In short

- Jacob Zuma, South Africa's recently elected president, has inherited a country of contrasts
- Science and technology were not big election issues, but the change of leadership raises many questions for the country's scientists
- South Africa's scientific workforce is an aging one, and the country is not producing enough science graduates to fill the skills gap
- Government and industry alike are working to tackle the skills shortage by improving science teaching in schools

Cape Town, below Table Mountain

At the crossroads

Fifteen years after Nelson Mandela won South Africa's first democratic elections, the 'rainbow nation' continues to face challenges as diverse as its people. Linda Nordling reports

TIBOR BOGNAR / CORBIS

On a sunny day, the disparities of modern-day South Africa are clearly visible from the 'upper campus' of the University of Cape Town, perched on the slopes of Table Mountain. Close-by suburbs are characterised by large houses in leafy streets – the rule of thumb in Cape Town being that the closer to the mountain, the more expensive the property. In the distance, the sun reflects off the corrugated iron roofs of Khayelitsha, Africa's second largest slum.

Such contrasts are commonplace here. In the big cities, first world technology and infrastructure exist side by side with third world poverty. The legacy of apartheid is everywhere – in the education system, the property market, even where people choose to go for their Sunday picnics.

It has been difficult to second-guess South Africa since the end of apartheid. The race war that pessimists predicted in the early 1990s was averted – mostly thanks to the example of reconciliation set by Nelson Mandela.

But the days when South Africa was a place of boundless optimism are over. Many voters who headed to the polls in the country's fourth free elections in April this year felt disillusioned with how the African National Congress (ANC) is running the country. Although support for the ANC remains strong nationwide, the ruling party lost ground in all South African regions except for KwaZulu-Natal, the birthplace of Jacob Zuma, South Africa's new president.

'The message from the government is genuine – they want to boost science'

Science and technology was never going to be a big election issue. Nevertheless, there is a lot at stake for South African researchers as Zuma takes up the reins.

A central question is whether year-on-year increases will continue in the country's gross expenditure on R&D. This plummeted in the early 1990s when the apartheid regime's

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Jacob Zuma promises to be a charismatic leader

military projects were wound down, but after hitting a low of 0.60 per cent of GDP in the mid-1990s, it has risen again and measured 0.95 per cent of GDP in 2006/07.

While the ANC government under Thabo Mbeki promised further boosts – in a science and technology strategy published in 2007, the ANC said it wants to increase the country's total R&D spend to 2 per cent of GDP by 2018 – questions remain over Zuma's science spending plans. And while the 2 per cent target would have placed South Africa between France and Canada (based on 2005 figures), it remains far behind the country that tops the league, Sweden, which spends around 4 per cent of GDP on R&D. Meanwhile, R&D investment by South African industry is continuing to fall (see box).

Scientific heritage

South Africa has a long and noble tradition in research. Initially an outpost of Europe's scientific outfits, it built its own strong research community in the 20th century. A landmark in this process was the establishment in 1945 of the Council for Scientific and Industrial Research (CSIR), and many senior researchers look back to the early years of the CSIR as a 'golden era'.

The nature of the industries that emerged in South Africa meant that chemistry became a key subject for research. In the early days, explosives and fertilisers were needed in mining and agriculture. Later, companies involved in chemicals, coal- and gas-to-liquids and nuclear technology went on to create huge industrial demand for chemists.

'Chemistry has been one of the strongest sciences in South Africa,' says Piet Steyn, a chemist who worked at the CSIR in its heyday and made a name for himself in the field of fungal toxicology. Today, he is emeritus professor at Stellenbosch University, an hour's drive from Cape Town.

Steyn is a fine representative of the strong tradition of South African chemistry. But he also symbolises a central challenge. Data show that South Africa's scientific workforce is largely male, largely white and ageing rapidly.

According to a study by the Centre for Research on Science and Technology (CREST) at Stellenbosch University, 50 per cent of the country's scientists who published peer-reviewed articles were aged over 50 in 2004, compared with only 20 per cent in 1990. Equally worryingly, between 1990 and 2004 there had been no significant change in the demographic profile of publishing scientists. Whites still produced over 90 per cent of all articles, and men

Industrial investment

Despite the government's recent increases in research spending, R&D expenditure in South Africa's industrial sector continues to fall. Last year, the Organisation for Economic Co-operation and Development (OECD) reported that South African businesses' share of the gross domestic expenditure on R&D (GERD) had dropped from 56 per cent in 2001 to 44 per cent in 2005.

