is the Infrastructure Unit Systems Support (IUSS) initiative of the Department of Health. The other one is targeted at tuberculosis infection control. De Jager attended a course on building design and engineering for airborne infection control at Harvard University. The CSIR was instrumental in introducing the course – adapted for local circumstances – to southern Africa. It has been held twice in both South Africa and Botswana.

What does architecture offer to society? "We believe that what we do results in more sustainable public buildings, while we keep pushing the envelope to be more innovative." And what is the most common misconception that people have of architects? "Some think we only design beautiful buildings, which is but one aspect of our job.

"Designers do not have absolute freedom to express themselves – they have to take the clients' requirements and budgets into account. Designers could become irresponsible when they become self-indulgent with their product. I prefer to work in an interdisciplinary team, where all the skills are used, including those of engineers and the rest of the team."

De Jager says the CSIR is a supportive environment and the continuing professional career development that the organisation offers, is great. "I love getting involved in the research, which is something an independent consulting engineer in the private sector can't do."

– Hilda van Rooyen

Enquiries:
Peta de Jager
pdejager@csir.co.za

ARCHITECT

CHARACTERISTICS

One requires good communication skills, creativity, attention to detail, effectiveness, sensitivity for composition and design, an understanding of cultural issues and technology, as well as the ability to work in multidisciplinary teams.

RELATED CAREERS

Landscape architect, interior designer, urban designer and product designer.

WHAT PETA DE JAGER STUDIED

Peta de Jager attained a Master's degree in applied ethics and a Bachelor of Architecture (BArch) as well as the professional registration (PrArch) following two years of practical experience in a firm of architects. The BArch degree and practical registration are now generally replaced with the Master of Architectural Studies. De Jager has furthermore done an extensive leadership training course at the CSIR to assist her in her career development.

WHERE TO STUDY

Many universities and the larger universities of technology offer undergraduate courses and postgraduate degrees in architecture.

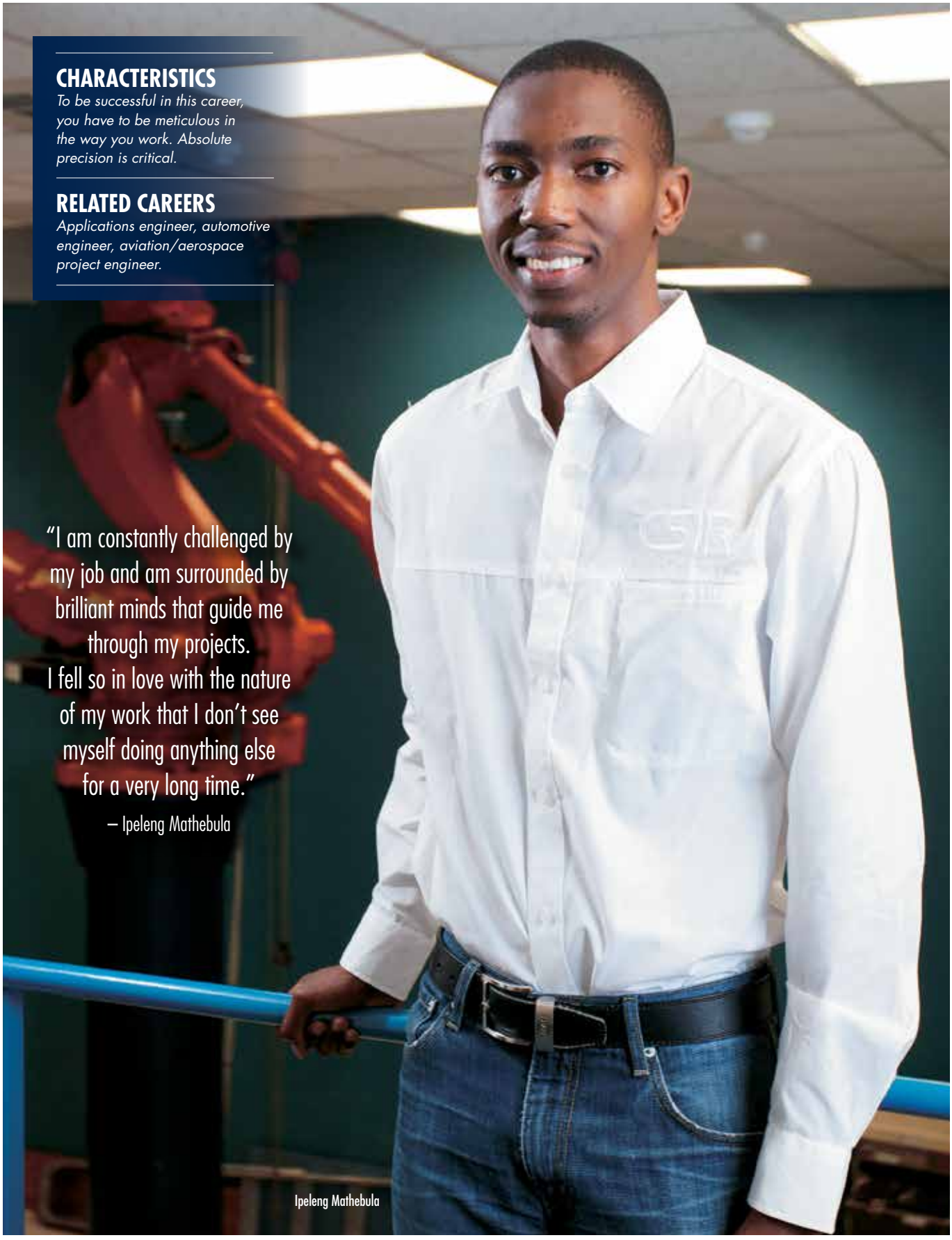
Research leader of architecture engineering at the CSIR, Peta de Jager.

CHARACTERISTICS

To be successful in this career, you have to be meticulous in the way you work. Absolute precision is critical.

RELATED CAREERS

Applications engineer, automotive engineer, aviation/aerospace project engineer.



"I am constantly challenged by my job and am surrounded by brilliant minds that guide me through my projects. I fell so in love with the nature of my work that I don't see myself doing anything else for a very long time."

– Ipeleng Mathebula

Ipeleng Mathebula

PRECISION ENGINEERING DOWN TO A FRACTION OF A MILLIMETRE

Ipeleng Mathebula builds cameras. Not the kind that you buy at your local electronics shop, but high-tech optronic sensor systems used for specialised purposes such as detecting small objects in adverse conditions and tracking subjects in low visibility or stabilising cameras mounted on unstable platforms.

AT THE CSIR'S OPTRONIC SENSOR systems group, the success of a project relies on a multitude of skills: atmospheric modelling, lens design, mechanical and electronic engineering, embedded software design, image processing and systems engineering. Mathebula's contribution lies between that of the lens designer and the mechanical engineer as he designs the actual hardware used for capturing images.

An opto-mechatronic engineer is a rare breed within the engineering world, with only three in Mathebula's group. Mathebula says that he did not go looking for a career in optronics, but that it found him. After he completed his Master's degree in electronic engineering, he started working at the CSIR. "I am constantly challenged in my job and am surrounded by brilliant minds that guide me through my projects. I fell so in love with the nature of my work, that I don't see myself doing anything else for a very long time."

Not yet beyond his twenties, Mathebula has brought a meticulous and an innovative approach to the development of cameras and optronic systems. These are critical in surveillance and detection used, for example, to keep watch over our ocean borders and guard against piracy. He says, "To be great in this kind of working environment, you have to be absolutely meticulous, you must enjoy the challenges associated with the process of innovation and, most importantly, you have to be able to 'see' something coming before it actually happens."

"To work as an opto-mechatronic engineer you need to pay close attention to detail. If your measurement is off by a fraction of a millimetre, it won't work. Absolute precision is critical to the success of what I build," he continues.

The optronics team implements an iterative design process, whereby the mechanical engineer is responsible for optimising cost, weight, size and ergonomics. "Some of my biggest but most rewarding challenges come from integrating commercial off-the-shelf hardware into a technology demonstrator that is functional and cost effective," Mathebula explains. The hardware that he works on includes thermal cameras, sensitive printed circuit boards and delicate mirrors and lenses coated with films.

"For me, very few things compare to the exhilaration you experience when you see something you have envisioned become a reality, used on-board a patrol vessel helping to secure our shoreline and our country," he concludes.

– Lèsa van Rooyen

Enquiries:
Ipeleng Mathebula
imathebula@csir.co.za

WHAT IPELENG MATHEBULA STUDIED

He obtained a BEng, BEng (Hons) and his Master's degree in mechanical engineering from the University of Pretoria.

WHERE TO STUDY

Mathebula studied at the University of Pretoria, but most universities offer both undergraduate courses and postgraduate degrees in engineering.

Ipeleng Mathebula applies his skills as a mechanical engineer in the field of opto-mechatronics.

ENERGY EFFICIENCY STARTS WITH SOMETHING EVERYONE CAN DO

As a CSIR senior researcher in renewable energy and energy efficiency, Wim Jonker Klunne feels strongly that we can all do our bit to conserve energy. "Just switch off any energy source you aren't using," he says.

ALTERNATIVE ENERGY INCLUDES renewable energy – wind, hydro, biomass and solar energy. "Too often, people aim to implement one of these before looking at the basic reduction of energy consumption," says Jonker Klunne. "People tend to have a limited understanding of where energy is being used, for example in equipment that is in stand-by mode even when they are off, such as computers and TVs, which still consume energy."

