SWISS-SOUTH AFRICA
JOINT RESEARCH PROGRAMME

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2008 - 2018

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This book captures the 10-year science and technology collaboration between Switzerland and South Africa, and the impact of the 61 projects that emanated therefrom.

It is proudly produced by the Embassy of Switzerland, in collaboration with the Department of Science and Innovation.

A PDF version is available at www.eda.admin.ch/pretoria

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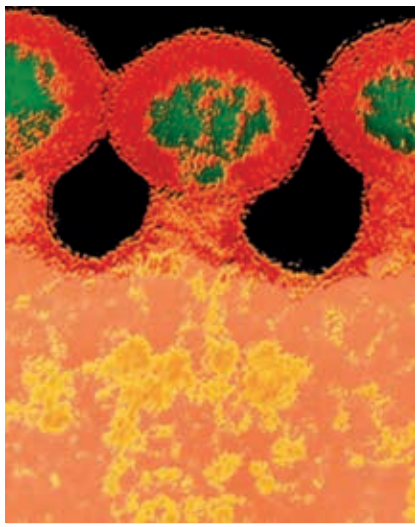

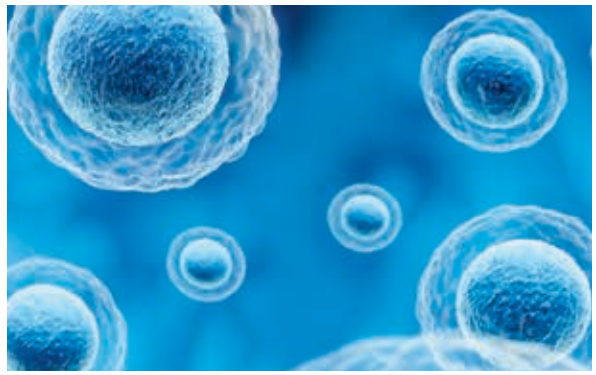

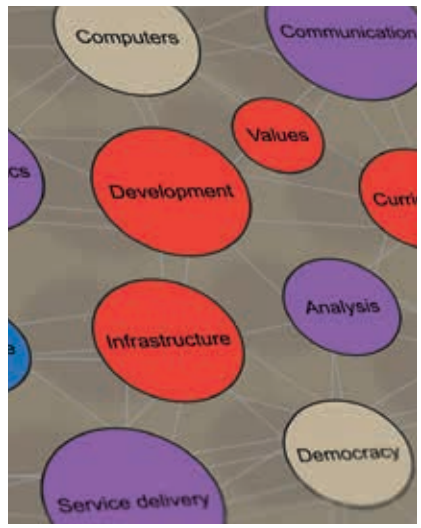

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ANNEXURE 1

Forewords

Daan du Toit, International Cooperation and Resources Deputy Director-general, DSI, South Africa

South Africa and Switzerland celebrate successful STI collaboration

The South African Department of Science and Innovation is responsible for ensuring that science, technology and innovation (STI) are harnessed to contribute to improving the quality of life of all South Africans. This has been a consistent policy priority for every administration since the election of South Africa's first democratic government in 1994.

For the current (sixth) administration, science and innovation are still considered crucial in resolving South Africa's triple challenge of poverty, unemployment and inequality. This recognition of the integral role of STI in national growth and development strategies is one South Africa shares with Switzerland. Indeed, there is much South Africa can learn from Switzerland's success as one of the world's leading innovation and knowledge economies.

South Africa, like Switzerland, firmly believes that science knows no borders – that international cooperation, i.e. the pooling of resources and the sharing of experience and expertise, is a critical enabler for the progress of science. International exposure through training and mobility programmes is an essential component of human capability development for STI. Furthermore, global challenges like climate change, food security and pandemics require a concerted science-intensive global response. South Africa therefore pursues an active science diplomacy agenda, informed by a commitment to reinforced international solidarity and shared responsibility, as set out in the Sustainable Development Goals and the African Union's Agenda 2063. We share these values with Switzerland and are proud of, and privileged to enjoy, a vibrant multi-faceted STI partnership with Switzerland.

This publication is a celebration of the successes that have been achieved through our bilateral cooperation over the years. More importantly, however, it is an opportunity to reflect on how to enhance our partnership – a shared objective – and to recommit to a much valued relationship; one we are not taking for granted. The Department of Science and Innovation and its entities, such as the National Research Foundation and the Technology Innovation Agency, are ready and eager to expand cooperation with Switzerland.

We truly appreciate the partnership we enjoy with our friends at the Swiss State Secretariat for Education, Research and Innovation, the Swiss National Science Foundation, the Swiss Tropical and Public Health Institute and other Swiss organisations.

This publication is also a chance for us to say to them: Thank you! Vielen dank! Merci beaucoup! Grazie! Grazcha fich!

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Mauro Moruzzi, Head of International Relations for SERI, Switzerland

Since the opening of its first consulate in Pretoria in 1887, Switzerland has cultivated diverse and close economic relations with South Africa. Today, as a strategic partner on the African continent, Switzerland's relations with South Africa are no longer limited to business and trade, but encompass education, research and innovation as important domains of collaboration. This mutual interest in advancing joint cooperation in research culminated in the signing of a bilateral Science and Technology Cooperation Agreement between the Swiss Federal Council and the Government of the Republic of South Africa in December 2007. Shortly thereafter, in 2008, the Swiss-South Africa Joint Research Programme (SSAJRP) was launched, leading to, among other activities, 61 joint research projects and the training of over 900 entrepreneurs in the Swiss-South Africa Business Development Programme.

The ten-year anniversary of the SSAJRP offers an opportunity to reflect on the achievements of our collaboration. This book, published by the Swiss Embassy together with its South African partners, provides an historic overview of the fruitful relations that have developed between Switzerland and South Africa in the areas of education, research and innovation. A promising starting point back in 2008 has resulted in tangible, significant, and high-quality research outputs ten years down the line.

Collaboration between Switzerland and South Africa in the areas of education, research and innovation extends well beyond the activities supported under the SSAJRP. Institutional collaboration between Switzerland and South Africa has witnessed a steady growth over the last decade, demonstrating the strong interest in scientific and technological exchanges among the researchers of our two countries. Joint efforts have seen this network of Swiss-South African partnerships steadily expanding year by year.

Establishing governmental and institutional cooperation is only one aspect of the process of connecting our two countries in the domain of education, research and innovation. Ultimately, it's the individual professor, lecturer, researcher, entrepreneur and student who bring our governmental and institutional initiatives to life. This book gives a voice to the South African and Swiss actors who have been part of this success story. It's a voice that needs to be heard as Swiss and South African researchers have achieved significant breakthroughs together and deepened the ties between our countries and our people. I would like to thank them sincerely for their scientific excellence, for having contributed to this publication and, more importantly, for strengthening our bilateral cooperation in science.

This ten-year anniversary, however, is not just an occasion to dwell on past achievements. Our journey does not end here. While we have indeed reached important milestones, I am also convinced that there is still significant potential to further deepen our collaboration, to intensify and diversify the existing relations between our countries and our stakeholders in the domains of education, research and innovation, and to further expand them through the new involvement of young scientists and entrepreneurs.

Finally, my thanks go to all those who have sponsored and contributed to this book. In particular, I must mention the Office of Science and Technology of the Embassy of Switzerland in South Africa, led by Jacquelene Friedenthal, an eminent and valuable advocate of our bilateral relations.

As you turn these pages, I trust you will enjoy discovering ten years of science and innovation history made by South Africa.

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1 SWISS-SOUTH AFRICA JOINT RESEARCH PROGRAMME (SSAJRP)

The Swiss-South Africa Joint Research Programme (SSAJRP) promotes science collaboration between Swiss and South African scientists and/or entrepreneurs. The Programme has three components: joint research projects, staff and student exchanges, and a business development programme (science to market).

Photograph courtesy of Philene Spring, Swiss TPH

Phase II principal investigators.

Joint Research Projects

JOINT research projects are the cornerstone of the SSAJRP. The Swiss National Science Foundation (SNSF) and the National Research Foundation (NRF) make a joint call for these projects every four years.

The SSAJRP has supported joint research projects over three phases as well as a bridging phase, as follows:

- **Phase I**, implemented from 2008-2012, supported 16 projects in the domains of public health and biomedicine; biotechnology and nanotechnology; humanities and social sciences.
- A **Seed Funding Call**, implemented during 2012 and 2013, supported eight projects with a focus on industry-academia collaboration.
- **Phase II**, implemented from 2013-2016, supported 25 projects in the areas of public health and biomedicine; green technology and clean technology (climate change); biotechnology and nanotechnology; social sciences and humanities.
- **Phase III**, which is currently being implemented from 2017-2020, is supporting 12 projects in the following domains:
  - Ensuring healthy lives and promoting well-being: from new tools to systems understanding,
  - Sustainability, focusing on the fields of environmental sciences, engineering and energy-related issues,
  - Social sciences and humanities in the context of current and future societal challenges, and
  - Methodologies and technologies for data-intensive applications.

The 61 joint research projects supported, were in the following domains:

Domain	No. JRPs
Communicable Diseases	20
Non-Communicable Diseases	15
Social Sciences and Humanities	7
Clean Technology	10
Sustainable Systems	7
Big Data	2

In many instances these categories use a cross-cutting platform such as biotechnology, nanotechnology and/or big data to address the national and global challenges. The big data domain was only added in Phase III of the SSAJRP.

These joint collaborations have wide impact: from joint publications to mutual learning; capacity enhancement; and the establishment of networks both in Europe and in Africa. Equally important is the establishment of mutual trust and friendship, serving as a catalyst to take the collaboration beyond that of formal agreements, as reported during a review of Phase I.

There were 61 joint research projects, which were conducted as follows:

PHASE I

2008 - 2012

TOTAL PROJECTS: 16

DOMAIN
Public health and biomedicine; biotechnology; nanotechnology; and social sciences and humanities.

SEED FUNDING CALL

2012 - 2013

TOTAL PROJECTS: 8

DOMAIN
Phase I domains but now to include an industry partner.

PHASE II

2013 - 2016

TOTAL PROJECTS: 25

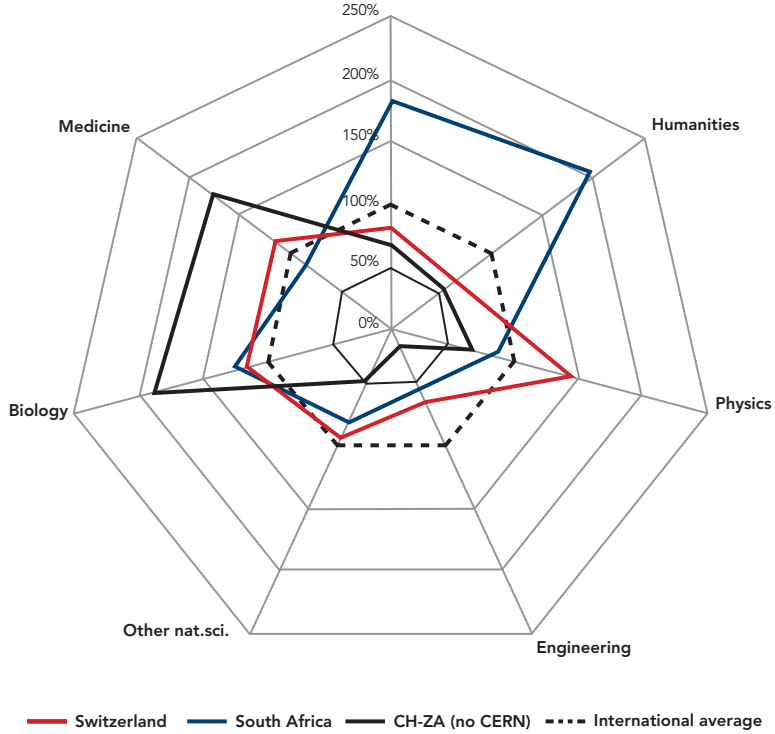
DOMAIN
Phase I domains but also including clean technology.

PHASE III

2017 - 2020

TOTAL PROJECTS: 12

DOMAIN
Health and well-being; sustainability; social sciences and humanities (including law); data-intensive applications.



Domains of collaboration between Switzerland and South Africa measured against international and national outputs respectively (SNSF, 2017)

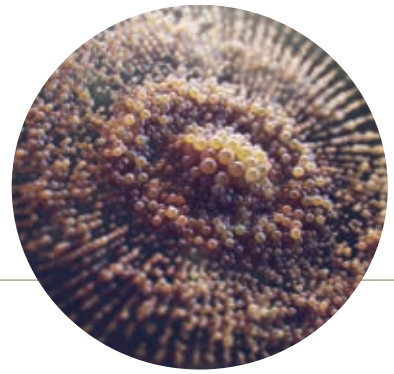
Out of these calls 15 projects were chosen in the domain of non-communicable diseases; 20 in communicable diseases; seven in social sciences; seven in sustainable systems; two in big data and 10 in clean technology. Biotechnology, nanotechnology and big data served as cross-cutting domains featuring in a number of these projects.

The domains of the 61 joint research projects in the SSAJRP are also evident in the Swiss-South African joint publications beyond the SSAJRP as presented in the figure alongside, where the strongest joint collaborations are in the fields of medicine, biology and physics, which include the domains of non-communicable diseases, communicable diseases, and sustainable systems.

Cross-cutting Domains

BIOTECHNOLOGY

Switzerland's biotech industry is second only to that of the US. Biotechnology is one of Switzerland's three flagship science-based industries (the other two are pharmaceuticals and speciality chemicals). The country's excellent science base, well-organised technology transfer, and big pharma companies are the key to its biotech success. Switzerland's biotechnology sector, together with South Africa's emerging biotechnology research and rich biodiversity, offer excellent opportunities for innovation.



Courtesy Prof A Grobler

NANOTECHNOLOGY

Nanotechnology is a set of techniques that allows the manipulation of properties at a very small scale. The ability to see nano-sized materials has enabled, for example, the manufacture of polymers based on molecular structure, and the design of computer chip layouts. South Africa's National Nanotechnology Strategy (2005) has been hailed by the science community as one of the best in the world. It aims to address challenges in the areas of water, health and energy, as well as to give a competitive edge to some of the country's strategic industries (mining and minerals, advanced materials and manufacturing, and chemicals and bioprocessing).

Courtesy SARAO

BIG DATA

Big data is a new interdisciplinary field combining statistics, computer science, mathematics, and engineering. Big data is not simply about the volume of data but more specifically about how data is organised and analysed. Data scientists create algorithms to create order from the sheer volume of big data. They discover previously unknown patterns in big volumes of data and reveal new relationships, insights and business models. Big data enables companies and researchers to look into the future. Data science facilitates the creation of disruptive innovations like autonomous vehicles, precision medicine and precision agriculture, smart cities and financial technology. The SSAJRP included collaboration in the domain of big data in the 2016 joint call for proposals where two projects were supported. In addition, a number of previously supported joint projects made use of the big data platform in searching for answers to questions related to their research topics.

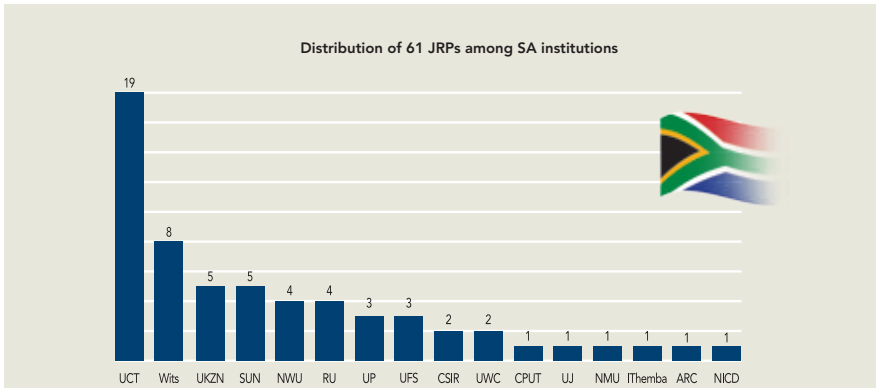
Results of the Joint Research Projects

Quantitative and qualitative data have been gleaned from individual surveys conducted among the principal investigators and wrap-up workshops. The related infographics highlight pertinent results and observations.

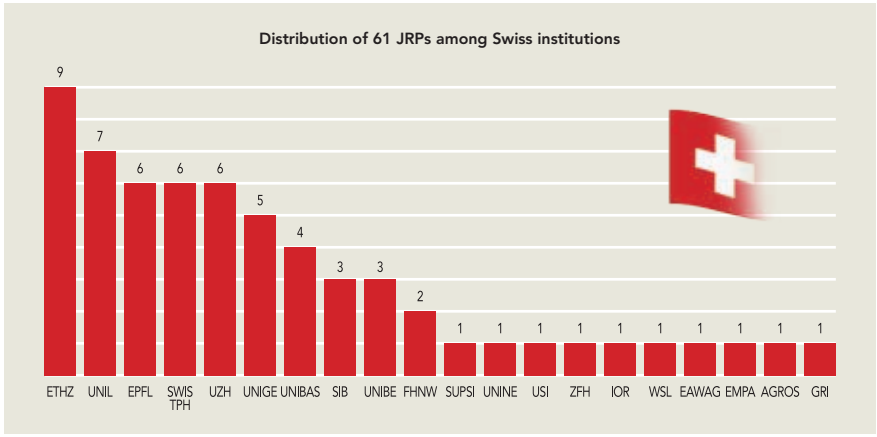
SSAJRP and Project Budgets

The funding of the Swiss and South African national systems of innovation differs quite markedly. South Africa provides for a university subsidy through the Department of Higher Education and Training (DHET) calculated at approximately 33% of the total value of the overall project cost. Additionally, the central coordination of funding for postgraduates through the National Research Foundation is based on an annual open call. The SSAJRP on the South African side is bulked up by third-party funding, with most of these funds coming from governmental funding instruments such as the Research Chairs (SARChI), the South African Medical Research Council, scholarship grants and the Technology Innovation Agency.