The government has not missed the significance of this decline. In 2006 the government began offering companies tax deductions on R&D expenditure, and in its 2007 science policy, the Department for science and technology emphasises the need to encourage the growth of innovative businesses in order to become a 'knowledge economy.' It wants South Africa to commandeer a 25 per cent share of the global hydrogen and fuel cell catalysts market by 2018, and for the country to be one of the top three emerging economies in the global pharmaceutical industry.

The government's 2007 strategy outlines five 'grand challenges' that it wants the country's science base to address. Areas targeted are biotechnology; space science; clean and affordable energy; climate change; and understanding shifting social dynamics in developing and emerging economies.

But while South Africa has plenty of chemistry-hungry big corporations such as Sasol and Anglo American, its tally of small innovative companies is low. An Innovation Fund set up in 1999 to encourage the creation of new companies has only produced modest results, and is now being merged with South Africa's four Biotechnology Regional Innovation Centres into a one-stop-shop for innovation support.

The problem has only been worsened by the global financial crisis, which is taking its toll on the country's technology-intensive businesses. Falling commodities prices have impacted on the mining industry. The collapse in the global car market is hitting South Africa's platinum industry – which supplies metal for much of the world's vehicle emissions catalysts – where it hurts. Employment forecasts are gloomy. But this could mean that more students choose to remain in academia – a faint silver lining for universities.

accounted for over 83 per cent.

The 'greying workforce' is a serious problem in chemistry, says Graham Jackson, deputy head of the department of chemistry at the University of Cape Town (UCT). It is 'virtually impossible' to attract professors from overseas, he says. Not just because it is difficult to compete on salaries, but also because uncertainty about the long-term security of South Africa puts many off.

Skills shortage

Intensifying the problem of the aging academic workforce is the shortage of science graduates flowing into research. The country's own universities are a leaky pipeline. Some graduates move overseas, many decide to take well-paid jobs in industry. Since the country's skills shortages affect business too, students can sometimes walk into jobs without even graduating, Jackson says. 'My MSc student was offered a salary twice mine and a BMW convertible, and he hadn't even finished his degree.'

One of the companies feeling the shortage of science and engineering graduates in South Africa is Sasol, the country's coal- and gas-to-liquids giant (see box p50). It has embarked on a 10 year, Rand250 million (£20 million) programme to boost chemistry and chemical engineering departments in the country. 'We source almost all of our scientists and engineers from within South Africa,' says Jacqui O'Sullivan, Sasol group communications manager.

Sasol offers bursaries to both undergraduates and graduate students and has established a charitable trust, the Sasol Inzalo Foundation, to improve mathematics and science training in schools. 'This is essential given the severe shortage of adequately prepared students entering the science and technology fields at university level,' says O'Sullivan.

TAMERYN STRINGER

Tameryn Stringer has benefited from UCT's support programme, and recently came near top of her honours class

The key problem restricting the supply of science students into South Africa's universities is the low quality of science teaching in the schools catering for the country's many poor – the majority of whom still belong to black and 'coloured' (mixed race) communities. The scale of it is such that government support programmes – though genuinely well-intended – cannot cope, says Mike Green, former manager of the homogenous catalysis and organic synthesis group at Sasol who recently took up a post as head of chemistry at the University of Newcastle, UK.

'The message from the government is genuine, they want to boost science. But the service delivery is hampered by poverty and by a lack of teachers,' he says.

The Royal Society of Chemistry (RSC) has joined forces with the Sci-Bono centre for school science in Johannesburg to fund a 'chemistry bus'. This will tour schools in the Soweto township and showcase chemistry experiments to students whose schools lack the facilities to teach them practical science.