Advice to students

A management studies expert and engineer by training, his advice to people who would like to pursue the fields of renewable energy and energy efficiency is that physics and mathematics are absolute musts, while marks in other science subjects also need to be good. "Start off with any engineering studies where you will also get technical training, and then you can specialise afterwards," he says.

PhD studies

Jonker Klunne is currently registered for a PhD degree. Through his studies he looks at the implementation of off-grid models for small and medium enterprises, meaning enterprises not connected to Eskom as the main energy supplier. "I am looking at ensuring that the technology will remain operational for its full life-span." He furthermore looks at the institutional set-up and the management of technology.

"Technology itself is linked to most things, but is not a solution in itself. The people who will use it must accept it first and be part of the equation."

Work at the CSIR

Before joining the CSIR in 2009, Jonker Klunne worked for the African Development Bank in Tunisia on projects all over the African continent. A major research and development (R&D) project he is currently working on, is a study of energy management in small-scale industries in seven countries in southern Africa together with the Danish Technological Institute and funded by the European Union (EU).

"Our main objective is to create and enhance awareness of the value of energy management among selected small and medium enterprises. Thus, they can improve their energy efficiency and with it, their competitiveness," explains Jonker Klunne.

Why did he decide on the CSIR as an employer? "Here I can do research and in general, one has the freedom to develop yourself in any direction you want to, within your broad field. The CSIR affords one opportunities to make international links, present papers and serve on different panels with your peers, locally and abroad," he says. "The CSIR furthermore has international recognition and stability as an organisation with a track record, which helps to open doors internationally and assists me in my career development."

– Hilda van Rooyen

Enquiries:
Wim Jonker Klunne
wklunne@csir.co.za

This brewery is part of a major R&D project that Jonker Klunne is currently working on. He studies energy management in small-scale industries in seven countries in southern Africa with the Danish Technological Institute.

CIVIL ENGINEER

CHARACTERISTICS

Those interested in this field require an inclination to pay attention to detail, the ability to unite people behind a common goal and aptitude and passion for technology, as well as applying and adapting these technologies in real situations.

RELATED CAREERS

Infrastructural engineer and technical project manager.

Wim Jonker Klunne, a renewable energy expert at the CSIR, with a solar lamp and a model wind turbine.

WHAT JONKER KLUNNE STUDIED

He first completed a degree in civil engineering and management studies in the Netherlands. Thereafter he obtained his MEng in technical management studies and is working towards his PhD.

WHERE TO STUDY

Jonker Klunne recommends that students follow any field of engineering at any of the universities that offer engineering degrees, after which technical management courses could be pursued.

CHARACTERISTICS

You will need an understanding of chemistry, maths and physics with a specific interest in how materials are made, how they perform, why they fail and what the limitations of application technologies are.

RELATED CAREERS

Metallurgist/metallurgical engineer, polymer scientist, cement/concrete technologist, glass technologist.

WHAT DR JOE MAPIRAVANA STUDIED

He completed a BSc degree, majoring in chemistry and geology at the University of Zimbabwe, an MScTech in the science and technology of materials awarded with distinction by the University of Sheffield, a PhD from the University of Leeds and the postgraduate Executive Development Programme certificate awarded by the UNISA Graduate School of Business Leadership.

WHERE TO STUDY

Materials engineering can be studied at postgraduate level after completing a BSc in physical sciences or engineering in South Africa. Introductory engineering materials modules are taught as part of undergraduate engineering degree courses.

Dr Joe Mapiravana with samples of geopolymers that are greener cement replacement materials.

DEVELOPING NEW AND SUSTAINABLE CONSTRUCTION MATERIALS AND METHODS

Most of the resources that we use to build our cities and infrastructure come from the ground and can be exhausted.

MATERIALS ENGINEERS, like the CSIR's Dr Joe Mapiravana, look at the development, production and application aspects of engineering materials such as metals, ceramics, concrete, glass and polymers.

They do research to develop new materials which are cost-effective and sustainable to produce, but also offer a good performance and life-cycle.

"One option is to develop bio-based materials for use in composite materials. For example, we have used fibres from the sisal plant which grows in arid conditions. Sisal fibre was traditionally used in making ropes and the cellulosic fibre can be employed for composite reinforcement in the place of asbestos," says Mapiravana.

Early years

He grew up in Zimbabwe and was always fascinated by science.

"I completed a BSc, majoring in chemistry and geology at the University of Zimbabwe. I was always interested in making things and soon realised the value of mineral-based raw materials."

After his studies, Mapiravana was recruited by the Ministry of Mines, where he worked for 10 years. "During this time, I worked as an understudy to experts from the United Nations Industrial Development Organisation. The projects focused on the development and use of ceramics and metals. I also had the opportunity to get industry exposure, spending time in several local, European and Indian factories that produced commodities, including steel, ceramics, electrical components and refractory materials that are used as linings of high temperature furnaces."

Further studies

Mapiravana completed an MScTech in the science and technology of materials, with distinction, at the University of Sheffield, focusing on ceramics, glass and metals and returned to Zimbabwe where he joined the Scientific Industrial Research Development Centre (SIRDC). He later completed a PhD in microstructure mechanical property relationships in nitride-bonded silicon carbide materials at the University of Leeds and returned to the SIRDC.

The CSIR

After a decade at the SIRDC, Mapiravana joined the CSIR in Pretoria.

"One of our projects involves the development of geopolymers as part of a joint venture with Mongolia. These are greener cement replacement materials that can consist of waste slag from steel making and fly ash from thermal power stations or coal gasification."

"This follows on an earlier project which showed that geopolymer concretes could be the solution to sewer pipe corrosion."

Mapiravana says the CSIR has highly-qualified experts, a good track record and the right systems and resources in place for good research.

– Antoinette Oosthuizen

Enquiries:
Dr Joe Mapiravana
jmapiravana@csir.co.za

CIVIL ENGINEERING HAS WIDE APPLICATION

After majoring in physics, chemistry and advanced mathematics in high school, Julius Komba dreamt of becoming an engineer. He went to the University of Pretoria (UP) in 2006 to study civil engineering, as UP "… is ranked very highly internationally, specifically for its engineering courses," Komba says. After attending a CSIR presentation at UP in 2008, Komba followed up the opportunities discussed and became a CSIR bursar.

Fields of civil engineering

"Civil engineering offers many subdisciplines. Some of these, with general examples of where they are used, include transportation engineering (roads, traffic and railway engineering); hydraulic engineering (dams, reservoirs and pipelines); coastal engineering (shoreline management and construction in coastal zones); structural engineering (e.g. working with architects on buildings); and geotechnical engineering (ground investigations, etc.). It makes a whole range of careers possible," emphasises Komba.

Research at the CSIR

As it happens, Komba chose transportation engineering and thus works with roads. What gives him work satisfaction? "Searching for solutions for different things." The challenge of much of Komba's work deals with various aspects of road design, advanced testing and modelling of road building materials, as well as long-term performance monitoring of roads. He is currently involved in various projects, including the revision of the South African Pavement Design Method and characterisation of road building materials by using laser scanning.

"The transport infrastructure engineering area where I work has attracted some of the best researchers internationally and I can learn from them daily," says Komba. In addition, the CSIR has an advanced road material testing laboratory, with equipment that can be found in only a few places in the country.

Komba is also involved in the implementation of High Modulus Asphalt (HiMA) technology in South Africa. HiMA, which was first used in France, has been adapted to local South African conditions and is being implemented on a number of heavily trafficked roads. These include South Coast Road at Durban Harbour, where the CSIR provided technical guidance and monitored the performance of the road over a period of two years. A HiMA test section on road R104 – the extension of Pretoria Road – has also been constructed, with the CSIR being involved during the design and laboratory testing. It is envisaged that HiMA will be applied on various roads in South Africa.

Komba sees transportation engineering as something directly linked to the public: "People and goods travel on roads, and our research and guidelines on road design, construction and maintenance, as well as the material with which roads are built, are of the utmost importance to ensure roads with a long lifespan."

So what next, in addition to his studies? Komba wants to join the Engineering Council of South Africa (ECSA) where one can register as a professional engineer, with ECSA accreditation being based on your first degree. He is registered as a candidate engineer at present and working towards a professional engineer registration.

– Hilda van Rooyen

CIVIL ENGINEER

CHARACTERISTICS

A civil engineer needs to be passionate about solving problems and about paying attention to detail. One needs to subscribe to high ethical standards as one deals with infrastructure that can affect large numbers of people. Teamwork and the ability to work under pressure to deliver projects on time for clients are a must.

RELATED CAREERS

Hydraulic engineer, structural engineer and geotechnical engineer.

Komba with a machine that tests rutting resistance of asphalt samples.

WHAT JULIUS KOMBA STUDIED

All his tertiary studies have been at the University of Pretoria. He completed a BEng in civil engineering, a BEng Honours in transportation engineering and an MEng *(cum laude)* in transportation engineering, with a focus on road materials. Komba is currently planning for his PhD studies.

WHERE TO STUDY

Most major universities offer graduate studies in civil engineering.

Enquiries:
Julius Komba
jkomba@csir.co.za

CHARACTERISTICS

Logical thinking, problem-solving skills, strong capabilities in subjects such as maths and physical science, and a love for the sea and being outdoors are required.

RELATED CAREERS

Marine engineer (often in the deeper ocean or on ships), coastal engineer specialising in construction (the building of harbour structures, for example).