Distribution of Joint Research Projects in Switzerland and South Africa



UCT	University of Cape Town
Wits	University of Witwatersrand
UKZN	University of KwaZulu-Natal
SUN	Stellenbosch University
NWU	North-West University
RU	Rhodes University
UP	University of Pretoria
UFS	University of Free State
CSIR	Council for Scientific and Industrial Research
UWC	University of Western Cape
CPUT	Cape Peninsula University of Technology
UJ	University of Johannesburg
NMU	Nelson Mandela University
iThemba	iThemba Laboratories
ARC	Agricultural Research Council
NICD	National Institute for Communicable Diseases



EPFL	Swiss Federal Institute of Technology in Lausanne
ETHZ	Swiss Federal Institute of Technology in Zurich
FHNW	University of Applied Sciences Northwestern Switzerland
SIB	Swiss Institute of Bioinformatics
SUPSI	University of Applied Sciences and Arts of Southern Switzerland
Unibas	University of Basel
Unibe	University of Bern
Unige	University of Geneva
Unil	University of Lausanne
Unine	University of Neuchâtel
USI	University of Lugano
UZH	University of Zürich
ZFH	Zürich University of Applied Sciences
IOR	Institute of Oncology Research
WSL	Swiss Federal Institute for Forest, Snow and Landscape

Evaluation of the SSAJRP

NO external evaluation of the SSAJRP has been undertaken thus far. However, a survey was conducted in 2011 among the 32 principal investigators in Switzerland and South Africa for the development of the SSAJRP publication that was launched in 2012 in South Africa.

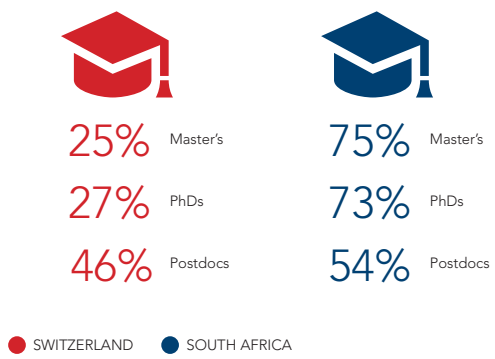
An SSAJRP Phase I wrap-up workshop was held in November 2012 to celebrate progress, reflect on and emphasise good practice, and to acknowledge areas in need of improvement. The inputs for the wrap-up workshop consisted of 29 presentations by the project administration team and the principal investigators of the joint research projects, followed by a plenary session. In general, the participants thought that the joint research projects resulted in mutual learning, capacity enhancement, and the establishment of networks both in Europe and in Africa. Mutual trust and friendship between the research partners were further presented as a concrete outcome that will stimulate future research collaboration.

A mid-term review for Phase II was held in October 2015 in Switzerland. The mid-term review brought together the principal investigators of Switzerland and South Africa and/or PhD and postdoctoral representatives. These reviews were jointly implemented by the Swiss and South African leading houses. A survey was launched in 2018 among the 122 principal investigators in Switzerland and South Africa to generate the content of the SSAJRP publication. The survey was complemented by information gathered during the 2012 wrap-up workshop and the 2015 mid-term review, as well as the submissions of Phase I for the first SSAJRP publication. The outcomes of these reviews and surveys constitute the evaluation of the SSAJRP 2008-2018 as presented in this publication. The results are presented as expressions by the principal investigators constituting the qualitative data and the recordings submitted by these principal investigators as the outcomes of their joint research projects.

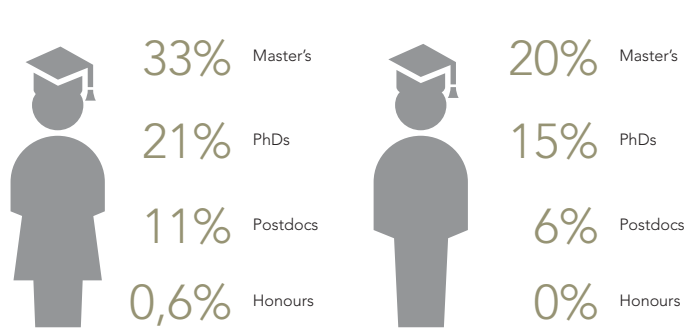
Human Capacity Development

61 joint research projects trained 395 postgraduates from 2008 to 2018 of whom 256 (72%) were South African postgraduates and 102 (28%) were Swiss. Of the 256 South African postgraduates, 188 (50%) were from historically disadvantaged backgrounds (HDI).

% Swiss and SA of the 395 postgraduates in the 61 JRPs from 2008 - 2018



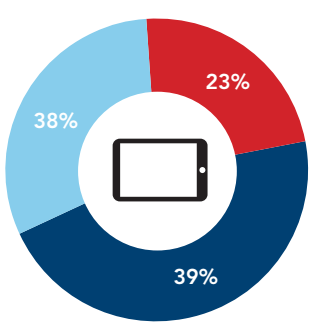
Of the 256 SA Postgraduates, 188 (50%) were from HDI



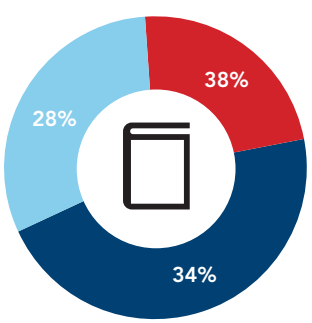
Publications

The joint research projects produced 316 peer-reviewed publications of which 72 (23%) were produced by the Swiss partners, 125 (39%) by the South African partners, and 119 (38%) were jointly produced. In addition 32 book contributions were made, of which 12 (38%) were contributed by the Swiss partners, 11 (34%) by the South African partners, and 9 (28%) were joint contributions.

316 publications



32 book contributions

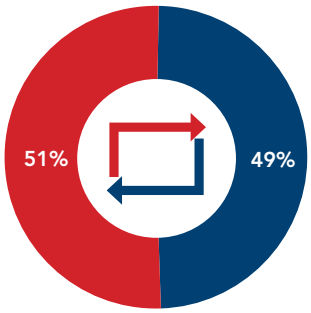


SWITZERLAND SOUTH AFRICA JOINT

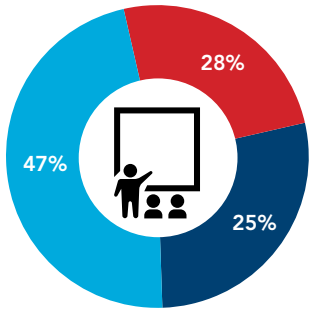
Mobility

The joint research projects benefited from 254 student and faculty exchanges from 2008 – 2018, of which 129 (51%) were to South Africa and 125 (49%) to Switzerland. Equally, the beneficiaries of the joint research projects benefited from the 533 local and international conferences attended, or where papers were presented. Of these conferences, 136 (25%) took place in South Africa, 147 (28%) in Switzerland, and 250 (47%) globally. The project partners participated in 162 workshops during the implementation of the projects, of which 86 (53%) were held in Switzerland and 76 (47%) in South Africa.

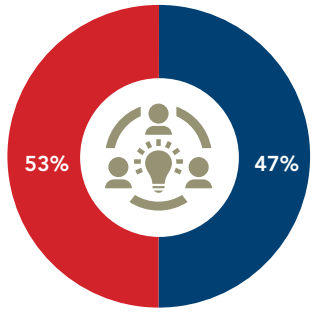
254 Student and Faculty Exchanges



533 Conference Attendance and Presentations



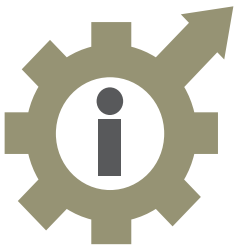
162 workshops



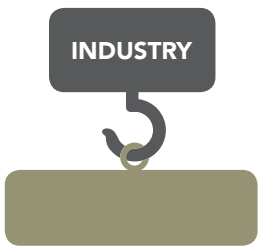
SWITZERLAND SOUTH AFRICA GLOBAL

Innovation

A key outcome noted in the 2018 survey by the principal investigators was that at least half of the projects had created an opportunity for innovation, but the industry collaboration and intellectual property achievements were weak. These opinions were expressed during the 2012 wrap-up workshop as well as the 2015 mid-term review.



INNOVATIONS	PROJECTS	OPINIONS
Project achieved innovation	20	33%
Impact innovation achieved	14	23%
Innovation potential beyond project	25	41%



INDUSTRY LINKAGES		
Research support from industry	9	15%
Industry funding	6	10%
Industry partner SA	9	15%
Industry partner CH	8	13%
Industry interested	8	13%
SA Industry funds received	3	5%
Swiss Industry funds received	3	5%

INTELLECTUAL PROPERTY		
Joint IP	2	3%
Swiss IP	5	8%
SA IP	5	8%
Swiss IP protected	4	7%
SA IP protected	3	5%
Joint IP projected	1	2%
Open innovation	1	2%

Impressions of the SSAJRP

The 2012 wrap-up workshop and the 2015 mid-term review were solely focussed on the viewpoints of the principal investigators, whereas the 2011 and 2018 survey focussed on both the principal investigators and the actual output of the collaboration. The views of the principal investigators are presented below.

Financial Resources

Funding will remain a contentious issue regardless of efforts to increase research funding support. The experience of the SSAJRP is no exception, with the principal investigators submitting in the 2012 review and the 2015 mid-term review a number of recommendations to align the guidelines between the SNSF and the NRF to, for example:

- assist with workshop administration versus expenses and salary,
- anchor the projects within a programmatic framework with diverse funding opportunities,
- protect the South African projects against the recovery of value added tax and project administration cost of the universities,
- align budget guidelines between the Swiss and South African funding agencies,
- allow more flexibility in the use of the budget lines according to the needs of the projects, and
- avoid a delay of funding after the project has started.

In addition to the above, the 2018 survey noted constraints regarding funding for equipment, a decrease in the South African project funds linked to a decrease in the rand value, the high costs of flights to Europe, and a lack of follow-up funding.

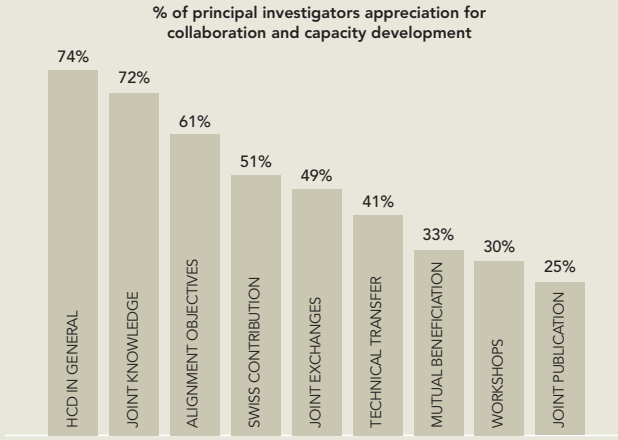
The 2018 survey recorded an appreciation by 21% of the participants for the ability of the joint research projects to leverage third-party funding, while 7% were satisfied that there was adequate funding. Only in Phase III did the principal investigators indicate that there was adequate funding, mainly because of the decision to decrease the number of projects and increase the funding along with the length of the project cycle.

Phase III funded 12 projects for the period 2017-2020. The increase of the funding cycle from three to four years was extensively discussed during the 2015 mid-term review, with the biggest fear being that reducing the projects to only 12 with more funding would decrease the inclusion and diversity issue drastically for South Africa, as well as increase the competition significantly.

Human Capacity Development

Phase I and II principal investigators expressed an appreciation for mutual learning and capacity enhancement as major benefits of the joint research projects. Further appreciation was expressed for access to expertise, skills and technology, as well as the acquisition of knowledge.

The Phase II PhD and postdoctoral students noted the following: that the joint research projects provided visibility and credibility which, in turn, attracted motivated students; internationalisation opportunities; joint and multi-disciplinary expertise; opportunities for mentorship; opportunities to work with highly reputable experts in the field; improvement of methodological skills; and knowledge transfer.



According to the 2018 survey, 74% of all principal investigators appreciated the human capital development in general, followed by an appreciation for the development of joint knowledge, aligned objectives and joint exchanges. Just over half (51%) of the South African principal investigators were appreciative of the Swiss contribution and 41% of the transfer of technical skills to South Africa.

Phase I principal investigators recommended an increase in support for scientific meetings, workshops, and summer schools and student and faculty exchanges. They also recommended that capacity enhancement instruments, such as scholarships, partnerships and training opportunities, be identified and communicated beyond the joint research projects. These sentiments were also expressed by the Phase II principal investigators in addition to the recommendation that every student should have an opportunity to gain experience by visiting their project partners, with a focus on master's students.

South African principal investigators also recommended an increase in the number of Swiss principal investigators' visits, and 13% asked for additional funds for capacity development and 16% asked for an increase in scholarships and bursaries for students.

54%

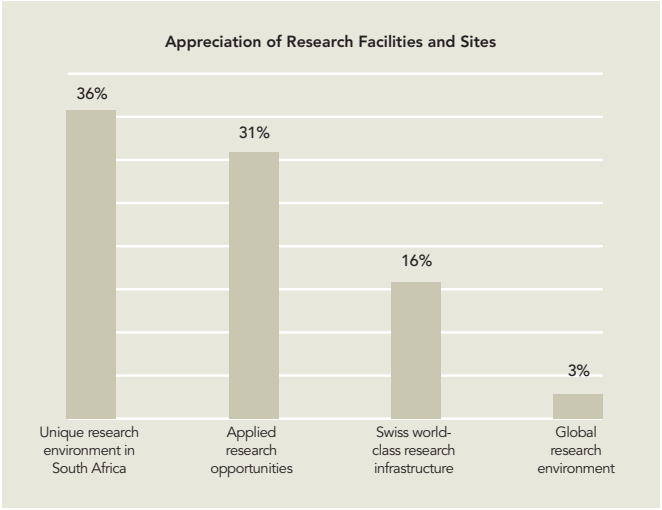
Appreciation for development of HDIs

28%

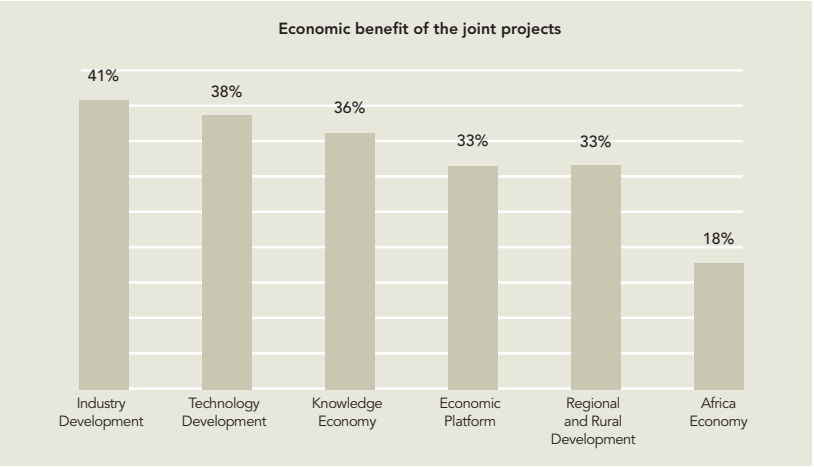
Appreciation to address gender balance

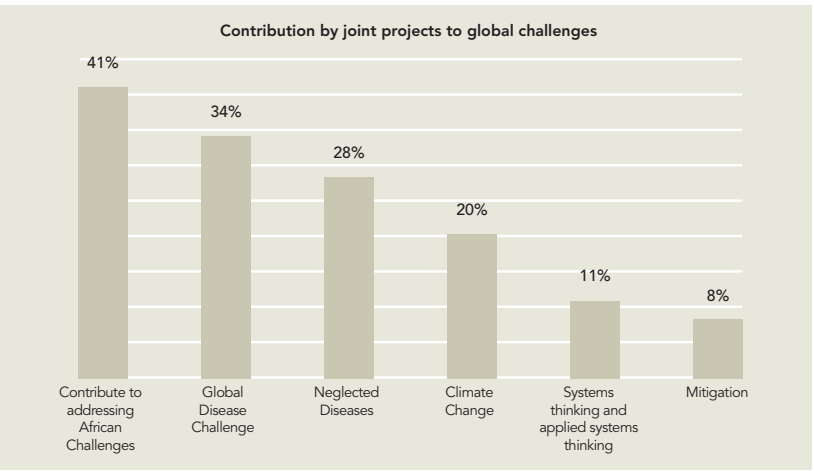
Implementation and Deliverables of the Joint Research Projects

The success of the joint research projects and the achievement of knowledge production – evident in publication and conference contributions – hinge on the availability of research infrastructure, scientific research material, a supportive regulatory environment, and financial support. The 2018 survey presented an interesting viewpoint concerning the research environment and infrastructure. The Swiss principal investigators recognised the value of the unique and diverse research environment of South Africa, whereas the South African researchers appreciated the world-class research infrastructure of Switzerland. Applied research opportunities were appreciated by 31% of the principal investigators.



Value of the Joint Research Projects





30%

Our project has a policy impact

52%

Our project addresses key South African strategies and national objectives

According to the reviews of Phase I and II there were difficulties in acquiring scientific material, difficulties in the the regulatory environment for the exchange and shipment of research material to and from Switzerland, and difficulties with obtaining visas. One-third of the principal investigators in the 2018 survey indicated that the exchange of research material was a challenge (plant and animal material). Gaining access to research areas and/or populations in some projects was difficult, while access to data and concluding experiments in South Africa were also found to be challenging during the implementation of the projects.

Of South African principal investigators, 41% appreciated the opportunity to demonstrate research excellence in South Africa.

During the 2011 and 2018 reviews a question was asked about the national and global value of the projects. Industry development was ranked the highest by the principal investigators, with 41% believing that their projects contribute to industry, while 38% chose their contribution to technology development, followed by a contribution to the knowledge economy. One project also indicated mineral beneficiation since a rare earth material is required in the development of the technology.

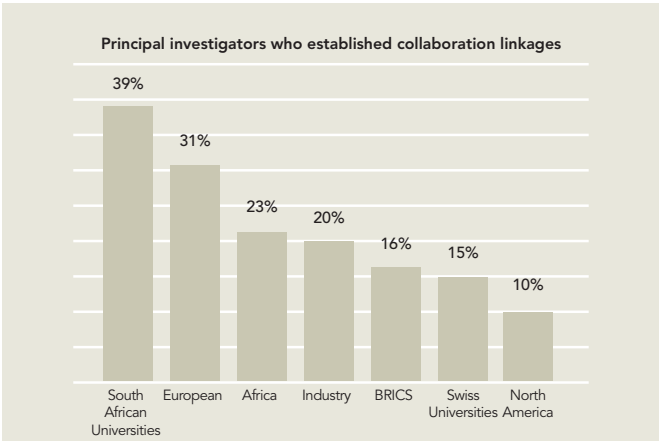
The joint research projects are geared to address global challenges such as climate change, new and emerging diseases, lifestyle diseases and sustainable development. Nearly half of the principal investigators found that the joint research projects contribute to African challenges in the domains of neglected diseases and climate change. More than a third of the principal investigators said that their projects contribute to global disease challenges like cancers, HIV/AIDs, tuberculosis, and lifestyle diseases such as diabetes.

