SCIENCE FOR SOUTH AFRICA

Quest

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AFRICAN SKIES

CONTAINING EXPLOSIONS

Astronomy and sustainable development

TIME MACHINE IN MY POCKET

ACADEMY OF SCIENCE OF SOUTH AFRICA

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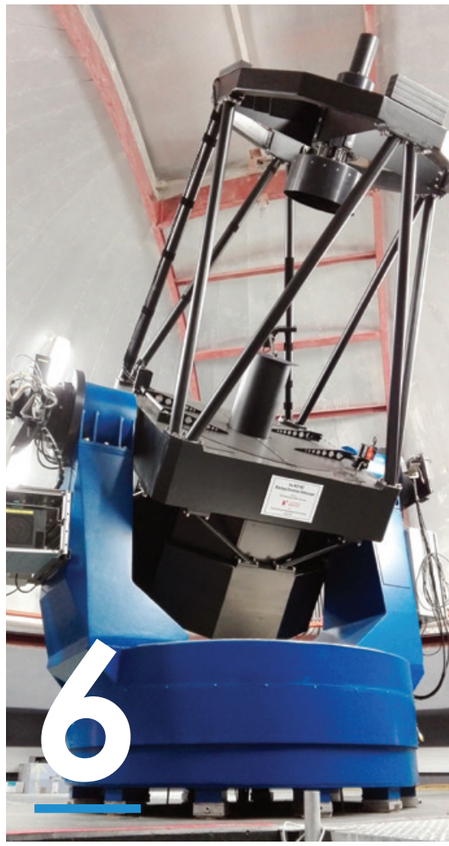

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EYE IN THE SKY...

The theme of this year's Scifest Africa – the 21st anniversary of the event – is 'Tour de Science' – referring to the United Nations declared International Year for Sustainable Tourism for Development. The theme encourages contributors to 'embark on a journey that explores the milestones, accomplishments, mysteries, discoveries and the historic and exciting wonders of their field of science'.

This issue of *Quest*, which is traditionally distributed at Scifest Africa, reflects this 'tour de science' in the broad range of topics covered. We wander through the joys, concerns and eventual excitement of installing a new telescope in Sutherland. We take a look at how materials scientists use controlled explosions to keep us safer in a world where terrorism is a sad reality.

Autophagy is the word used to describe the major protein degradation pathway that operates in all eukaryotic cells – vital for cellular homeostasis – and found in organisms from yeasts to humans. Stellenbosch University is a world leader in research into this essential process in cell biology – doing research into neurodegenerative diseases such as Alzheimer's and also into brain tumours and how to prevent and treat these.

Science is a constant tour – it never stops. There is no limit to knowledge. We will never 'find out everything'. New discoveries occur almost daily – about our Universe and its planets and stars, about the laws of physics – once thought to be immutable – to the science of evolution – fundamental to all life sciences. This is the beauty of science and the study of science – you will never stop learning.

Bridget Farham
Editor – QUEST:
Science for South Africa

TIME MACHINE IN MY POCKET

The new dome
Hannah Worters

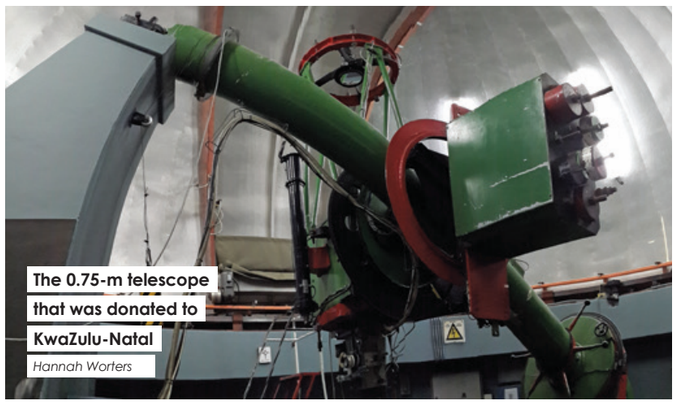
Hannah Worters explains what is involved in commissioning a new telescope

Two years ago, I was asked to take on a very exciting but extremely daunting task: to install and commission a brand new, custom made, modern telescope at the South African Astronomical Observatory's (SAAO's) Sutherland observing base. It would be the first new telescope owned entirely by South Africa to be acquired in the past four decades, and its ability to be operated remotely would introduce a versatile new approach to optical astronomy at SAAO. It would be a R17 million, multifaceted project, incorporating the building and commissioning of the telescope itself, the construction of a suitable enclosure for it, and the design and building of instruments to collect data from the telescope. As a relatively young astronomer with no project management experience, what do you say to such a request? 'Bring it!.'

BRING ON THE NEW

The South African Astronomical Observatory has operated four core telescopes at the Sutherland observatory since the 1970s (which have been joined on the plateau in recent decades by the Southern African Large Telescope (SALT) and a number of internationally owned and operated facilities). These reflecting telescopes are referred to by the diameter of their main mirror: 0.5, 0.75, 1.0 and 1.9 metres. Unfortunately, bringing in a new telescope meant making one of the older ones 'domeless', so after 42 years of service, the 0.75-m telescope was donated to the University of KwaZulu-Natal, to spend its twilight years as a training facility for astronomy students. At the same time, the 0.5-m telescope was given to the University of the Free State, to make room for an optical telescope that will track the MeerKAT radio telescopes. The 1.9-metre (which we affectionately know as 'Old Orange') and 1.0-m telescopes admirably continue their quest to observe the Sutherland skies every night of the year.

The vacant two-storey dome was extensively renovated in preparation for its new resident. It had been purpose built for the way astronomy was done 40 years ago: upstairs was a tall concrete pillar on the south side, and a shorter one in the north, forming the two attachment points for the 0.75-m telescope's equatorial mount; and a wooden cupboard we called the 'warm room', providing shelter from the elements for the astronomer to sit and control the instruments without straying far from the telescope. Downstairs there was a 'dark room' with several sinks and assorted plumbing where astronomers used to develop their photographic plates at the end of a night's observations, as well as a kitchen and toilet.



The 0.75-m telescope that was donated to KwaZulu-Natal
Hannah Worters

The list of modifications required was long, and it was fun to plan the new layout and see it realised in architectural and electrical drawings put together by contracted civil and electrical engineers, and begin to take shape at the hands of the building contractors. The new telescope would have an alt-az mount, which requires a flat surface to sit on. The original concrete pillars that anchored the old equatorial-mount telescope extended through both storeys and into the bedrock, and are isolated from the rest of the building to prevent vibrations being transmitted to the telescope, as this could cause jumping or blurring of the images. So we needed to keep the bases of the north and south pillars and engineers from the Stellenbosch University were consulted to eliminate any danger of vibration in the new design.

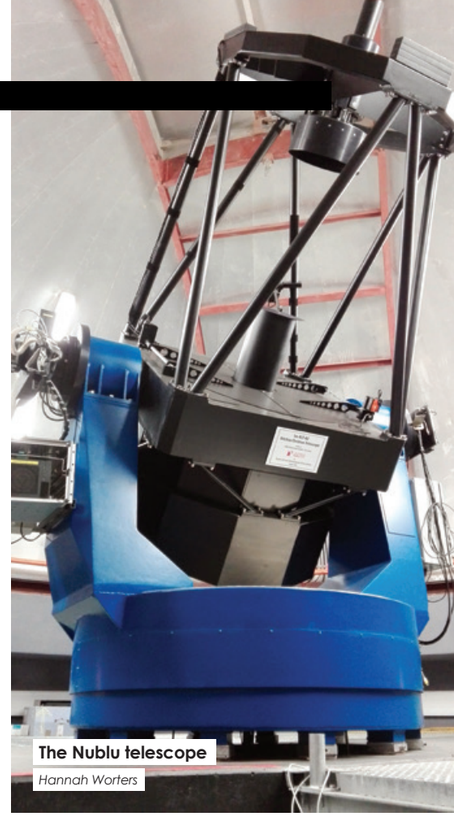
Heat sources – including humans – cause turbulence in the air that is detrimental to producing clear images in a telescope, so anything that could be distanced from the telescope was accommodated downstairs. The old dark room was converted into a new control room with an adjoining temperature-regulated server room. Part of the kitchen was walled in to create an air-conditioned cooler room to house the uninterruptible power supplies (UPSs) – large battery packs that provide emergency power to the telescope in case of a mains power cut – and coolers that remove heat from the instruments' detectors. The heat extracted from these systems is vented 5 m away from the dome.

Other renovations included functional changes (cutting a large hatch in the 30-cm thick concrete upstairs floor, and moving a downstairs wall to allow the telescope's mirror to be lowered downstairs periodically for a fresh coat of aluminium, and a smaller hatch to route cables and coolant pipes to pass from the telescope upstairs to the server room downstairs); safety features (complete rewiring of the building); and environmental considerations (fitting modern, energy-saving lighting throughout, and blocking up the unnecessary windows to prevent accidental light pollution on the plateau).

'NEW BLUE'

While all this was going on in the foreground, the telescope was under construction in the background. A panel of SAAO astronomers had put together a specification for the telescope and submitted a request for tender. APM-Telescopes in Germany won the bid to work on our unique 1-m telescope. I needed to ensure that every aspect designed by APM met the specifications of SAAO, that the homegrown instruments would interface with the telescope, and that once the dome was renovated, everything would fit where it was intended. Even after measuring the distance from the top of the dome to the height of the proposed new concrete bridge several times, and comparing it with the planned dimensions of the telescope, I still had nightmares about installing the telescope and finding it was so tall that we couldn't close the roof! The various aspects of the project involved countless individuals across almost all of SAAO's disciplines and departments: Telescope Operations, Instrumentation, Electronics, Supply Chain Management, Mechanical, the Cape Town workshop, Finance, IT, the Sutherland site maintenance and hostel teams and the Outreach department. With a telescope built in Germany, optics manufactured in Russia and instruments designed in South Africa, it was vital that no detail was allowed to slip through the net.

In April 2016, I went to snowy Baden-Baden in Germany and saw the telescope for the first time. Thankfully our long-distance communications had been a success, and the only surprise was that the telescope was blue! It was immediately dubbed 'New Blue' – to complement its big sister, Old Orange – a nickname that soon evolved to 'Nublu'. The purpose



The Nublu telescope
Hannah Worters

The observing floor before renovations began
Hannah Worters

of the visit was to carry out the factory acceptance tests, an important milestone that defined the telescope's readiness for shipping to South Africa. The tests were passed with flying colours and Nublu was dismantled, packed up into a shipping container and set sail for Cape Town.

The day we had all been working towards came on 2 August 2016, when we prised open the shipping container to find all the pieces of this 3D jigsaw puzzle clean and dry and still neatly arranged, despite six weeks on the ocean. Nublu had been designed modularly, so that each component could be lifted in through the 1.3-m wide opening of the dome shutter using a crane. This was a really nerve-racking process, watching the various components hanging 6 m above the ground, before swinging in through the dome and being laid to rest in the centre of the concrete slab. Rigwell's team of three were masters of their trade and stuck with us from 10:30 until 20:00 that night. Each oddly-shaped piece lowered into the dome was added to the pre-fabricated time machine, and by the end of a long day, we had something very closely resembling a telescope!

FIRST LIGHT

Over the next few days we levelled the base of the telescope, installed and aligned the mirrors and their covers, mounted all the controller boxes, set up all the motors and adjusted the encoders, networked the servers, mounted the field-flattening optics, installed the guiding systems and when darkness fell on 5 August 2016 we took our first look through the telescope. This is a true 'make or break' moment for a telescope project, especially when the optics have never before been installed, as was the case for Nublu. We had gathered the whole team and all the observers from domes across the plateau for the occasion. Everyone was excited; the project team was nervous. We pointed the telescope to Saturn. Equally cursed and blessed, I was sent up the ladder to look through the eyepiece and announce the verdict. Wow! Words cannot describe the bright, colourful, striped, ringed planet that seemed suspended in space before me! The optics are impeccable, Nublu is spectacular. We popped the champagne to celebrate first light, then with new eyes on the universe, embarked on a tour of the Southern sky, looking back in time at such magical displays as the globular cluster 47 Tuc, and the Ghost of Saturn planetary nebula. We had welcomed a new telescope to the SAAO family.

Lifting the telescope components in through the open dome
Hannah Worters

NUBLU'S NICHE

In order to appreciate where Nublu fits in, it is helpful to refer to the current user model of the existing SAAO telescopes. These function by the traditional 'visiting observer' model, whereby astronomers from all over the world may apply several months in advance to conduct a particular research project. The proposals are assessed by a panel of scientists, who ensure that priority is given to research programmes of particular scientific merit, and to those proposed by researchers in Africa. Successful applications are then allocated telescope time in week-long blocks. The astronomers travel to Sutherland for their allocated week(s), where they are trained to use the relevant telescope before spending each night making their own observations.

This observing model is appropriate for many research programmes, but is less well suited to others, such as monitoring programmes, which require repeated, regular short observations, or target-of-opportunity programmes, whereby an optical follow-up request is triggered by a satellite or radio telescope observation, and the telescope must be pointed to the target within minutes. This is one area in which the new telescope comes into its own. Instead of visitor mode, it will be operated in service mode. Telescope time will not normally be allocated in week-long blocks, nor will the applicant come to the telescope. Instead, requested observations will be entered into a database and carried out by a team of local observers, who will take it in turns to work the night shift.

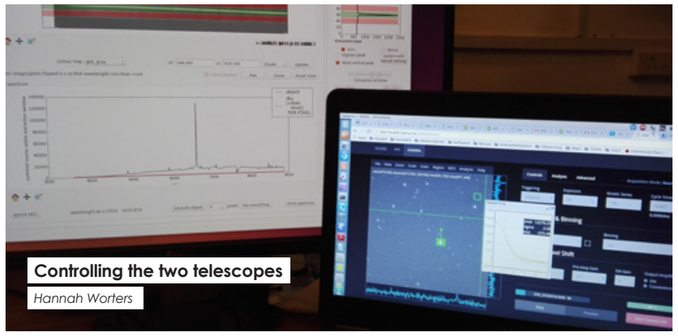
The telescope team with Nublu: Markus Ludes (APM-Telescopes), Michael Knopf (APM), Hannah Worters (SAAO) and Jurgen Winges (APM)
Hannah Worters

Significantly, it is intended that this team will consist largely of South African astronomy students who will develop skills in critically assessing the observing proposals and using the telescope as part of their training. This not only opens up huge opportunities for new types of research that can be done at SAAO, but also removes barriers to obtaining observational data. Service mode is expected to be particularly beneficial for researchers at previously disadvantaged institutes, who may lack the funds to make regular trips to Sutherland, and students of emerging astronomy departments, who may lack an experienced supervisor in observational astronomy who has the time to accompany them on their first observing run.