André Theron

WHAT ANDRÉ THERON STUDIED

He holds a BEng (Civil) and MEng (thesis on coastal engineering) from Stellenbosch University.

WHERE TO STUDY

There are no Bachelors degrees in coastal engineering offered at South African universities. Most tertiary education institutions offer degrees in civil engineering (four years) during which students are exposed to subjects such as hydrodynamics. To qualify as a coastal engineer, students will have to complete a Master's in coastal engineering, which is offered at Stellenbosch University and the University of KwaZulu-Natal.

Theron studies the characteristics of (beach) sand grains.

BUILDING IN AND AROUND OUR COASTAL ZONES

South Africa's coastal zone and the tourism that it generates provide fantastic opportunities for socioeconomic development, but often structures and amenities built along the coast have costly consequences in that they are unsustainable and can destroy natural assets.

COASTAL ENGINEERS, such as the CSIR's André Theron, assess the impact of proposed developments, such as harbour infrastructure or sand mining in estuaries, on the physical environment.

"Coastal engineering is a specialist field of civil engineering," Theron explains. "My job is to understand the processes of winds, waves, tides, currents, sediment transport (the movement of sand) and shoreline morphology and to predict the impact of man's proposed structures on these natural dynamics. Another speciality of coastal engineering is to focus on the actual construction of coastal structures, such as harbours, to ensure that they can withstand the forces of nature."

Man's costly mistakes

Failure to do these impact studies can, for example, cause the erosion of sandy beaches in a popular tourist area, or lead to flooding and damage to harbour structures.

In one example, many of the sandy beaches on the Durban shore are now artificially maintained after a harbour that was built more than a century ago, blocked the natural transport of sand to the shore. "Sand mostly moves in one direction along the shore, transported by waves and currents. If this process is not quantified properly before construction of a new harbour, it may cause erosion downstream of the development. In Durban, the natural system to sufficiently replenish the sand was destroyed and the beaches were gradually washed away from the 1930s to the 1970s."

Coastal and port engineers had to develop a plan to remedy the problem. "Every year, a big dredger sucks up 300 000 cubic metres of sand from a sand trap upstream of the port. It is then pumped to an area downstream of the port to be washed along the shore.

"This has been done for decades and is the only reason why the central Durban beaches still exist.

If a city relies on the income of its sandy beaches through tourism, as is the case in Durban, it has no option but to implement a costly sand bypassing/replenishment system in conjunction with the port authorities."

"We also advise municipalities on the management of coastal zones. For example, we have discouraged further sand mining in certain river estuaries in KwaZulu-Natal after we found that two thirds of the sand intended for a 100-km shoreline was not reaching the ocean due to the combined effects of existing mining activity and dams in the rivers."

CSIR coastal engineers also focus on the construction of harbours. They construct scaled models of harbours in a laboratory housed in a hangar-sized hall in Stellenbosch where they test for factors such as breakwater stability and safety for moored ships.

Renewed awareness of climate change

Climate change is causing the sea level to rise. If this is not taken into account when new developments are approved near the shoreline, buildings and infrastructure could be flooded during storms.

"Coastal engineers determine the setback lines for development and advise where safe, sustainable development can take place."

According to Theron, despite many opportunities, there is always a shortage of expertise in his field.

– Antoinette Oosthuizen

Enquiries:
André Theron
atheron@csir.co.za

CREATIVE THINKING FOR MANUFACTURING SOLUTIONS

Ashley Bhugwandin is an experienced industrial engineer whose skills and aptitude have equipped him for his role as manager of the Technology Localisation Implementation Unit, a Department of Science and Technology (DST) initiative hosted by the CSIR.

INDUSTRIAL ENGINEERING is an engineering discipline that looks at the improvement of processes and systems in the manufacturing and services sectors. "An industrial engineer analyses production engineering, process optimisation, work study, facilities layout and planning, automation and logistics, " explains Bhugwandin. "Our role as industrial engineers is to act as the 'brain of the body' to streamline processes, taking a medium to long-term planning perspective.

"It's like having a bird's eye view of manufacturing, which allows one to think laterally about solutions."

Bhugwandin worked in a number of sectors, including automotive, fast moving consumer goods, printing and so-called white goods or household appliances. "This involved development work, such as prototype design and experimentation with new ideas and methodology," Bhugwandin explains. "These aspects make the job both challenging and interesting."

National responsibilities

From 2012 onwards, Bhugwandin's responsibilities expanded considerably in his role as manager for the DST's localisation initiative. "While industrial engineering is traditionally geared to making a difference in a particular sector or domain, I now lead a team of eight people whose task it is to make South African manufacturing companies more competitive." It is particularly important to ensure that local state-owned companies are able to rely on local suppliers for infrastructural expansion.

Bhugwandin has taken on this new challenge with characteristic enthusiasm. "Although the area of application is different, my industrial engineering background equips me with skills and versatility, and the ability to think strategically when planning an intervention or solution."

His self-confidence is matched by his willingness to delegate effectively to and support his team. "Mapping out solutions is the final step after effective consultation," he cautions. "There are no shortcuts to arrive at the most applicable best practices that are relevant to an entire company or sector. Team engagement and involvement are important, as everyone needs to be part of the solution."

Notching up successes

Bhugwandin and his team have assisted 26 foundry-related companies and 47 manufacturing companies in Gauteng, Eastern Cape, Western Cape and KwaZulu-Natal with technology assistance packages to support them as potential competitive suppliers to state-owned companies. These packages benefit companies through research and development, accreditation, advanced manufacturing systems, high-end skills development, access to expertise and design and tooling support.

Focused projects, the so-called sector-wide technology assistance packages, include a shared Magma Simulation centre to support the foundry sector with systems to optimise their processes and tooling, and thereby improve their competitiveness. A second project is aimed at enhancing the current testing capability in South Africa with respect to short-circuits within transformers.

How to gain experience

Bhugwandin confirms that the manufacturing sector was a good entry point for his career. "The variety of processes in this domain requires out-of-the-box thinking, logic and creativity. In short, manufacturing requires the industrial engineer to come up to speed on applying theory in practice, in a very hands-on manner."

A second piece of advice is to be open at all times to the sharing of ideas and possibilities. "As industrial engineers, we achieve far more as part of a team than when we work as individuals."

– Biffy van Rooyen

Enquiries:
Ashley Bhugwandin
abhugwandin@csir.co.za

WHAT ASHLEY BHUGWANDIN STUDIED

His BTech: Industrial Engineering was complemented over the years with short courses such as the Six Sigma Green Belt certification, the Verband für Arbeitsgestaltung, Betriebsorganisation und Unternehmensentwicklung (REFA) motion analysis system and a Total Preventative Maintenance course.

WHERE TO STUDY

Various South African Universities of Technology offer the BTech degree in industrial engineering. These courses include one year of practical training. Alternatively, a more theoretical course (BEng Industrial) is offered by the universities of Pretoria and Johannesburg, the Nelson Mandela Metropolitan University, and Stellenbosch University. Industrial engineering is taught widely at overseas institutions, including the Massachusetts Institute of Technology.

INDUSTRIAL ENGINEER

CHARACTERISTICS

An industrial engineer should have a strong solutions-focused interest in industrial processes. The ability to think laterally and a willingness to engage widely when formulating and implementing solutions, are essential qualities for the job.

RELATED CAREERS

Systems engineer, manufacturing engineer, ergonomics or human factors engineer.

Ashley Bhugwandin at the University of Pretoria's Sasol Laboratory for Structural Mechanics, where the TLIU-funded research project with Powertech Transformers is being conducted.

"As a child I wanted to invent things. I took apart my toys and any broken appliance left unattended."

– Asheer Bachoo

COMPUTER SCIENTIST

CHARACTERISTICS

To be a successful image processing researcher you must enjoy solving complicated problems, have a keen interest in mathematics and science and be able to learn from your mistakes.

