FROM **HOPE** TO **ACTION** THROUGH **KNOWLEDGE**

The Renaissance of the
University of the Western Cape

2001 – 2014

Editors

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22

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

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Introduction

Brian O'Connell became the Vice-Chancellor of the University of the Western Cape in 2001. By then I had completed my doctoral research at UWC and had taken up a postdoctoral fellowship abroad. Meaningful personal interaction with Prof O'Connell began once I returned to South Africa in late 2007 to take up a research position at the South African National Bioinformatics Institute (SANBI) at UWC. At the time of my return, Prof Vladimir Bajic was Director of SANBI.

Bioinformatics is an interdisciplinary field. Researchers strive to manage copious amounts of information – data – from the traditional academic disciplines such as biology, mathematics, statistics and computer science. Historically, bioinformatics was perceived as a field that provides technical support to the more established medical and biological studies disciplines. However, since the mid-1990s and early 2000s there has been an exponential growth in the accumulation of medical and biomedical data. The only researchers who were at ease carefully and properly processing – following all the correct research protocols – large volumes of data were the researchers in the bioinformatics fraternity. Increasingly, medical and biomedical researchers re-evaluated their perception of the field as a support area and leaned more towards these researchers as

FROM HOPE TO ACTION THROUGH KNOWLEDGE

integral members of research projects. The perception of bioinformatics as a service offering only had been breached and it was now accepted as a full interdisciplinary research discipline. Researchers were expected to have a full grasp of biology and computer science, still the dominant components of this field, but also a sound knowledge of mathematics, statistics and especially genetics.

In the early part of the 21st-century bioinformatics was securely located in the broad area of science research as most of the researchers follow traditional scientific methodologies. However, while the researchers were schooled in the hard sciences, they had to adapt their own perception of their research focus to include collaborations with public health scholars and community health practitioners. Today bioinformatics is regarded as a scientific discipline. Scientists from this discipline need to collect, to classify, to interpret and to be able to store large swathes of genomic data using general and specifically designed computer programs to do so.

Prof Brian O'Connell, by disposition and training an educationist who had previously worked in the teacher-training profession, and later as a provincial administrator of education in the Western Cape, was gifted with the ability to see the University as a research entity made up of disparate research areas that, together, could draw on and support each other in his vision for a research-led UWC. SANBI was already a microcosm of this vision, especially as the influence of its founder, Prof Winston Hide, who began this enterprise in 1996, continued to have an impact on the way we expand our interdisciplinary programme.

Prof O'Connell was instrumental in seeing and enabling the ever-growing SANBI to distinguish itself beyond the boundaries of UWC and to pursue research with other institutions in South Africa and also the rest of the world (by this time, Prof Hide had relocated to the USA to take up a position at an Ivy League university).

The influence of Prof O'Connell on my leadership style

The idea of differentiating UWC from other higher education institutions was foremost in the mind of Prof O'Connell, who positioned SANBI as a niche area for UWC at a time when universities were being restructured. He appreciated that the innovation space could position UWC's role in part through the work that SANBI had done in the preceding 5 years and what it potentially could do in future. Prof O'Connell's support of

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

SANBI's contribution to the national agenda was evident when he would passionately defend SANBI's contribution, and that of its first spin-off company (Electric Genetics), at meetings with national stakeholders.

Once on the staff at UWC, I attended events where I often listened carefully to Prof O'Connell's opening remarks. He was able to capture the attention of the audience quickly by often using his idea of 'sense-making' (Chapter 1, Figure 1.1). He used this term to explain how he grappled with the complex challenges facing South Africa. I found myself eagerly attending events where he would be speaking in order to appreciate his approach of trying to locate challenges, describe them and refine our responses as we navigated these interventions. This strategy provided for a diverse set of individuals who could collectively respond to a need. This resonated with my own research area.

Prof O'Connell was known for highlighting the influence of philosophers and sociologists on his thinking processes. One example that stuck with me over the years as I moved into a leadership role at SANBI was a comment that he made about "Why education matters". O'Connell noted that "social thinkers from Confucius through ... Castells in our present day all allocate a special place in their theories of development to knowledge. Education for them is the foundation for whatever form of development or progress one espouses". At other times O'Connell would remind us to consider whether we are 'knowledge consumers' or 'knowledge producers'. This challenge was personal. Often when he would see me after an event, he would ask me: "So what is the current cutting-edge project at SANBI?" This question rightly assumed that there is always something innovative underway. In answering Prof O'Connell's question today, I will outline a few initiatives that demonstrate the innovative solutions developed at SANBI as our staff and students grapple with the local and global challenges facing our society.