The telescope itself forms only part of the system that allows us to do astronomy: it collects the light from the stars or galaxies, but needs an instrument with which to detect that light. For decades, SAAO's small instrumentation department has been bringing together its mechanical, electronic, astronomical, machining and software expertise, keeping one step ahead of the latest technologies to design and build bespoke instruments with specific observational capabilities for the telescopes in Sutherland. One of the characteristics that sets Nublu apart from the pre-existing SAAO telescopes is its wide field of view: the area of the sky that it can image is 70 times larger than the others. Go large or go dome ... or both! To fully exploit this feature, we are building WiNCam (Wide-field Nasmyth Camera), which will incorporate one of the largest single detectors in the world, and will be by far the biggest that the observatory has ever worked with: a 36 million pixel charge-coupled device, or CCD. At a cost of about R3.5 million for the detector alone, we have a lot more careful work ahead. WiNCam will be ready in late 2017, and SAAO's small but speedy SHOC (Sutherland High-speed Optical Camera) – capable of taking an image every 14 milliseconds – is already at work on Nublu.

SAAO's pre-existing telescopes each allow one instrument (e.g. an imaging camera) to be mounted at any one time. Alternative imaging cameras and spectrographs are available, but each instrument has to be manually removed from the telescope for another to be mounted, which is a process that can take a few hours. Instrument changes are therefore kept to a minimum, so that one instrument will be used on a telescope for at least a week. The new telescope has a flat tertiary mirror at a 45 degree angle that intercepts the light path from the secondary mirror. The tertiary mirror can be rotated by 180 degrees to direct the light path to one of two different instruments that can both be permanently mounted, one on either side of the telescope. With software-controlled tertiary rotation, observers can switch between instruments at the click of a mouse, any time of night. A further option allows more than one instrument to be mounted on each instrument port, accommodating a whole suite of different instruments that can be selected at any time without manual intervention.

Lowering the 1-m diameter primary mirror into its cell
Hannah Worters



Controlling the two telescopes
Hannah Worters

Nublu has been designed to have a number of features that facilitate remote operations: spontaneous switching between instruments is just one of them. The telescope is controlled by software called rts2 (Remote Telescope System, 2nd version), a versatile open source package, operating under Linux, that allows interaction with each of the telescope's subsystems via a command line interface or basic GUI. This includes control of the dome, and reading the local weather station to safeguard the telescope by ensuring that the dome is only open in appropriate weather conditions. With various such safety measures in place, it will no longer be essential to have a human presence in the dome. For the first time, observers will have the choice of travelling to the telescope in Sutherland, or operating it remotely, making observational astronomy more accessible than ever before.

Six weeks after the installation, two great milestones were reached. I carried out the first simultaneous observations of the same binary star system using a spectrograph on Old Orange, and the SHOC imaging camera on Nublu. This trial run went flawlessly and was a excellent demonstrator of the synergies between our old and new capabilities. Simultaneous observations of this nature are usually near impossible to schedule – I have been trying for several years – but with our new remote service mode we can pair Nublu with SALT and SAAO telescopes on the fly. Furthermore, these were the first remote observations made with Nublu, controlled from Old Orange's dome across the plateau. If we can run Nublu from a laptop in another dome, we can run it from anywhere with an internet connection, on any device: a cell phone, for example. I effectively have a time machine in my pocket!

Commissioning Nublu is a bit like training a new puppy – it's playful. One night it closes the mirror covers the minute I open them. On another night it closes the dome when it decides that the night has been long enough. It's all in the programming, of course, but it takes time to optimise each setting and unravel the complexities. I will be in Sutherland for a while yet ... there's no place like dome.

Hannah Worters *is lucky enough to have been catching photons on the astronomical front line in Sutherland for quite a few years. She is an Astronomer working in the Telescope Operations team, looking after the observatory's suite of telescopes and developing new instruments. Her research interests include stars that flicker and flare.*

CURRICULUM CORNER

MATHEMATICAL LITERACY
Measurement
► Working with provided data in an unfamiliar context.

LIFE ORIENTATION
World of work
► Career choices.

DEGRADING PROTEINS
CELL MAINTENANCE

Ben Loos explains the importance of autophagy in eukaryotic cells

Have you ever wondered, how cells can survive for such a long time some of them, like the cells in the brain or the heart for as long as you live, maybe for 70, 80 or more than 90 years?

What cleans and maintains them? What keeps them functioning, if 'spares' need to be replaced? What is it that takes out the old, unused or even poisonous structures? The answer is the process of autophagy.

THE PROCESS OF AUTOPHAGY

Autophagy, from Greek meaning 'self-eating', is a major protein degradation pathway that operates in all eukaryotic cells. It degrades and recycles primarily long-lived proteins, of which there are many in the cell. This pathway is so important for cellular homeostasis that it is preserved in organisms ranging from yeast to humans.

Professor Yoshinory Ohsumi
Wikimedia Commons

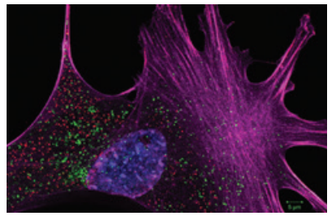
How would a cell describe autophagy for us in human terms? It may say 'autophagy is my dishwasher and my washing machine, it is my cleaning staff, my soap and clean water. It is my toothbrush and my dentist. It is my rubbish bin and my rubbish removal. It is my car service and oil-check that keeps my engine running. It is also my spare fridge with an emergency food parcel and a survival pack, and it is my generator during power failure'.

THE 'FATHER OF AUTOPHAGY'

So it is no wonder that the discovery of such a pathway, by Prof. Yoshinory Ohsumi from Tokyo University in Japan, was awarded the 2016 Nobel Prize in Physiology and Medicine. He is often called the 'father of autophagy'.

By using the yeast model, *Saccharomyces cerevisiae*, Prof. Ohsumi discovered a highly complex molecular machinery that starts up when the cell is deprived of nutrients, leading to the formation of unique vacuolar structures with a diameter between 400 and 900 nm. He called these structures 'autophagic bodies' and found that they contain cytoplasmic material.

This was the first discovery showing that nutrient starvation induces such a process of self-digestion. Seventy-five mutant strains were subsequently screened, all defective in protein degradation, showing that this process is indeed indispensable for protein degradation. Also viability was negatively affected in these mutants, since they died much faster during nutrient starvation compared with the normal/wild-type cells. Subsequently, the molecular biology behind the conjugation system that governs this process was revealed, and the same processes were found in mammalian cells.



A cell showing autophagosomes (green), mitochondria (red), the nucleus (blue) and cytoskeleton (magenta) *Ben Loos*

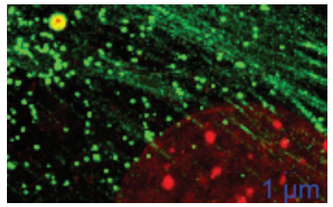
This laid the foundation to open the field up to the mammalian, and hence the human autophagy system – fundamental to the study of life sciences. In the years to come, it was found that autophagy dysfunction plays a major role in many human diseases, such as neurodegenerative diseases, cancer or heart disease.

VITAL TO LIFE

You can imagine, the relevance and impact of such pathway. What happens to a household where dishes are never washed, the house never cleaned and rubbish never removed?

If cells are under stress, if metabolites are not available, autophagy is the first response mechanism. The cell forms autophagosomes and degrades some of its own cytoplasm, thereby digesting cytoplasmic proteins and recycling amino acids that can be used to either make extra energy (ATP) or to synthesise stress or survival proteins.

Of course, too much autophagy would be dangerous, since the cell would start to degrade its own crucial reserves. Too little autophagy is also dangerous, since dysfunctional proteins would start to aggregate, becoming toxic species that would kill the cell.



Sick or dysfunctional mitochondria can be degraded through autophagy. Top left: a mitochondrion is engulfed by an autophagosome. Such selective autophagy, called mitophagy, is part of a quality control system *Ben Loos*

AUTOPHAGY RESEARCH IN AFRICA

So, what about autophagy at the tip of Africa? At the Department of Physiological Sciences at Stellenbosch University (SU), autophagy research started 10 years ago when I started my PhD research supervised by Prof. Anna-Mart Engelbrecht. This was at a time when autophagy was not researched in South Africa at all. She foresaw the relevance of autophagy to cell death and her foresight certainly changed my life and career path.

Today, in my research group at Stellenbosch University, we literally eat, sleep and breathe autophagy. So far we have established a small glimpse of its role in cellular function and published many papers in international journals.

We focus on the precision control of this pathway to control cell death. In neurodegeneration, such as that occurring in Alzheimer's disease, we want to enhance autophagy, to assist the cell in its fight to remove toxic proteins, thereby preserving its life.

In brain cancer on the other hand, we wish to inhibit this process, so that the cancer cell dies selectively as the patient is undergoing chemotherapy.

Hence, a key focus of our group is to use a combination of techniques, many of which include cutting-edge microscopy, to make this process highly measurable.

HOW TO MEASURE AUTOPHAGY

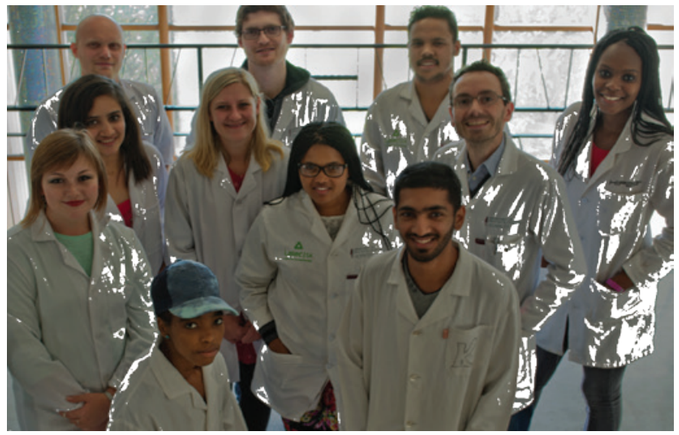
If we can measure autophagy well, we can implement interventions to finely control it. If we are able to control its activity, we can tune it for either cell death or cell survival.

The enthusiastic students in my group work hard to implement this idea, each trying to solve a small but crucial puzzle piece. How does autophagy differ across the brain? How well can drugs that enhance autophagy actually clear the toxic proteins? Too much or too little autophagy can kill the cells, but what is too much or too little? What exactly happens molecularly in that time of too much or too little autophagy? How will a cancer cell respond if we speed up autophagy, like a racing car in a crash test, and then abruptly block it? Could we model autophagy in silicon?

In collaboration with colleagues such as Prof. Jannie Hofmeyr, Prof. Kristian Muller-Nedebock and Prof. Willie Perold, we attempt to unravel autophagy, often through unconventional means, combining expertise on molecular cell physiology with systems complexity, theoretical physics and engineering. Microcopy is an indispensable tool in this research.

In collaboration with Dr Craig Kinnear from the South African Medical Research Council, we are looking at the role of autophagy in tubercolosis (TB). And together with Prof. Bert Klumperman from the Department of Chemistry and Polymer Science, we seek to enable autophagy in dysfunctional neurons by re-establishing lysosomal function.

You can find out more about our work at http://www0.sun.ac.za/physiologicalsci/eng/research.php?id=29.



The Neuro Research Group (NRG) 2016: Andre du Toit, Jurgen Kriel, Yigael Powrie (back), Punya Bhat, Dr Chrisna Swart, Dr Ben Loos, Akile Khosa (middle), Danielle Millar, Claudia Ntsapi, Dumisile Lumkwana and Khaalid Khaan (front) *Ben Loos*

FUTURE CHALLENGES

The next major challenges, I believe, hinge around the clinical implementation of autophagy control, to use it in the treatment of cancer, neurodegeneration and even TB. The discovery of this pathway by Ohsumi and many key leaders in the autophagy field was the beginning of something highly significant.

On a personal note, I have had the pleasure to meet Ohsumi at conferences, and have been inspired by many of his colleagues in the field, such as Ohsumi's former student, Prof. Noboru Mizuhima or Prof. Daniel Klionsky, colleagues who form part of the 'research family' I grew up in.

The Nobel prize is a wonderful recognition of a life time of extraordinary work. It is now our task to put it to good use.

***Dr Ben Loos** is a Principal Investigator with the Neuro Research Group, Department of Physiological Sciences, Stellenbosch University. His passion is the role of autophagy in neurodegenerative diseases such as Alzheimer's disease and in brain cancers, particularly gliomas.*

TOUR DE SCIENCE

Tsepo Majake takes Quest on a science tour

Quest, a popular science magazine embarked on a national tour to promote science and encourage engagement in line with the mandate of the Academy of Science of South Africa (ASSAf).

Exhibitions are quite tricky for publications such as *Quest*. In a society where reading has lost its prestigious position, it is becoming increasingly difficult to compete with interactive science presentations and engagements. This requires the exhibitor to pull a rabbit out of the hat to attract and sustain interest through discussion and conversation.

These discussions and conversations are varied and always thought provoking, from administrative to scientific. The visitors are either specialists or people who are interested in a particular topic, and after every exhibition we find that we learn much that improves practice.

CURRICULUM AND CONTENT TOUR

The engagement with curriculum specialists across the country has been interesting, particularly in regards to what content needed emphasis. The focus was mainly on classroom-based science, without proper consideration for those outside of the classroom who may not have a particular interest in the content. These discussions always ended in an agreement to focus on context rather than content to accommodate readers across the spectrum and to allow users to use the magazine as best as they know how.

The other interesting curricular discussions were on what content was covered and why. The initiators of this discussion were those who felt that their subjects were minimally covered or that certain sections of them were not covered at all. This was a particular problem for physics and mathematics and we encouraged these specialists to share content and to become more involved through their associations and individual capacities to contribute more and also to influence which content to cover and the extent to which it should.

Quest 12(1) focused on the nature and use of time; 12(2) on the role of science in society; 12(3) dealt with bioprocess engineering and 12(4) was a special issue on optical astronomy.

SCIENCE AND CAREER EVENTS TOUR

Quest worked with many individuals and organisations in seven of nine provinces. In Gauteng we interacted with district offices, EdBook, DST, SABC and SAASTA in various events in the province. In Limpopo we engaged with 'Science without Borders' and Eding International in two separate festivals. In the Eastern Cape we were present at SciFest and a few district offices. And in the Western Cape we worked with the City of Cape Town, the Metropole East district and the DST. In the North West we worked with the Eding International in Vryburg and in KwaZulu-Natal with Ikusasa-Lethu and in the Free State with a district official.