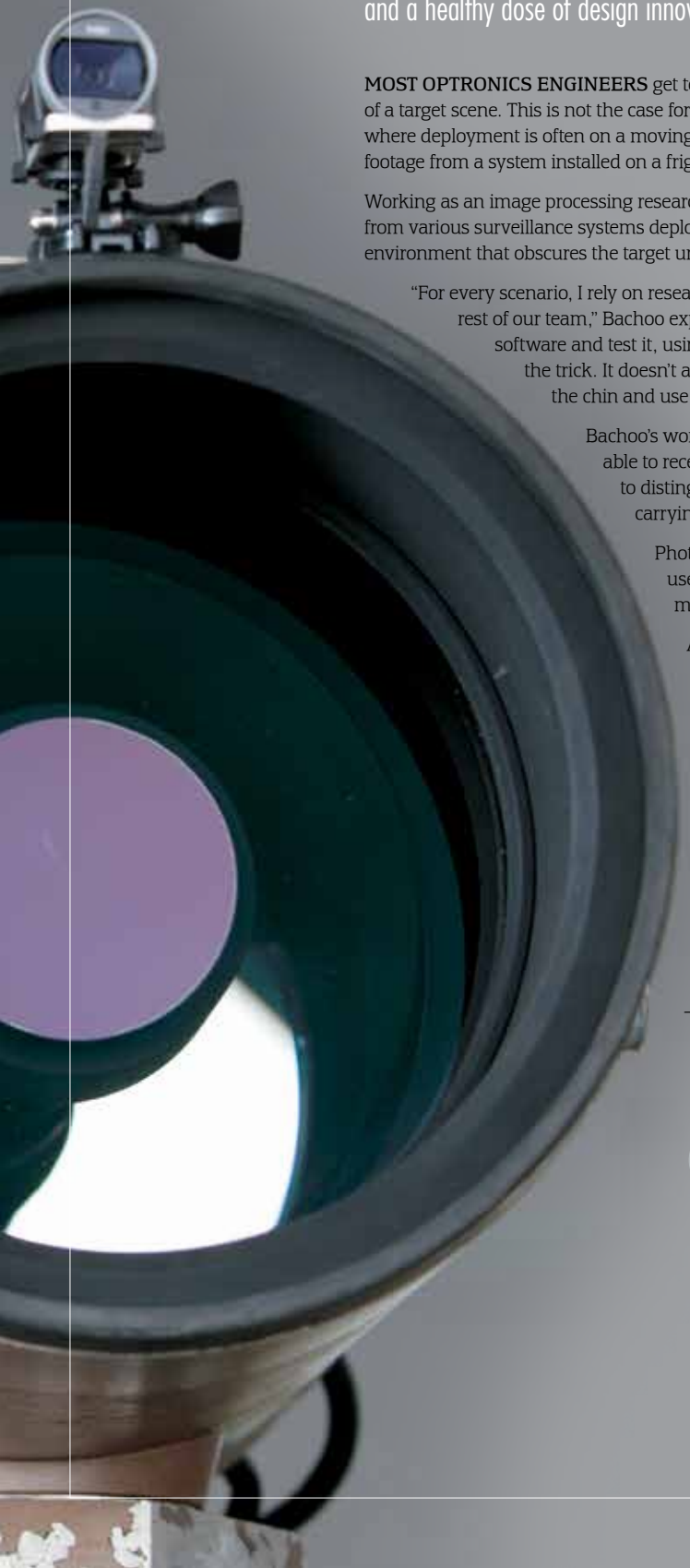
RELATED CAREERS

Software engineer, computer programmer, systems engineer.

Bachoo demonstrates an optronic surveillance system to clients.

A SHARPER IMAGE

An optronic sensor system combines photography, videography, engineering, image processing and a healthy dose of design innovation.



MOST OPTRONICS ENGINEERS get to work on steady systems, installed securely on Mother Earth with an easy view of a target scene. This is not the case for Asheer Bachoo, who works on surveillance operations in safety and security, where deployment is often on a moving ship or aircraft and under imperfect conditions. Imagine the surveillance footage from a system installed on a frigate patrolling the Western Cape's shoreline at night during a storm.

Working as an image processing researcher at the CSIR, Bachoo's task is to mathematically improve images received from various surveillance systems deployed in difficult conditions. This could be adverse weather or a cluttered environment that obscures the target under surveillance.

"For every scenario, I rely on research to understand how to remedy a specific problem, and run options past the rest of our team," Bachoo explains. He will then work through the mathematics, implement the solution in software and test it, using the camera or video data captured in real-world conditions to see if it will do the trick. It doesn't always work the first time. As Bachoo says: "You must be able to take failure on the chin and use it as a learning opportunity. I learn from my mistakes all the time."

Bachoo's work makes him part of ensuring the safety and security of South Africa. Being able to receive a clear and stable image from a surveillance system enables authorities to distinguish, for instance, whether an approaching target is a whale or a small vessel carrying illegal immigrants or smugglers.

Photography, video observation and image processing are capabilities not only used in defence but also in fields such as robotics, biosciences, materials and manufacturing, and the built environment.

According to Bachoo, to be a happy and successful image processing researcher, one has to thrive on the thrill of solving complicated problems.

He elaborates: "To be able to do the work that I do, I have to draw on my passion for learning and solving problems. As a child I wanted to invent things. I took apart my toys and any broken appliance left unattended. I was curious about everything and fell in love with mathematics when the teachers at my school gave me complicated mathematical problems to solve."

Bachoo says that working at the CSIR means working with brilliant local colleagues as well as international specialists. "Plus I get paid to be creative!" he says. "My level of success is determined by my enthusiasm and motivation."

Bachoo studied computer science and is currently working on his doctoral degree in engineering.

– Lèsa van Rooyen

Enquiries:
Asheer Bachoo
abachoo@csir.co.za

WHAT ASHEER BACHOO STUDIED

He studied BSc, BSc (Hons) and obtained an MSc in computer science at the University of KwaZulu-Natal. He is currently working towards a PhD in engineering at the University of Cape Town.

WHERE TO STUDY

Bachoo studied at the Universities of KwaZulu-Natal and Cape Town, but most universities in South Africa offer both undergraduate and postgraduate degree courses in computer science.

Riaan van den Dool with clients in front of a satellite dish in Tanzania. "A software engineer has to understand the environment where the system he develops will be deployed and used," he says.

Software engineer Riaan van den Dool in front of screens showing the Advanced Fire Information System as it appears live to users.

BUILDING SOFTWARE SYSTEMS WITH IMPACT

Riaan van den Dool, a software engineer at the CSIR, describes his career as being similar to that of a traditional architect or builder who builds houses or other buildings. "There is a great deal of planning involved, with you having to follow that plan closely to achieve your end goal – a well-designed and well-constructed software product," he explains.

A SOFTWARE ENGINEER starts with the development of a new software solution by first determining what the user requirements are and establishing the scope of the problem. He then designs a software solution that will solve the problem and meet the user requirements. If everyone is happy, the development can start. Once developed, the software is tested and updated as needed. This often happens in iterations so that the users stay involved and can give input along the way.

SOFTWARE ENGINEER

CHARACTERISTICS

You have to be a logical thinker (being good at maths helps). You should have a keen interest in being able to build something by following a plan.

RELATED CAREERS

Electronic engineer, computer scientist, software developer.

Software applications to prevent fires

At the CSIR, Van den Dool forms part of a team that has developed and is continuously improving an Earth observation system known as the Advanced Fire Information System (AFIS). This is a system that can detect fires from space by using Earth observation satellites and then alerts relevant authorities, now also through mobile applications for Apple iOS and Android devices.

The mobile application provides fire managers, farmers and disaster personnel with a tool on their smart devices to receive information regarding the prediction, detection, monitoring and assessment of wild fires across southern Africa, as well as globally.

"On the AFIS web applications we continuously deliver new features and improvements even while the system is up and running. This mimics the trend amongst companies such as Facebook and Twitter who deliver up to 20 updates every day, most of which a user will not even notice," says Van den Dool.

He describes AFIS as a very challenging and interesting project, for a few reasons: "It is unique in that it is a specialised service that we provide from within the CSIR to a global user base. It uses satellite technology but also more familiar technology, such as the sending of SMS text messages to fire fighters in the field. It has a social impact because part of the bigger system is to assist government with involving the unemployed to help fight fires."

Study and work

Van den Dool started specialising in Earth observation systems while doing his Master's degree. "I was part of the first group of students at Stellenbosch University who, in order to become software engineers, had to study electronic and electrical engineering while including the major computer science subjects. Our course ran for four and a half years and we had to do our Master's directly after completing the undergraduate degree. My Master's focused on image processing on board Earth observation satellites."

For Van den Dool the CSIR is an interesting and enjoyable workplace: "I have worked at smaller companies in the private sector but enjoy my work here much more," he says. "Here, the impact you can make is much bigger and has a wider reach – you really will be improving the lives of people across the country and across the continent. There are also many opportunities for further studies and access to great mentors."

– Petro Lowies

Enquiries:
Riaan van den Dool
rvddool@csir.co.za

WHAT RIAAN VAN DEN DOOL STUDIED

He studied BSc Electronic and Electrical Engineering at Stellenbosch University, followed by an MSc Eng at the same institution.

WHERE TO STUDY

You will need to do an engineering degree with a mix of computer science and engineering subjects.

The University of Pretoria and the North West University offer a BEng Computer Engineering degree. Most universities offer engineering and/or computer science degrees.

THE INTELLIGENCE BEHIND ARTIFICIAL INTELLIGENCE

Things produced by humans are said to be artificial. In contrast, things occurring in nature are deemed natural. Humans often observe what is natural and then produce something that has the characteristic of what has been observed. For instance, humans observed a bird flying and produced machines that do likewise. At the CSIR, a handful of scientists use this principle to produce intelligence and since this intelligence is human-made, it is termed artificial intelligence (AI).

AI as a career in South Africa

Being a broad field, there are many disciplines that serve as an entry point to AI, says Professor Tommie Meyer, one of a few experts in the field of AI at the CSIR.

"One can approach the field from an applied point of view or from a science point of view," explains Meyer. "If you were to approach the field from an applied point of view, you would typically be an engineer or a computer programmer. AI scientists, on the other hand, are concerned with investigating and understanding what is needed to make machines intelligent," he adds.

According to Meyer, in South Africa there is no formal qualification for AI. "There is no qualification that is specific to AI. Instead, if one wants to pursue a career in the field, you would typically study computer science or computer engineering. You may choose to take courses in psychology, neuroscience and/or cognitive science to augment your studies before specialising in AI in your postgraduate work," he says.

"What goes without saying is that anyone looking to pursue this field not only needs to excel in computer science, linguistics, and mathematics, but also needs to love these subjects. Much of AI is mathematics and linguistics," he says.

A reasoning machine

Meyer's focus in AI is mainly in the area of knowledge representation and reasoning, especially non-monotonic reasoning, belief revision, description logics and formal ontologies.