Innovation

From the outset, the SSAJRP ensured that the joint research projects focus on science to market. With the launch of the seed funding call in 2012, the grant was conditional upon the incorporation of an industry partnership. Most of the principal investigators have innovation as an objective or outcome of their projects. These innovations are not only linked to an economic benefit but in many instances also have a social impact.

It is clear that the principal investigators are aware of the value in taking science to market but the know-how remains a challenge in addition to uncertainty on how to address the intellectual property (IP) issues of the projects.

The principal investigators recommended that the IP issues be addressed at the start of the projects, a framework be provided on how to establish industry-academia linkages, advocacy be done for the uptake of research results in policies where relevant, and the joint research projects be linked with the Swiss-South Africa Business Development Programme.



Research Linkages

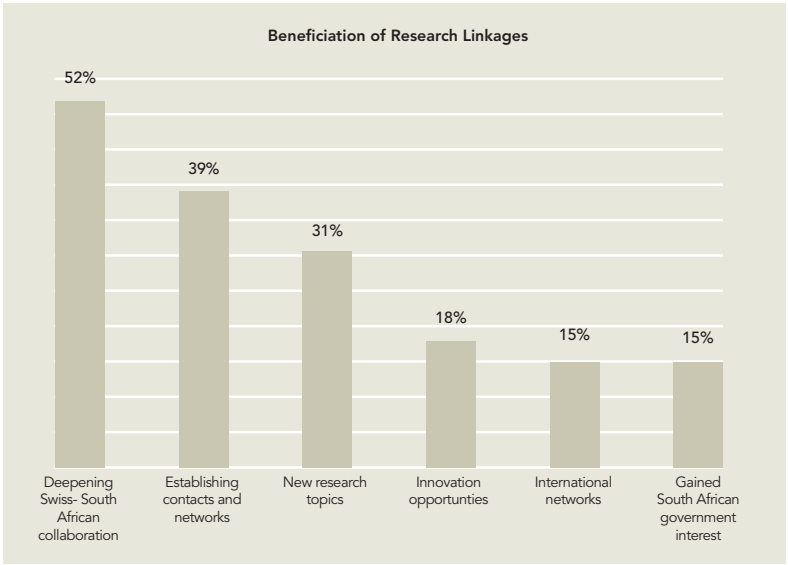
Overall, the joint research projects either deepened existing collaboration with third-country partners and universities in Switzerland and South Africa or established new linkages. These linkages were considered a major contribution to the sustainability of the collaboration beyond the SSAJRP. The linkages allow for the development of new research questions, access to funding beyond the SSAJRP, and the potential to participate in EU funding opportunities. Additionally, the Phase II principal investigators recorded that research linkages enhanced cross-disciplinary research and collaboration, increased involvement of the NRF Centres of Excellence, improved new partnership development, spilled over to industry and universities of technology, increased translation into civil society, provided opportunities for young researchers in developing countries, and resulted in governmental uptake of project results. The Phase I principal investigators indicated in the 2012 review that networks and partnership opportunities with other African countries should be enhanced.

In 2015, the Phase II principal investigators again indicated the need to include other African and European countries in the call for joint proposals, based on the discretion of the Swiss and South African principal investigators and depending on the need of the projects. They believed that the SSAJRP presented a unique opportunity to establish partnerships, especially with the francophone countries.

The 2018 survey revealed that 39% of the projects had research linkages with South African universities and 15% with Swiss universities. Cross-country linkages included 31% with European partners followed by 23% with African research partners and 16% with BRICS countries. The establishment of industry linkages as an enabler for taking science to market was encouraging.

Of the principal investigators involved in these research linkages, 52% said the deepening of the Swiss-South Africa collaboration with universities in either Switzerland and/or South Africa were benefits of the research linkages. The establishment of contacts and networks were also appreciated by 39% of the principal investigators, followed by the discovery of new research topics. Research linkages also contributed to the discovery of innovation opportunities, international networks and government's interest.

The joint research projects either deepened existing collaboration with third-country partners and universities in Switzerland and South Africa, or established new linkages.



Exchanges, Networking and Workshops

During the 2015 mid-term review in Switzerland, the PhD and postdoctoral students indicated that only one out of seven postgraduates on the joint research projects had the opportunity of an exchange visit for a period of two months in Switzerland. A further constraint was that students in Switzerland work in teams whereas in South Africa most students work alone, which hampers human capacity development. The time constraints for PhD students to be actively involved in the joint research projects was also indicated as a challenge.

The postgraduate students recommended that the SSAJRP administration team provide clarity on the role of students in the projects; support additional conferences in South Africa to ensure a flow of Swiss collaborators to South Africa; promote an exchange programme between Switzerland and South Africa; explore the possibility of joint or double PhD degrees; include international students in the joint research projects; and provide specific funding instruments for students.

Project and Administration Communication

Project communication from the administration teams was indicated as a major constraint during the 2012 wrap-up review. This was resolved in the administration of the follow-up calls. A major achievement after Phase I was the alignment of calls, the joint evaluation of calls and aligned administration processes between the SNSF and the NRF. A remaining challenge is the different university administration and auditing procedures and the different academic years, which lead to communication challenges.

Joint Research Chairs

THE South African Research Chairs Initiative (SARChI) establishes research professors in universities across South Africa through a grant of either R2,5 million or R1,5 million a year for a period of fifteen years. Its aim is to enable research professors to create world-class centres of research by undertaking frontier research themselves and by training a new school of researchers. Each research professor supervises on average 10 postgraduates. The SARChI programme began with 21 research professors in 2006 and has grown to 202 research professors in diverse disciplines across the natural sciences, engineering, humanities and social sciences.

In 2015, as part of Phase II of the SSAJRP, it was decided to establish a joint Swiss-South Africa SARChI and a Swiss visiting fellowship to an established SARChI.

South African Research Chair for Mobility and the Politics of Difference

The Swiss collaboration with the SARChI for Mobility and the Politics of Difference is a visiting fellowship. Prof Didier Ruedin from the University of Neuchâtel and Prof Lauren Landau of the University of the Witwatersrand at the African Centre for Migration and Society examined the impact of migration, mobility, and diversity during 2015 and 2017.

A direct outflow of this collaboration was the Swiss sub-Saharan African Migration network with a focus to build and strengthen long-term partnerships between migration researchers in sub-Saharan Africa and Switzerland.

The University of the Witwatersrand SARChI trained 10 students (four honours, two masters, two doctoral students and two postdoctoral fellows) and is currently supervising four doctoral students. Besides the human capital contribution, the research output for this chair included four articles published in various human science journals and a chapter in a book called *Justice and Real Politics: Freedom, Needs and Representation*.

Swiss-South Africa Global Environmental Health Research Chair

The Swiss-South Africa Global Environmental Health Research Chair was the first to involve another country in co-founding a Research Chair under the umbrella of SARChI.

The two chairholders are:

- Associate Professor Mohamed Aqiel Dalvie from the University of Cape Town (UCT), an expert researcher in environmental health focussing on pesticides, endocrine disruption and air pollution, and
- Associate Professor Martin Roosli from the Swiss TPH, an environmental epidemiologist and international expert on exposure assessment, aetiological research and health risk assessments of passive smoking, climate change, noise exposure and ambient air pollution.

Professor Guéladio Cissé from the Swiss TPH is closely associated with the Chair. He is an expert in issues of water, sanitation and hygiene, waste management, urban agriculture, climate change, disaster risk reduction, ecosystems and ecosystem services, and air pollution.

What is novel about this collaboration is the association with the Cape Peninsula University of Technology (CPUT). It is providing the training facility for environmental health practitioners, allowing research findings and recommendations to inform the training of students.

The collaboration consists of four projects:

- A cohort study on the effect of agricultural pesticides on the development and respiratory health of rural children in the Western Cape.
- A cohort study on the effect of ambient air pollutants on childhood asthma in the Western Cape region.
- An ecosystem approach on the health risks associated with chemical pollution and bio-contamination of water sources and soil in the Western Cape.
- A health risk assessment on the impact of climate change on ecosystems, water, chemical usages and health, including vulnerabilities assessment and adaptation challenges in the Western Cape and the rest of South Africa.

The Research Chair hosted at UCT has produced six master's students, five of them females. The chair is supervising eight doctoral students (one of them has already graduated) and 10 MPH or MD students (five of whom have graduated).

Launch of the Swiss-SA Global Environmental Health Research Chair in 2015. From left: Ambassador Christian Meuwly, Dr Thomas Auf der Heyde, Dr Aqiel Dalvie, State Secretary Dr Mauro Dell'Ambrogio, South African Minister of Science and Technology, Naledi Pandor, Prof Marcel Tanner, Dr Max Price and Dr Gansen Pillay.

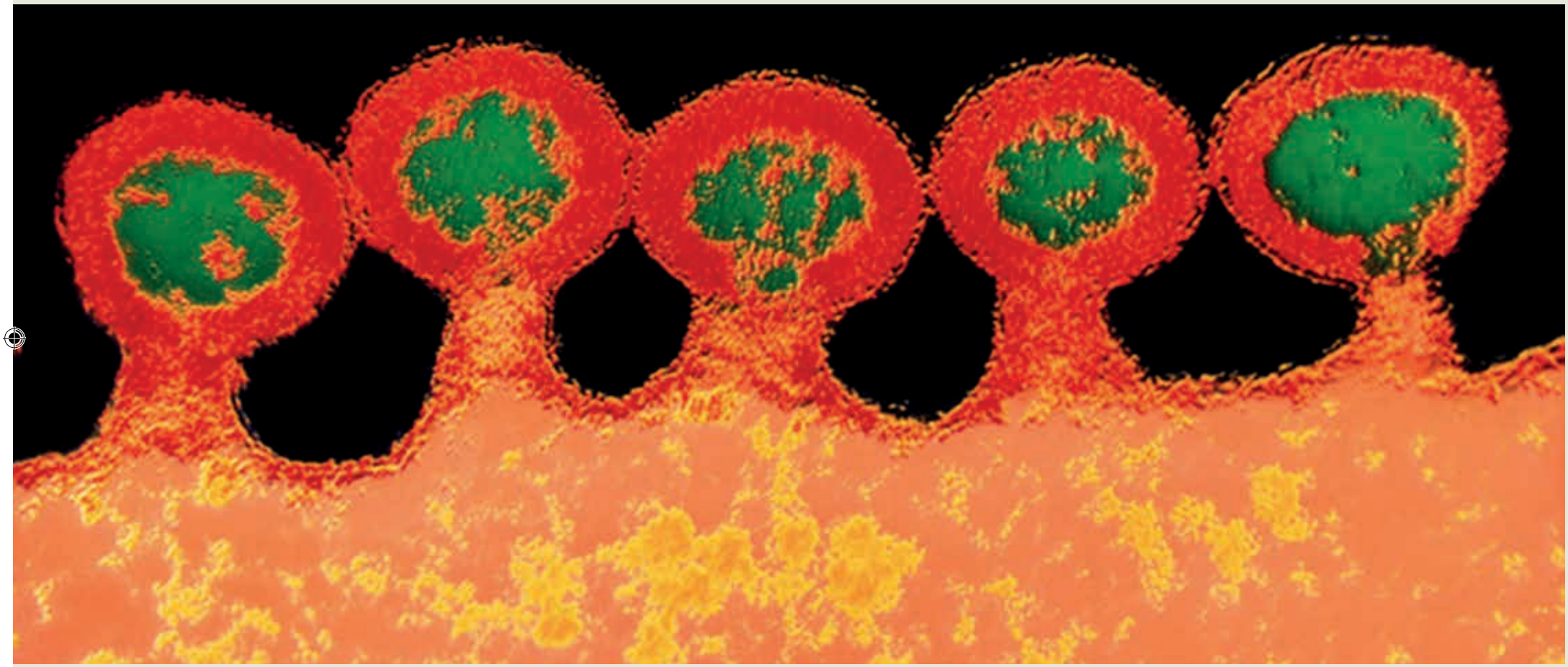
Photograph courtesy of Barblin Michelsen

Swiss-SA Global Environmental Health Research Chair water quality monitoring station.

2

JOINT RESEARCH PROJECTS

COMMUNICABLE DISEASES



HI Virus

Sanitation, food control and antibiotics have reduced the toll of communicable diseases, saving millions of lives. Smallpox was eradicated in 1977, and poliomyelitis eradication is close. Measles mortality has reduced drastically yet outbreaks occur where immunisation lags.

But for every step forward, a substantial obstacle has appeared. For example, micro-organisms have developed resistance to some antibiotic drugs and they continue to mutate in ways that make their eradication ever more difficult. The human immunodeficiency virus (HIV) emerged in the 1980s, grew into a global HIV/AIDS pandemic costing millions of lives and, despite progress, remains a major global health issue. Highly active antiretroviral therapy (HAART) has transformed HIV into a manageable chronic disease; however, significant HAART-induced and/or HIV-related morbidity continues to exist.

Malaria and tuberculosis (TB) still cause millions of deaths. The worldwide prevalence of malaria is estimated to be in the order of 250 million clinical cases annually, of which one million people die.

TB is a disease that is thousands of years old and, while other diseases that have subsequently emerged have been effectively controlled, TB still stands out today as one of the worst public health threats with which modern medicine is battling. More people are dying of TB than ever before and Mycobacterium tuberculosis (MTB), the causative agent of TB,

is now responsible for the largest numbers of human deaths due to a single bacterial pathogen.

The lethal combination of HIV and TB, coupled with the evolution and spread of multi- and extensively-drug-resistant MTB strains, has magnified the burden of disease, particularly in developing countries.

Influenza pandemics with new, deadly versions continue to appear. Neglected tropical diseases are responding to global donor efforts, but newly emerging diseases move to new regions and become endemic, while deadly localised haemorrhagic fevers threaten to transmit more widely. Rapid mass travel allows infectious diseases in isolated villages to quickly become global threats and has brought the opportunity for nearly anyone anywhere to become infected with what were formerly thought to be "exotic" diseases.

About one new infectious disease organism has been discovered each year for the past 50 years. "The 21st Century is likely to be marked by a proliferation of infectious viral illnesses," says Antonio Hernandez Conte in *Infectious Diseases*. "There are few new antibiotics under development to combat gram-negative organisms." (Conte, 2018).

New strains of viruses, antibiotic resistance and micro-organisms causing chronic diseases are challenges for infectious disease control requiring continuing political, financial and scientific support and much tenacity (Tulchinsky and Varavikova, 2015).

South Africa is still battling the burden of infectious diseases, but according to health findings published in a dedicated issue of *The Lancet* as part of the Global Burden of Diseases, Injuries, and Risk Factors Study (GBD), South Africans are living longer lives than they were 10 years ago. In South Africa, HIV/AIDS was the leading killer, resulting in 112 243 deaths in 2015. The second and third top causes of death were ischemic heart disease and tuberculosis related to HIV/AIDS, killing 45 119 and 42 943 people respectively (Centre for Disease Control and Prevention).

The CDC in South Africa has implemented a quality improvement system within 1 159 facilities providing HIV-rapid testing within the 27 focus districts in the country. The first cycle of proficiency testing has seen a pass rate of 97% for all facilities enrolled.

TB still remains a crisis in South Africa. At the time of the launch of the latest National Strategic Plan in 2017, the South African Government said: "We have made major gains in terms of treating millions of people living with HIV and TB, slashing the death toll due to these infections, and reducing the number of new infections. However, there is still a great deal to be done." The National Strategic Plan aims to intensify efforts in the geographic areas that are most affected. In addition, the highest impact interventions are to be used in these areas.

Switzerland has an internationally recognised history in supporting research and implementation of pilot approaches to control communicable diseases, mainly in the field of malaria and neglected diseases, such as Trypanosomiasis (Health Network of the Swiss Agency for Development and Cooperation – SDC).

Global, national and local capacities are strengthened to reduce the morbidity and mortality related to communicable diseases such as HIV and AIDS, malaria and TB as well as to achieve and/or sustain high levels of immunisation.

Other communicable diseases – such as diarrhoea or acute respiratory infections (pneumonia) – are also prioritised, as they are major causes of mortality among children under the age of five in low-income countries. Neglected tropical diseases affecting the poorest quintiles of society remain a priority for the SDC. Throughout its programming, SDC promotes a multisectoral and systemic approach, including the mainstreaming of HIV and AIDS. It also promotes the integration of HIV and AIDS and sexual and reproductive health services. To mitigate the impact of the epidemic in countries with a high HIV prevalence, SDC prioritises prevention activities, psychosocial support and social protection mechanisms.

OUTCOME OF THE COMMUNICABLE DISEASES DOMAIN: ECONOMIC VALUE

Projects in this domain featured strong industry support, with the resultant social impact. Of particular importance is the innovation impact of the projects and their potential going forward.

INNOVATIONS	TOTALS	%
Project achieved innovation	8	40
Impact innovation achieved	5	25
Projects have innovation potential	11	55
Innovation potential beyond project	11	55

INDUSTRY LINKAGES	TOTALS	%
Research support from industry	7	20
Industry funding	3	15
Industry partner SA	7	20
Industry partner CH	2	10
Industry interested	2	10
SA Industry funds received	0	0
Swiss Industry funds received	2	10

INTELLECTUAL PROPERTY	TOTALS	%
Joint IP	1	5
Swiss IP	2	10
SA IP	3	15
Swiss IP protected	2	10
SA IP protected	3	15
Joint IP projected	1	5
Open innovation	1	5

Joint Research Projects

Outcomes of the Communicable Diseases Domain (20 projects)

RESEARCH DOMAIN: COMMUNICABLE DISEASES

UNIVERSITY PARTNERS

University of Basel
University of Bern
Esperanza Medicines Foundation
Swiss Tropical and Public Health Institute
Swiss Federal Institute of Technology in Lausanne
Swiss Federal Laboratories for Materials Science and Technology
University of Lausanne
University of Geneva
Swiss Institute of Bioinformatics
Swiss Federal Institute of Technology Zurich
University of Zurich
University of KwaZulu-Natal
University of Cape Town
University of the Witwatersrand
University of Pretoria
University of Western Cape
Nelson Mandela University
North-West University
National Institute for Communicable Diseases
National Health Laboratory Service

SEED FUNDING

PHASE I — 2008 – 2012, 6 projects
PHASE II — 2012 – 2013, 5 projects
PHASE II — 2013 – 2016, 6 projects
PHASE III — 2017 – 2020, 3 projects

Phase III projects have not as yet reached full scale scientific outputs.