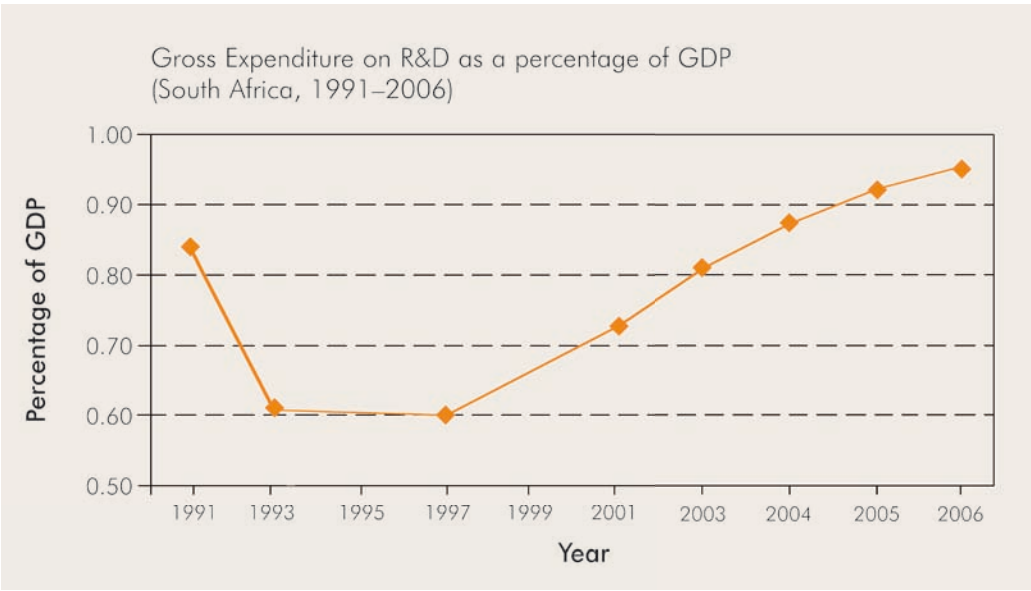
These are the young people the government must draw on if it wants to fulfil its ambition to increase the number of active researchers in the country from 11 500 in 2005 to 20 000 in 2018, says Ian Scott from UCT's Centre for Higher Education Development. 'If we don't get the growth from black and coloured populations, we won't grow,' he says.

Scott has studied trends in university admissions and pass rates since 1994. An impressive 70 per cent of students enrolling at university are now black, he says. But this number represents just 12 per cent of black youth aged between 20 and 24 years, while the corresponding number for whites is 60 per cent. Pass rates among blacks are also lower, he adds.

Much of this discrepancy boils down to poor primary and secondary schooling, Scott says. Even good students from these schools often struggle at university.

Universities have introduced schemes that give inadequately prepared students extra tuition and support. At UCT, this programme is called the General Entry for Programmes in Science (GEPS) and usually involves doing the first year of an undergraduate degree over two years.

Can South Africa's new leadership maintain the coutry's impressive growth in R&D spending?



Support systems

The GEPS model is working well. One measure of its success is that a number of chemistry students who have gone through GEPS every year go on to do 'honours' degrees – a one-year qualification between a bachelor's and master's. To enter the honours programme, students must attain at least a 60 per cent pass rate in their third year.

Tameryn Stringer, a first year masters student doing medicinal chemistry at UCT, is one of these success stories. The first in her family to go to university, she started out in the GEPS programme but went on to score among the top three in her honours class. Her family is egging her on to do a PhD. 'They are very proud,' she says. But she thinks she might work in industry first for a

MICHELINE PELLETIER

Tebello Nyokong, chemistry professor at Rhodes University, is a powerful role model

few years after her master's degree. It might mean moving abroad, she concedes. 'There's not much opportunity in South Africa.'

Some academics claim that the extra teaching burden is squeezing research. But, says Scott, if you study budgets it's actually the other way around. At UCT, researchers are winning large amounts of money from external sources. Since the university does not get enough funding to meet the overheads for these projects, this money comes from the only available source. 'Student tuition fees end up subsidising research,' he says.

In chemistry the overheads funding gap has led to poor maintenance and dilapidated laboratories across the country. But the government recently set aside sizeable amounts of money for infrastructure projects. Although

Company profile: Sasol

Global concern about oil supplies has played into the hands of Sasol, a South African company that has been converting coal and gas into liquid fuels since the 1950s, and which is now the biggest employer of scientists and engineers in the country.

Sasol started out as a state-owned company to reduce apartheid South Africa's dependence on overseas oil producers. It uses Fischer–Tropsch (FT) catalysis to convert syngas – a mixture of carbon monoxide and hydrogen that can be made by heating coal or gas – into liquid fuels. The technology was developed in Germany in the 1920s and used to feed Hitler's war machine. At the outset, it found few takers since it was more expensive than producing fuel from crude oil.

But rising oil prices and supply concerns, as well as the perceived environmental benefits of the sulfur-free fuel, mean FT technology is back in vogue. And Sasol, which was privatised exactly 30 years ago, is the market leader. Its share value has grown steadily and last year its operating profit was Rand34 billion, a 32 per cent increase from 2007.