The track record of SANBI over the past 25 years is that of an entity that produces new knowledge and in so doing finds itself at the forefront of innovation. We have developed an international reputation for advancing bioinformatics and have forged an extensive African network throughout this period through a comprehensive research capacity development programme in bioinformatics across the continent.

Advances in Bioinformatics at SANBI

A hub for training the next generation of scientists

Over a period of 25 years SANBI has served as an academic hub for training the next generation of bioinformatics scientists, many of whom have taken up leadership roles at other SA universities and abroad (Mulder et al., 2016).

Under the leadership of Prof Hide during the mid-1990s to mid-2000s, PhD student training was, and is today, centred on international collaborations. This approach offered many of us the opportunity to grow our academic networks and refine a perspective of research beyond our borders early in our careers. Consequently, many of the SANBI PhD students have taken up positions elsewhere, including Prof Junaid Gamieldien, recently appointed as Head of Bioinformatics at Roche Diagnostics based in Cape Town. Another graduate is Prof Janet Kelso, who leads a group at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany.

Leading multinational teams

As far back as 2004 UWC had a central role in guiding international consortia such as the Tsetse Genome Project (Christoffels et al., 2014). Through this multi-national project that brought together 11 countries, PhD students at SANBI were at the very forefront of bioinformatics research, actively engaged in unravelling the genetic code of the tsetse fly and subsequently using that knowledge towards health interventions. The bioinformatics expertise available at SANBI to piece together the genetic code of an organism was subsequently sought after by international consortia including the Coelacanth Genome Project (Amemiya et al., 2013) and the Asian Seabass Genome Project (Vij et al., 2016).

Drug discovery and artificial intelligence

The rapid and cost-effective access to large amounts of genetic data for pathogens (bacteria, viruses and parasites) has motivated continued attempts to include these datasets as part of the strategy for finding new drugs. In an attempt to integrate a range of drug discovery steps as part of a computer-based analysis toolkit for pathogens, SANBI researchers have demonstrated the impact of this toolkit when using it with routine protein 3-D modelling and screening for anti-TB molecules (Cloete et al., 2016).

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

In partnership with the UWC School of Pharmacy we demonstrated the power of artificial intelligence to prioritise medicinal compounds as anti-malarial candidates (Egieyeh et al., 2018).

Disease surveillance

Understanding the how, where and when of pandemics such as COVID-19 and tuberculosis relies heavily on access to genetic material of the corona virus (SARS-COV2) and tuberculosis bacteria (*Mycobacterium tuberculosis*), respectively. Using a range of computational tools, it is possible to analyse these genetic datasets ideally in real-time as part of a disease surveillance strategy.

At a national level or continental level, such genetic and associated clinical data must be carefully documented and verified. It is at this level that our research group has been working meticulously on different aspects of pathogen surveillance including data storage (COMBAT-TB-NeoDB¹), a workbench for analysis (COMBAT-TB²) and visualisation³ (COMBAT-TB-Explorer), and biospecimen tracking (Baobab LIMS⁴). More recently SANBI staff (Mr Peter van Heusden and Dr Ruben Cloete) supported the National Institute for Communicable Diseases in South Africa to analyse the genetic material of SARS-COV2 from the first South African patient with COVID-19.⁵

The Africa Centres for Disease Control and Prevention (Africa CDC), established under the auspices of the African Union, represents a strategic continental collaborating partner of SANBI as of 2016. Through this partnership we strengthening the data analytics capacity of individuals to augment interventions by public health institutions in Africa through their regional centres based in Egypt, Gabon, Kenya, Nigeria and Zambia.

There is global interest in exploiting DNA technologies for diagnostics and surveillance. Yet there is a recognition that much of the computing analytics for health is carried out in universities or industry and removed from the public health sector.

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¹ <https://bit.ly/2FToSbd>

² <https://bit.ly/2RDd0wN>

³ <https://bit.ly/3cbIW4M>

⁴ <https://bit.ly/33CKt04>

⁵ <https://bit.ly/336LsW2>

FROM HOPE TO ACTION THROUGH KNOWLEDGE

In March 2019 the Bill and Melinda Gates Foundation called a meeting of 20-30 global bioinformatics and public health stakeholders. At this meeting we deliberated the need for aligning bioinformatics more closely to the needs of public health. Within 12 months a global initiative called the Public Health Alliance for Genomic Epidemiology (PHA4GE) was established with the Secretariat based at SANBI-UWC. The founding partners of PHA4GE are the US Centers for Disease Control and Prevention (CDC), Africa CDC, Washington University, the University of Melbourne, University of British Columbia and BC Centre for Disease Control, the Broad Institute in Boston USA, University of Birmingham, Big Data Institute at the University of Oxford, and H3Africa.