All these events are different and bring a different experience to the table, but all have the same motive of outreach and science promotion. The DST invited *Quest* to several events that assisted in supporting our goal to promote science to over 200 000 people by the end of 2016. These numbers were derived from statistics sent after every event by organisers to participating organisations. At least 10% of this number was made up of face-to-face interaction and we specifically used the National Science Week and the Science Forum South Africa to achieve this goal.

Learners at outreach events ASSAf


Learners at outreach events ASSAf

We forged relations with various of the organisations we worked with, some NPOs and some government departments. For example, we participated in a career guidance event in Mamelodi through an invitation by the Department of Public Works as the result of a relationship forged earlier in a DST-organised event. *Quest* also participated in a workshop organised by Dr Sefotho of the University of Pretoria, and were actively involved in extending invitations to other entities of the DST in line with the spirit of cooperative engagement and networking as promoted by the DST in the past. Dr Sefotho had previously worked with *Quest* in KwaZulu-Natal in an event organised by Ikusasa-Lethu.

SCIENCE DISCOVERY TOUR

► Gravitational waves

For the first time, scientists have observed ripples in the fabric of spacetime called gravitational waves, arriving at the Earth from a cataclysmic event in the distant universe. This confirms a major prediction of Albert Einstein's 1915 general theory of relativity and opens an unprecedented new window onto the cosmos.

Gravitational waves carry information about their dramatic origins and about the nature of gravity that cannot otherwise be obtained. Physicists have concluded that the detected gravitational waves were produced during the final fraction of a second of the merger of two black holes to produce a single, more massive spinning black hole. This collision of two black holes had been predicted but never observed.

The gravitational waves were detected on 14 September 2015 at 5:51 a.m. Eastern Daylight Time (09:51 UTC) by both the twin Laser Interferometer Gravitational-wave Observatory (LIGO) detectors, located in Livingston, Louisiana, and Hanford, Washington, USA. The LIGO Observatories are funded by the National Science Foundation (NSF), and were conceived, built, and operated by Caltech and MIT. The discovery, published in the journal *Physical Review Letters*, was made by the LIGO Scientific Collaboration (which includes the GEO Collaboration and the Australian Consortium for Interferometric Gravitational Astronomy) and the Virgo Collaboration using data from the two LIGO detectors (http://mediaassets.caltech.edu/gwave).

► Graphene production

For the first time, it has been possible to produce functional OLED electrodes from graphene. The process was developed by Fraunhofer researchers together with partners from industry and research. The OLEDs can, for example, be integrated into touch displays, and the miracle material graphene promises many other applications for the future.

The Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP from Dresden, together with partners, has succeeded for the first time in producing OLED electrodes from graphene. The electrodes have an area of 2×1 cm^2. 'This was a real breakthrough in research and integration of extremely demanding materials,' says FEP's project leader Dr Beatrice Beyer. The process was developed and optimised in the EU-funded project 'Gladiator' (Graphene Layers: Production, Characterisation and Integration) together with partners from industry and research.

Graphene is considered a new miracle material. The advantages of the carbon compound are impressive: graphene is light, transparent and extremely hard and has more tensile strength than steel. Moreover, it is flexible and extremely conductive for heat or electricity. Graphene consists of a single layer of carbon atoms, which are assembled in a honeycomb pattern. It is only 0.3 nanometres thick, which is about one hundred thousandth of a human hair. Graphene has a variety of applications. 'The first products could already be launched in two to three years', says Beyer with confidence. Due to their flexibility, the graphene electrodes are ideal for touch screens. They do not break when the device drops to the ground. Instead of glass, one would use a transparent polymer film. Many other applications are also possible: in windows, the transparent graphene could regulate the light transmission or serve as an electrode in polarisation filters. Graphene can also be used in photovoltaics, high-tech textiles and even in medicine.

2016 was an interesting year for science promotion and *Quest* hopes 2017 will be even more exciting.

The Austria Conference Centre where EGU General Assemblies and GIFT workshops take place *GIFT*

Science in tomorrow's classroom

Fifteen years of Geosciences Information for Teachers (GIFT) Workshops of the European Geosciences Union. By Carlo Laj, Friedrich Barnikel, Wendy Taylor and Daksha Naran

The Committee on Education (CoE) of the European Geosciences Union (EGU) was created in 2002 with the aim of bringing state-of-the-art science into tomorrow's classrooms via high-school teachers. In 2003, the first GIFT Workshop took place at the General Assembly, in Nice, France, with 42 teachers from seven European countries.

The challenges of a multicultural, multilanguage audience were not only met but were also built on from the beginning so that European GIFT workshops could include teachers from Europe and elsewhere in the world around a general theme that changed every year.

Hands-on activities : teachers finding their way using GPS and aerial photos *GIFT*

2003–2009: SIX YEARS OF GROWING SUCCESS

The workshop quickly became known among teachers all over Europe and the number of participants doubled over time. In 2005, the EGU Assembly moved to Vienna, Austria, and 70 teachers from 17 countries attended the presentation by Nobel Prize laureate, Paul Crutzen, at the GIFT workshop.

The workshop has now become a two-and-a-half days fixture within the General Assembly calendar.

GIFT: MORE THAN 'JUST' A WORKSHOP

GIFT workshops now typically include a general theme for each workshop; two and a half days of workshop; about 80 participants from about 20 countries; eight to nine conferences presented by world-class scientists who are present at the general assemblies; one half-day with hands-on activities with specialised educators; one poster session 'Science in Tomorrow's Classroom' where teachers are encouraged to present their out-of-the-official-programme school activities and which is open to non-teacher participants.

See: http://www.egu.eu/education/gift/workshops/

With so many teachers wanting more access to research experience, the CoE added the Teachers-at-Sea programme, in which high-school teachers can apply to become members of staff on scientific research vessels during research expeditions. In addition to those from Europe, teachers from countries such as China, Malaysia and the USA were invited to the GIFT workshops. Teachers began to apply for second participation slots at the workshops and started to form networks beyond their national borders. A few years later, the European GIFT concept also became international, with the CoE helping to organise workshops abroad.

2009–2010: GIFT ON VIDEO AND IN THE FOOTSTEPS OF ALEXANDER VON HUMBOLDT

In 2009 there were further additions to the GIFT concept. For the first time some lectures were filmed during the workshop. Along with all the other workshop material (programmes, brochures, abstracts and PowerPoint files of the presentations) these recordings were made available as web streams and are accessible free of charge via the EGU website. In 2010, the first GIFT workshop in connection with an EGU Alexander von Humboldt Conference took place in Merida, Mexico.

In addition, the CoE launched the GIFT Distinguished Lectures Series, which brings GIFT speakers to anywhere in Europe whenever an assembly of 80–100 teachers asks for them.

2014: GIFT MOVES TO AFRICA

The EGU Committee on Education teamed up with UNESCO to take the GIFT workshop idea to Africa, in order to support development of the next generation of Earth scientists in Africa. The opportunities and challenges in the Earth sciences in Africa are huge, starting with traditional mineral extraction and extending into environmental management such as climate change adaptation, prevention of natural hazards, and ensuring access to drinking water. The first EGU-UNESCO GIFT workshop on African soil took place at the African Earth Observatory Network at the Nelson Mandela Metropolitan University in Port Elizabeth, South Africa in partnership with the African Applied Centre for Climate and Earth Systems Science. Some 40 teachers from all over South Africa, attended this workshop on climate change and human adaptation. A teacher from South Africa was then invited to attend the Vienna GIFT Workshop in 2015.

2015: VIENNA AND AFRICA AGAIN

In 2015, in addition to the traditional GIFT workshop in Vienna on 'Mineral Resources', GIFT moved again to Africa, this time to Ethiopia where the workshop, organised in collaboration with Addis Ababa University, took place in the newly developed Gullele Botanical Garden, in the northern part of Addis Ababa. The theme of the workshop 'Water' was the same as for the Alexander von Humboldt conference, organised at the same time and also at Gullele. Forty-five teachers (25 from the Addis Ababa area, 20 from the rest of Ethiopia) actively participated over the three days of the workshop. Speakers were from

Carlo and five teachers on board the *Marion Dufresne* *GIFT*

Sunrise at Dzibilchaltun during the summer equinox *GIFT*

The *Marion Dufresne* in a foggy Chilean fjiord *GIFT*

Excursion to Machu Pichu *GIFT*

Teachers in Cape Town GIFT

Ethiopia, Europe and the USA. Their presentations focused on global freshwater availability and distribution, overexploitation of water, strategies for sustainable use of water in the future and the threats posed by environmental changes. These topics are of particular importance for Ethiopia and stirred the interest and excitement of the teachers. The highlight of the workshop was the presentation of a hands-on programme 'Monitoring Climate, Droughts and Floods: The trans-African Hydro-Meteorological Observatory' in which high schools have a major role, by Professor Nick van de Giesen of the Delft University of Technology in the Netherlands.

2016: VIENNA, MERIDA, AND CAPE TOWN

2016 was a very productive year for the CoE. Not only was the annual workshop in Vienna, 'The Solar System and Beyond', organised in collaboration with the European Space Agency (ESA), but also two non-European GIFT workshops took place, one in Merida (Yucatan, Mexico) on 'Natural Hazards', in cooperation with the Mexican Academy of Sciences and the Secretaria de Educacion de Yucatan and with a large participation of the Italian Istituto Nazionale di Geofisica e Volcanologia (INGV), and one in Cape Town, South Africa, on 'Mineral Resources and Natural Hazards' associated with the 35th International Geological Congress (35IGC). The Cape Town GIFT Workshop was hosted at the Iziko South African Museum. Some 50 teachers from Namibia, Nigeria, the Western Cape and other parts of South Africa were welcomed, together with scientists from Algeria, United Kingdom, France, Germany and South Africa.

There were nine sessions accommodated in the programme, and presentations showed the excitement around discoveries, exploration, new insights and new technologies. Teachers were enthralled by the exciting science content and hands-on activities. They sat through presentation after presentation, connecting with scientists and absorbing the richness that is offered through varied research fields. There was a tremendous buzz – an atmosphere of learning and teaching promoted from shared conversations, querying and clarifying. Teachers were further inspired by the Iziko Natural History museum as a venue, where museum tours showcased the varied opportunities available to teachers and how to use the exhibited objects to enrich school curriculum connections and drive the educational process.

2017: VIENNA AND CAPE TOWN AGAIN

To honour its 15 years of existence, the CoE will present two GIFT workshops in 2017, the classical one in Vienna, and a second GIFT workshop again in Cape Town.

GIFT-2017 will take place in Vienna, 24–26 April, 2017, during the General Assembly of the European Geosciences Union, on the theme 'The Mediterranean'.

Over two and a half days, the workshop will explore the major characteristics of this region, which has often been referred to as 'a natural laboratory for geophysics'.

Indeed, the Mediterranean Sea is a sea almost completely surrounded by land: on the north by Europe and Anatolia, on the south by Africa, and on the east by the Levant. The area shows a distinctive geological fingerprint that has attracted generations of Earth scientists. Mountain chains, orogenic belts, subduction zones, extensional basins, active volcanoes, violent earthquakes, tsunamis, landslides and floods testify to the vigorous active tectonics that characterise the region. The same area, owing to the favourable climate, availability of resources (i.e. water and raw materials) and the presence of the sea, allowed for trade and cultural exchanges, and made it a cradle of culture.

Currently, the area is densely populated with progressively increasing anthropogenic pressures, which, when combined with the peculiar geological setting, result in heightened vulnerability to climate change enhanced by increasing atmospheric carbon dioxide. The Mediterranean is thus a key region for understanding the complexities and delicate relationships between civilisation, natural processes, catastrophic events and protection of the environment.

And, at the end of August, a second GIFT workshop will be held

Teachers and scientists at the Gullele Botanic Gardens, Adis Ababa GIFT

in Cape Town on the occasion of the joint Conference of IAMAS-IAPSO-IAGA, which are the three world organisations dealing with Meteorology and Atmospheric Sciences, Physical Sciences of the Oceans and Geomagnetism and Aeronomy respectively.

Accordingly, the GIFT workshop will be planned for three days (roughly one day each for the IAMAS, IAPSO, IAGA) and will comprise a mixture of topical presentations and small, inexpensive hands-on activities for the classroom following the tradition of the EGU-GIFT workshops.

Teachers will also be invited to present any particular activity they may have developed with their own pupils during a poster session 'Science in Tomorrow's Classroom' which will be an integral part of the GIFT workshop (as in the European GIFTs, but for the first time out of Europe). In this poster session, which is open not only to teachers but to all participants to the joint conference, teachers will be invited to interact not only with their fellow teachers from schools in South Africa and elsewhere, but also with the scientists from all over the world.

The workshop will provisionally be held at the Cape Town International Convention Centre (CTICC) over at least two days, the third day at the Iziko Museum, given the large variety of opportunities that this museum offers for teachers, as clearly shown during the 2016 GIFT workshop.

We expect at least 50 teachers/educators and 10 organisers/speakers. With this 4th GIFT workshop, Africa becomes the continent where most of the non-European GIFT workshops will have been held.

After 15 years, the GIFT idea has not only grown significantly and reached more than 1 400 science teachers and through them thousands of high-school kids, it has also progressively broadened its views and targets to share scientific findings beyond the borders of Europe.