Since the end of apartheid, Sasol has jumped at the opportunity to expand its business internationally. It owns a large stake in the Oryx gas-to-liquids (GTL) plant in the gas-rich Gulf state of Qatar, which is the world's largest GTL facility outside South Africa. However, the plant, which opened in 2006, has been beset by teething problems. Not least of these is the high level of fine powder-like material formed in the complex cobalt slurry-bed reactors Sasol chose for the FT process. This material impacts the subsequent steps of the GTL process, limiting throughput. Although Sasol says these problems have been solved, the plant still produces far below its full capacity of 34 000 barrels per day – producing an average of 22 000 barrels per day in the six months to 31 December 2008.

Lessons learnt from Oryx will be applied to future ventures, says Sasol, which include a GTL plant being constructed in Nigeria. It is also exploring joint ventures in China and India and signed an agreement to develop a GTL project in Uzbekistan in April this year.

In addition to using coal and gas as feedstocks, Sasol has also looked into biofuels, co-feeding biomass with coal, which, the company says, works well. The challenge is the logistics of collecting, drying and transporting sufficient plant material to a production facility. 'While we keep studying these opportunities, we believe that there are very limited locations in the world where this can be done in a CO_2 negative or neutral manner,' a Sasol spokeswoman told *Chemistry World*.

Sasol has a long history with synthetic fuels

SASOL

Sasol is actively trying to reduce its environmental footprint to shrug off its image as a major polluter. Although synthetic fuels can be cleaner than those produced from crude oil, their production traditionally creates large amounts of CO_2. Sasol-funded scientists at the University of St Andrews in Scotland embarked on a £4.5 million project in December to investigate ways of improving the efficiency of the production process.

For example, the refining of FT-produced 'syncrude' has the potential to be more efficient than crude oil refining, argues Arno de Klerk, who until 2008 headed Sasol's Fischer–Tropsch Refinery Catalysis group.[1] On a molecular level, syncrude is significantly different to crude oil, but little attention has so far been paid to tailoring the refining process to FT-derived material. Such research would have commercial as well as environmental benefits, de Klerk concludes.

However, the global financial crisis has not spared the company, and research will be hit. Earlier this year it announced a 40 per cent cut in its capital expenditure. This will affect R&D, although exactly which programmes may be scaled back is not clear, a spokesperson said. 'Technology has always been at the heart of Sasol and the company tends to keep a longer term view. Hopefully, this will allow us to protect our R&D activities through this turbulent time.'

Reference:
1 A de Klerk, *Green Chemistry*, 2008, **10**, 1249 (DOI: 10.1039/b813233j)

SCI-BONO CENTRE, JOHANNESBURG, SOUTH AFRICA

by no means enough to meet universities' every refurbishment need, it has helped them invest in new equipment and facilities.

The University of the Western Cape, a former 'black' university, is building a new Rand550 million life sciences building, another hopeful sign that change is underway. A string of research-minded appointments has transformed the university, says Renfrew Christie, its dean of research. This allows 'modern science, not 1980s science' to be taught to its students, most of whom are from humble backgrounds, he says.

Role models

A number of young, black scientists are leading the way for the future of South African academia. One of them is Tebello Nyokong, professor of medicinal chemistry at Rhodes University in Grahamstown, on the country's east coast. She won the 2009 Africa/Asia category of the L'Oréal-Unesco Award for Women in Science for her work on photodynamic cancer therapy.

Inspiring school students is key to attracting more of them to study science at university

'African countries are not seen as equal contributors of knowledge, and I want to change that perception'

Nyokong is a passionate advocate for women in science and a powerful role model. She says she will never leave South Africa for a better-paid job overseas. 'African countries are not seen as equal contributors of new knowledge and I want to change that perception. Can I do this alone? No! But I will try anyway.'

There are others. Kelly Chibale, a Zambian, holds a chair in medicinal chemistry at UCT and leads a research group that studies treatments for HIV, malaria, hypertension and cancer. And Lindiwe Khotseng, born in the township of Gugulethu near Cape Town as one of six siblings, carries out nanotechnology research at the University of the Western Cape.

It is tricky to say what is around the corner for South African science. The new science minister, former education department head Naledi Pandor, will have her work cut out to beat the reputation of Mosibudi Mangena, who kept his nose clean and the Department for Science and Technology's coffers filled during his five years in office. This will be especially challenging as flagging economic growth likely puts pressure on government budgets.

Next year, South Africa will host the football world cup. It is an acid test for the country, and many eyes will be straying from the pitch to gauge whether the 'miracle' of the 1990s has succumbed – as some fear – to the rampant corruption and nepotism that afflict many of its neighbours. But those who expect South Africa to fit neatly into either of those two extremes will be sorely disappointed. They will see hope for the future mixed with fear, great opportunities alongside great despair. For better or worse, South Africa remains a country of contrasts.

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