Cost-effective HIV drug resistance testing

The HIV drug resistance testing software that was developed at SANBI and is now being rolled out worldwide as a partnership between Hyrax Biosciences⁶ (a spin-off company established by one of our academics, Associate Prof Simon Travers) and Thermo Fisher Scientific. Any users who purchase Thermo Fisher's low-cost HIV drug resistance (HIVDR) testing kit are provided with free access to the software for the analysis and interpretation of the data generated by the kit. Access to a low-cost, scalable, end-to-end HIVDR solution is an exciting development in the global fight against HIV and we are very proud that part of this solution was developed at SANBI. In 2019 national laboratories from Africa, Asia, Central and North America signed up to use the service. Furthermore, 2019 saw an expansion of the software to enable TB drug susceptibility testing – this will also be rolled out globally through Hyrax Biosciences.

Social Innovation

How to be a Health Activist

In 2009 SANBI embarked on a multidisciplinary American-funded PEPFAR project to the value of \$70 000 per year for 5 years. This project was a collaboration with UWC's School of Public Health, Education Faculty and UWC's Centre for Innovative Education and Communication Technologies. We developed an innovative tuberculosis intervention for schools, namely *How to be a Health Activist*. In collaboration with curriculum content developers, software programmers, Western Cape Education Department

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⁶ <https://bit.ly/3kyjpWj>

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

(WCED) LifeSkills Advisers and eight pilot schools from historically disadvantage communities, including rural schools in the Western Cape, we developed a resource in English and Afrikaans comprised of:

- o an eight-chapter book (with exercises and games) for learners;
- o an accompanying Teachers Guide;
- o an interactive DVD; and
- o an interactive website (www.skill4life.org).

The education material has been mapped to the National Education Department's CAPS requirement, piloted in schools by an independent team with a survey of 536 learners and 121 teachers. At the announcement of the final education product in September 2013 at UWC, the Western Cape Education Department (through Mr Wessel Havenga, Chief Education Specialist: HIV & TB Life Skills Education) agreed to adopt the resource Kit. By December 2013 UWC and WCED signed an MOU on the roll out.

How to be a Health Activist was launched at Vanguard Primary School in Athlone in July 2014, where Prof O'Connell and the then Provincial MEC for Education, Ms Debbie Schäfer, were in attendance. Prof O'Connell reminded learners that the greatest gift that they could get was to have the opportunity to learn how to read (Figure 22.1 below). The production of the material started in 2014 for distribution to 162 schools in the Western Cape in socio-economically disadvantaged communities, identified as Quintile 1 and 2 schools. As of 2020 a total of 76 000 books have been distributed.

Figure 22.1 The launch of the book *How to be a Health Activist* in 2014 at Vanguard Primary School in Athlone. Prof Brian O'Connell addressing the learners, on the left is the then Provincial MEC for Education, Ms Debbie Schäfer.

Speaking book: Biobanking and Me

Biomedical research based on genetically diverse data and samples from the African continent has the potential to address health issues, yet there is the risk of exploitative research practices when studies are conducted in societal environments in which public knowledge on scientific concepts may be lacking. In response to the need for public engagement, we developed a richly illustrative speaking book in English,⁷ Afrikaans⁸ and Xhosa⁹ to engage individuals on topics related to genetics and biobanks (Bedeker et al., 2020). This intervention lies at the heart of Brian O'Connell's philosophy and legacy, namely trying to make sense of our environment followed by the process of refining our responses to an identified need.

Capacity development in Africa

The capacity development activities at SANBI achieved national recognition as far back as 2002, when SANBI obtained a South African Medical Research Council (SAMRC) Bioinformatics Capacity Development Unit status. Through funding obtained from the SAMRC and the then Department of Science and Technology, SANBI hosted a highly sought-after four-week national bioinformatics training programme for 25 postgraduate students selected from universities across South Africa. By 2009 bioinformatics capacity had expanded from UWC across the country and the national training programme was reduced to a regional training course for the Cape Peninsula University of Technology, University of Cape Town, Stellenbosch University and the University of the Western Cape.

International Tsetse Genome Project

SANBI's bioinformatics outreach into Africa started with the International Tsetse Genome Project. In 2004 the molecular entomology programme of the World Health Organization Tropical Diseases Research (WHO-TDR) Unit began an initiative (International Glossina Genome Initiative (IGGI)) that brought together an interdisciplinary group of researchers from multiple countries and institutions to explore possibilities for genomics and post-genomics research in the tsetse field. Founding institutions of this global project included the University of the Western Cape, International

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⁷ <https://bit.ly/32MzORj>

⁸ <https://bit.ly/3muOmN4>

⁹ <https://bit.ly/2FH7GWH>

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

Centre of Insect Physiology and Ecology (ICIPE), Kenya, The Wellcome Trust Sanger Institute, United Kingdom, Liverpool School of Tropical Medicine, Liverpool, UK and Yale School of Public Health, Department of Epidemiology and Public Health, USA. Training in the context of this global genomics initiative ensured that we delivered five 10-day workshops at UWC for 75 students and researchers from 18 African countries who had the opportunity to engage with invited international partners.