The cover of the brochure for the Adis Ababa GIFT

Dismantling a cell phone GIFT

Carlo Laj *is the Founder and Chair of the Education Committee of the European Geosciences Union. After his PhD in solid state physics, he spent a few years working on scattering of laser light, before moving into the field of geophysics. His main interest in the field is in the magnetic properties of sediments and igneous rock, particularly in the Eastern Mediterranean and Andes. His scientific career was with the French Atomic Energy Commission, first as a researcher in the Physics Department then in geophysics. In 1985, he was appointed Deputy Director of the Centre des Faibles Radioactivités and Head of the Department of Earth Sciences. He created and was the first director of the Laboratoire de Modélisation du Climat et de l'Environnement, which was later united with the Centre des Faibles Radioactivités to form the present Laboratoire des Sciences du Climat et de l'Environnement (LSCE). After three terms as Head of Department (12 years) he stepped down to pure research until his retirement since when he has gradually reoriented his activities towards education.*

Friedrich Barnikel *is a high-school teacher and the Educational Coordinator for Geography in Munich, Germany and is a committee member of the Education Committee of the European Geosciences Union. He has had an interest in the paleoecolgy of Africa since his thesis in 1998, which was on the state of the Sahara desert in the Holocene. He received a PhD from the University of Göttingen, on natural hazards in the European Alps, in 2003. His particular interest is in mountainous areas and earthquakes, but he also has a deep interest in climate change.*

Wendy Taylor *holds a PhD in Geology from the University of Rochester, USA. She began her career working as a collections manager, museum educator and exhibit developer at several major natural history institutions in the United States including the Paleontological Research Institution, The Field Museum and the University of Chicago. Pursuing strong interests in geoscience education, she then spent over 10 years working as an education specialist and programme developer at Arizona State University. At ASU, she was involved in developing education programmes for several NASA missions to the Moon and Mars and served as the education and public outreach lead for ASU's Astrobiology Program and at the Center for Meteorite Studies. Today she divides her time between education and research, working as a curriculum developer for ASU's Center for Education Through eXploration (http://www.etx.io/) and studying the evolution of early life across the Ediacaran-Cambrian boundary at the University of Cape Town, South Africa.*

Daksha Naran *has an MSc in Ichthyology from Rhodes University, Grahamstown, South Africa. Her deep passion in natural sciences: collections, curation biodiversity research and education emerged from her postgraduate experiences at the South African Institute of Aquatic Biodiversity (SAIAB), formerly the JLB Smith Institute. An initial career embedded in freshwater-based field and laboratory experiences consolidated her interest in aquatic biodiversity, including taxonomy, biosystematics and evolutionary biology with implications for sustainable environmental conservation. Currently, in her role as senior educator: natural history educator at Iziko museum, she is instrumental in developing a platform for engagement through the museum's vast natural science collection and inspiring educational practice for sustainability, environmental and conservation. The role has allowed her to consolidate a passion for natural sciences; scientific research to science education, and to mobilise efforts to broaden participation and access for Iziko South African Museum's rich collections.*

AFRICAN SKIES

Sivuyile Manxoyi reflects on the indigenous astronomy of southern African peoples

Southern Africa is home to some of the most important telescopes in the world, including the High Energy Stereoscopic System (HESS) in Namibia and the Southern African Large Telescope (SALT) in South Africa and is due to host the greater portion of the world's largest radio telescope, the Square Kilometre Array (SKA).

Recently questions have been raised about the objectivity of science and calls for the decolonisation of astronomy have emerged sporadically here in South Africa and more vociferously in the USA, particularly in Hawaii. Even though the multi-cultural roots of astronomy are generally accepted, indigenous astronomy is seldom specifically acknowledged.

PREHISTORY

In ancient times, people had access to pollution-free, clear dark skies and naturally developed a relationship with the stars, observing them frequently. Africa was no exception and in fact since we know that humanity originated in Africa, we can argue that the skies were first observed in Africa. Contributions from west and North Africa, particularly Mali and Egypt, are well known, and their associated ancient stone monuments attract tourism.

But what of southern Africa? Were celestial patterns and the jewels of the night sky never seen in southern Africa before colonial people arrived and before the invention of the telescope? The existence of ancient astronomy in southern Africa is not seen in stone monuments as it is in west and North Africa but found expression in daily and seasonal practices. It was part of holistic living and was and is linked with daily practices, cultural ceremonies, and rites of passage and has been retained and transferred through oral media, art and music.

THE PATTERNS OF THE STARS

Southern African people observed and used the big bright stars, the Sun, the Moon and the pattern of the stars for various purposes, including development of calendars, navigation, regulation of ceremonies, determination of the time and also for agricultural purposes.

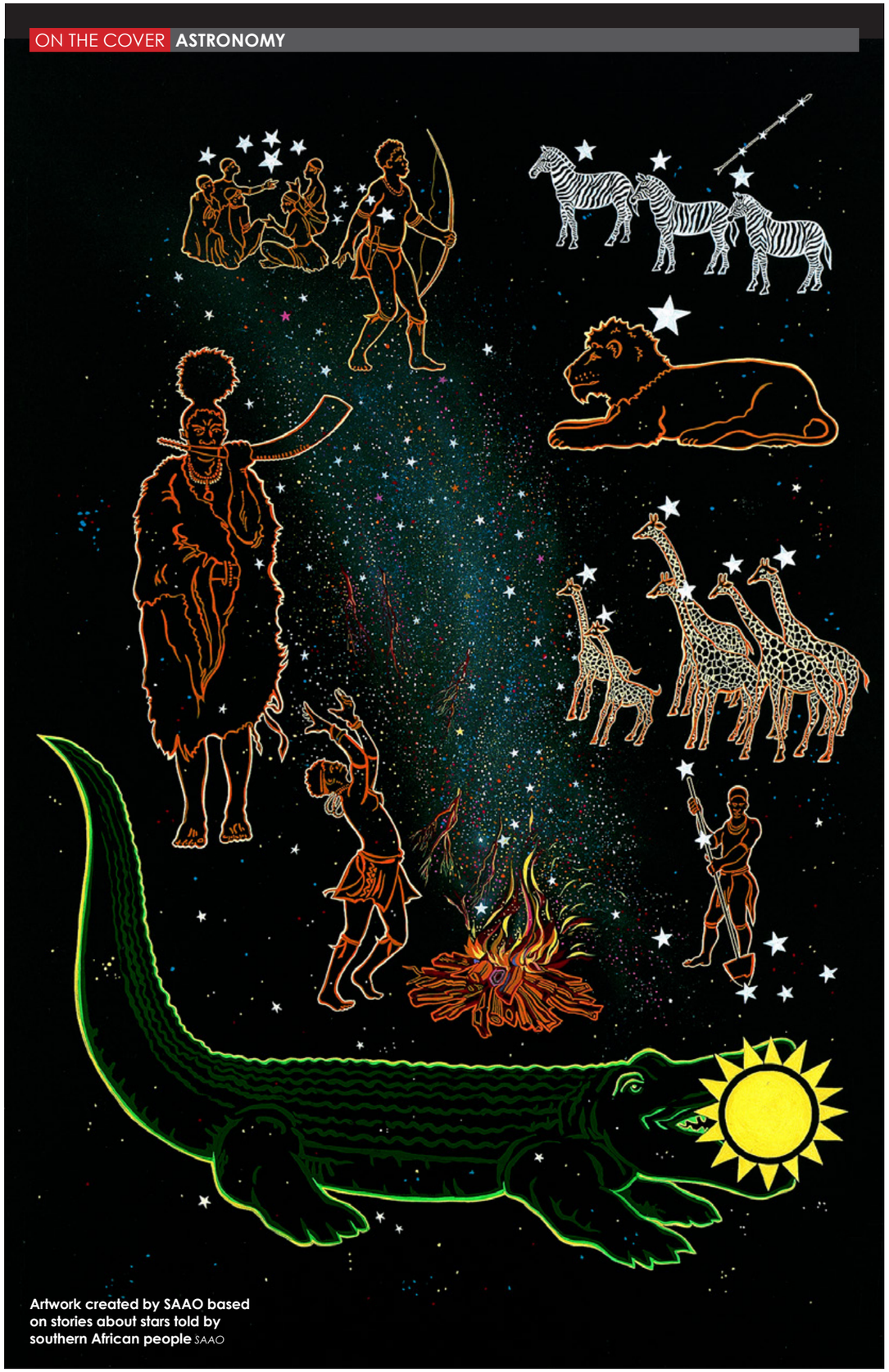
This is how some of the stars were used.

► Canopus

Canopus, the second brightest star in the sky, is used as a celestial marker to signify the beginning of the winter season. As most people were dependent on agriculture, the prediction of seasonal change and the first rains was a key factor in their lives. Canopus is known as Naka by Sesotho and Setwana speaking people, Nanga by the Venda, u Canzibe by the isiXhosa speaking people, u Cwanzibe by isiZulu speaking people, Khwekheti by the Tsonga people and Inkhwekweti by the Swazi people. The fifth month of the year is named after Canopus in the Xhosa and Swazi calendar. In isiXhosa, the month of May is called Eka Canzibe and in the Swazi calendar, it is called Inkhwekweti. For the Xhosa people Canopus was also used by the boys for 'ukutshitsha', because May is the month in which boys celebrate and mourn the end of their boyhood before they go to initiation school to become men. Most southern African people make a distinction between boyhood and manhood and the transition from one stage to the other is marked by attendance at the initiation school and, in many cultures, includes circumcision. For the Sotho, Tswana and Venda people, Naka and Nanga (meaning the horn star) was used as a signal for the beginning of winter. In ancient times, the first person to see the star would run up a hill or a mountain a blow the horn known as phalaphala to announce the first observation of the dawn rising of Canopus.

► Venus

The southern African people, in common with many other peoples of the world, also had a relationship with the planet Venus, and like most people of the time, thought of Venus as a star rather than a planet. The Xhosa people have four names for Venus: Ikhwezi (when Venus is observed in the morning in the east), Ikhwezil lesibini (the 'second Venus', during the day) and in the early evening is called by two names, u Madingeni (an appointment star) and u Cel'izapholo (Venus seen as begging for milk). The Xhosa people associated the appearance of Venus in the morning with diligence and people expected to either wake before or at the same time as the appearance of Venus in the morning. Even today some parents name their children as Khwezi or Nomakhwezi or Khwezi lomso, all names based on Venus and the parents'wishes and hopes that their children will be industrious and diligent members of the community.



Artwork created by SAAO based on stories about stars told by southern African people *SAAO*

Similarly, the Zulu people also called the morning Venus Ikhwezi, and Isicelankobe in the early evening (as in Xhosa, the star was viewed as begging for food). The Sotho and Tswana people also have two names for Venus, Mphatlalatsana (the brilliant one) in the morning and Kopadilalelo (the seeker of evening meals) in the evening. Most southern African people thought that the evening Venus and the morning Venus were different bodies.

► Pleiades

The linguistic and cultural unity of Africa is demonstrated by the star cluster, the Pleiades. In isiXhosa and isiZulu, it is called Isilimela. In seSotho and in seTswana, Selemela. The Pleiades are called Shirimela in Tsonga, Tshilimela in Venda, Chirimera in Shona and Karanga, Lemila in Nyasa and Cilimila in Gogo of Tanzania. The Pleiades were linked to agriculture and used to mark the time for cultivation. 'Ukulima' is to plant and therefore these stars were seen as 'digging, ploughing or planting stars'. The Xhosa people also linked the morning visibility of the Pleiades in June with counting the years of manhood. Even today, the years of manhood of Xhosa men are expressed in 'izilimela'. June is called Eyesilimela in isiXhosa.

The southern African people observed and used many constellations and galaxies such as Orion, the Southern Cross and the Large and Small Magellanic clouds, respectively, but these will not be covered in this article. They also used observations of the Moon in various ways.

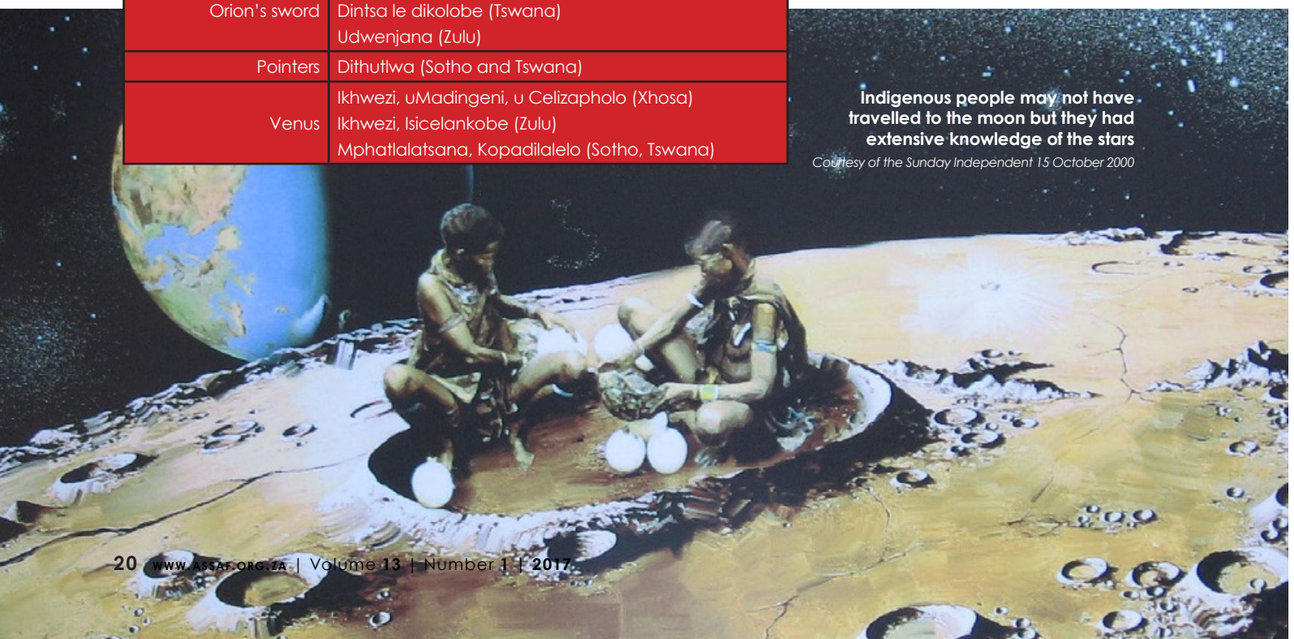
INDIGENOUS NAMES FOR PLANETS AND STARS

Jupiter	Moliana (Sotho) Imbalibusuku/Candabusuku (Xhosa)
Sirius	Qhawe/Ingqaqhawuli (Xhosa) Kgogamasigo (Tswana) Kgogamashego (Sotho) I Donsa (Zulu) Khohamutsho (Venda)
Canopus	U Canzibe (Xhosa) Cwanzibe (Zulu) Naka (Sotho, Tswana,Pedi) Nanga (Lobedu, Venda) Khwekweti (Swazi)
Achernar	Senakane (Sotho, Tswana) Tshinanga (Venda)
Alpha and Beta Crucis	Thuda (Venda)
Capella	Intshola (Zulu)
Fomalhaut	Ntshina (Tswana) Ndemera (Shona)
Gamma and Delta Crucis	Thudana (Venda)
Orion's belt	Amakroza (Xhosa)
Orion's sword	Dintshwa (Sotho) Dintsa le dikolobe (Tswana) Udwenjana (Zulu)
Pointers	Dithutlwa (Sotho and Tswana)
Venus	Ikhwezi, uMadingeni, u Celizapholo (Xhosa) Ikhwezi, Isicelankobe (Zulu) Mphatlalatsana, Kopadilalelo (Sotho, Tswana)

INDIGENOUS ASTRONOMY OUTREACH

In a bid to make the indigenous astronomy knowledge accessible, the SAAO, through its education and outreach unit, has created a number of opportunities and platforms for the general public to access this information. A colourful A4 page which summarises indigenous southern African knowledge on stars can be sourced at the SAAO. Further work has been done to include artwork based on the indigenous knowledge of the southern African people in the freely accessible planetarium programme Stellarium. Assistance and guidance can be offered by SAAO outreach staff. Also available here: http://www.saao.ac.za/?attachment_id=6829

World Wide Telescope tours based on indigenous starlore are also obtainable at SAAO.