TOTAL FUNDS INCLUDING THIRD-PARTY FUNDING:
CHF 9 362 172 ZAR 144 525 148

BENEFICIATION

ECONOMIC
- **35%** Technology development
- **45%** Economic platform
- **35%** Industry development
- **15%** Africa economy
- **15%** Knowledge economy

GLOBAL CHALLENGES
- **90%** Global disease
- **85%** Africa challenge
- **75%** Neglected tropical diseases

NATIONAL OBJECTIVES
- **25%** Policy beneficiation
- **70%** National strategies in South Africa
- **45%** HCD of historically disadvantaged
- **5%** Gender balance redress in SER

PUBLICATIONS

12 48 25

85 TOTAL

POSTGRADUATES

11	MSc	52
8	PhD	37
7	Postdoc	14

129 TOTAL

BOOK CONTRIBUTIONS

2 2 1

5 TOTAL

HDI

24	MSc	7
14	PhD	5
5	Postdoc	1

56 TOTAL

EXCHANGES

31 TO SWITZERLAND
61
30 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS

26 55 52 133

WORKSHOPS

7 12

APPRECIATION

COLLABORATION	**65%** Alignment of PIs objectives **70%** Joint knowledge **5%** Joint publications **45%** Joint exchanges **25%** workshops
HUMAN CAPITAL DEVELOPMENT	**65%** Appreciate Swiss contribution **80%** HCD in general **50%** Should demonstrate South Africa research excellence
RESEARCH FACILITIES	**50%** Access to unique research environment in South Africa **30%** Opportunity for applied research
GENERAL APPRECIATION	**35%** New research opportunities **40%** Leverage funds from other grants **5%** adequate project funds

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
- 5% BRICS COUNTRIES
- 35% EU COUNTRIES
- 15% AFRICAN COUNTRIES
- 5% NORTH AMERICA

UNIVERSITIES AND NETWORKS
- 45% SOUTH AFRICAN UNIVERSITIES
- 20% SWISS UNIVERSITIES
- 30% CONTACTS AND NETWORKS ESTABLISHED
- 15% EXTEND COLLABORATION TO INTERNATIONAL NETWORKS

BENEFITS OF LINKAGES
- 20% NEW RESEARCH TOPIC
- 70% EXTENT COLLABORATION WITH SWISS AND SOUTH AFRICAN PARTNERS
- 20% GOVERNMENT INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
- **25%** Exchange and transfer of research material to and from CH
- **15%** Inadequate equipment and funding thereof
- **10%** Challenge reaching research environment for fieldwork
- **5%** Experiment challenges

GENERAL
- **30%** Inadequate support for HCD (e.g. scholarships)
- **5%** Decrease in ZAR value - decrease in project funds
- **5%** Lack of follow-up funding
- **5%** High flight costs to EU

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Novartis – a Swiss Private Sector Company in Public Health Research and Innovation

As a one of the global leaders in Research & Development (R&D) and employing 23 000 scientists worldwide, Novartis invests in scientific capability development as part of an integrated strategy to strengthen healthcare systems in middle/lower income countries. The Swiss pharmaceutical giant invests US$9 billion in R&D every year to ensure patients around the world can have access to transformative medicines.

Through its science and healthcare development partnership with South Africa, Novartis' business activities contributed US$250 million towards the GDP of South Africa in 2018. Furthermore, Novartis' total employment impact exceeds 5 000 jobs in South Africa with direct jobs totalling more than 700 and an indirect employment impact of just over 1 000 jobs. The indirect impact is as a result of Novartis buying goods and services from local vendors.

Novartis also delivers a significant positive human capital impact. These include various initiatives each year to enhance the skills and knowledge of healthcare professionals, as well as multiple programmes to build medical research capacity in South Africa.

Novartis drives the Chronic Disease Foundation initiative to sustainably improve healthcare delivery for chronic diseases and focuses on the localisation of products in pursuit of locally relevant and globally competitive research and innovation (Novartis, 2018).

Novartis, the DST and SAMRC signed an MoU on 25 May 2017 in Cape Town. The agreement not only brought opportunities for additional collaboration in education, research and innovation but builds on the longstanding support that Novartis provides to South Africa in research capabilities, human capacity development and innovation.

Novartis Global CEO Vasant Narasimhan said during his first visit to Ghana, Kenya and South Africa on 7 June 2018, that after just one year of signing the MoU the collaboration showed promise for successful partnerships in communicable and non-communicable diseases. For Novartis, increasing clinical research skills had the potential for multiple positive knock-on effects to strengthen local healthcare systems, while innovation would attract further investment with positive outcomes for the economy and job creation. (Professional Healthcare Press Room, 2018).

"Previous efforts to build capacity have tended to focus on well-recognised academic facilities. In partnership with the DST and the MRC, we have now been able to identify candidates and programmes in under-resourced facilities, where excellent work deserving of our support is being carried out. It has been encouraging to see the scope of research in under-resourced facilities, and it has been gratifying to contribute to building capability and supporting these facilities," said Narasimhan.

A key contribution of Novartis to South Africa specifically and to Africa in general is the support for drug discovery, initially for malaria and TB. The H3-D Director, Prof Kelly Chibale, and his research team are benefiting from the collaboration with the Novartis Institute for BioMedical Research (NIBR), ensuring that they take basic science and clinical research to that of innovation. Novartis will also provide H3-D with new chemical starting points for drug discovery against tuberculosis.

Key elements of the Novartis collaboration with H3-D include: human capacity development in pre-clinical and clinical research areas, including FDA-level clinical study sites for the testing of new molecular entities; exchange programmes through internships, postdoctoral fellowships and sabbaticals; and financial support from the Novartis Research Foundation for training and infrastructure.

INITIATIVES

Novartis South Africa initiatives include: • The young physicians' skills development programme, funding postgraduate studies in Clinical Epidemiology at Stellenbosch University • The Next Generation Scientist programme at the University of Kwa-Zulu-Natal • Partnering on the MSc degree course in Regulatory Sciences at UWC and Hibernia College • Clinical trials capability building with UCT • Young Scientist training in Genetic Research in collaboration with Wits University and drug discovery and clinical trials (28 trials involving 1 602 patients across 163 trial sites in the private and public sector).

Novartis South Africa is also a corporate citizen that is relevant and sensitive towards the needs of the communities it operates in. The company has partnered with the Clicks Foundation to address a challenge faced by adolescent girls in the country.

According to UNICEF, one in 10 girls in Africa miss four days of school per month during their menstrual cycle due to a lack of sanitary towels. This means in a year, 10% of girls that have reached puberty are absent from school for a total of 48 days (nearly two months) for this reason. This has an impact on their ability to perform in class at the same level as their male counterparts.

To address this challenge, the Novartis and Clicks Foundation partnership saw 1 000 girls in two schools in Diepsloot, Johannesburg receive reusable sanitary towels with a life span of 3 – 5 years. This is a huge saving for families in the low income community.

Discovery and development of novel natural plant products as leads against neglected tropical diseases

UNIVERSITY PARTNERS

University of Basel
Professor Matthias Hamburger
Swiss Tropical and Public Health Institute
Professor Dr Reto Brun
University of Pretoria
Professor Vinesh Maharaj

Data generated by the WHO indicates that approximately 800 million individuals in several countries worldwide have succumbed to neglected infectious diseases, with protozoan diseases such as Leishmaniasis, African Trypanosomiasis and Chagas disease high on this list.

Unfortunately, there has been drug resistance by the protozoan, an expression of undesired effects, as well as reduced drug availability and access. Due to the high cost of research and development in potential drugs and the lack of return on their investment because of the economically disadvantaged position of the patients, this group of diseases has become unpopular to players in the pharmaceutical industry.

This project aimed to investigate novel natural plant molecules against malaria, Leishmaniasis and Trypanosomiasis parasites and develop these as far as the preclinical candidate stage. This would subsequently lead to reduced cases of disease-induced mortality and morbidity as well as poverty among the affected populations in the disease-endemic countries.

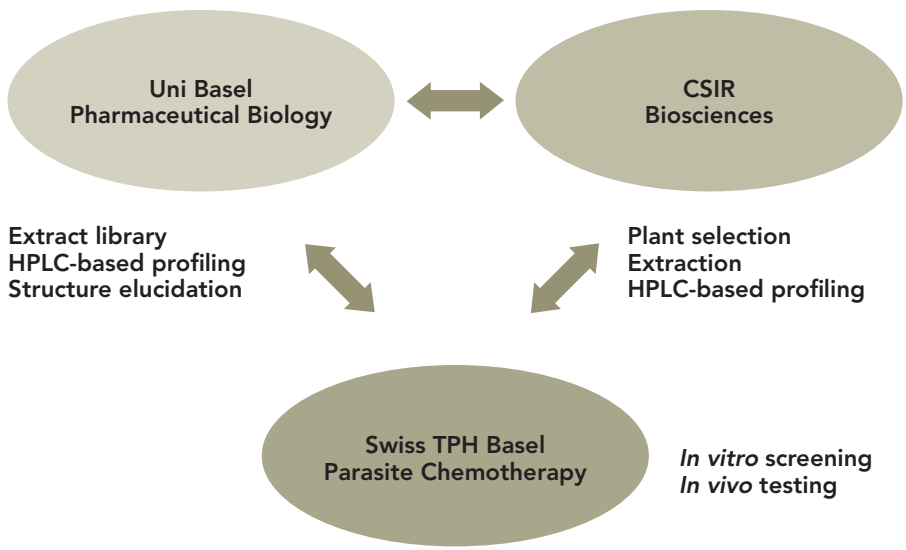
The researchers could not identify lead compounds that would be of direct interest to industry. The compounds identified from *Abrus precatorius* could have potential as starting point for a medicinal chemistry effort, with the aim of providing material for *in vivo* testing, and possible structural optimisation.

A collaborative network was established between the two countries, which exposed South African plant biodiversity to biological assays that are not readily accessible to South African scientists. Modern chromatographic technologies to rapidly identify active compounds from complex plant extracts have been transferred to South Africa. This technique does not rely on the classical bioassay-guided fractionation, which is time-consuming and results in wasted resources, but rather on a miniaturised, resource-sparing and rapid approach.

The collaboration has provided the Swiss scientist with new, unique and unexplored biological materials. South Africa's largely untapped biodiversity was accessed to identify new chemotypes for natural product-based lead

Photograph courtesy of Reto Brun

From left: Dr Heindrich Hoppe, Dr Joe Molete, Dr Paolo Meoni, Dr Nivan Moodley, Professor Vinesh Maharaj and Dr Dashnie Naidoo.



discovery in the area of neglected diseases. Knowledge generated from the project provides new entries for medicinal chemistry and potential activities in the areas of drug development.

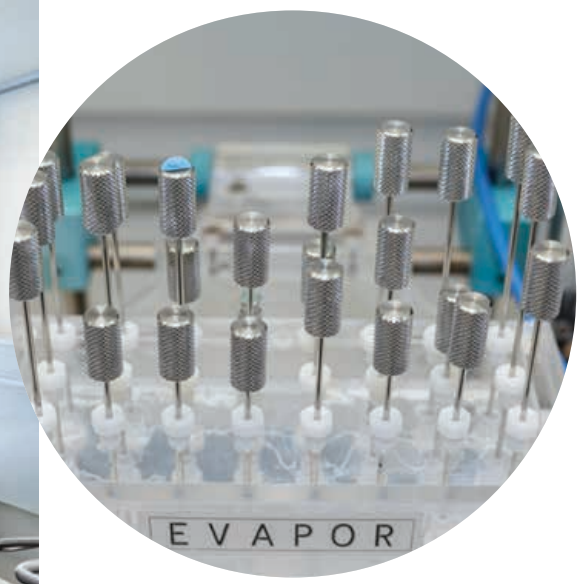
Of the 300 plant extracts prepared, *in vitro* biological evaluation against the protozoan parasites resulted in 102 (34%) being identified as "hits". The hits were selected for further research after review of the selectivity of their biological efficacy across the various parasites, analysing parameters such as ethnobotany strength, plant part used and probable compound type present. This resulted in two lists totalling 30 selected hits. Twenty of the more favoured candidates underwent immediate fractionation with the remaining hits reserved as back-up in the event of unacceptable results from the favoured candidate group.

At CSIR and University of Basel, the selected hits were submitted to a so-called HPLC-based activity, profiling a miniaturised approach to localise the active compounds in the extracts. Testing of the minute fractions obtained in 96-well format was performed at Swiss TPH. At the University of Basel, this approach was combined with spectroscopic detectors enabling, to some extent, a structural characterisation. The follow-up on the most promising extracts via a targeted preparative purification led to a range of compounds with *in vitro* activity. They represented different structural classes of secondary metabolites. Unfortunately, the most promising compounds, with high potency and selectivity *in vitro*, and favourable physico-chemical properties (a measure for "drug-likeness"), could not be progressed to *in vivo* testing due to the minute amounts of compounds obtained.

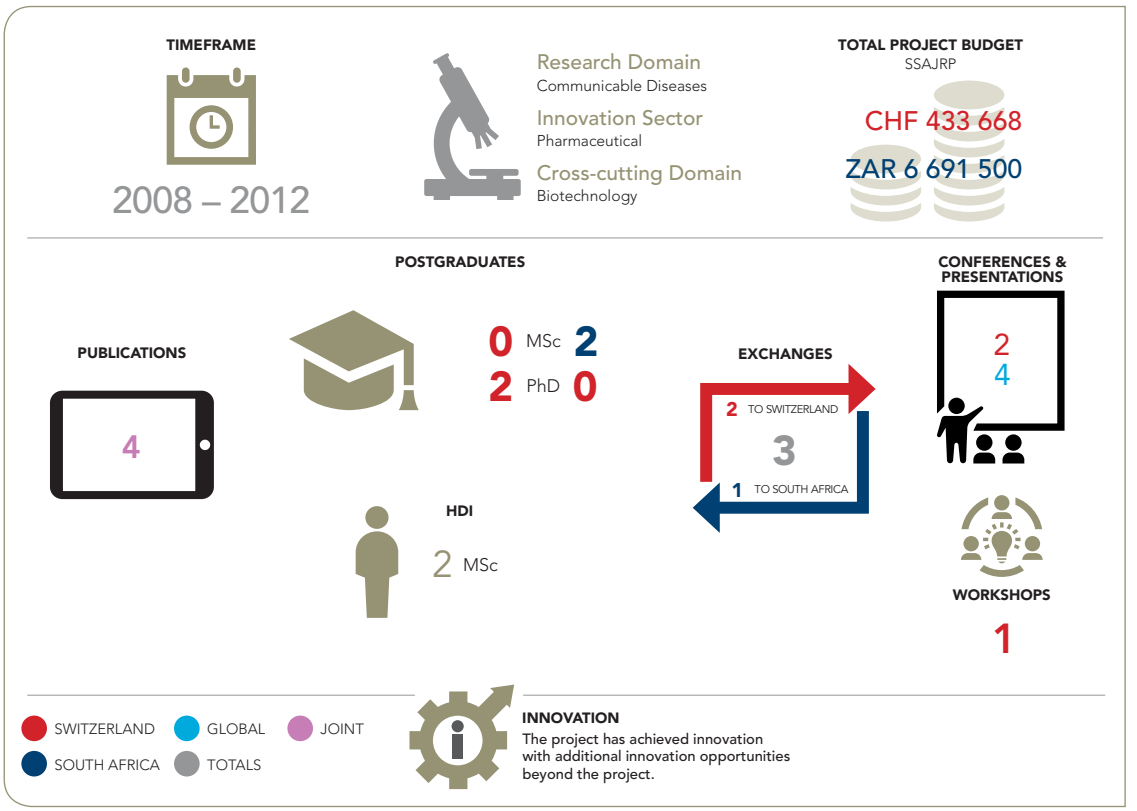
The research data has provided scientific data that substantiates the traditional use of medicinal plants, which have been used to treat neglected diseases. The data ultimately will be incorporated into research reports for communities, an initiative driven by the DST.

The collaboration included the University of Basel (with a focus on Pharmaceutical Biology); the CSIR (with a focus on Biosciences), and the Swiss Tropical and Public Health Institute (with a focus on Parasite Chemotherapy).

Microprobe NMR instrument for structure analysis.



Small scale evaporation of active extracts.



Impact of disease burden on schoolchildren's physical fitness and psychosocial health

UNIVERSITY PARTNERS

University of Basel
Professor Dr Uwe Pühse
Nelson Mandela University
Professor Cheryl Walter

Schoolchildren participating in the standardised 20m shuttle run test, which measures cardiovascular endurance.

The goal of the project was to assess the burden and distribution of communicable diseases and non-communicable chronic conditions among children in selected schools near Port Elizabeth, South Africa, and to assess their impact on physical fitness, cognitive performance and psychosocial health.

The objective was to undertake the scientific component with the SSAJRP grant and follow up with a school-based health promotion intervention for which the participants still had to source funding at the time.

The scientific component included an assessment of the extent of non-communicable chronic conditions (diabetes and obesity) and communicable diseases (helminth infections) and how they affect children in disadvantaged South African schools. Further aspects included assessment of the anthropometric indicators of the children where the results were correlated with the communicable and non-communicable diseases in the study population; a randomised pilot study to assess the effect of specific interventions, (lifestyle interventions and deworming); and an assessment of common allergens in children reporting allergies. The project

Deputy Vice-Chancellor for Research and Engagement at the Nelson Mandela University, Professor Dr Andrew Leitch, and the South African principal investigator, Professor Cheryl Walter, presents the university's Engagement Excellence Award 2017.