"What this means in a nutshell is that we are focused on making machines use the intelligence around us. We want to ask machines questions and we want the machines to provide reasoned answers," he explains. "Thus, the work we do is about machines structuring information and reasoning intelligently about the information.

"We are building decision-support systems, which have applications in health, safety and security, the natural environment and the green economy. An interesting project that we are working on, is building a health system that can help assess which patients are more likely to be resistant to TB drugs. This information will help doctors in rural areas to decide which patients need to go for further testing.

"When applied in this way, AI can be a useful tool for synthesising reams of data into information for decision-making at critical times," he adds.

– Bandile Sikwane

Enquiries:
Prof Tommie Meyer
tmeyer@csir.co.za

A low-cost, unmanned aerial vehicle for ecological visual surveillance and decision support.

Unmanned aerial vehicles can track moving objects and reason about behaviour for applications such as monitoring wildlife.

Prof Tommie Meyer

COMPUTER SCIENTIST

CHARACTERISTICS

To pursue a career as scientist in artificial intelligence you must excel in maths and languages and be able to detect trends and patterns.

RELATED CAREERS

Computer engineer, systems architect, robotics engineer.

WHAT PROF TOMMIE MEYER STUDIED

He studied computer science for his undergraduate, Honours, Master's and Doctoral qualifications.

WHERE TO STUDY

Most universities in South Africa offer degrees in computer science.

Natasha Govender

A WORLD OF CREATIVITY IN COMPUTER SCIENCE

"It's not so much about the programming; it is about what the programming enables me to do." That is according to Natasha Govender, a computer scientist working at the CSIR's Mobile Intelligent Autonomous Systems (MIAS) group.

THE MIAS GROUP SPECIALISES IN FIELD ROBOTICS that enables mobile robots to operate in dynamic human environments. These robots are required to navigate and plan a path in unknown environments, avoid and recognise objects and perform scene understanding to allow them to interact with the environment.

"We write software that enables robots to perform certain functionalities such as scene understanding, human detection and tracking, object recognition, path planning and more," she explains. "I work mostly on computer vision applications. We add sensors such as lasers or cameras to a robot and then I write a programme that helps them interpret data from these sensors, so as to 'see' and interact with the environment."

The idea is to use these robots in environments that are hazardous to humans, such as the disposal of nuclear waste, in search-and-rescue scenarios, and to inspect the safety of mines after blasting.

Natasha Govender installing a camera onto a robotic platform that will act as a sensor to help the robot 'see' its environment.

COMPUTER SCIENTIST

CHARACTERISTICS

Computer scientists are generally people who can think creatively, logically and analytically.

RELATED CAREERS

Software developer, software engineer, systems engineer.

Wide, interdisciplinary application

Computer scientists can be found applying their trade in literally every field of modern society, from banking, telecommunication and medicine to nature, manufacturing, mining and beyond. They use different computer languages (coding) to programme software that enables computers to perform certain functions.

Govender's main focus is on active vision. She explains: "An active vision system is one that can manipulate the viewpoint of a camera or of an object in order to obtain more useful information," adding that this reduces time and improves accuracy for object recognition systems. Her PhD study focuses on techniques that can assist robots to look for useful information. She leads a joint project with the synthetic biology group that aims to use these techniques to improve the detection and tracking of various elements within a cell.

There are many computer scientists working in different fields and projects at the CSIR. Govender's PhD study, which is also a project she runs for the organisation, is a perfect example of just how multidisciplinary the work of a computer scientist can be.

"It's especially true when you work for a research organisation such as this," says Govender. "The projects are always exciting and challenging. I get to work on a variety of interesting and very cool robotic applications. In the field of computer vision and robotics, there are always new challenging engineering problems to solve and there are cutting-edge advances happening almost daily. This is an extremely exciting field to be in."

She adds that working at the CSIR also enables her to participate in community and youth outreach programmes, which is another passion of hers. "There I get to stimulate kids' interest in both robotics and computer science, especially when I show them how to build their own simple-purpose robot that can follow a line or react to different sounds."

– Petro Lowies

Enquiries:
Natasha Govender
ngovender@csir.co.za

WHAT NATASHA GOVENDER STUDIED

She completed a BSc and a BSc (Hons) both in computer science at the University of KwaZulu-Natal; and an MSc in computer science at the University of Pretoria *(cum laude)*. Her subjects had a strong bias towards mathematics with most being different types of mathematics and computer science. She is currently enrolled for a PhD in computer science at Oxford Brookes University in the United Kingdom.

WHERE TO STUDY

Most universities in South Africa offer both undergraduate courses and postgraduate degrees in computer science.

HIGH PERFORMANCE COMPUTING HELPS US TO SEE THE DATA

Researchers and big companies often work with large volumes of data which they need to analyse and interpret before it can be used in making decisions. Experts who are trained in high performance computing write software and applications to crunch these numbers and to visualise complex data sets in such a way that they can be understood and communicated properly.

THE CSIR'S SEBASTIAN WYNGAARD works at the Centre for High Performance Computing (CHPC) and specialises in data visualisation. The CHPC is part of South Africa's national cyber infrastructure and embodies one of the key investments of the Department of Science and Technology (DST) to establish cyber infrastructure in South Africa and the southern African region. The CHPC is managed by the CSIR.

"We help users from across the country. For example, one researcher needed to visualise how molecules interact when aluminium and titanium are smelted at very high temperatures. For this, we created a three dimensional digital image using the researcher's data," Wyngaard says.

"Another example is that of a research team at a South African university who did scans for rheumatic heart disease on some 3 000 children in polluted areas in the Western Cape. We helped the team to move from a paper-based system to a paperless system."

Hooked by computers as a child

Wyngaard went to high school in Muizenberg in the Western Cape and remembers always being busy with computers. "I used to help my friends and family to fix computers and loved playing video games, especially those with a lot of graphics."

Computer science was not a subject at his school and he did not have the resources to study it at another school. "However, when I reached university, I could immerse myself in this field."

The importance of mathematics

He obtained a BSc and BSc (Honours) in computer science at the University of Cape Town (UCT), majoring in computer science with minors in maths and applied maths.

"Maths and science are good subjects to have if you want to go into my field – that is doing high performance computing in the science and financial fields. If you don't have maths, you will be less involved in the science field and perhaps study in the field of information technology where you use and apply applications and monitor machines, for example, to check that software is installed correctly."

Recruited by the CSIR

At the end of his Honours year at UCT, Wyngaard was spotted by a CSIR research manager during an open evening. He was showing off his molecular visualisation software which impressed the researcher so much, that Wyngaard was invited for an interview at the CSIR some weeks later.

"I got the job and joined the CSIR straight after university. Working here provides a great opportunity to grow. I work around experienced people and learn so much from them."

The importance of understanding data

According to Wyngaard, data which can't be understood or communicated properly is of little use to humankind. "Experts in my field develop methods to see data and to draw meaning from it. Our work is an important step between generating and using research results."

– Antoinette Oosthuizen

Enquiries:
Sebastian Wyngaard
swyngaard@csir.co.za

Sebastian Wyngaard works at a supercomputer that is housed at the Centre for High Performance Computing in Rosebank, Cape Town.

COMPUTER SCIENTIST – HPC

CHARACTERISTICS

To excel in this career, you should enjoy spending long hours behind a computer; be good at problem solving and logical reasoning; and be able to express yourself succinctly.

RELATED CAREERS

Software engineer, software developer, business analyst.

Sebastian Wyngaard

"If you have always liked tinkering with computers, think logically and have good problem solving skills, high performance computing might be for you."

– Sebastian Wyngaard

WHAT SEBASTIAN WYNGAARD STUDIED

He obtained a BSc and BSc (Hons) in computer science at the University of Cape Town.

WHERE TO STUDY

Most South African universities offer courses in computer science. Subjects such as mathematics and science will help a student to find employment at science organisations or financial institutions. There are no specific courses for high performance computing and Wyngaard advises students to research the field in their own time and to consider applying for winter school courses offered by the CHPC.

Angeline Dludla

WHAT ANGELINE DLUDLA STUDIED

She completed her undergraduate and Honours degree in computer science at the University of Zululand. She then completed her Master's degree in information technology and telecommunications in South Korea.

WHERE TO STUDY

Dludla says: "Most South African universities offer degrees in computer science."

COMPUTER SCIENTIST

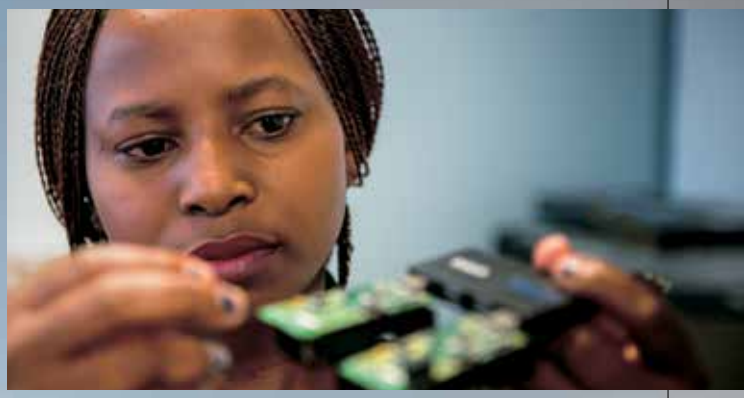
CHARACTERISTICS

To work in this field, you need to have self-belief, curiosity, a love for learning new things and solving problems, and a love for mathematics and physics.