Indigenous people may not have travelled to the moon but they had extensive knowledge of the stars

Courtesy of the Sunday Independent 15 October 2000

ASTRONOMY IS NOT COLONIAL, IT'S ALL OURS

Astronomy is neither foreign nor colonial in Africa – its origin is within the continent. Southern Africa peoples must rightfully claim their contributions and participate in modern astronomy. The continent's history has sadly been characterised by race, class and gender oppression, domination and discrimination, and eras in which many voices were either suppressed, excluded or marginalised. However, this does not make astronomy colonial in any way, but highlights the interconnection between science and society, but also shows that science in an abnormal society runs the risk of also being abnormal. In the past, we used rock art and stories to preserve our knowledge. Today we have added new methods of data collection, analysis and interpretation. Today, the youth of Africa have opportunities to study and utilise advanced forms of data collection and analysis. Let them seize the opportunities that are rightfully theirs and use modern science to give the world a better and human face. SALT, HESS and SKA are not only beacons of hope and inspiration but also mark the continuation and deepening of what the ancients had already started. The universe is yours too – rediscover it.

REFERENCES

► The Crocodile who swallowed the Sun and other stories: This is for young children and is available free of charge from SAASTA and SAAO. It has also been translated to various languages.

► Cosmic Africa: a documentary based on Prof. Thebe Medupe's work. He explores the relationship between ancient African astronomy and modern astronomy. He undertakes a journey to Botswana, Mali and Egypt, and examines the relationship between indigenous and modern astronomy. This is available at libraries and commercially. It was produced and directed by Craig and Dannon Foster.

► The Ancient Astronomers of Timbuktu, a documentary on the work done by a group of astronomers led by Prof. Thebe Medupe in exploring ancient astronomy in Timbuktu. Available in the local libraries and commercially.

► World Wide Telescope tours for young children including the popular 'The Hopless Hunter' obtainable freely from SAAO.

► The SAAO What Up Note – freely available from SAAO website, print copies available at the SAAO library.

__Sivuyile Manxoyi__ manages the Southern African Large Telescope Collateral Benefits Programme (SCBP), which is responsible for astronomy education, communication and awareness. He also manages socio-economic development linked to SALT. He believes that culture can be utilised to advance science and technology.

CURRICULUM CORNER

NATURAL SCIENCE:

► Earth and Beyond – historical development of astronomy and indigenous knowledge based on stars for grade 7 and 8.

GRADE 4 – 7 :

► Earth and Beyond – the need to clarify that all people have a relationship with the stars and they used them for various purposes.

Containing explosions

Genevieve Langdon discusses the research that helps us understand how layered materials behave in explosions

ON THE COVER MATERIALS SCIENCE

Layered materials are sometimes used to combine the best properties of metals and composites into one structure. Composite materials, like fibre-reinforced plastics, are made from at least two different materials – the fibres and the plastic. When these materials are combined into the composite, a new material with different characteristics to the individual parts is produced. Composites are very strong and stiff for their mass, but they are also easily damaged in an explosion. Metals are heavier but are more able to withstand damage. By combining layers of metal and composites we hope to make a material that is more damage proof (like a metal) but still lightweight (like a composite) (Figure 1).

One of the problems of putting layers into a material is joining the layers together. In an explosion, the loads are very high and 'normal' glue breaks, making the material very weak. We need to understand how to join the layers together to make the materials stronger and better able to withstand explosions.

THE RESEARCH – JOINING PROPERTIES

Before we can test our materials under explosions, we first have to make them and assess whether the bonding between layers is good. To do this, we make panels with thin sheets of aluminium alloy and woven glass fibre-reinforced plastic. We use different types of surface treatments on the aluminium surface to try and to improve the bonding, such as special cleaning techniques, grit blasting, etching and chemical surface treatments. We have also tried using a film adhesive between the sheets to improve the bonding.

We then manufacture special test pieces with a small crack in the bond between the metal and composite layer. The official name of the test is the single leg bend experiment. Using a bend test machine, we cause the crack to open up and measure the force required to do that (Figure 2). From that we can work out the crack opening forces and energy needed to break the bonding. This lets us know which surface treatments work the best. From our experiments we found that using grit blasting and a chemical surface treatment together gave the best results.

THE RESEARCH – EXPLOSION TESTING

At the Blast Impact and Survivability Research Unit (BISRU) we have been performing small-scale explosion tests to understand how layered materials behave under blast loading. We detonate small quantities of plastic explosive under realistic conditions near to the layered panels. All materials absorb some of the explosion energy by breaking in some way under different levels of loading. Some of the possible ways to fail the composite materials are shown in Figure 3. The test set up is shown in Figure 4.

Some of our recent work has shown that panels containing composites, like our layered panels, are better able to contain explosion loading that is uniformly distributed. We also see that improving the bonding of the layers makes the materials perform better in explosion tests. So far we have found that the best layered material containing glass fibre and aluminium layers is a commercial material called GLARE. GLARE is used to manufacture Airbus aircraft parts, so it is encouraging that this is the best of the layered materials. A ruptured GLARE panel is shown in Figure 5.

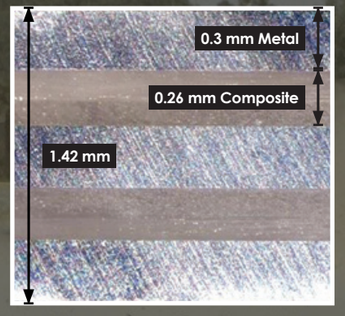


Figure 1: A cross-section of layered material with metal and composite parts *Genevieve Langdon*

WHAT IS AN EXPLOSION?

An explosion is quick release of a large amount of energy in a very short time. There are three main types – mechanical, chemical or nuclear. The most common type and the one that creates the biggest news headlines is a chemical explosion. Explosive detonations are the ones that make the headlines – as a result of deliberate terrorist attacks. A lot of effort goes into preventing explosives from detonating in public spaces, such as trying to identify potential terrorists before they act and by increasing security. Unfortunately, as you have probably watched on the news this year, terrorists can still find ways to hurt people and destroy structures by detonating explosives. Prevention is definitely the best option, but it is still necessary to understand the effects of explosions on materials just in case the worst should happen.

Once an explosive (like TNT or C4) detonates, it sends shock waves out that rapidly compress the surrounding air. This causes a high-pressure blast wave that travels through the air and has destructive effects on objects in its path. As the blast wave comes into contact with an object, a very high pressure rise occurs almost instantaneously, followed by a decay in pressure back to atmospheric pressure. The peak pressure magnitude and duration of the blast wave depend upon the source of the explosion (how much and what type of explosive), how far the waves travel (pressure decreases with distance) and what it's travelling though (air, water, sand, for example). If the blast occurs in a confined space, like a tunnel, the explosive energy is greater because the pressure waves cannot escape.

Figure 2: Single leg bend testing to test the bond properties – the crack is opening up
Genevieve Langdon

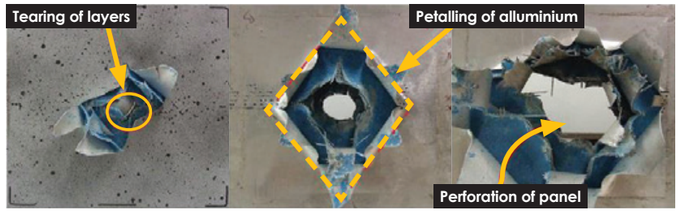


Figure 3: Some of the damage types observed in blast test layered panels
Genevieve Langdon

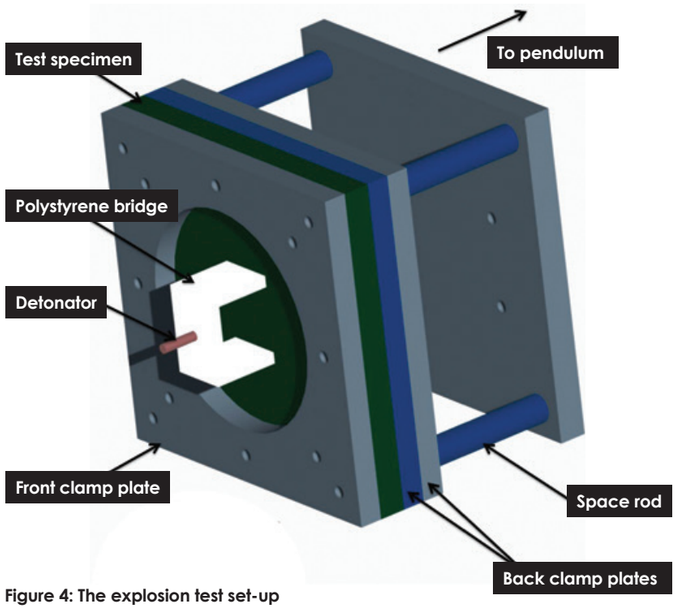


Figure 4: The explosion test set-up
Genevieve Langdon

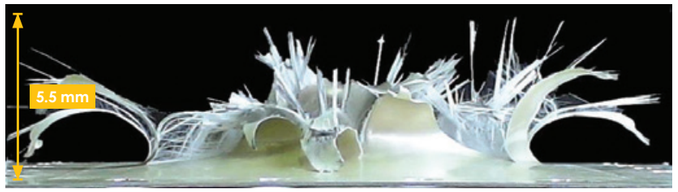


Figure 5: Ruptured GLARE panel *Genevieve Langdon*

CURRICULUM CORNER - NATURAL SCIENCES

► Matter and Materials ► Properties of materials ► Chemical reactions

WHY ARE COMPOSITES BEING USED?

THE ADVANTAGES OF COMPOSITE MATERIALS, WHEN COMPARED WITH METALS, ARE:

► Lightweight (a big advantage in the design of transportation vehicle).
► High stiffness/strength-to-weight ratios.
► The ability to tailor the properties of the composite to suit the precise application by changing the fibre directions.

WHY USE A LAYERED MATERIAL?

LAYERED MATERIALS (WITH METAL AND COMPOSITE LAYERS) ARE:

► Lighter than metals alone
► More damage-proof than composites alone
► Offer better fatigue resistance than metal alone
► Show improved fuel efficiency (important for transport applications because of the low weight).

Professor Genevieve Langdon *is Professor and Deputy Head of the Mechanical Engineering Department at the University of Cape Town (UCT). She heads up research on lightweight materials at the Blast Impact and Survivability Research Unit (BISRU) at UCT. She investigates blast-resistant materials and structures for use in structural and transportation applications. She seeks to make the world a safer place by improving our understanding of a structures' response to explosion loading. She has a PhD in Mechanical Engineering from the University of Liverpool. She has published her research in many journal articles, conference proceedings, popular media and books. Genevieve is also a chartered engineer, member of the South African Young academy of Sciences and an NRF rated research scientist.*

A lure at both ends - Puff adders leave nothing to chance

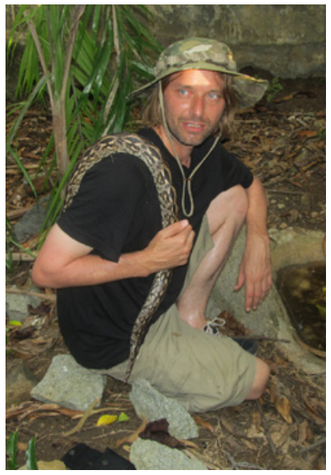
The puff adder *(Bitis arietans)* is one of Africa's deadliest snake species, not only because of its deadly venom, but also because of its stealthy hunting behaviour, ambushing prey. Making it even more deadly, research has now shown that puff adders actively lure prey into striking range.

By capturing and analysing thousands of hours of video footage of puff adders hunting in the wild, Wits University researchers, Xavier Glaudas and Graham Alexander, have shown that puff adders use what is termed 'lingual luring' to attract amphibian prey closer, and increase the odds of catching it.

'A puff adder's strike is typically no longer than one or two head lengths (5 - 10 cm) in distance, so it needs a strategy to attract potential prey to come within that striking range in order to catch it,' says Glaudas, a herpetologist and post-doctoral fellow at the Alexander Herpetology Laboratory at Wits University. 'We have found that puff adders use their tongues, which resemble the invertebrates that frogs feed on to increase prey-capture rate.'

Funded by the National Geographic Committee for Research and Exploration,

A puff adder *Wits University*



Xavier Glaudas with a puff adder
Wits University

Glaudas and Alexander tracked 86 puff adders over three years at the Dinokeng Game Reserve, about 100 km north of Johannesburg in South Africa. Glaudas captured wild snakes and tracked them by surgically implanting radio transmitters into the snakes and releasing them at their place of capture.

'We really wanted to have a closer look into the secretive lives of these fascinating animals, and specifically study their foraging ecology,' says Glaudas.

To aid his research, Glaudas and Alexander used video cameras set up in front of puff adders that were lying in ambush position.

'We placed our cameras mounted on a tripod about 70 cm away from the snake, and the camera continuously recorded what was going on. We came back the next morning to get the memory cards and reviewed everything that happened during the night,' says Glaudas. 'We gathered over 4 600 hours of video footage of snake foraging. So, that is 193 days of continuous footage – over half a year.'

What Glaudas and Alexander saw surprised them. 'It was complete luck,' says Glaudas. 'We know that snakes use their tongues to pick up scent cues in their environment, but these snakes were extending their tongues out of their mouths for up to 30 seconds, which is dramatically longer than what they do when they are just using their tongues to "smell" their environment. We know of several species that use tongue-luring to attract prey. Some wading birds, like egrets do it, as well as alligator snapping turtles and some aquatic snakes, but this is the first time that it is reported in a terrestrial snake,' says Glaudas.

Even more surprising was the fact that the snakes only used lingual luring to attract amphibian prey.