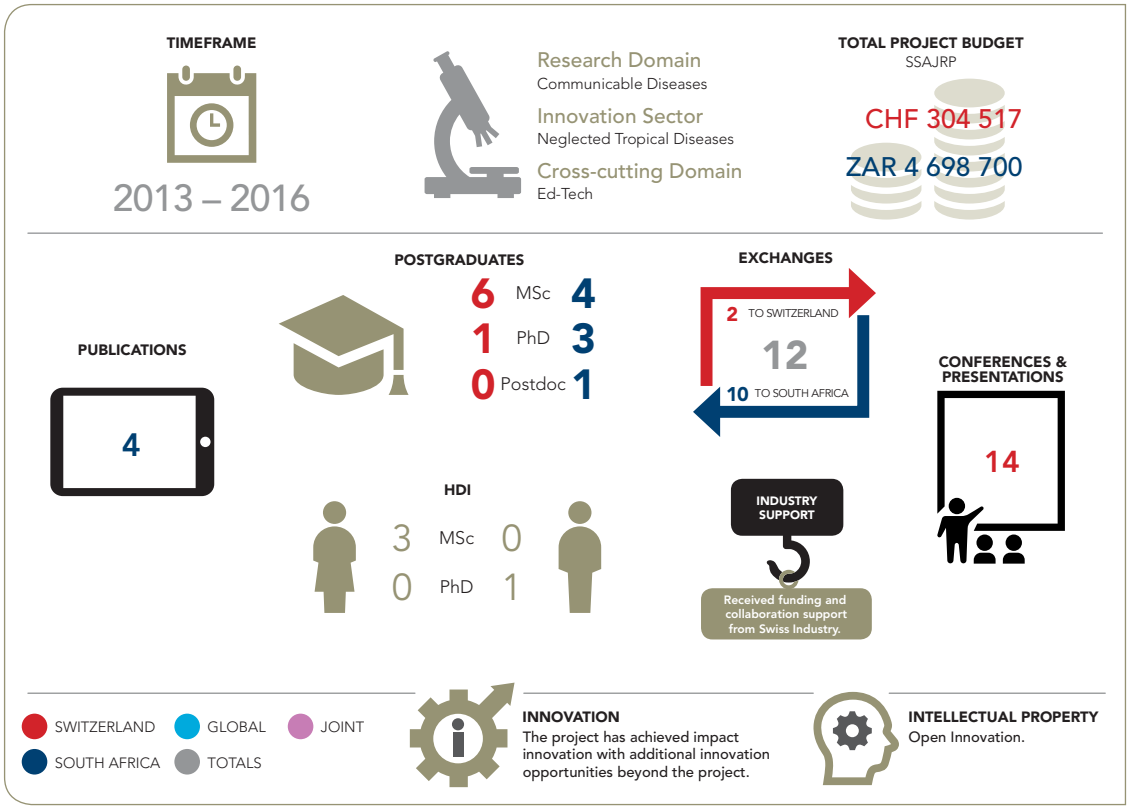
Photographs both courtesy of Nelson Mandela University

Qualified Medical Laboratory Sciences students conduct diagnostic tests on collected urine and stool samples.

assessed 1 000 children from eight project schools.

From the baseline results, schools were match-paired and divided into the intervention and control groups. The intervention Phase I included three main components: physical activity, health education and a nutritional intervention. Post-intervention testing took place when the entire set of tests was conducted again. The research team followed this up with the treatment of disease-positive schoolchildren, a second intervention phase and a last round of testing in 2016.

An allergy-testing component was added to assess sensitisation to common allergens, disease-burden among children with allergic symptoms and the correlation of allergy with socio-demographic and clinical characteristics.



HIV drug discovery from medicinal plants

UNIVERSITY PARTNERS

Esperanza Medicines Foundation
Professor Alex Matter
Professor Thomas Klimkait
University of Pretoria
Professor Vinesh Maharaj

The rapidly increasing number of HIV infection cases, especially in sub-Saharan Africa, has led to the increased use of traditional medicines in an effort to combat the disease. These traditional medicines have been noted to boost immune systems and control HIV in infected individuals. Although it is claimed that the general quality of life of the patients who take these traditional medicines is better than that of those not on the medication, there has not been scientific evidence to substantiate this claim to date.

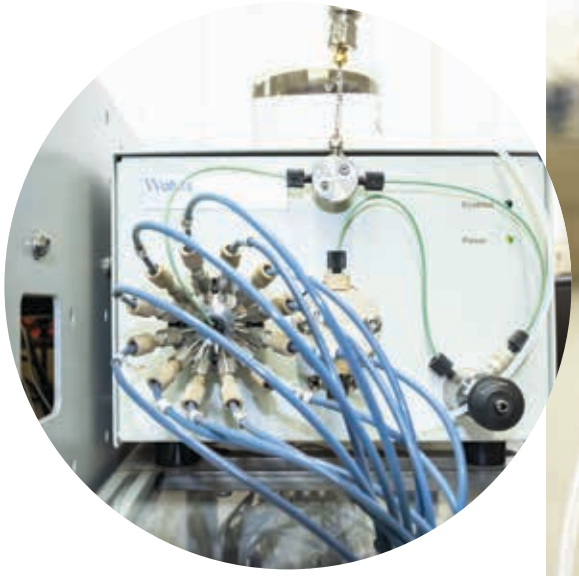
The successful isolation of the active ingredients from the traditional medicines should provide the necessary evidence to support these claims and will, more importantly, have a global impact on the availability of novel and less expensive natural-based HIV treatments. This project has the potential to increase global acceptance and legitimacy of traditional medicines.

This scientific endeavour was complemented by a combination of indigenous knowledge and the extensive biodiversity found in Africa.

The project team aimed to fill a compound pipeline with substances isolated from plants and lower organisms. They initially selected indigenous plants based on their traditional use related to HIV, and followed this up with the plant extract preparation. The extracts and pure compounds (obtained from the CSIR compound library) were divided into three batches and biologically assayed for their anti-HIV activity using a Swiss state-of-the-art cellular-based screening technology called the cellular infection anti-HIV system (deCIPh). Of the 88 plant extracts, six displayed potential for further development and were classified as "hits".

They evaluated a selection of 27 South African plants for anti-HIV activity, based on a desktop chemotaxonomic study of indigenous plants containing chemo-types with the backbone similar to those compounds in HIV clinical trials. Three plant extracts showed potent activity with no signs of toxicity while 24 extracts showed high potency but high levels of cytotoxicity. They also screened a traditional mixture of five plants traditionally used for the treatment of HIV, of which two exhibited good anti-HIV activity. The collaborative work they did on four Tanzanian medicinal plants and previous

PhD student from the University of Pretoria, Babalwa Tembeni.



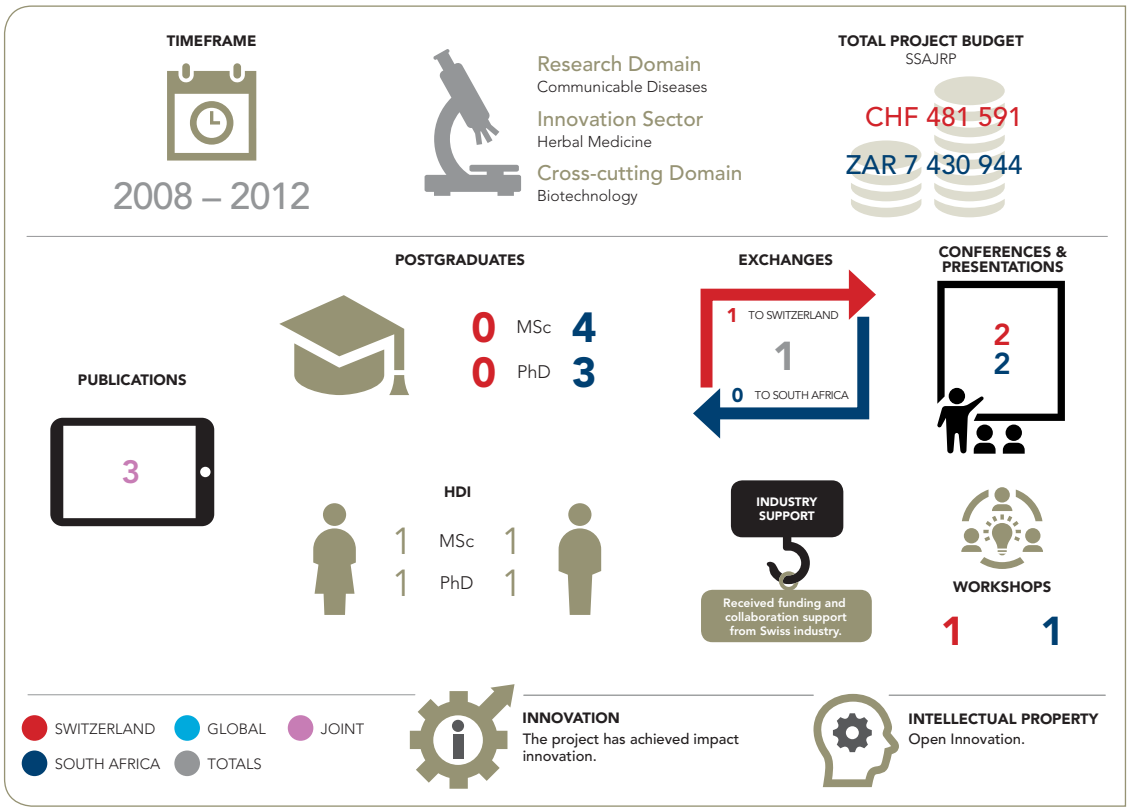
Maharaj laboratory

screening results of the extracts, showed that two plant extracts exhibited potent anti-HIV activity and these will be investigated further.

The team also screened crude organic and aqueous extracts as well as partially purified fractions of the South African *Helichrysum psilolepis* (Asteraceae family) for their anti-HIV-1 activity and found them to be very active at micro-Molar concentrations with two strains of HIV-1.

This project established the groundwork for collaboration between leading organisations in South Africa and Switzerland. It allowed South African scientists to further develop their skills in drug development based on the leads identified. A new technology has been introduced at the CSIR Biosciences: HPLC-based activity profiling of plant extracts into 96 well plates were implemented. In addition, the implementation of an accelerated approach to identifying the active compounds in complex plant extracts using semi-preparatory HPLC MS/MS technology has shown to be a powerful tool in drug discovery and a valuable asset to the CSIR.

Ultimately, plants identified with active ingredients will serve as the starting point to produce affordable and easy-to-produce anti-HIV/AIDS and anti-parasitic medicines. It has further led to traditional healers having their medicines exposed to modern biotechnology-based HIV and neglected diseases assays.



Evolution and epidemiology of rifampicin-resistant tuberculosis in Khayelitsha, Cape Town: implications for biology and disease control

UNIVERSITY PARTNERS

University of Basel
Professor Sebastien Gagneux
University of Cape Town
Associate Professor Helen Cox

Associate Professor Helen Cox from the University of Cape Town, Dr Lizma Streicher and Professor Robin Warren both from Stellenbosch University.

Professor Sebastien Gagneux from the University of Basel.

Bacteria resistant to multiple antibiotics are a growing threat for global public health and the economy. Multidrug-resistant tuberculosis (MDR-TB) and extensively drug-resistant TB (XDR-TB) are particular problems in many parts of the world, including South Africa. Yet, little is known of the bacterial factors driving the global epidemics of MDR/XDR-TB.

In the past, the common view was that the *de novo* acquisition of drug-resistance determinants during patient treatment was the main driver of drug resistance in TB. It was thought that, due to the fitness costs associated with resistance, drug-resistant strains were less likely to transmit to other patients. However, recent experimental and epidemiological data show that the fitness of drug-resistant *Mycobacterium tuberculosis* (MTB) is heterogeneous and that most MDR-TB is in fact transmitted. Preventing ongoing transmission of drug-resistant TB (DR-TB) is fundamental to controlling the epidemic. Understanding the drivers behind the *de novo* emergence and subsequent transmission of DR-TB, and the impact of treatment with currently available treatment regimens and those that include newly available drugs, is essential to improving control strategies.

The research group is aiming to use next-generation whole genome sequencing (WGS) to describe and understand the evolution and epidemiology of DR-TB in Khayelitsha, a high HIV, TB and DR-TB burden setting in South Africa. As part of a community-based DR-TB treatment programme, initiated in Khayelitsha in 2008, a detailed patient-level clinical database is being maintained. Project members proposed to link this data to a biobank of stored DR-TB strains held at Stellenbosch University to address their objectives.

The first objective was to assess the between-host evolution and extent of transmission of DR-TB through analysis of WGS, among drug-resistance categories, over time (data was available for a 10-year period from 2008-2017), between HIV-negative and HIV-infected patients, and across geographical areas within Khayelitsha. Another objective was to assess within-patient strain evolution among initially DR-TB strains during treatment for individual

Processing TB isolates in a biosafety Level 3 laboratory.

Stored frozen TB isolates.

patients, focussing on resistance acquisition for key existing and new TB drugs and contrasting HIV-negative and infected individuals.

The study, which is currently under way, is both retrospective – using data and stored isolates from 2008-2015 – and prospective, utilising data from the Khayelitsha programme from 2016-2017. MTB isolates are sub-cultured and bacterial DNA extracted in South Africa and then sent to Switzerland for WGS. Data analyses will be performed in close collaboration between the teams.

Through describing the role of strain diversity and resistance acquisition in transmission of DR-TB in a high DR-TB setting, this study has the potential to dramatically improve understanding of DR-TB transmission and the impact of current control strategies. In addition, as Khayelitsha is one of the pilot sites for expansion of access to new TB drugs, this study provides opportunity to study the impact of expanded use of new drugs on resistance evolution. The data generated through this study also provides an opportunity to assess the potential feasibility and impact of using WGS for routine, rapid determination of TB drug resistance, in order to optimise and individualise second-line treatment.

TIMEFRAME

2017 – 2020

Research Domain
Communicable Diseases

Cross-cutting Domain
Bio-Infomatics

TOTAL PROJECT BUDGET
SSAJRP

CHF 512 985

ZAR 7 915 363

POSTGRADUATES

0	PhD	1
1	Postdoc	1

HDI

1 Postdoc

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Development and characterisation of Shigella glycoconjugate vaccines

UNIVERSITY PARTNERS

Swiss Federal Laboratories for Materials Science and Technology
Professor Dr Linda Thöny-Meyer
Dr Michael Kowarik
University of Cape Town
Professor Neil Ravenscroft
3rd Party
GlycoVaxyn AG, now LimmaTech Biologics AG

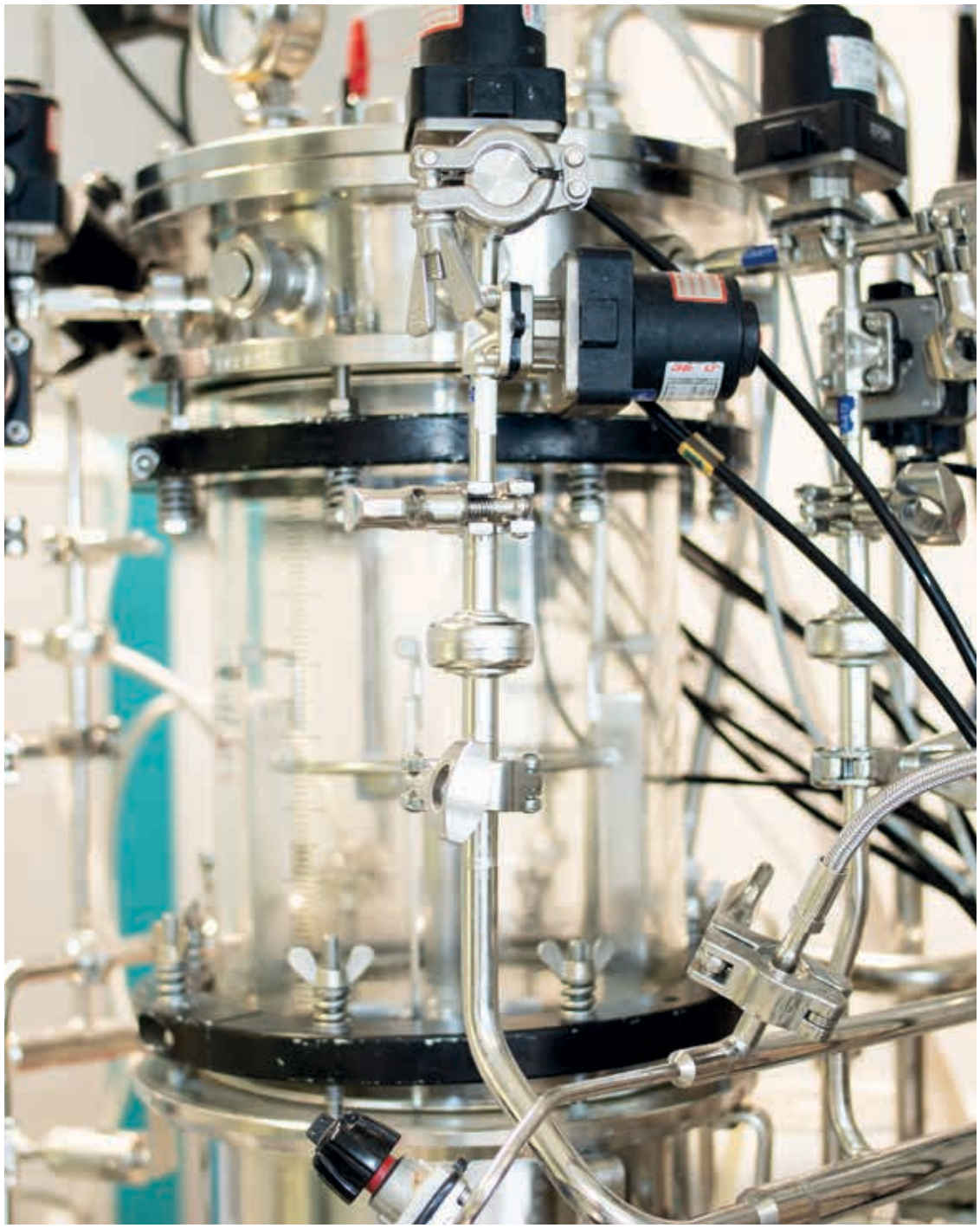
The participants in this project employed an interdisciplinary approach to the research and development of affordable vaccines to address health needs, such as Shigellosis, in the developing world. Shigellosis is an infectious disease caused by a group of bacteria called Shigella. Shigellosis results in diarrhoea, fever and stomach cramps one or two days after being exposed to the bacteria.