RELATED CAREERS

Electrical engineer, computer scientist.

Testing latency and bandwidth via homeplug connectivity.



Angeline Dludla inspecting telos-b sensors.

THE SIXTH SENSE

AUGMENTING PEOPLE'S ABILITY TO INTERACT WITH EACH OTHER, AND THINGS, THROUGH SENSOR NETWORKS

If a tree falls in the middle of a forest and no one is around to hear it, does it make a sound? This is a well-known philosophical thought experiment that seemingly has no real-world applications. But according to Angeline Dludla, this is precisely the type of question that scientists and engineers who specialise in sensors seek to answer.

IT's complicated

Simply put, these specialists design and build devices and systems that detect the change of all physical properties. What this means is that with a type of sensing device in-hand, it is possible to detect just about anything, including a sound that emanates from a falling tree somewhere in a forest when no one is around to hear it.

But 'simply put' does not quite do justice to the complexities involved in sensor network engineering. This is because sensor network systems do not just detect change. They are able to convey sensed data over distance to sense-making platforms that will make this intelligible for human action. "It can be said that sensors augment people's ability to interact with each other and with things," Dludla elaborates. For this reason, building sensor networks is a complicated affair. "A lot goes into designing and building these systems," explains Dludla. "One needs to conduct research, test, analyse and verify various types of technologies, standards and protocols," she says.

When IT gets real

"There are actual, real-world applications with tangible results for the devices we build, other than providing answers to philosophical quandaries," quips Dludla. "The knowledge that at the end of the day – after all the work you have put in – there is a tangible utility to show, is what really attracted me to this field," she says. "One does not have to look too hard to find sensing devices. In fact, sensors are probably the most ubiquitous of all devices," she continues. "For example, your mobile phone is a sensor," she says. "The devices that we build make a real difference to people's lives. Because whether the sensor is integrated into cars or dangerous chemical detectors, our work is deeply entangled with living experiences," she says.

Currently, Dludla and her team are working on a project that will allow people to interact with their houses or office buildings. "This is part of the Smart World project. We are trying to design and build sensor networks that can be installed in your home or office in order to detect whether you have left the lights or the geyser on. If you have, the sensor network will send a notification via a communication platform of your choice. You will then send a message back instructing the relevant actuator to switch off the lights or the geyser. This will be part of an integrated system of course. Our part in the project is to design, build, analyse and test various sensor networks and configure standards and protocols," explains Dludla.

– Bandile Sikwane

Enquiries:
Angeline Dludla
adludla@csir.co.za

Neo Motsisi

WHAT NEO MOTSISI STUDIED

She completed a BSc in computer science at the University of Manitoba in Canada and a Master's degree in business administration at the University of the Witwatersrand.

WHERE TO STUDY

Many South African universities offer degrees in computer science or information technology.

DEVELOPING SYSTEMS FOR BUSINESS

Some years ago, the CSIR embarked on a project to upgrade the information technology system that underpins some of its core functions. Behind the team that successfully completed this project on time and within budget, was Neo Motsisi, a woman who knows how to carefully balance her management role with her passion for the technology-based profession of computer science.

THE CSIR'S APPLICATIONS SYSTEM serviced a key line of business processes across the CSIR, but it was at the end of its life cycle and the upgrade was urgent and going to be challenging.

"Successfully completing this project was an awesome feeling," Motsisi says of the two-year project which involved the upgrading of three systems through three to four versions.

"Initially, we did not realise the magnitude of the project. There was a lot of pressure on the team. The upgrade could not be avoided and giving up was never an option. We pulled together and it took a team consisting of stakeholders, developers, business representatives, project managers and technical teams to get the job done."

The importance of information

Motsisi is the manager of enterprise business applications at the CSIR. This unit is part of the organisation's Information and Communications Technology Services Centre and it offers solutions that improve the efficiency and effectiveness of the organisation's operations. These include financial, human resources and customer relationship management systems, as well as important maintenance for the scientific systems infrastructure which enables CSIR researchers to do their work.

"We make a difference in that we enable the CSIR to achieve its goals and objectives through the use of innovative and cost-effective solutions. We help the organisation to grow and have impact by providing the right information to the right people in the right format at the right time," Motsisi says.

Moving to management

Motsisi was born in South Africa, but has lived abroad for most of her life. Her interest in computer science started in high school and she graduated with a BSc in computer science in 2000 while living in Manitoba, Canada. This developed to a broader interest in information technology service delivery and management, particularly in bridging the gap between the needs of an organisation and how these needs are provided for by technological solutions.

For this reason she obtained a Master's degree in business administration from the University of the Witwatersrand after her return to South Africa.

Women in science and technology

The engineering and technology field still struggles to attract and retain women, which worries Motsisi.

"If there are not enough women at the helm, it can be discouraging to someone who seeks guidance in that space. I have never wanted to focus on the issue of gender in terms of my capabilities, but I had to take cognisance of it because of the reality of the ratio of men to women in this field. I have been fortunate to be mentored by phenomenal women in my career and believe that the CSIR is an environment in which I can thrive because it provides equal opportunities for development and advancement."

– Antoinette Oosthuizen

Enquiries:
Neo Motsisi
nmotsisi@csir.co.za

COMPUTER SCIENTIST

CHARACTERISTICS

Someone in this role should be driven by results, be service oriented and have a need to serve through leadership.

RELATED CAREERS

ICT project manager, enterprise architect.

"We help the organisation to grow and have impact by providing the right information to the right people in the right format at the right time."

– Neo Motsisi

COMBATING CYBERCRIME FROM BOTH SIDES OF THE FENCE

"To be really good at cyber defence, you need to think like a hacker." This is the advice of Angel Shozi, a software developer at the CSIR, who specialises in cybercrime and coming up with cyber defence solutions.

An unsecured printer hard drive being scanned for sensitive information.

SHOZI'S WORK ENTAILS coming up with secure applications that are totally without vulnerabilities. She explains, "You have to be skilled at intrusion prevention and detection techniques. You need an understanding of computer forensics and you must be able to put yourself in the shoes of a cybercriminal and always remember that someone out there will try to undo, break or reverse engineer the system you built to get to important, confidential information."

Shozi is proud to say that she loves her job. "Whenever I have to describe how I feel about my work, I use the famous Confucius quote: 'If you love what you do, you will never work a day in your life.' I have enjoyed the world of information technology (IT) from a very young age, back when floppy discs were the latest and greatest piece of technology you could own," she explains. These days the work she does is the stuff great spy novels are made of.

The world is shifting and becoming anchored in IT. Systems are moving from being paper based to being electronic. Businesses are competing with each other, always wanting to know what their competitors are up to. With the growth of IT, they are leveraging its power to spy and access information unlawfully.

Shozi explains, "Fairly recently, there have been international examples of such spying devices being used. A spy phone is a normal mobile phone that has malicious code injected into it to turn it into a device that can spy. It does this by taking pictures and videos, recording conversations, intercepting text and emails – and all without the subject's knowledge."

Software developers and cyber security experts at the CSIR have the capability to provide their various clients with defensive strategies to prevent them becoming victims of such cyber incidents.

"Hypothetically speaking, if one of our clients had to ask for this, I would be involved in researching the security vulnerabilities of mobile phones and coming up with defensive strategies and developing robust software solutions to defend and protect their privacy and information so that they do not become victims of cybercrime," Shozi explains. "When we develop such solutions, we ensure that the information on our databases is protected and the security we put in place cannot be tampered with."

Through a process called penetration testing, organisations' network vulnerabilities are tested. If Shozi manages to compromise the security system, she will discuss the problems with the client and suggest ways to improve their security.

"Humans are the weakest link in any system. This is mainly due to negligence, ignorance and the ease with which he or she can be exploited. These weaknesses expose individuals and their organisations to cyber attacks. It does not matter how good your security measures are; if the user is negligent and decides to write the password on a piece of paper and stick it on the computer screen, it will compromise the entire system."

Shozi makes it clear that the cyber defence environment requires grit and perseverance to work through the challenges. "IT is not a static environment and you have to be one step ahead at all times. Developing complex cyber defence solutions is challenging, but this is just one aspect of my job. As a software developer in this environment, we are also responsible for creating the graphical user interface of these systems. We have to ensure that we find a balance by making a difficult solution easy to use, function optimally and look appealing in order to keep the user engaged," she explains.

"This is the best part of my work, I get to be creative and stimulated – plus I know that my work impacts directly on the security of an organisation and of South Africa."