'All the cases of lingual luring that we have observed, occurred with frogs, which suggests that puff adders are able to distinguish between amphibian prey and other prey like small mammals.'

Glaudas and Alexander also witnessed puff adders waving their tails, suggesting that they use their tails as lures as well. However, none of the tail-luring behaviour attracted prey within the camera's field of view, and more data on this are needed.

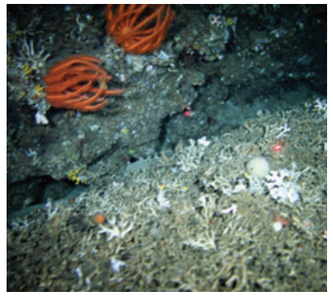
'We suspect that this behaviour is also used to attract prey, as it is pretty common in snakes, including adders, but we weren't able to observe prey capture with the videos' says Glaudas.

Issued by: Schalk Mouton, Senior Communications Officer | Wits Communications

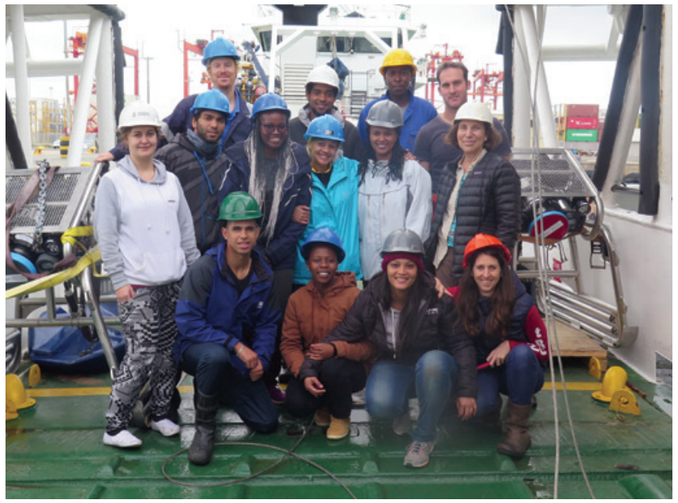
Deep secrets revealed: research expedition sheds light on deep-sea ecosystems

After a month at sea, 13 scientists, technical experts and students returned from the 'Deep Secrets' research cruise that has expanded ocean knowledge in South Africa. The team sailed from Cape Town on 26 September 2016 traversing the shelf edge from off Robben Island on the west coast to the outer shelf off the Kei River mouth via the very tip of the Agulhas Bank, the southernmost point of the African continental shelf. The cruise track covered more than 3 000 km collecting information about the geology, oceanography, biodiversity and ecology at 61 research stations. Most of the stations were below 200 m, providing new insights into South Africa's poorly studied deep-sea ecosystems. The researchers used a towed camera and a Go-pro in specialised underwater housings to shed light on a range of never-before-seen habitats. The deepest station surveyed was at a depth of 1 035 m off Knysna and represents the deepest visual biodiversity survey in South Africa to date.

'Deep Secrets' is a project of the multi-disciplinary African Coelacanth Ecosystem Programme, catalysed through a joint initiative with the Oceans and Coasts Branch of the Department of Environmental Affairs and the Department of Science and Technology, facilitated through the Presidential Operation Phakisa Oceans Economy Laboratory. The project and expedition was led by the Principal Investigator, Dr Kerry Sink, a scientist at the South African National Biodiversity Institute. One of the key project goals is to develop deep-sea research capacity across multiple institutions and as such the expedition included staff from nine of the 15 organisations collaborating on the project. These include the Oceans and Coasts Branch of the Department of Environmental Affairs, the South African National Biodiversity Institute, the South African Institute for Aquatic Biodiversity, the South African Environmental Observation Network, Nelson Mandela Metropolitan University, the University of Cape Town, the University of the Western Cape, Eastern Cape Parks and Tourism and Scripps Institution of Oceanography in California. Research goals focused on characterising different habitats in the outer shelf, shelf edge and slope to inform management and spatial planning in South Africa's ocean. This includes the development of offshore Marine Protected Areas (MPAs) and the implementation of Marine Spatial Planning, a process to optimally zone the increasing number of activities in the sea.



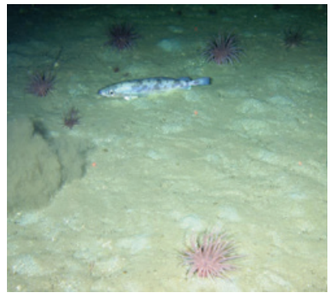
One of the first images of a cold water coral reef in South Africa's deepsea environment *SAIAB*



Scientists and technicians from nine organisations collaborated in this multi-disciplinary expedition to deepen ocean understanding in South Africa *SAIAB*

The cruise was hosted aboard the Department of Environment's research vessel *Algoa*. The sampling was designed to understand different aspects of the marine environment. Echo-sounder surveys were conducted to examine features on the sea floor, particularly submarine canyons, offshore ridges, deep reefs and mounds thousands of years old made by cold-water corals. Although museum records indicated the presence of reef-building corals in deep-water, such habitats have never before been observed in South Africa. Biodiversity sampling included deep-water camera surveys and many specimens were collected using a sled (towed sampling device) and a grab (steel jaws that take a bite out of the seabed). The biodiversity samples provided specimens so scientists can identify and count animals seen in photographs and video footage and examine the small creatures that live within seabed sediments. They will also be used for genetic barcoding and in studies to characterise the foodweb and understand energy flow. Innovative plankton sampling was also done using nets attached to the tow camera. Oceanographic sampling provided measurements of sea temperature, oxygen and the pH of the water, which varies with depth and region. Such information is critical to help understand climate change sensitivity and impacts, which must be factored into spatial ocean management.

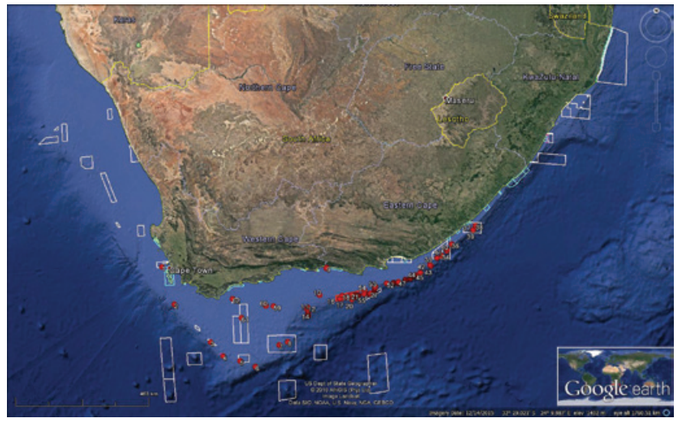
The findings of the cruise were extensive, with over 3 000 seabed images, many gigs of video footage and more than 600 biodiversity samples. A steep coral-encrusted rocky ridge on the slope off Port Elizabeth, submarine canyons in the Amathole area and coral habitats at Browns Bank on the west coast are some the key undocumented features that were investigated by the team. 'We were amazed at the complexity and variability in seabed ecosystems' said Sink, reflecting on 'the mosaic of sandy habitats, the diversity on gravel slopes, the strange creatures captured in the Agulhas muds and the beauty and fragility of the deep coral ecosystems'. Some of the more surprising finds included a garden of giant pink sea anemones off Port Elizabeth, kingklip in sandy burrows off Kenton and the presence of fish eggs and larvae in the fronds of soft corals across the study area. The latter discovery indicates that coral habitats may serve a nursery function for fish and the team is excited to learn the identity of the fish species involved.



A hake in among a garden of anemones in an untrawled area off Port Elizabeth *SAIAB*

The expedition covered seven of the 21 new proposed Phakisa MPAs, providing the first images in five of these areas and contributing baseline information to inform MPA implementation and management. Fortuitously, a fuel stop provided an opportunity to engage with fisheries stakeholders and together with further radio communication at sea, this helped raise awareness and build understanding of the interaction between trawlers and south coast rock lobster fishers and cold-water coral habitats.

The journey was not easy, with a number of challenges such as equipment failure, contending with severe weather and port delays while trying to achieve project goals and pioneer new sampling approaches. Achievements could not have been realised without the skill of the navigating officers, capable technicians and dedicated crew aboard the vessel. Deep-sea lectures were held to complement the practical experience gained by the team with international collaborator Professor Lisa Levin (Scripps Institution of Oceanography) sharing scientific knowledge and application with links to the Deep Ocean Stewardship Initiative (DOSI).



Map showing the 61 cruise research stations covering 15 habitat types and 7 of the proposed new Phakisa Marine Protected Areas in South Africa *SAIAB*

Kerry Sink and scientist Zoleka Filander from the Oceans and Coast Branch of the Department of Environmental Affairs examine corals collected at the newly discovered Secret Reef, a reef composed of many years of coral growth on the shelf edge off Knysna *SAIAB*

Highlights of the expedition include the first photographs of deep-water coral ecosystems in South Africa, new live coral specimens for further research, the discovery of the potential role of soft corals as fish nurseries and first observations of some fish and invertebrates in their natural deep-water habitats. Areas of future research were identified including understanding the effects of climate change on deep-water coral habitats and the impact of demersal trawling on deep-sea ecosystems. Back on dry land, the team will return to their laboratories to analyse specimens, video, images, bathymetry and oceanographic data collected in the field. New student projects will also be developed offering exciting research opportunities for other young scientists to work with the Deep Secrets team in 2017 and beyond.

Cellphone-based maths competition subtracts Mxit, adds Android

The week starting 26 October 2016 marked the end of a landmark Mxit-based maths competition – which has run nationally, provincially and city-wide since 2013 – and the launch of a brand new android-based maths competition, which will kick off in 2017.

The TouchTutor™ Maths Competition, sponsored by the Capitec Foundation, was developed to 'popularise' maths among tech-savvy learners – and its developers, Nelson Mandela Metropolitan University's Govan Mbeki Mathematics Development Unit (GMMDU), are determined to keep it fresh by shifting to the latest cellphone technology.

Next year's competition will run on a new app, available free from the App Store. The app gives access to assigned tests for competition purposes, along with other downloadable tests, which can be used for curriculum support by learners anywhere in the country.

'It's so important to recognise, support and flag talent among the youth – and this is an innovative way to stimulate interest,' said GMMDU head Prof. Werner Olivier.

The announcement of the new competition format took place on Wednesday 26 October 2016, at the prizegiving for last year's Grade 9 and 11 competition winners. Ironically, the top spots in each went to learners in the grade below – Alexander Road High Grade 8 learner Brandon le Roux, 14, and Pearson High Grade 10 learner Kianna Peterson, 16.

Neither had studied the Grade 9 or 11 maths syllabus before attempting the curriculum-aligned maths tests. 'I just get maths,' said Le Roux, who is interested in pursuing an accounting career. 'I've entered many other maths competitions … Maths comes easily to me.'

Peterson, 16, who is planning to study actuarial sciences, said her win was a surprise, 'not knowing Grade 11 work.' 'I just looked at the different equations and figured it out.'

The school with the highest number of participants was Get Ahead College in Queenstown.

GMMDU's Dr Philip Collett, who heads up the mobile maths competition, said: 'We want to see it grow – we have big plans for it.'

The mobile competition is just one of the high-tech resources that have been developed by GMMDU. They also have a curriculum-aligned teaching and learning model for maths and science, called TouchTutor™, which is available on tablets for selected Grade 10 to 12 learners, and laptops for teachers. And they have a desktop model, which is placed in schools to form resource labs.

The maths competition – and the other tests that will be available through the new app – is part of their focus on 'mobile assessment and support'. The tests will have automated feedback on scores and solutions.

'We would love to get this app to thousands of learners in far-flung places, who can then use their phones to revise maths,' said Collett.

Downloadable and assigned tests, which will be available online or offline on the new app, can also be used for in-school, local, district, provincial and national competitions. 'The Capitec Foundation will continue to sponsor this project – and may also introduce some financial literacy competitions, linked to maths.'

The new app will have language support in six indigenous languages, and will be available from Grades 8 to 12.

The app can also be extended to other subjects, provided the right partners are found.

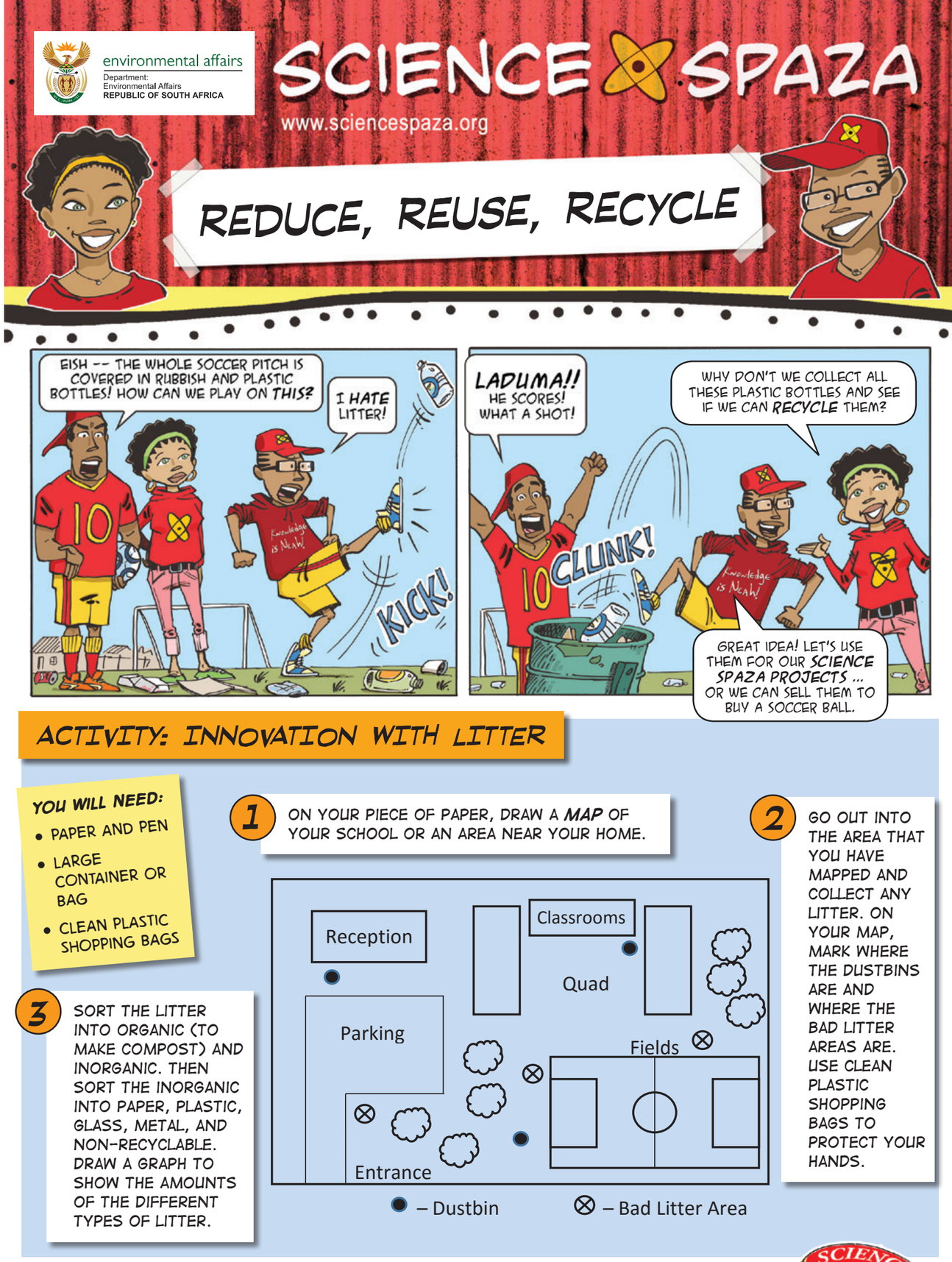
Capitec Foundation's Neptal Khoza said: 'We believe maths is the one thing we need to solve the challenges of the country … When you've done maths, it makes things much easier. You're able to reason … You're able to engage as a society and come up with a solution.'