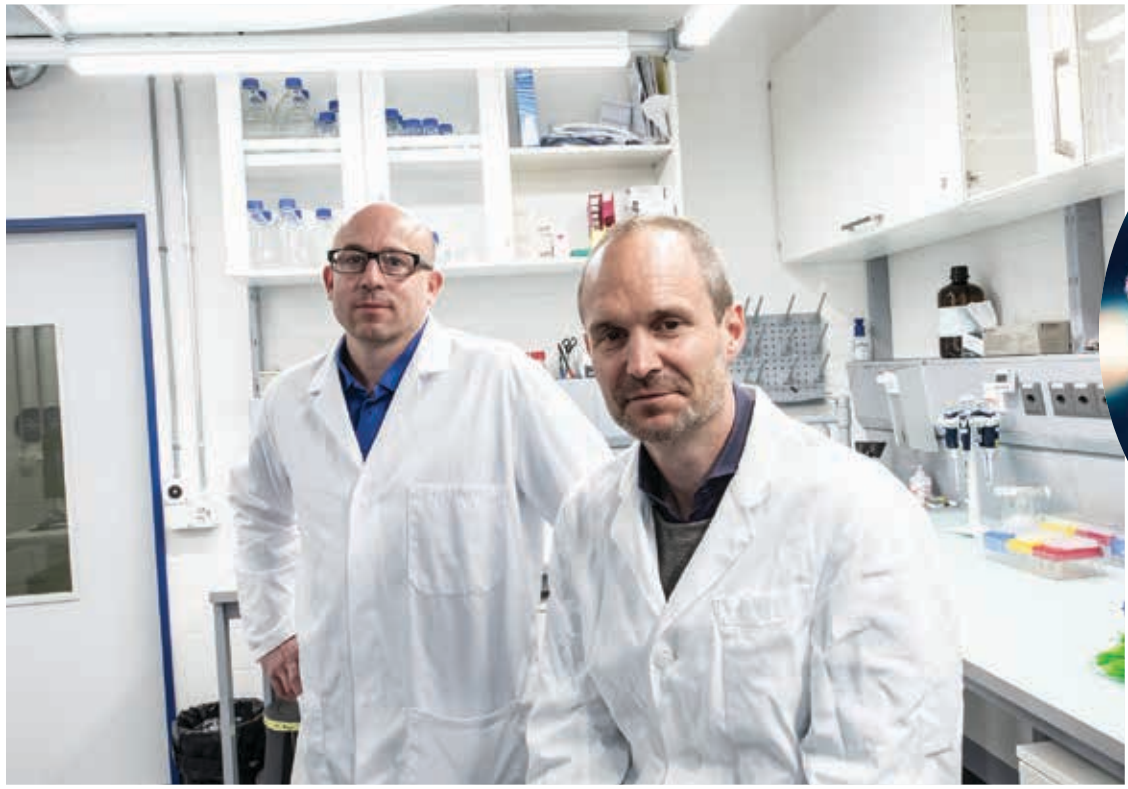
Shigellosis is a major public health concern with approximately 165 million cases annually, resulting in about five million hospitalisations and over 1,1 million deaths, mainly in the developing world. No vaccine is available.

The collaboration between the University of Cape Town, Empa St Gallen and GlycoVaxyn was aimed at *Shigella flexneri 2a* and *Shigella sonnei* glycoconjugate production, chemical synthesis of the *S. sonnei* O-antigen repeating unit and the physicochemical characterisation of the glycoconjugate vaccines. Empa St Gallen focused on developing a downscale model for upstream process development and GlycoVaxyn provided *S. flexneri 2a* glycoconjugate, auxiliary materials as well as analytical and process know-how. This collaboration resulted in successful *S. flexneri 2a* glycoconjugate production, detailed analytical characterisation and establishment of a downscale model, including the identification of critical process parameters for fermentation.

Researchers at UCT established protocols for the structural elucidation of the carbohydrate antigens and applied them to the bioconjugates produced by GlycoVaxyn and Empa St Gallen. They achieved even more detailed nuclear magnetic resonance (NMR) spectroscopy characterisation of the carbohydrate and associated amino acids on conjugates following proteolytic treatment and purification. By preparing a well-characterised glycoconjugate vaccine candidate against *S. flexneri 2a*, the partners have established a suitable platform for the production and analysis of other glycoconjugate vaccines.

Despite the many challenges presented by the zwitterionic *S. sonnei* antigen, the researchers





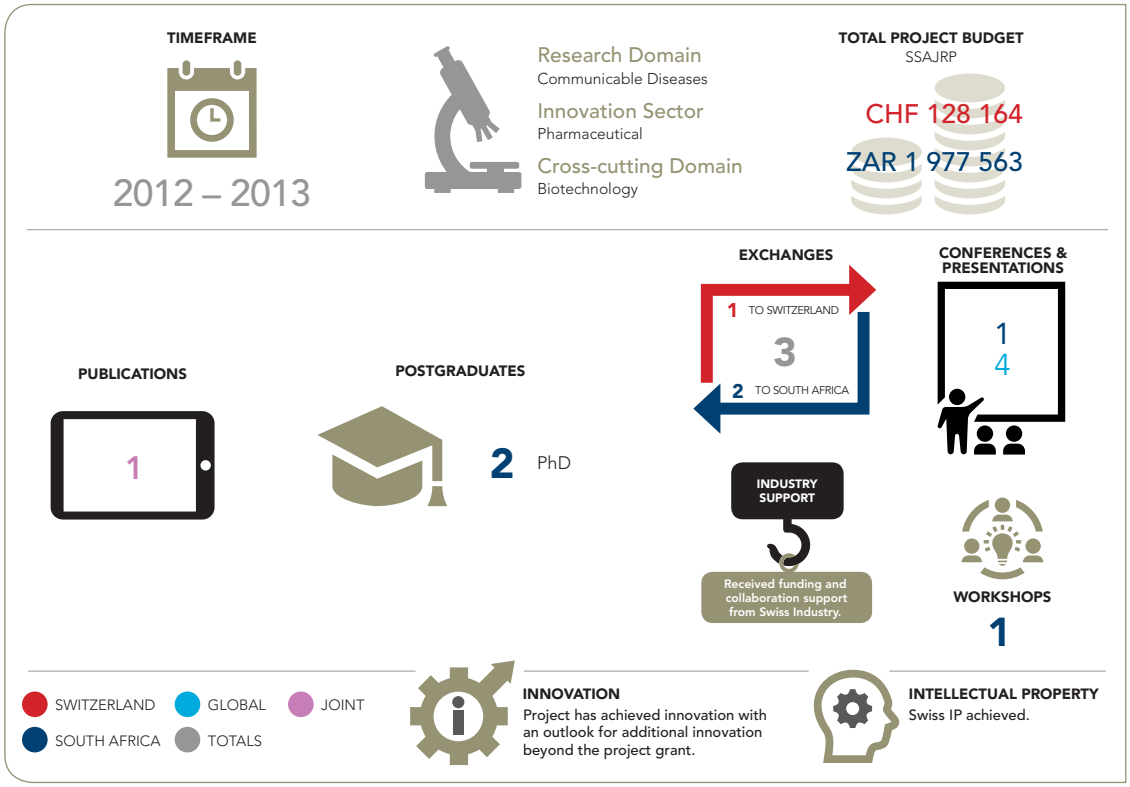
Michael Steffen and Dr Michael Kowarik.

Shigella bacteria.

made some progress with regards to the chemical synthesis and characterisation of the *S. sonnei* O-antigen, and production of the recombinant *S. sonnei* polysaccharide in *Escherichia coli* cells. However, the strain construction, manufacturing process and associated yield of the *S. sonnei* glycoconjugate require further attention.

Vaccine development and licensure take 8-10 years and even longer if a multivalent vaccine is required. The Global Enteric Multicenter Study showed that broad-spectrum vaccine protection against Shigellosis can be achieved with a tetravalent vaccine comprising O antigens from *S. sonnei, S. flexneri 2a, S. flexneri 3a,* and *S. flexneri 6*. No such vaccine is currently available.

GlycoVaxyn, now GSK (using its subcontractor LimmaTech Biologics AG), is continuing to develop a multivalent Shigella conjugate vaccine and has just completed a Phase 2b clinical study with the well-characterised bioconjugates vaccine against *S. flexneri 2a*. All the vaccines in development and clinical trials are based on the bioconjugates production and characterisation methodology investigated during this project.



Nano-vesicle and micro-sponge Pheroid® drug delivery system for antimalarial drugs with probable reversal of drug resistance for chloroquine

UNIVERSITY PARTNERS

Swiss Tropical and Public Health Institute
Professor Dr Reto Brun
North-West University
Professor Anne Grobler

Photograph courtesy of Anne Grobler

Research conducted in Professor Grobler's laboratory.

The worldwide prevalence of malaria is estimated to be in the order of 250 million clinical cases annually, of which half a million people die. This can mainly be ascribed to the rapidly escalating acquisition of drug-resistance by *Plasmodium falciparum* strains, which subsequently renders the administered treatments ineffective. In addition to drug resistance acquisition, other contributing factors that promote the global increase in malarial cases are the elevated cost and limited availability of conventional anti-malarial drugs.

The main aim of the project was to develop Pheroid®-entrapped antimalarial drugs and investigate the potential increases in efficacy and uptake or absorption of these antimalarial drugs in Pheroid®-drug micro-sponge and nano-vesicle carrier combinations. This project hinged on the nature of the Pheroid® technology and the versatile project task force with their particular facilities. Pheroid® is a stable lipid-based submicron emulsion delivery system. It is unique in that its morphology, structure, size and function can be manipulated as required. The non-toxic nature of this delivery system is attributed to its constituent natural and/or essential fatty acid compounds that have been formulated with various drugs for novel and innovative dosage forms.

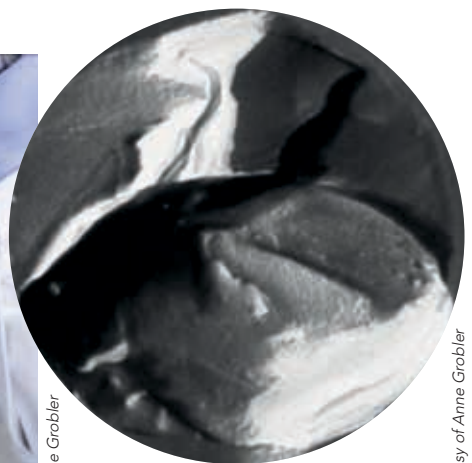
The North-West University (NWU) successfully characterised the chemical and physical nature of the formulations and entrapment of antimalarials in Pheroid® micro-sponges and nano-vesicles. Both the NWU and the Swiss Tropical and Public Health Institute (Swiss TPH) performed *in vitro* and *in vivo* studies of the efficacy of the entrapped antimalarials on resistant malaria parasites. The entrapment of the antimalarials amodiaquine (AQ) and artemisone in Pheroid® vesicles resulted in enhanced uptake in mice. No toxicity or discomfort was exhibited by any of the animals in these studies.

The re-use of cheaper raw materials in the low start-up and manufacturing cost requiring Pheroid® manufacturing process will significantly reduce the costs for pharmaceutical companies. There is still the potential to treat latent disease and multidrug-resistant malaria parasites. Pro-Pheroid® formulations did increase the stability of previously unstable active pharmaceutical ingredients (APIs). Novel adult and paediatric dosages can and have been formulated and the Pheroid®-based concept may be applied to the treatment of other parasitic diseases.

Initiation meeting of project at the NWU with representatives from STPHI, NWU, CSIP and UP.

Photograph courtesy of Reto Brun

In vitro *evaluation of Pheroid®-antimalarial formulations at the Swiss Tropical and Public Health Institute.*



Photograph courtesy of Anne Grobler

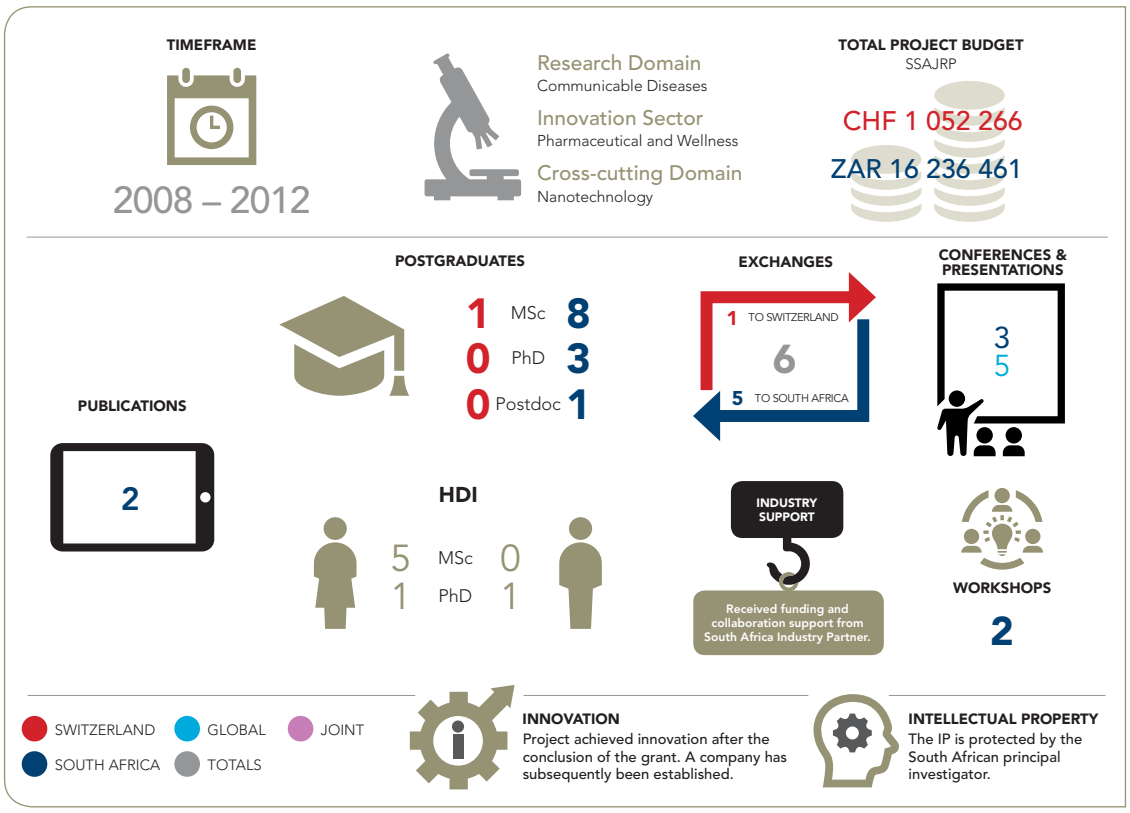
Pheroid® with antimalarial compound entrapped below.

Photograph courtesy of Anne Grobler

While the original aim was not reached, the contribution that the project made to the future commercialisation of home-grown South African technologies cannot be underestimated. The industrialisation phase of this research project is ongoing and is already making a contribution to job and wealth creation in the North-West Province.

To date, five Pheroid® antimalarial vesicle and micro-sponge complexes have been manufactured with upscaling to pilot batch size. Development and validation of Pheroid® size and morphology measurement methods were undertaken and entrapped drug verification is now feasible. Accelerated stability studies were performed for two of the antimalarial drugs entrapped in Pheroid®. The uptake and pharmacokinetics of the Pheroid® -based malarial formulations have since been determined in non-human primates. These studies showed clinically relevant improvement of the absorption of Pheroid® CQ (chloroquine) but not of Pheroid® AO (artemisone). Furthermore, in the case of Pheroid® CQ, preferential targeting to the erythrocytes were observed, which should result in improved efficacy. The use of a carrier system, such as the Pheroid®, is still under investigation at the NWU.

The project enabled the scientific exchange of scientists and technical personnel of the Swiss TPH and counterparts of the NWU in Potchefstroom and other institutions in South Africa. The project was an early enabler in the development of a Pheroid® manufacturing facility with the resultant creation of new jobs and capacity building. The cost-effective African-focussed new formulations studied during the course of the project are helping to improve the health and well-being of individuals outside the scope of these projects.



Protein bioinformatics resource development for important health-related pathogens

UNIVERSITY PARTNERS

Two parallel efforts to unravel the causes of drug resistance of M. tuberculosis and HIV:

Swiss Institute of Bioinformatics
Professor Ioannis Xenarios
Updated and extended the annotation of targeted sequence
Contrasted predictions with experimental literature
Updated and structured virus annotation around HIV-1 and host interactions

University of KwaZulu-Natal
Dr Tulio de Oliveira
Identified a subset of HIV viruses for selecting representative sequences, Predicted HIV resistance and used Viralzone knowledge representation

University of Cape Town
Professor Nicola Mulder
Provided a list of proteins for annotations
Provided network-based priority targets

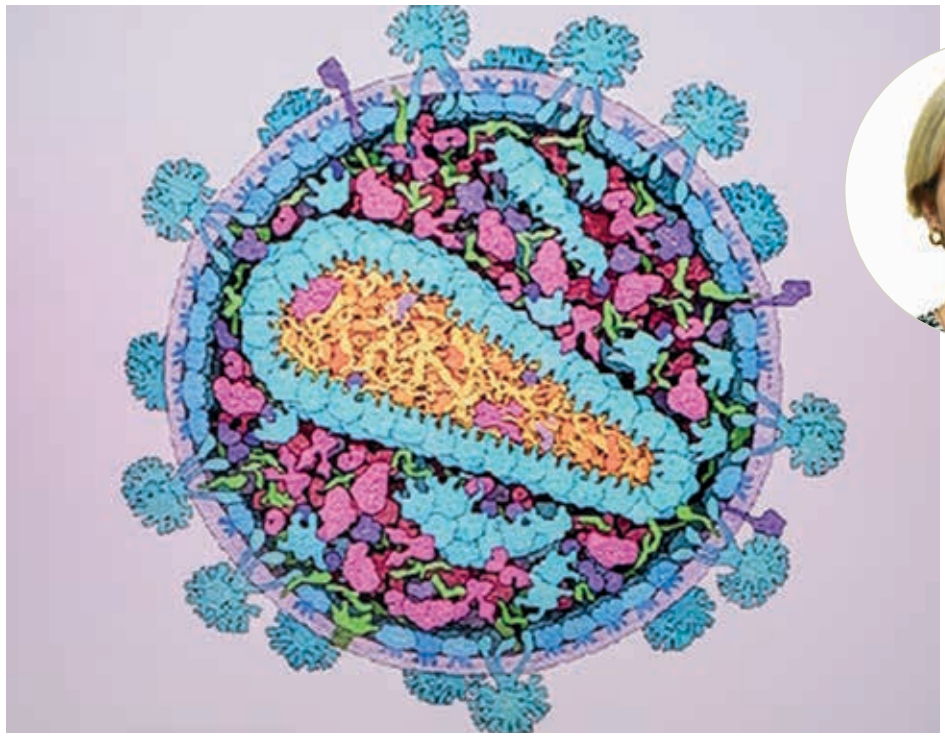
The **first phase** of this project aimed to create the first African protein annotation group to unravel the causes of drug resistance acquisition by some southern African HIV-1 and tuberculosis (TB) strains, and also to strengthen viral protein annotation and proteomics resources.