– Lèsa van Rooyen

SOFTWARE DEVELOPER

CHARACTERISTICS

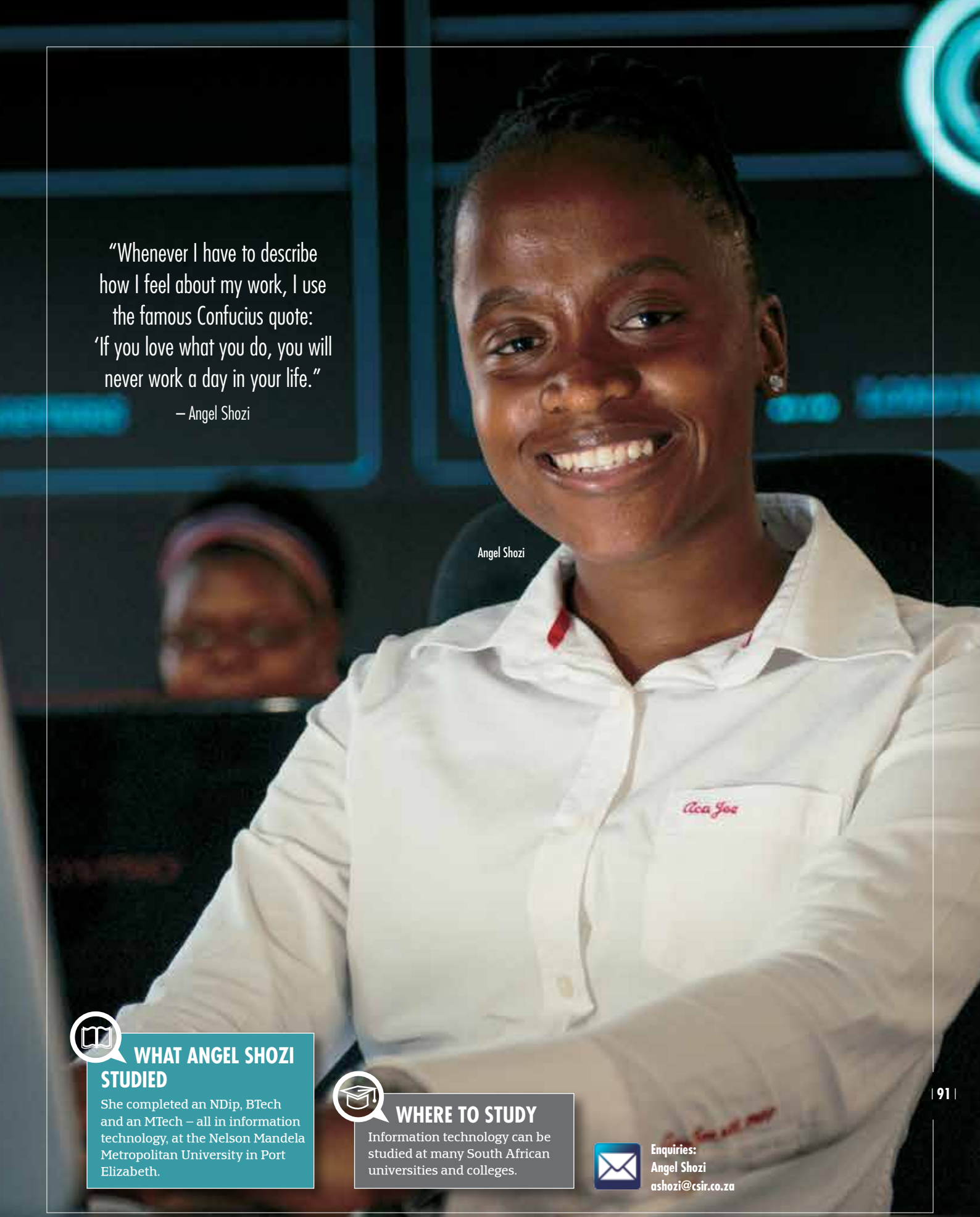
You must have the drive to learn new things, a lot of patience to see it through and an analytical mind to work through the processes. Problem solving forms a big part of your daily work and you must enjoy figuring out coding languages that you have never used before.

RELATED CAREERS

Software developer, application and verification tester and website developer.

"Whenever I have to describe how I feel about my work, I use the famous Confucius quote: 'If you love what you do, you will never work a day in your life."

– Angel Shozi



Angel Shozi

WHAT ANGEL SHOZI STUDIED

She completed an NDip, BTech and an MTech – all in information technology, at the Nelson Mandela Metropolitan University in Port Elizabeth.

WHERE TO STUDY

Information technology can be studied at many South African universities and colleges.

Enquiries:
Angel Shozi
ashozi@csir.co.za

GETTING PEOPLE CONNECTED THROUGH WIRELESS TECHNOLOGY

Nowadays, children tap away on tablets even before they reach school age, but this was not the case for CSIR future wireless technology researcher, Mofolo Mofolo. It is hard to believe that this future wireless technology researcher saw a computer for the first time when he entered high school.

"DURING MY BREAKS I hovered at the secretary's desk where the school's only computer stood. I wanted to know what this 'box' was and she showed me the keyboard and the mouse, but unlike others who were perhaps fascinated mostly by its function, I was also intrigued to understand exactly how it was built and how it worked," Mofolo recounts.

He grew up in Ha-Setoko, a rural village in Quthing, the southernmost district in Lesotho, where computers and even landlines were luxuries and many people were not literate. This was in the days before the fast expansion of cellphone connectivity.

Now, with more than an estimated 80% of South Africans having access to at least one mobile phone in their households and more getting smart phones, being connected to the Internet is fast becoming the norm. Also, most institutions and businesses need to be connected to the Internet to function.

Researchers in future wireless technology develop solutions to keep up with this insatiable demand for connectivity. "Developed communities need wireless solutions that enable seamless broadband connection across different networking technologies. We also require solutions that specifically target emerging economies to overcome the digital divide, so that every person can have access to information and communication technologies," says Mofolo.

He went to a high school in Maseru where he excelled in physical science and mathematics. As he approached his final year, teachers encouraged Mofolo to consider further studies in science and engineering.

He completed a Bachelor's degree in electronics engineering at the National University of Lesotho, then joined the Lesotho Communications Authority for in-service training and completed an internship at Telcom Lesotho.

"During my internship, I realised that my job entailed a lot of routine work and I heard about CSIR studentships being advertised. After getting the necessary permits and university admission, I joined the CSIR while completing a Master's degree in electrical and electronic engineering at the University of Johannesburg.

"Two years later, I was offered a three-year contract with the CSIR's wireless computing and networks research group."

CSIR projects

Mofolo works on several projects, one of which is the development of a 'smart antenna'.

"We are designing a low-cost, energy-efficient and electronically controllable antenna system for wireless local area network (WLAN) devices. The antenna system comprises a radio frequency hardware subsystem, a control circuit board to interlink the antenna system and device, as well as a Linux software package to easily integrate the antenna system with networking devices."

He is also working on the design of energy-efficient network protocols and on incorporating algorithms into the drivers for the WLAN devices.

"We are also carrying out laboratory experiments and field tests to evaluate new technological developments in addressing wireless network efficiency. This includes providing WLAN by using unoccupied television frequency channels to provide broadband connectivity to rural and underserved communities."

"If you look around your home environment, almost every device exists thanks to the research done by an electrical, electronic or computer engineer. As humankind continues to embrace this new technology, the networks that connect us need to improve to accommodate larger volumes of people and data while still being fast enough and energy-efficient," he concludes.