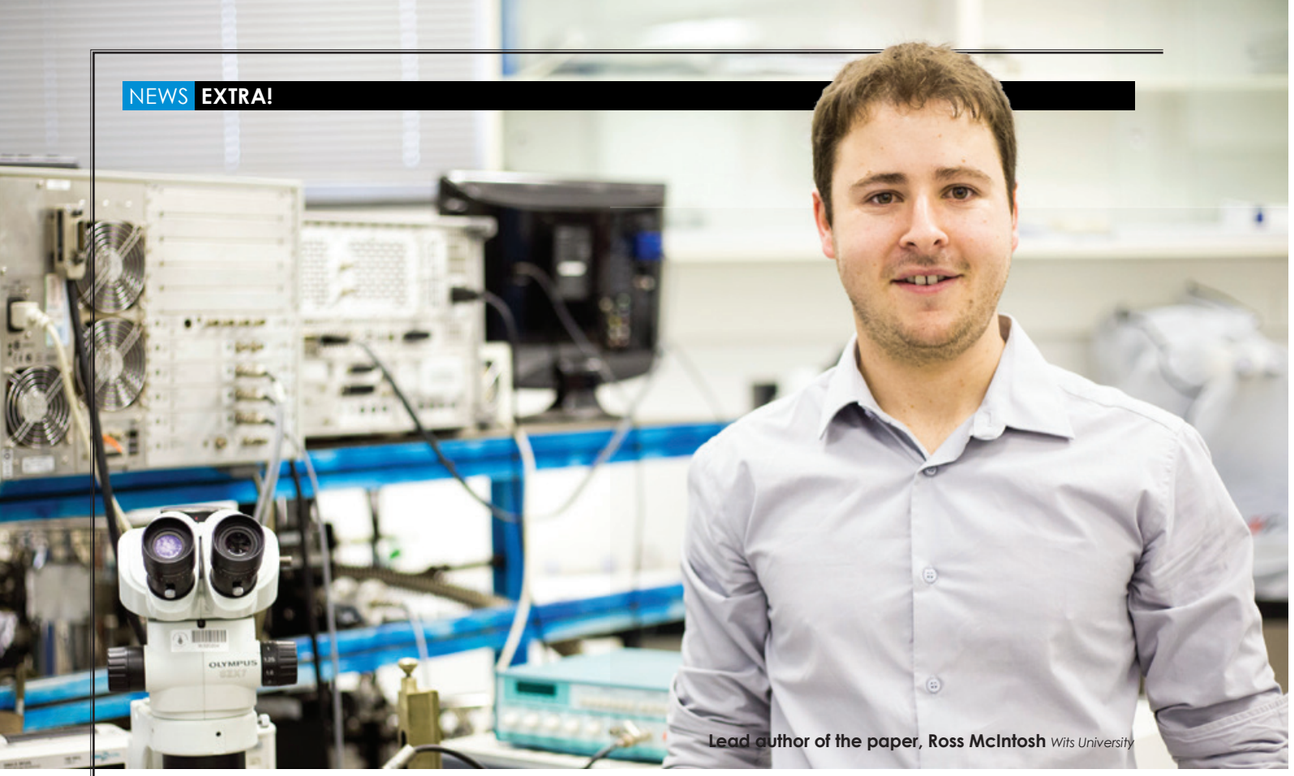
He said levels of numeracy and critical thinking had deteriorated among school-leavers – with many learners being discouraged from taking maths.

'There's no silver bullet to fix education [in South Africa] but there's no excuse for us not to do what we can.'

The other Grade 9 winners in this year's mobile maths competition, all from Pearson, were Bianca Gouws (second), Peter Mehrtens (third) and Paige-Louise Katz (fourth). The other Grade 11 winners, also from Pearson, were Abby Sieberhagen (second) and Tyler van Huyssteen (third). All the winners received money vouchers for Capitec bank accounts.

Congratulating the cellphone-based TouchTutor™ Maths Competition winners Brandon le Roux, 14, from Alexander Road High and Kianna Peterson, 16, from Pearson, are (from left) Capitec Foundation's Neptal Khoza and Nicky Mbelebele, and Prof. Werner Olivier, head of Nelson Mandela Metropolitan University's Govan Mbeki Mathematics Development Unit *GMMDU*





Lead author of the paper, Ross McIntosh *Wits University*

Wits researchers find techniques to improve carbon superlattices for quantum electronic device applications

Researchers at the Nanoscale Transport Physics Laboratory from the School of Physics at the University of the Witwatersrand (Wits) have found a technique to improve carbon superlattices for quantum electronic device applications. Superlattices are made up of alternating layers of very thin semiconductors, just a few nanometres thick. These layers are so thin that the physics of these devices is governed by quantum mechanics, where electrons behave like waves. In a paradigm shift from conventional electronic devices, exploiting the quantum properties of superlattices holds the promise of developing new technologies.

The group, headed by Professor Somnath Bhattacharyya, has been working for the past 10 years on developing carbon-based nano-electronic devices.

'Carbon is the future in the electronics field and it soon will be challenging many other semiconductors, including silicon,' says Bhattacharyya.

The physics of carbon superlattices is more complex than that of crystalline superlattices (such as gallium arsenide), since the material is amorphous and carbon atoms tend to form chains and networks. The Wits group, in association with researchers at the University of Surrey in the UK, has developed a detailed theoretical approach to understand the experimental data obtained from carbon devices. The paper has been published in *Scientific Reports* (Nature Publishing Group) on 19 October 2016.

'This work provides an understanding of the fundamental quantum properties of carbon superlattices, which we can now use to design quantum devices for specific applications,' says lead author, Wits PhD student, Ross McIntosh. 'Our work provides strong impetus for future studies of the high-frequency electronic and optoelectronic properties of carbon superlattices.'

Through their work, the group reported one of the first theoretical models that can explain the fundamental electronic transport properties in disordered carbon superlattices.

Bhattacharyya started looking at the use of carbon for semiconductor applications almost 10 years ago, before he joined Wits University, when he and co-authors from the University of Surrey developed and demonstrated negative differential resistance and excellent high-frequency properties of a quantum device made up of amorphous carbon layers. This work was published in *Nature Materials* in 2006.

McIntosh undertook the opportunity at honours level to measure the electrical properties of carbon superlattice devices. Now, as a PhD student and having worked extensively with theoretician Dr Mikhail V Katkov, he has extended the theoretical framework and developed a technique to calculate the transport properties of these devices.

Bhattacharyya believes this work will have immense importance in developing carbon-based high-frequency devices.

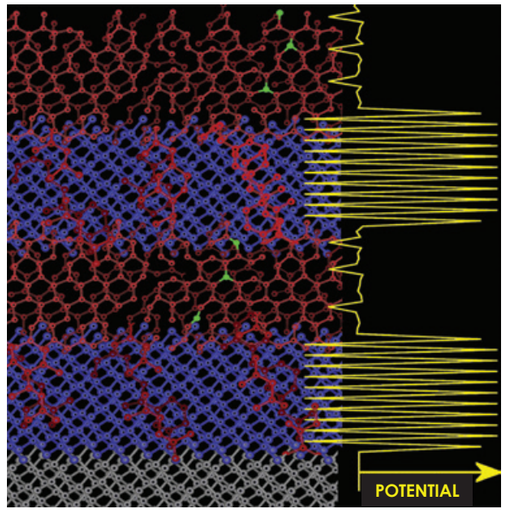
'It will open not only fundamental studies in carbon materials, but it will also have industrial applications in the electronic and optoelectronic device sector,' he says.

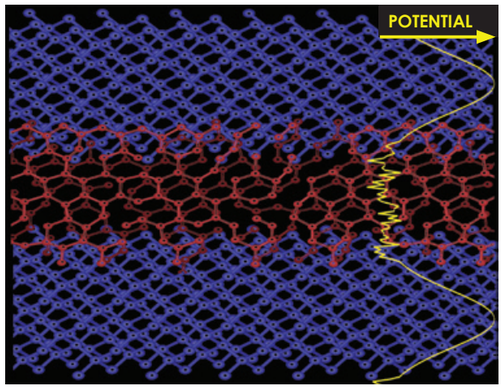
Superlattices are currently used as state-of-the-art high-frequency oscillators and amplifiers and are beginning to find use in optoelectronics as detectors and emitters in the terahertz regime. While the high-frequency electrical and optoelectronic properties of conventional semiconductors are limited by the dopants used to modify their electronic properties, the properties of superlattices can be tuned over a much wider range to create devices which operate in regimes where conventional devices cannot.

Superlattice electronic devices can operate at higher frequencies and optoelectronic devices can operate at lower frequencies than their conventional counterparts. The lack of terahertz emitters and detectors has resulted in a gap in that region of the electromagnetic spectrum (known as the 'terahertz gap'), which is a significant limitation, as many biological molecules are active in this regime. This also limits terahertz radio astronomy.

Amorphous carbon devices are extremely strong, can operate at high voltages and can be developed in most laboratories in the world, without sophisticated nano-fabrication facilities. New carbon-based devices could find application in biology, space technology, science infrastructure such as the Square Kilometre Array (SKA) telescope in South Africa, and new microwave detectors.

'What was lacking earlier was an understanding of device modelling. If we have a model, we can improve the device quality, and that is what we now have,' says Bhattacharyya.





A schematic atomic diagram of a quantum well made from amorphous carbon layers. The blue atoms represent amorphous carbon with a high percentage of diamond-like carbon. The maroon atoms represent amorphous carbon which is graphite-like. The diamond-like regions have a high potential (diamond is insulating) while the graphite-like regions are more metallic. This creates a quantum well as electrons are confined within the graphite-like region due to the relatively high potential in the diamond-like regions. The maroon chains through the diamond-like regions represent polymeric chains, a feature which is unique to carbon superlattices. Superlattices are made up of a series of quantum wells. The green atoms represent nitrogen impurities *Wits University*

About the Wits Nanoscale Transport Physics Laboratory

The Wits Nanoscale Transport Physics Laboratory (NSTPL) was established in 2009 under the leadership of Bhattacharyya when Professor João Rodrigues was the Head of the School of Physics at the University of the Witwatersrand, South Africa. The department is known as a leading physics school in the African continent, having one of the largest academic staff complements on a single campus. Since the opening of the laboratory, the NSTPL has gone from strength to strength in establishing a facility that houses world-class fabrication and measurement equipment, an initiative strongly supported by research entities such as the NRF, CSIR, Wits Research Office and DST/NRF Centre of Excellence in Strong Materials.

The NSTPL is well equipped with various sophisticated synthesis facilities, as well as a cryogenic micro-manipulated probe station to conduct sensitive quantum transport measurements at temperatures near absolute zero. The NSTPL also houses a fully operational electron beam lithography scanning electron microscope, used to fabricate nanoscale devices based on these carbon materials.

Some noteworthy current projects include the fabrication of spintronic devices using supramolecular Gd-functionalised carbon nanotubes, the fabrication of graphene field effect transistors and most recently the study of the unconventional superconductivity observed in boron-doped diamond. The NSTPL group has also published a number of papers on theoretical investigations, led by Dr Mikhail Katkov and Dr Dmitry Churochkin, on the role of disorder on the quantum transport in carbon systems. These various topics form part of the broader direction the group has taken, that being, investigating the physics of carbon materials in the hopes of finding application in quantum information systems as well as detector devices valuable for space exploration.

Issued by: Schalk Mouton, Senior Communications Officer | Wits Communications

Who made the art?

Researchers find way to determine the sex of the artists who created ancient rock art

Prehistoric human ancestors that created hand stencils in caves 40 000 years ago can now be identified as male or female with more than 90% accuracy.

Ancient hand stencils were made by blowing, spitting or stippling pigment onto a hand while it was held against a rock surface, leaving a negative impression on the rock in the shape of the hand. Hand stencils are frequently found alongside pictorial cave art created during a period known as the Upper Palaeolithic. Stencils found in Sulawesi, Indonesia, date back 40 000 years, and those discovered in Europe are estimated to be as old as 37 000 years.

This study, published in December 2016 (open-access) in the *Journal of Archaeological Science*, utilised techniques used in modern forensics to analyse stencils created by student volunteers and researchers as part of a collaborative research project between anthropologists and archaeologists at the University of Liverpool, the University of Central Lancashire (UCLAN) and the University of the Witwatersrand (Wits) in South Africa.

University of Liverpool biological anthropologist, Dr Emma Nelson, led the study. She said: 'Archaeologists are interested in hand stencils because they provide a direct, physical connection with an artist living more than 35 000 years ago.'

The cave in daylight – an artificial portable cave wall that allows students and researchers to produce rock art without having to go underground
Jason Hall, University of Liverpool

The cave in action – experimental reproduction of cave art in simulated cave conditions by researchers and students at the University of Liverpool
Jason Hall, University of Liverpool

'Now, using a new experimental application, results from our study indicate it is possible to determine, with more than 90% accuracy, the sex of someone who lived tens of thousands of years ago, from the shape and size of their hand outline. We have even applied the method to hand stencils where digits are missing – common in Palaeolithic art – something prior studies have not been able to do.'