Human Immunodeficiency Virus (HIV) and Mycobacterium tuberculosis (MTB) are two of the most important health-related pathogens in Africa, causing Acquired Immune Deficiency Syndrome (AIDS) and tuberculosis (TB) respectively. It is, therefore, paramount for an inaugural African protein annotation group to be created to generate scientific research data that shed light on the drug resistance of southern African HIV-1 and TB strains, specifically in multiple and extremely resistant strains, and the characterisation of the MTB metabolome. Knowledge of this resistance and the ability to create drugs that fight against it can result in significant advancements in the fight against these diseases, especially in developing countries.

The researchers selected a set of MTB proteins that is adequate for both training and annotation purposes. They annotated a total of 102 MTB proteins from this set and 10 others have had their annotations updated. The MTB proteins cited in recent literature as being involved in virulence were also annotated. They assigned Enzyme Commission (EC) numbers to up to 60 uncharacterised proteins.

In the HIV research sector, team members carried out entries to update the 353 HIV-1 UniProtKB/SwissProt while they conducted the curation of approximately 2 500 genotypes with clinical data from antiretroviral (ARV) treatment cohorts in the South African region. The HIV proteomics resource and the RNA virus database were updated with information from Swiss-Prot. In addition, two drug-resistance databases, the mirrors of the Stanford HIV drug resistance and RegaDB database, were published.

Strengthening viral protein annotation and proteomics resource is important to the international medical research community. One of its many applications is as a tool that is used globally to feed the drug development pipeline. Capacity of South African researchers was built in the field of protein bioinformatics and resource development. This project thus addressed the national goal of human capacity development in a scarce skills area. Moreover, it allowed the expansion of resources in South Africa to fight the pandemic of HIV and AIDS via the publication of the "Public database for HIV drug resistance in Southern Africa" database in *Nature* (2010).



Characterisation of multiple and extremely drug-resistant HIV and MTB strains in Africa for potential treatment of HIV/AIDS and tuberculosis.

Professor Nicola Mulder

An integrated Mycobacterium tuberculosis resource for drug discovery

The **second phase** of the project aimed to provide the TB research community with a portal that integrates reference information on the MTB genome and proteins and research information derived from Mulder's laboratory in South Africa and Cole's laboratory in Switzerland. Reference information is based on TubercuList, the major knowledgebase for H37Rv, the reference MTB strain. The UniProt knowledgebase provides high-quality functional annotation and gene ontologies of thousands of proteins, including MTB proteins, for manual biocuration and annotation.

The Swiss group performed a comparison of the TubercuList and UniProtKB databases, determining which proteins in each database to focus annotation efforts on in order to provide a synchronised and more complete dataset to the scientific community. The Mulder laboratory developed and implemented the function prediction algorithms and used a functional interaction network between proteins in MTB to predict gene ontology (GO) biological process terms and TubercuList functional classes for unknown proteins. This increased the number of GO annotated proteins in this organism

substantially and predictions have been linked to relevant protein entries in TubercuList.

The group also used network properties to predict likely essential proteins and thus potential drug targets, and has compiled a list of known or predicted targets from a variety of sources to provide to UniProt and TubercuList. Host-pathogen interactions were predicted by the Mulder group using interologs based on intra- and inter-species interactions. These were filtered to ensure the interacting partners are expressed at the appropriate time and in the appropriate subcellular location. The two networks can be visualised using a new interactive network visualisation tool developed by the group.

The project has improved public resources and the data therein for TB, an important disease for Africa and other parts of the world. The resource is open to researchers world-wide and thus has the potential to impact global research on TB. Most scientists use the public databases such as UniProt and TubercuList in their research on all aspects of TB, including new drug design and vaccine development, therefore the added value provided in this project will improve the ability of scientists using the resources to achieve their research goals.

The **third phase** of the project aimed to represent fundamental knowledge on HIV/AIDS and MTB in an innovative and interactive way, with links to relevant databases.

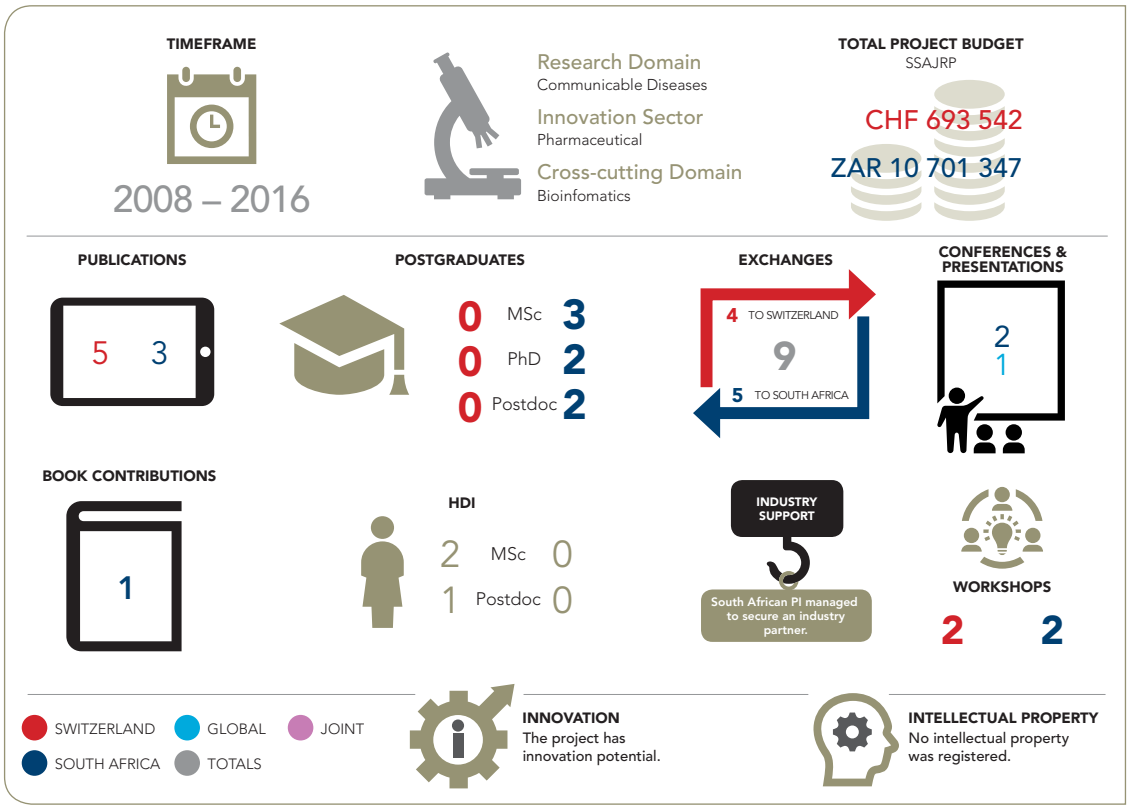
The Southern African Treatment Resistance Network (SATuRN), the Swiss Institute of Bioinformatics (SIB) and the University of Cape Town (UCT), constructed an online resource that provides specialised proteomic, host-pathogen interaction and bioinformatics information on HIV and TB and drug activity/resistance mechanisms. This unique web resource was constructed using one of the most advanced systems for protein data curation available in the world, in order to provide clinicians and researchers with new cutting-edge knowledge that can be used to combat drug resistance in Africa.

The UCT partner aimed to predict host-pathogen (MTB) interactions, do RNA-Seq analysis of TB strains, and develop an interaction visualisation tool. The host-pathogen predictions were complete, and around 200 interactions were predicted with validation from public expression data. Expression and mass spectrometry data from local strains were analysed. The proteomics data enabled proteogenomic analysis of the strains, and results are being fed to the Swiss partner to improve MTB annotations. A protein interaction network visualiser (PINV: http://biosual.cbio.uct.ac.za/pinv.html), which enables visualisation of intra- and interspecies interactions, was developed and published.

The project has produced an HIV proteome resource on the Swiss and South African websites. This resource has received over 50 000 visits since inception and has been published at *Database* (Oxford), the official journal of the biocuration community. The TB host-pathogen interaction and expression analysis has identified a number of key potential drug targets and proteins involved in virulence. The annotation has improved the quality of TB data in Swiss-Prot, which will benefit the entire TB community. The focus on drug targets for annotation will benefit industry partners.

A female South African student completed her MSc (cum laude) as part of this project, and a female coloured student registered for an MSc. Two previously disadvantaged individuals from De Oliveira's group attended Next Generation Sequencing training in Cape Town in 2016. Dr Mazandu, a black African, visited Geneva and Lausanne as part of this project.

Professor Ioannis Xenarios



Single cell analysis of peptidoglycan remodelling and resuscitation in Mycobacteria: implications for TB disease

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology in Lausanne
Dr Neeraj Dhar
University of the Witwaterstrand
Dr Bavesh Kana

Measuring cylinders in the South African partnering laboratory of Dr Bavesh Kana, used to prepare of reagents that are required to grow Mycobacterium tuberculosis under laboratory containment.

Considering the importance of successful bacterial proliferation to TB disease and the predicted effect that efficient interruption of these processes will have on treatment outcome, the research team of the SSAJRP-funded collaborative research programme between Wits University and EPFL aimed their work at identifying new drug targets in bacterial cell division. They directed their research specifically towards understanding how bacteria remodel their cell walls during division and how the enzymes involved in this process ultimately regulate bacterial growth and cell division.

The underlying premise of their work was that this remodeling process is critical for pathogenesis and represents a vulnerability within the mycobacterial cell, which can be exploited for killing tubercle bacteria in the lung.

The project united the complementary skills from the South African team in gene manipulation and mycobacterial physiology with that of the Swiss partner, who is a global leader in the field of mycobacterial single-cell time-lapse microscopy. The result has been a vibrant collaboration, with

rich knowledge and student exchange, which has resulted in high-impact outcomes and substantive capacity development.

Since the discovery of penicillin in 1928, disruption of cell wall biosynthesis with antibiotics has proven to be a clinically successful strategy with bacterial infections for close to a century. However, these benefits have not accrued to TB due to the refractory nature of MTB to treatment with conventional penicillin-type antibiotics. The research conducted in this project has allowed for an extraordinary view of cell division in tubercle bacteria and the resulting findings have extended the scientific understanding in this field. The researchers identified enzymes that could possibly be used as targets for the development of new TB drugs.

Numerous collaborative discussions have allowed the South African partner to further develop its TB research portfolio, which has facilitated the development of verification reagents for novel diagnostics, for TB detection. These tools have been provided to the National Department of Health to facilitate rollout of new molecular diagnostics and have also been approved for use by the World Health Organization. As a result, Wits University has spun out a company to market these reagents in over 20 countries. These efforts have also led to the filing of a patent and the licensing of intellectual property.

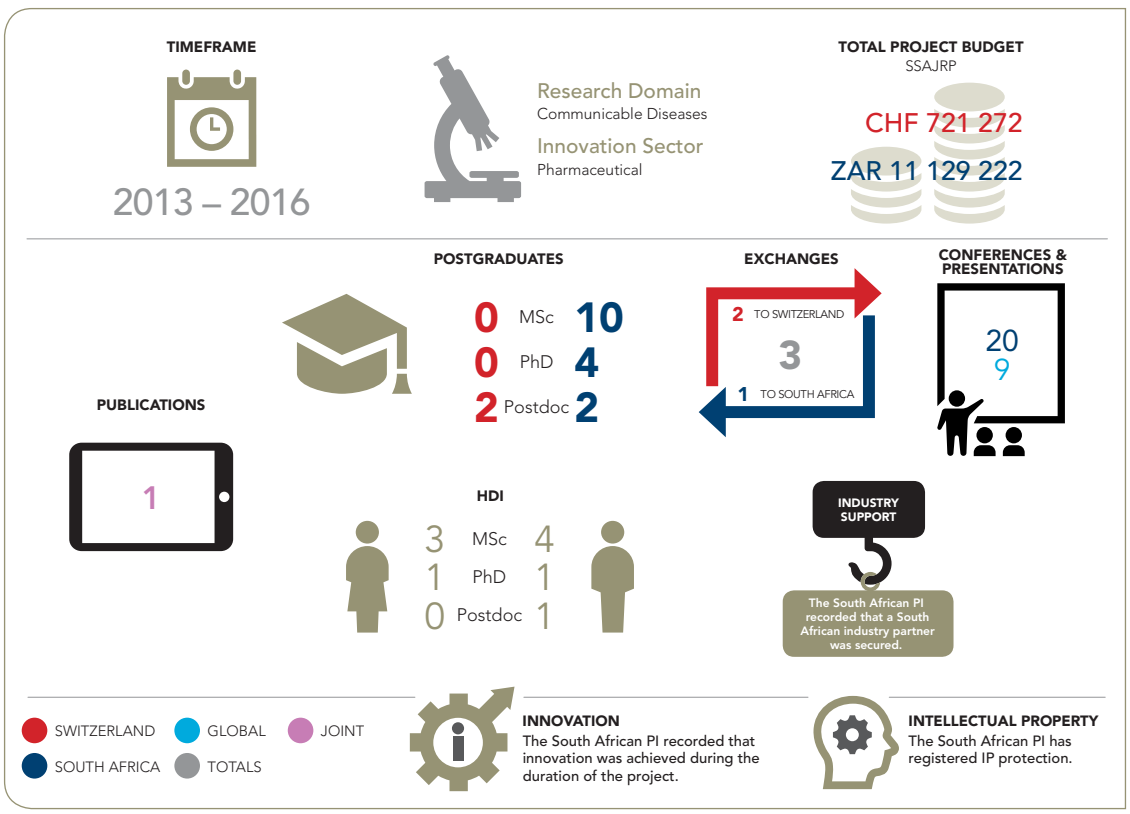
Students engaged in this programme have conducted numerous public awareness campaigns for TB and drug-resistant TB. These included participation in World TB Day activities and the hosting of stalls at local research days and symposia. The individuals within the research team that led this programme are community activists against TB. As an example, several students from the laboratory participated in the "Unmask Stigma" campaign, a social initiative targeted at reducing the stigma associated with TB and TB-HIV. Due to their unwavering commitment and innovative ideas, these students won a cash prize for their efforts.

Photograph courtesy of Neeraj Dhar

Dr Neeraj Dhar

Photograph courtesy of Bavesh Kana

Dr Bavesh Kana



Remodelling of Mycobacterial peptidoglycan during cell division in tuberculosis disease

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology in Lausanne
Dr Neeraj Dhar
National Health Laboratory Service
Dr Bavesh Kana

The development of novel therapeutic options for the treatment of tuberculosis (TB) has become a deep-rooted urgency in modern medicine, driven by the rapid emergence of drug-resistant TB and the substantive loss of human life associated with this disease. The emergence of complex forms of drug-resistant TB, such as extensively drug-resistant (XDR) and totally drug-resistant (TDR) TB, has heightened the global crisis associated with TB. Furthermore, treatment of TB is complicated by the prolonged period of time required to eradicate persisting bacteria, which is necessary to achieve non-relapsing cure.

This project is aimed at identifying new drug targets for TB, through an analysis of the peptidoglycan component of the mycobacterial cell wall; and at assessing how remodelling of the cell wall contributes to bacterial persistence during treatment.

The main focus was directed at mycobacterial cell division as substantive remodelling of the bacterial surface is required for this process and disruption thereof will unmask new vulnerabilities in the mycobacterial cell that could be exploited for killing the organism. Remodelling of the cell surface is driven by cell wall hydrolases and recent studies reveal that these enzymes play important and divergent roles in mycobacterial cell division. The research group is assessing the role of distinct classes of peptidoglycan hydrolases in cell division and bacterial survival through a multi-pronged approach involving bacterial physiology, chemical biology and immunology.

Furthermore, it has been demonstrated that sputum samples from patients with active TB disease, before the initiation of treatment are characterised by a large proportion of organisms that are unable to grow under standard conditions. These organisms, termed differentially culturable tubercle bacilli (DCTB), selectively require cell wall remodelling enzymes for recovery and also display drug tolerance, suggesting that they comprise persisting organisms that are able to withstand treatment. This observation confirms an important role for cell wall remodelling processes in modulating bacterial growth dynamics in pulmonary TB in humans.

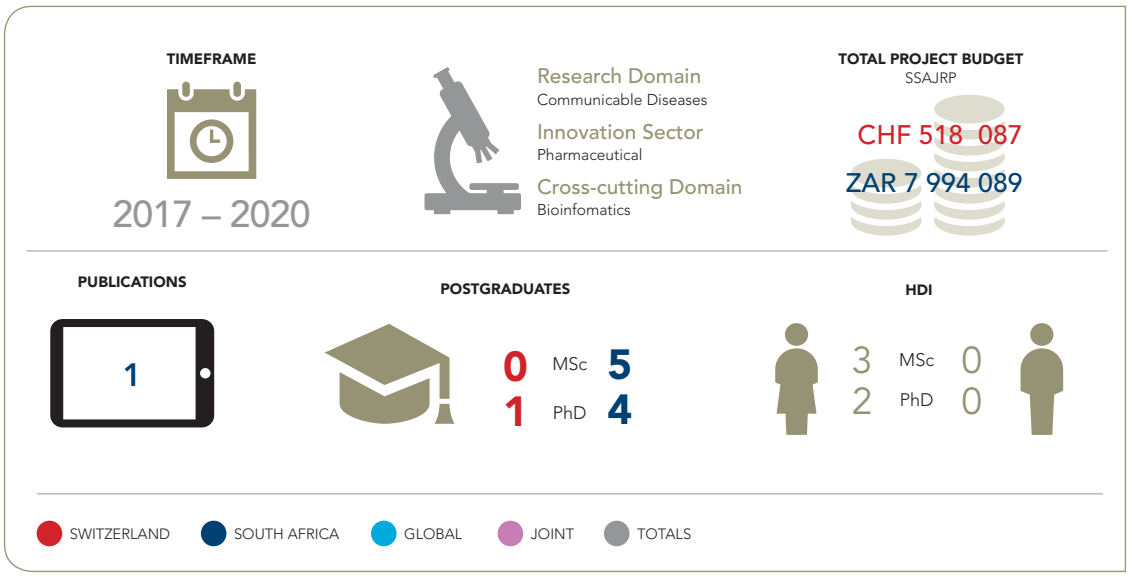
Using single-cell time-lapse microscopy, these processes will be studied to further understand how cell wall remodelling enzymes affect bacterial recovery from TB-diseased individuals.