– Antoinette Oosthuizen

Enquiries:
Mofolo Mofolo
mmofolo@csir.co.za

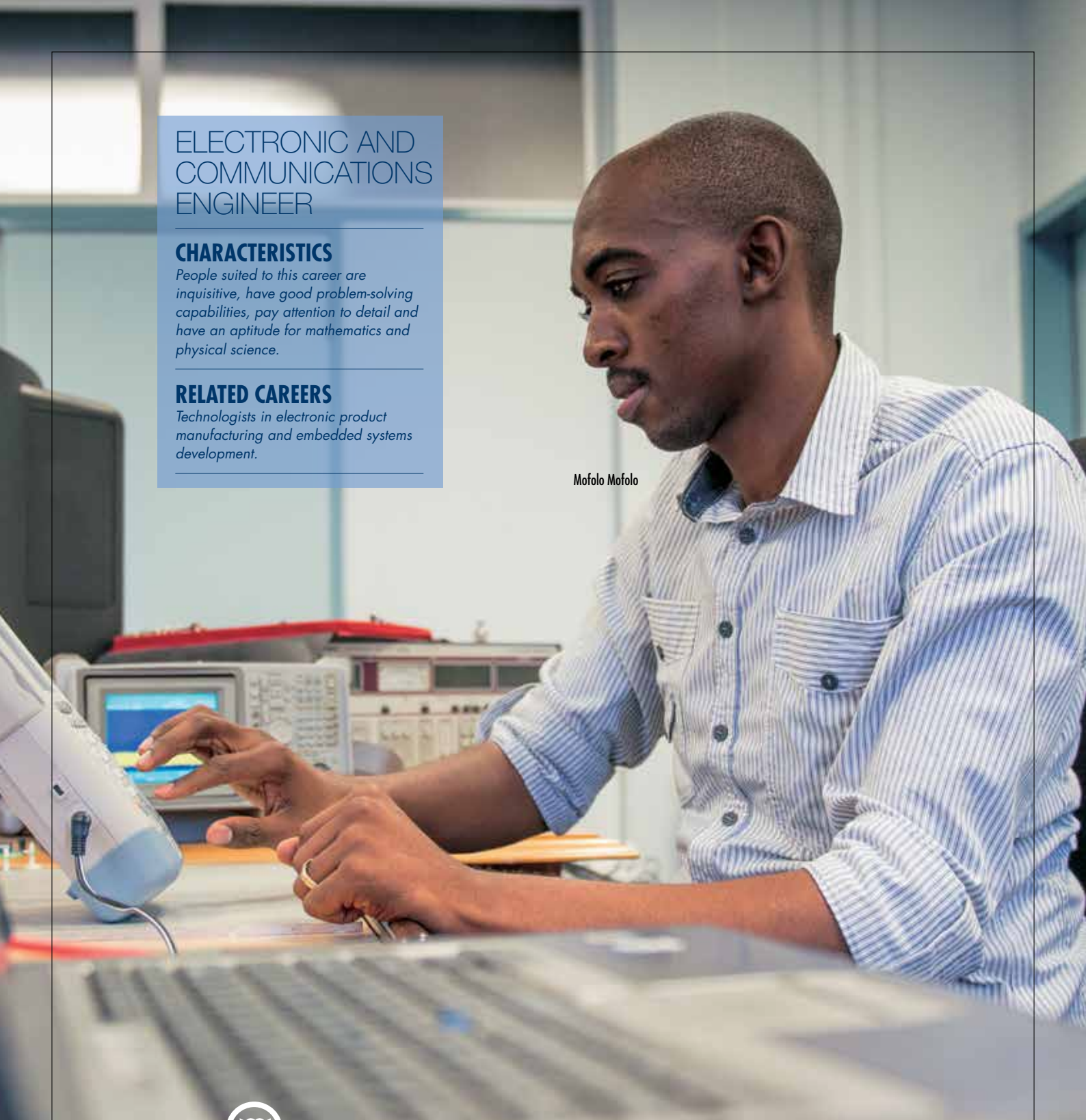
ELECTRONIC AND COMMUNICATIONS ENGINEER

CHARACTERISTICS

People suited to this career are inquisitive, have good problem-solving capabilities, pay attention to detail and have an aptitude for mathematics and physical science.

RELATED CAREERS

Technologists in electronic product manufacturing and embedded systems development.



Mofolo Mofolo

WHAT MOFOLO MOFOLO STUDIED

He completed a Bachelor's degree in electronics engineering at the National University of Lesotho. After completing his internship, he joined the CSIR and completed his Master's in electrical and electronic engineering at the University of Johannesburg.

WHERE TO STUDY

Most South African universities offer courses in electrical, electronic and computer engineering after which a student can decide to become a network engineer, specialising in the development and research of wireless technology solutions for the future.

ENTERPRISE DEVELOPMENT SPECIALIST

CHARACTERISTICS

An enterprise development specialist must have a passion for technology transfer to achieve socioeconomic benefits. The challenging work environment requires analytical thinking and planning skills, and the ability to engage with stakeholders and role-players during the whole process of enterprise creation.

RELATED CAREERS

Entrepreneur, economist, business manager.

Loyiso Nxumalo

Architectural drawings of the building to house the Hammanskraal Business Process Outsourcing enterprise. This marks an important milestone in the enterprise creation process.

PLACING NEW ENTERPRISES ON A FIRM FOUNDATION

The CSIR's Loyiso Nxumalo is passionate about his involvement in the various stages of enterprise development.

AN ENTERPRISE DEVELOPMENT SPECIALIST focuses on specific methods and processes, which are necessary to ensure that new enterprises become sustainable businesses that improve the quality of life of communities. The CSIR's team of enterprise development specialists focuses on the use of science and technology solutions to address poverty and underdevelopment. Clients include all tiers of government, non-governmental organisations and the private sector.

International learning finds local application

Nxumalo is a member of a CSIR team working with the City of Tshwane on the setting up of a business process outsourcing enterprise in Hammanskraal. As part of this team, he attended a conference in Malaysia and visited business process outsourcing parks in India to ascertain what conditions are needed for the sustainability of these enterprises. Business process outsourcing is gaining support for its potential to provide support for non-core business activities, freeing up companies to pursue core services.

His other study tours to Japan, the United Arab Emirates, Italy, Germany and Denmark have been valuable for providing the opportunity to learn best practice, interact with industry experts and assess capacity and technology suitable for South Africa.

However, the nature of his responsibilities keeps Nxumalo in the office in Pretoria for about three days a week. He explains, "The methodology we use takes a product or business idea through various planning stages, one of which includes a feasibility study. It is vitally important that no stages are excluded or skipped, as each plays a role in ensuring successful enterprise creation, incubation and support, and improvement."

No two projects the same

Nxumalo enjoys the variety of projects that he undertakes; they are both stimulating and challenging. He remarks, "It's great to always be working on something different."

He has gained extensive experience in the planning and establishment of enterprises in the waste industry. He says, " I worked on the establishment of three waste buy-back centres in North West, as well as the business planning for setting up a waste tyre granulation plant in the Northern Cape." The latter was in conjunction with the Finsch Diamond Mine, to create employment.

Nxumalo is equally comfortable when it comes to supporting the creation of food production, food processing and fruit growing projects. He undertook a scoping study in North West to assess the viability of growing pomegranates, pecan nuts, olives, figs and vegetables for processing.

"We set up a 12-hectare pomegranate orchard in Murraysburg," he reveals proudly. In cases such as these, economic impact projection is measured by the benefits of the activities to the community: job creation, indirect job creation and the generation of disposable income.

A crayfish holding facility in Doringbaai is another of his success stories. Subsistence fishermen were supported through the creation of a pooled catch system. The catch was sold on behalf of the shareholders at an improved market price.

What makes a good enterprise specialist?

Nxumalo has an affinity with numbers and is therefore able to develop comprehensive financial models for relevant business studies. He is a quick learner and has a keen interest in new discoveries and concepts. He confirms, "In our line of work it's important to use analytical skills to apply in our methodology."

A good dose of strong work ethic, and determination to see through project deliverables despite difficult circumstances is also important. He concludes, "It is important to keep focused on milestones and goals."

– Biffy van Rooyen

WHAT LOYISO NXUMALO STUDIED

He completed a national diploma in chemical engineering, a BTech in business management, and a Master's degree in development finance.

WHERE TO STUDY

Most universities offer degrees in business management and project management, although a degree in science or engineering is a good background qualification.

Enquiries:
Loyiso Nxumalo
lnxumalo@csir.co.za

KEEPING PACE WITH LEGAL ISSUES IN OUTER SPACE

An interest in doing 'something completely different' with her legal qualifications proved to be the deciding factor in Lulu Makapela's decision to become a specialist in space law.

SPACE LAW is an area of the law that encompasses national and international law governing activities in outer space. As the so-called last frontier, space has become an internationally contested domain. Lulu Makapela says, "I was drawn to a field that is changing every day, providing an opportunity to keep up with events."

She worked as Deputy Director: Advanced Manufacturing – Space Affairs in the Department of Trade and Industry before joining the National Earth Observations and Space Secretariat, a Department of Science and Technology-funded initiative. The secretariat has created the South African Group on Earth Observations (SA-GEO), to promote the use of Earth observations in South Africa for informed decision-making.

Her role includes providing advice on legal aspects pertaining to the access and sharing of Earth observations data. "Acquisition and access to Earth observation data is crucial for South Africa," she explains. "However, there are challenges with restrictions to access. We must therefore consider how best to advocate for free and open access to public data for scientific research and socioeconomical benefit."

SA-GEO operates through self-regulating South African communities of practice in domains such as agriculture, air quality, water, coastal and marine, to mention a few. Makapela has been responsible for research on existing legislation relevant to these communities, the drafting of terms of reference, guidelines and charters for these groups, as well as writing of reports to track the progress of these activities. She is also part of a community of practice that grapples with policy and legal matters.

CSIR's representative on SACSA

Makapela serves as the CSIR's representative on the South African Council for Space Affairs, a Department of Trade and Industry-appointed body that is responsible for enforcing compliance with international obligations under the space law treaties, through licensing and registration mechanisms.

"South Africa must conform to both international and national obligations, should we as a country wish to participate in space activities," she explains. The most recent example was the licensing by the council of South Africa's third satellite in space, ZACUBE-1, a nano-satellite that was successfully launched on 21 November 2013.

Training up new specialists in space law

Makapela is also responsible for facilitating the training of a new generation of specialists in space law in Africa. As a member of the International Institute of Space Law, she is the Africa regional organiser of the Manfred Lachs Space Law Moot Court competition, an annual international event that coincides with the International Astronautical Congress.

"Since 2011, African teams have been competing in this competition. In 2012 and 2013 we were proud to see our winning African team in the finals held in Naples and Beijing, respectively."

Makapela's interest in space law has seen her complete numerous short courses to enhance her understanding. She has served on the organising committee of the youth plenary of the International Astronautical Federation and is a member of the Space Generation Advisory Council that organises the Space Generation Congress.

– Biffy van Rooyen

WHAT LULU MAKAPELA STUDIED

She acquired an LLB from the University of Fort Hare and an LLM in corporate law through the University of Pretoria. Makapela is pursuing an LLD in space law through the University of Pretoria.

WHERE TO STUDY

Most South African universities offer law degrees, with public international law. Only the University of Pretoria offers a postgraduate programme in space law.

Lulu Makapela

SPECIALIST IN SPACE LAW

CHARACTERISTICS

A keen interest in national and international activities in outer space is required, as well as an understanding of the relevant legal context in terms of policies and regulations; charters and treaties.

RELATED CAREERS

Professionals in international law, commercial law, air law, telecommunications law.

Enquiries:
Lulu Makapela
lmakapela@csir.co.za

While more than 60% of the CSIR's workforce comprises scientists, engineers and technologists who are involved in research, development and innovation, they are supported by staff with skills in, among others, financial management, human resources management, commercialisation, administration, quality control, communication and the law. Each of these fields has specialisation areas of its own. For instance, legal specialists and lawyers take care of contracts, patent registration and licensing agreements, compliance specifications and a host of other legal matters.