Previously, researchers focused on hand size and finger length, often producing conflicting results. Here, a technique called geometric morphometrics was used to detect sex-based differences in hand shape and form. Known-sex hand stencils were digitised and a series of 2D landmarks were applied to statistically evaluate the true shape and relative size of each stencil.

Dr Patrick Randolph-Quinney, a forensic anthropologist at UCLAN and Wits University, said: 'The problem with focusing on hand size and finger length is that two different shaped hands can have identical linear dimensions and ratios. To capture shape, we applied geometric morphometrics, a technique that had never been tested on hand stencils.'

Randolph-Quinney says this geometric approach is very powerful as it allows researchers to look at the palm and fingers independently. 'It revealed that the shape of the palm is actually most indicative of the sex of the individual, rather than the finger size or length.'

Jason Hall, an archaeologist, also a member of the team from the University of Liverpool added: 'As part of this study we built a replica cave wall to allow us to experiment with how art was made, and how it might look under different lighting conditions – without having to go deep underground. This "portable cave" has been really popular with the public, especially school groups, who can make art in the same way that our ancestors did.'

Project co-ordinator, Dr Anthony Sinclair, a Reader in Archaeology at the University of Liverpool and an expert in Palaeolithic archaeology said: 'This is a great example of how archaeological science and forensic science are working together to advance our understanding of the past, and the social and cognitive systems that evolved during the Upper Palaeolithic.'

'We would encourage other researchers to apply this method to different human populations so we can build a more global understanding of hand variation.'

The full report, Beyond size: The potential of a geometric morphometric analysis of shape and form for the assessment of sex in hand stencils in rock art, appears in the *Journal of Archaeological Science*.

Find the article online here: http://dx.doi.org/10.1016/j.jas.2016.11.001 Issued by: Schalk Mouton, Senior Communications Officer | Wits Communications

ONLINE **COURSE**

Free online course

Extinctions: Past and Present

Have you ever wondered about the diversity of life on our planet, and how this came to be? Have you pondered over what happened to the dinosaurs, mammoths and other organisms that we find only as fossils? Given the high rates of extinctions today are you concerned about the future of organisms and ecosytems on our planet? Starting in March 2017 Professor Anusuya Chinsamy-Turan, based at the University of Cape Town, will be offering a free online course, *Extinctions: Past and Present*, on the UK Open University's online learning platform, FutureLearn. The course explores the history of life on Earth through geological time, and looks at how life on Earth has been shaped by the five mass extinction events that occurred in deep time. The last week of the course is about the crises that biodiversity is facing today. In the course Anusuya Chinsamy-Turan interviews several scientists (palaeontologists, microbiologists, ornithologists, ecologists, etc) who each share their research experiences in this area.

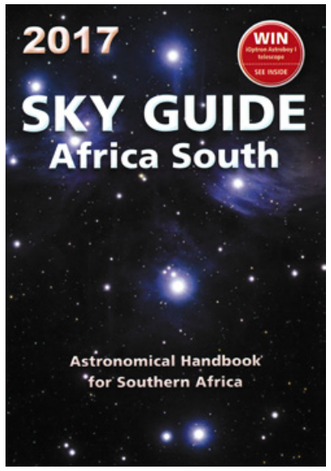
This five week course is at a popular level, and it is open to anyone with an interest in science or environmental issues. The course is delivered completely online through video lectures, short texts, optional discussions and quizzes as well as additional readings. Completing the course requires roughly two to three hours per week.

Extinctions: Past and Present is developed by the University of Cape Town, and filmed on location at the Iziko South African Museum, the West Coast Fossil Park, Kirstenbosch National Botanical Gardens, and the Table Mountain National Park.

Come and learn with Professor Anusuya Chinsamy-Turan, who is an acclaimed paleobiologist, NRF A-rated researcher, and author of academic and children's books on fossils. She is also former South African Woman of the Year, and in 2013 she was awarded the World Academy of Science's Sub-Saharan Prize for the Public Understanding and Popularization of Science.

If you would like to learn more or enroll in this course please visit: https://www.futurelearn.com/courses/extinctions-past-present

BOOK REVIEW

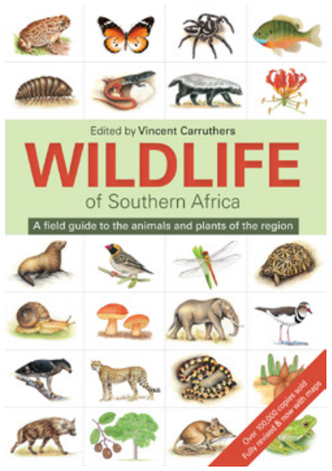


STARGAZING 2017

2017 Sky Guide Africa South – Astronomical Handbook for Southern Africa. By Astronomical Society of Southern Africa. 2017. Struik Nature. Cape Town.

The *Sky Guide Africa South* is published annually and is an invaluable resource for anyone who enjoys watching the night sky – and more to the point – enjoys understanding what they are watching. The handbook is prepared by the Astronomical Society of Southern Africa for use by the novice, amateur and professional astronomer and offers a wealth of information about the Sun, Moon, planets, comments meteors and bright stars. The information is clear and accessible, with diagrams that support the text.

This volume provides the 2017 information on the movement of the planets, any eclipses, the dates of meteor showers and has clearly-presented star charts to aid in identifying stars and constellations in the southern African night skies.



DIVERSE WILDLIFE

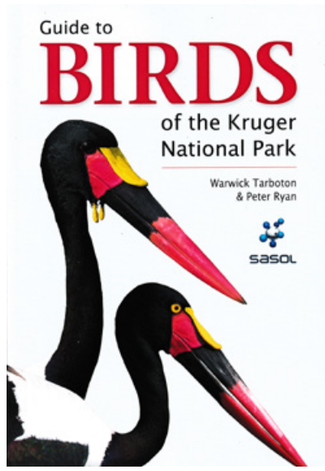
Wildlife of Southern Africa – a field guide to the animals and plants of the region. By Vincent Carruthers (Ed). 2016. Struik Nature. Cape Town.

This is a wonderful all-in-one guide for all adverturers, travellers and tourists. This edition is comprehensively updated and includes new artwork and, for the first time, range maps for all entries at species level. As in the previous edition, all entries are fully updated with the latest taxonomy and common names.

The book features more than 2 000 carefully selected plants and animals, large and small, that are likely to be encountered during a visit to any part of the region. Each chapter has been written by a leading expert in the field.

Each chapter is colour coded for easy reference and there are short accounts giving key diagnostic features, accompanied by accurate full-colour illustrations.

A must for all nature lovers.



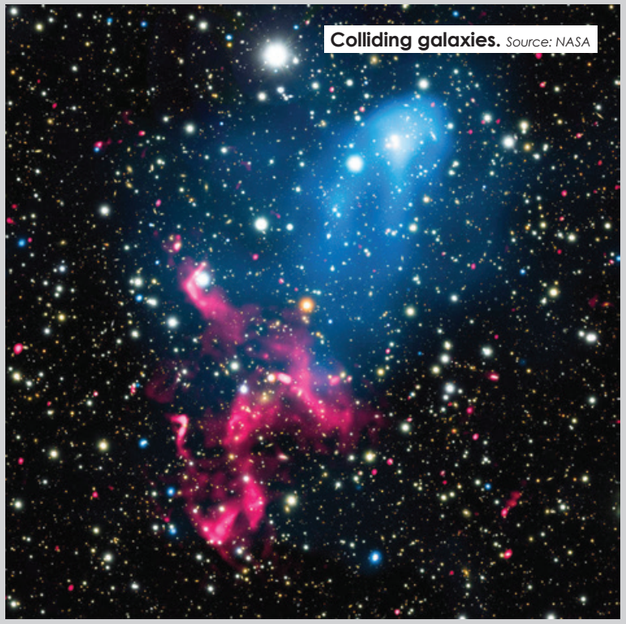
KRUGER BIRDS

Guide to Birds of the Kruger National Park. By Warwick Tarboton and Peter Ryan. 2016. Struik Nature. Cape Town.

The Kruger National Park is one of the largest and best-known conservation areas in the world. Although most people visit to see the famous Big Five, the bird life in the park is staggering in its diversity. There have been some 500 species recorded within its range, representing more than half the number of species found across southern Africa.

This book is filled with informative species accounts, full-colour photographs and distribution maps that show actual sightings, making it an essential guide for easy identification. There is an introductory chapter on the park's geology, vegetation types, climate and rainfall and the importance of these in bird distribution.

An essential companion on any trip to the Kruger area.



Colliding galaxies. *Source: NASA*

WHEN GALAXIES COLLIDE…

Astronomers have discovered what happens when the eruption from a supermassive black hole is swept up by the collision and merger of two galaxy clusters. This composite image contains X-rays from Chandra (blue), radio emission from the GMRT (red), and optical data from Subaru (red, green, and blue) of the colliding galaxy clusters called Abell 3411 and Abell 3412. These and other telescopes were used to analyse how the combination of these two powerful phenomena can create an extraordinary cosmic particle accelerator.

X-ray: NASA/CXC/SAO/R. van Weeren et al; Optical: NAOJ/Subaru; Radio: NCRA/TIFR/GMRT)

A person wearing eye glasses. *Wikimedia Commons*

NEW GLASSES MAY HELP MINIMISE PERIPHERAL VISION LOSS

Vision scientists may have discovered how to reduce pedestrian collisions in crowded and chaotic open-space environments like shopping malls involving individuals with partial blindness. Researchers have determined from which direction collisions with partially blind pedestrians are most likely to originate and this understanding will guide the development of new glasses that expand the sight of a person with limited peripheral vision.

Researchers at Harvard Medical School are developing new devices based on prism-containing eyewear they previously designed. New prism-containing glasses would bend light to hit areas of the eye that still function, expanding what a patient could see.

Harvard Department of Ophthalmology (with information provided by the Association for Research in Vision and Ophthalmology)

COMPOUND EYES FOR INDUSTRY AND SMARTPHONE

Fraunhofer researchers have developed a process enabling the production of a 2 mm flat camera. Similar to the eyes of insects, its lens is partitioned into 135 tiny facets. Following nature's model, the researchers have named their mini-camera concept facetVISION.

Just as with insects' eyes, the Fraunhofer technology comprises many small, uniform lenses positioned close together, similar to the pieces of a mosaic. Each facet receives only a small section of its surroundings. Just as an insect's brain aggregates the many individual images of the facets to a whole picture so in Fraunhofer's newly developed facetVISION camera, micro-lenses and aperture arrays take over these functions. Due to the offset of each lens to its associated aperture, each optical channel has an individual viewing direction and always depicts another area of the field of vision.

The cameras are suitable in medical engineering, for instance – for optical sensors, which will be able to examine blood quickly and easily, and in the printing industry, where such cameras are needed to check the print image at high resolution while the machine is running.

Further applications might include cameras in cars that help parking or in industrial robots that prevent collisions between man and machines, and in smartphones.

Fraunhofer-Gesellschaft

The first prototype of the technology transfers the images from the camera to the smartphone by Bluetooth via a transmission box

NEW EVIDENCE OF LANGUAGE-LIKE ABILITIES IN BIRDS

Scientists are reporting new evidence that birds can communicate meaningfully with each other by re-arranging the same sounds in different ways.

The ability to combine a limited number of words and phrases to create meaning is called syntax – a hallmark of human language. New findings suggest that birds known as Japanese great tits have a form of this ability as well, and they are not the only birds that may be revealing language-like abilities.

The scientists found that they use various calls and combinations of calls to interact in specific situations.

A combination of sounds known as 'ABC calls,' for instance, means 'watch out!' – the birds use them to warn each other of nearby predators such as raptors. Another type of call known as the 'D calls' means 'come over here,' a call the birds use after discovering a new source of food or when wanting their partner to come to the nest.

However, the birds often combine these two calls into so-called 'ABC-D calls' when, for instance, the birds encounter predators and join forces to frighten them away. When hearing a recording of these calls played in the natural order of ABC-D, the birds are alarmed and flock together, the scientists said. However, if the call ordering is artificially reversed to D-ABC, the birds don't respond.

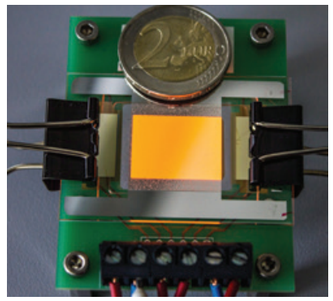
Japanese great tits use various calls and combinations of calls

Wikimedia commons

Source: World Science, http://www.world-science.net

MILESTONE IN GRAPHENE PRODUCTION

For the first time, it is claimed, it has been possible to produce functional OLED electrodes from graphene. The process was developed by Fraunhofer researchers together with partners from industry and research. The OLEDs can, for example, be integrated into touch displays, and the miracle material graphene promises many other applications for the future. It is claimed to be the perfect material: transparent, stable, flexible, conductive, and ideal for touchscreens, photovoltaics, wearables and much more.



Orange luminous OLED on a graphene electrode. The two-euro coin (exactly the same diameter as our similar-looking R5 coin) serves as a comparison of sizes

Researchers at the Fraunhofer Institute for Organic Electronics, Electron Beam and Plasma Technology FEP from Dresden, together with partners, have succeeded for the first time in producing OLED electrodes from graphene. The electrodes have an area of $2 \times 1cm^2$.

Graphene is considered a new miracle material. The advantages of the carbon compound are impressive: graphene is light, transparent and extremely hard and has more tensile strength than steel. Moreover, it is flexible and extremely conductive for heat or electricity. Graphene consists of a single layer of carbon atoms which are assembled in a kind of honeycomb pattern. It is only 0.3 nanometres thick, which is about one hundred thousandth of a human hair. Graphene has a variety of applications – for example, as a touchscreen in smartphones.

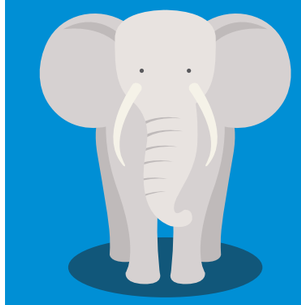
Many other applications are also conceivable: in windows, the transparent graphene could regulate the light transmission or serve as an electrode in polarisation filters. Graphene can also be used in photovoltaics, high-tech textiles and even in medicine.

Fraunhofer-Gesellschaft

MIND-BOGGLING MATHS PUZZLE FOR QUEST READERS

What is as large as an elephant but has no mass?

Answer to Maths Puzzle no. 39: 13 212



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