By 2009 a review of our Tsetse Genome training programme highlighted the need for more strategic investment in individuals. Funding obtained from the WHO-TDR programme was used to initiate a Tsetse Functional Genomics Network that allowed three African students who work in the trypanosomiasis field to participate in a 2-month exchange visits to the USA or Europe. Students were recruited from Kenya, Malawi, Sudan, Tanzania, Uganda and Zambia. As a result of initiating this international exchange programme between Africa and USA/Europe, SANBI initiated its first Swedish collaboration with Prof Erik Bongcam-Rudloff now based at SLU, Uppsala, Sweden. Prof Bongcam-Rudloff provided a portable bioinformatics computing analytical toolkit that was rolled out in Kenya and training provided to Egerton University's Faculty of Agriculture, Jomo Kenyatta University of Science and Technology, Moi University, Kenya Wildlife Services, and the Kenyan Ministry of Higher Education. Many of the professional relationships forged during these workshops have provided the impetus for subsequent pan-African collaborative projects, including Horizon 2020-funded projects such as Bridging Biobanking and Biomedical Research across Europe and Africa¹⁰ (B3Africa).

African and International footprint in Biobank Informatics

In 2009 the National Institutes of Health (NIH) and the Wellcome Trust convened a meeting of senior African scientists with extensive research experience in African populations. The only bioinformatics representatives included in these meetings were the then director of SANBI, Prof Winston Hide and myself (Alan Christoffels). Our deliberations led to a White Paper¹¹ titled "Harnessing Genomics Technologies Toward Improving Health in Africa" with recommendations for funding of the Human Heredity and Health in Africa (H3Africa) Initiative to the Wellcome Trust and the National Institutes of Health. This initiative has grown over a 10-year period to a consortium with 500 members and a total investment

¹⁰ <https://bit.ly/3mACYiT>

¹¹ <https://bit.ly/3iDG437>

FROM HOPE TO ACTION THROUGH KNOWLEDGE

of at least 176 million US dollars. Currently the bioinformatics network within this consortium is led by one of SANBI's alumni, namely Prof Nicola Mulder at the University of Cape Town.

Through our involvement in the above-mentioned H3Africa and subsequently in B3Africa, we have developed a biobank footprint throughout Africa. By 2010 regional biobanks or laboratories tasked with long-term storage and access to genetic material had started to gain momentum. It was apparent that many low- and middle-income countries (LMICs) could not afford the expensive costs of commercial software aimed at tracking biological material in a biobank laboratory. We responded to the need of LMICs by developing the open-source Baobab Laboratory Information Management System (LIMS)¹²¹². Baobab LIMS represent an African-led initiative, developed at the University of the Western Cape and funded through Horizon 2020, a European funding framework. As of March 2020, there have been 427 downloads of the manuscripts and 50 downloads of the software. Customisation of, or training in using this software, has been carried out in West Africa (Abidjan Biobank, Cote d'Ivoire; Lagos Biobank, Nigeria), East Africa (Virology Laboratory, Makerere University), Southern Africa (Centre for Proteomic and Genomic Research, Cape Town, South Africa), UK MRC funded PRECISE Network (Aga Khan University in Kenya; CISM in Mozambique; UK MRC Unit in The Gambia). As of February 2020, our LIMS partnership has been extended to the USA Centers for Diseases Control and Prevention.

Conclusion

The above-mentioned examples provide a snapshot of the research and innovation programme at SANBI that has accelerated under the inspiring and visionary institutional leadership of Brian O'Connell. The leadership of Prof Brian O'Connell, assisted by his Deputy Vice-Chancellor Academic, Prof Ramesh Bharuthram, nurtured an enabling environment for research-intensive programmes for more than a decade. It is worth noting that at a time when universities were grappling with their own identity in a post-apartheid South Africa, UWC has been a beacon of hope to both students and academics. UWC has grappled and responded to its own dilemma of sense-making – that is, as a place of access to quality higher education for learners with financial constraints and at the same time a place for ground-breaking research and innovation at the very cutting

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¹² <http://baobablms.org>

Africa's bioinformatics roots are grounded at UWC: O'Connell's Vision for innovation

edge that elevates our educational offerings. Holding onto this vision in a climate of limited resources, increased bureaucracy and massification of education, requires a leadership style that believes in interventions that are consistently being refined in response to our environment, as exemplified by Brian O'Connell.

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