Time-lapse microscopy serves as one of the principal tools to address mycobacterial phenotypic heterogeneity in Dr Dhar's laboratory.

The peptidoglycan component of the mycobacterial cell wall remains an underexplored area in TB drug development and in this context, the work proposed for this project has great promise to deliver new TB treatments.

In addition, the study of persisting bacterial organisms that display drug tolerance is essential to develop new treatment modalities that have a shorter duration and a reduced daily pill burden.

Considering this, the study of DCTB in patient sputum will provide insight into the environmental cues that tubercle bacilli use to modulate their growth and metabolism. The researchers expect that this enhanced understanding of bacterial growth will allow for the development of more accurate culture-based diagnostics and new measures of drug efficacy.



Molecular mechanisms of propionate catabolism in Mycobacterium tuberculosis

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Lausanne
Professor Dr John McKinney
University of Cape Town
Professor Valerie Mizrahi

Tuberculosis (TB) is an infectious bacterial disease caused by Mycobacterium tuberculosis (MTB). Major advances in mycobacterial research have been achieved in recent years, but research to date has not fully elucidated the metabolism of MTB during infection. The overall aim of this study was to develop better insight into the metabolism of MTB.

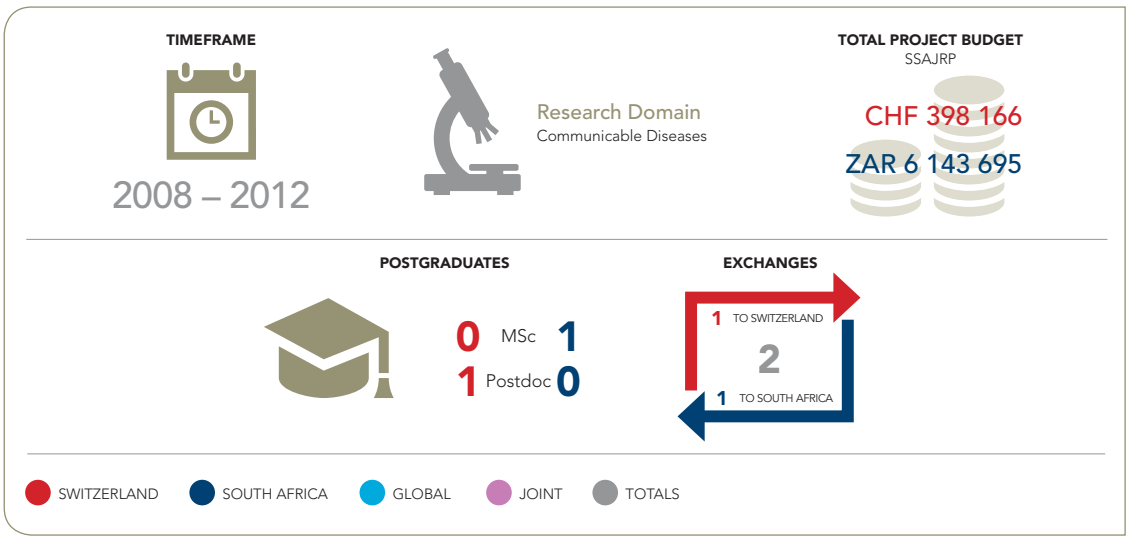
As an obligate pathogen, MTB must survive within disparate host environments during successive cycles of infection, replication, persistence, and transmission. In turn, this suggests that the organism must possess the metabolic flexibility to adapt to variable nutrient availability, in particular a deficiency in glucose as a carbon source and an abundance of fatty acids. The consumption of alternative carbon sources – including odd- and branched-chain fatty acids, branched-chain amino acids, and cholesterol – generates the compound, propionyl coenzyme A (propionyl-CoA) as a three-carbon (C3) terminal product. Propionate is a high-energy metabolite, but is toxic to MTB if accumulated in high concentrations. This dual nature implicates propionate metabolism in the growth and persistence of MTB during host infection.

The methylmalonyl pathway, one of the potential pathways of propionate metabolism in MTB, uses the enzyme methylmalonyl CoA mutase, which is dependent on a vitamin B12-derived cofactor for activity. As such, it constitutes a natural fulcrum for this collaborative project, uniting two primary research interests of the applicant laboratories: the regulation and function of carbon metabolic pathways (Swiss) and the contributions of vitamin B12 biosynthesis and B12-dependent enzymes (South Africa) to MTB pathogenesis.

The researchers assessed the effect of combined methylcitrate cycle and methylmalonyl pathway loss on virulence by undertaking processes including MTB mutant strain construction. Central in addressing the main aim of the project are *in vitro* characterisation of growth on alternative carbon sources; investigation of the capacity of MTB to transport and utilise selected vitamin B12 and pseudovitamin B12 precursors to support the function of B12-dependent pathways; and the identification of proteins involved in the transport of vitamin B12, vitamin precursors and cobalt in MTB are central in addressing the main aim of the project.

Exposure to state-of-the-art technologies that have been established in the Swiss laboratory has benefited the South African collaboration team on a technological level. These include single-cell microbiology based on time-lapse video microscopy and microfluidics, as well as metabolomics (large-scale metabolite analysis). The application of these techniques is changing the face of research in the field of mycobacterial metabolism.

Professor Dr John McKinney



Novel host-protective functions against Leishmaniasis using transcriptomics and cell-specific gene-deficient mice

UNIVERSITY PARTNERS

University of Lausanne
Professor Fabienne Tacchini-Cottier
University of Cape Town
Associate Professor Reto Guler

Leishmaniasis, one of the neglected infectious diseases, is a significant health problem in Africa with a rising concern of Leishmania-HIV co-infection. There is an urgent need to develop more effective drugs and vaccines in the fight against Leishmanisasis. In sub-Saharan Africa, Leishmaniasis is responsible for high morbidity and mortality. There is no efficient vaccine and an increase in resistance against the commonly used drugs is observed. It is therefore important to dissect the immunological pathways involved in the development of a protective immune response to *L. major* infection.

This collaborative project brought new insights regarding the mechanism required to develop a protective immune response against the parasite. Better knowledge of the immunopathology contributed to improving the design of an efficient vaccine against Leishmaniasis.

The data provided important insights into understanding the immune response taking place following infection with *L. major*, contributing to the knowledge needed to design an effective vaccine.

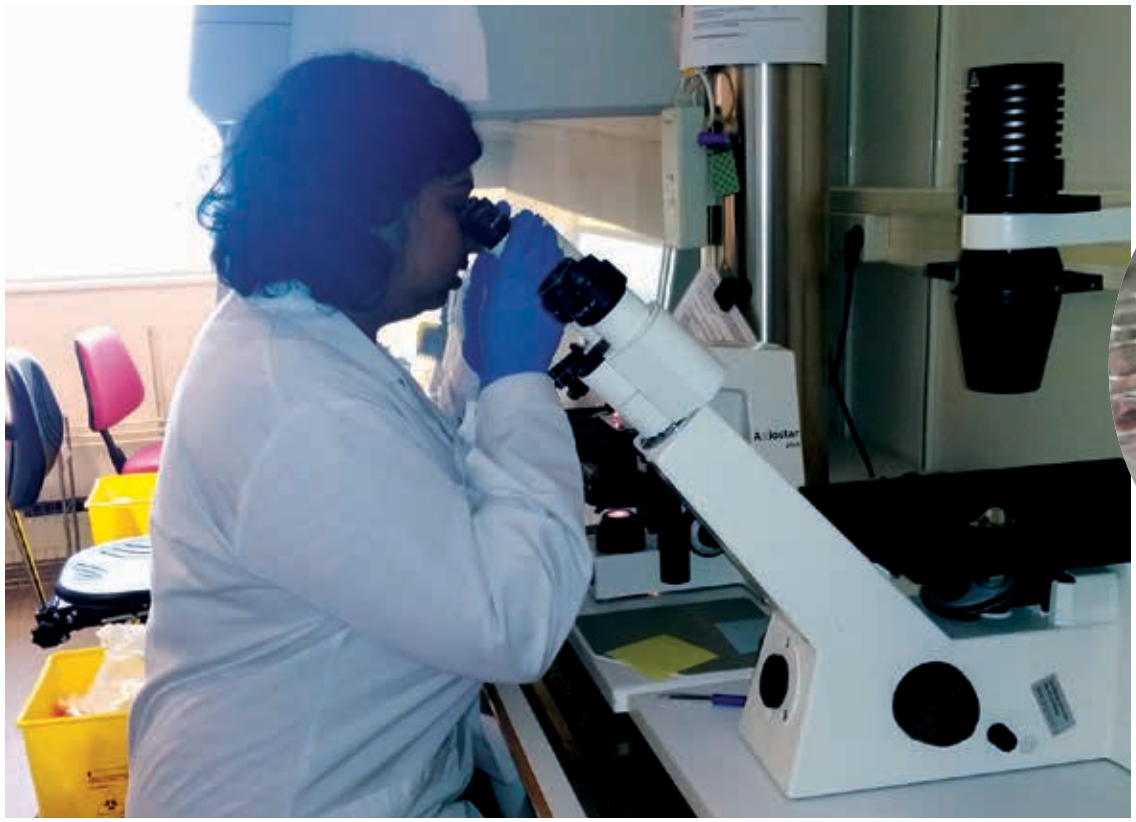
The short-term goal of the project was to better understand the cellular interactions between keratinocytes and other cells present in the microenvironment at the site of infection. They showed that IL-4 (interleukin-4, a small protein that plays an important part in certain immune reactions) interaction with keratinocytes during the first hours of infection is not critical in launching the adaptive immune response needed to cure the diseases. These results contributed to the team's long-term goal, which was to identify important therapeutics and drug targets for Leishmaniasis. The uncovered mechanisms may be relevant to immunopathogenesis of many other infectious diseases.

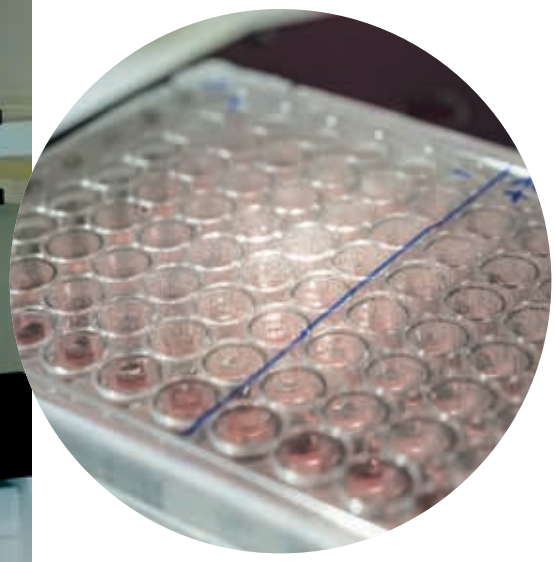
The collaboration of the Swiss and South African teams with complementary competencies in immunology, infectious disease and biotechnology enhanced capacity building of both partners' host institutes, and contributed in the long term to the much-needed international effort to fight neglected diseases such as Leishmaniasis.

Some of the laboratory members are (from left): Bere Salazar, PhD, Professor Fabienne Tacchini-Cottier and Katiuska Passelli, PhD student.

Research group of Associate Professor Reto Guler (UCT) with Dr Ramona Hurdayal, Shandra Pillay and Lorna Gcanga.

Photographs courtesy of Reto Guler



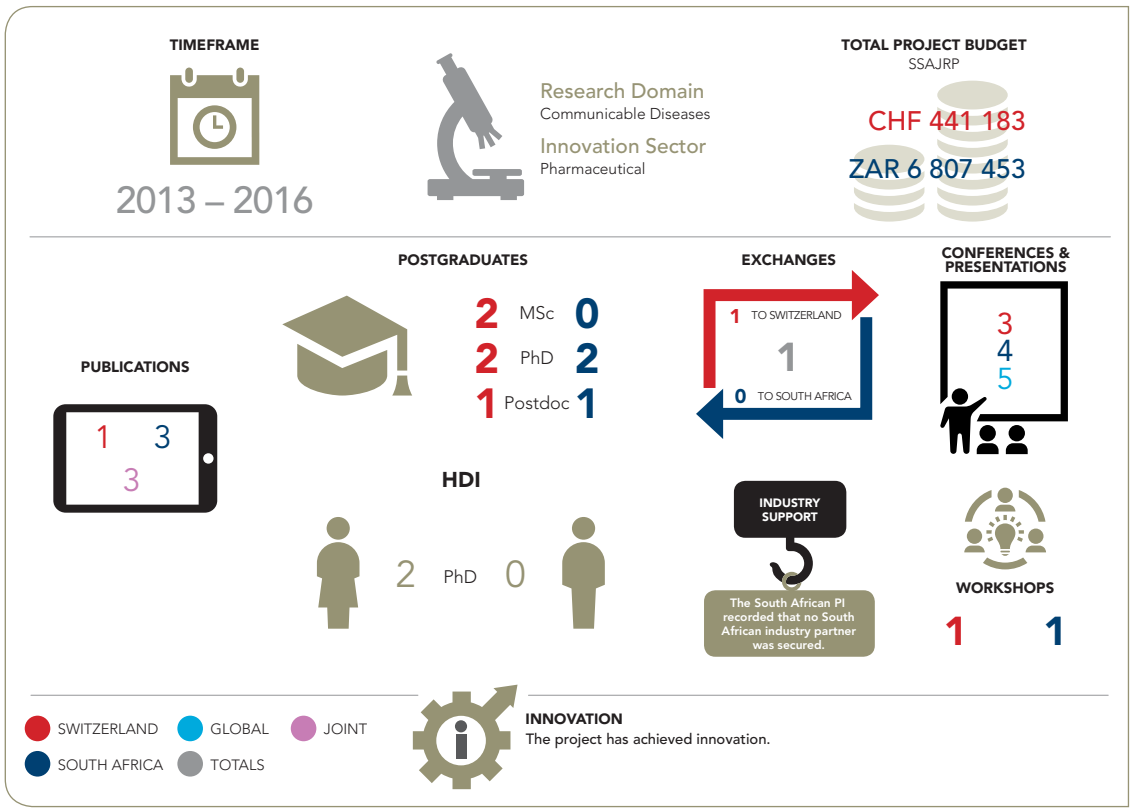


Photograph courtesy of Reto Guler

The lead author Dr Melissa Govender (UCT) evaluates parasites by microscopy.

The community at large will benefit from this project since this research work investigated the early protective immune response to *L. major* with a constructive impact for future development of potential novel host-directed therapy against Leishmaniasis. This research is of particular importance to developing countries where Leishmaniasis is highly prevalent with an estimated 1,3 million new cases occurring annually. It also raises the awareness for alternative host-directed drug treatments against Leishmaniasis with the benefits of avoiding drug resistance against Leishmania parasites.

The exposure of postgraduate students to international experts, along with technology transfer, provided scarce skill development and much-needed training for the South African biotechnology and industry sectors.



Virulence of pneumococcal serotypes in human meningitis

UNIVERSITY PARTNERS

University of Bern
Dr Lucy Hathaway
National Institute for Communicable Diseases
Professor Dr Anne von Gottberg

This project is aiming, firstly, to determine the relationship between pneumococcal serotype and the severity of infection and, secondly, to establish an *in vitro* model for the prediction of serotype severity in humans to inform future vaccine design. *Streptococcus pneumoniae* (or pneumococci) are Gram-positive bacteria known to cause infections such as pneumonia, meningitis, bacteremia, sepsis and otitis. The most severe form of disease is invasive pneumococcal disease (IPD) and includes bacteremia and meningitis.

In 2009, a published paper calculated that *S. pneumoniae* causes about 11% of all deaths in children aged 1 – 59 months, with Africa having the highest incidence rate and accounting for 66% of pneumococcal cases worldwide. In South Africa, the mortality rate from pneumococcal meningitis is particularly high.

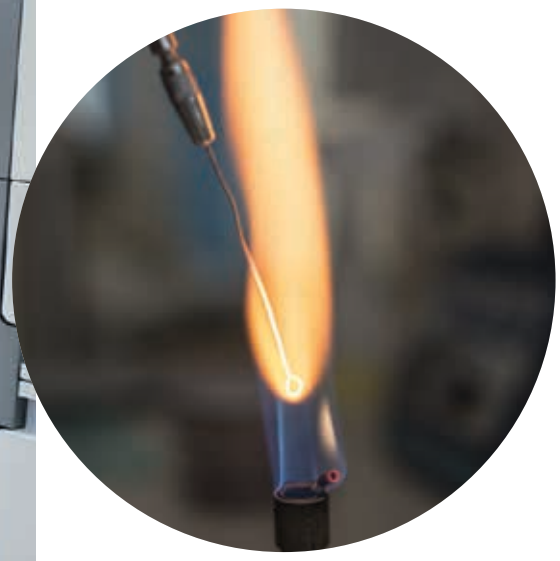
Among other factors, virulence of pneumococci can be attributed to the polysaccharide capsule that defines the pneumococcal serotype and of which more than 90 different serotypes exist. The polysaccharide capsule forms the basis for the manufacturing of vaccines, which play a large part in today's health by protecting people of all ages against diseases including IPD. In 2009, the 7-valent pneumococcal conjugate vaccine (PCV) was introduced for children in South Africa. Two years later, in 2011, it was replaced by PCV13. The introduction of these vaccines has led to a decline in vaccine-serotype IPD in all ages. However, while the prevalence of vaccine-serotypes is decreasing, increases in non-vaccine serotypes have been observed. A major reason for this is that currently all vaccines against *S. pneumoniae* target the polysaccharide capsule and are therefore specific for a fraction of the serotypes circulating in the human population. This gives a selective advantage to those serotypes absent from the vaccines. For this reason and to ensure that vaccines continue to be efficient in protecting against diseases, continued improvement and design of new vaccines is necessary.

Interestingly, some serotypes, referred to as invasive serotypes, are often associated with disease. Other serotypes are less likely to cause disease and are referred to as colonisers as they can be found colonising the nasopharynx of healthy adults and

Dr Lucy Hathaway and Annelies Müller in the laboratory in Bern, Switzerland.

Pneumococcal colonies growing on a blood agar plate.

Photograph courtesy of Prof A von Gottberg



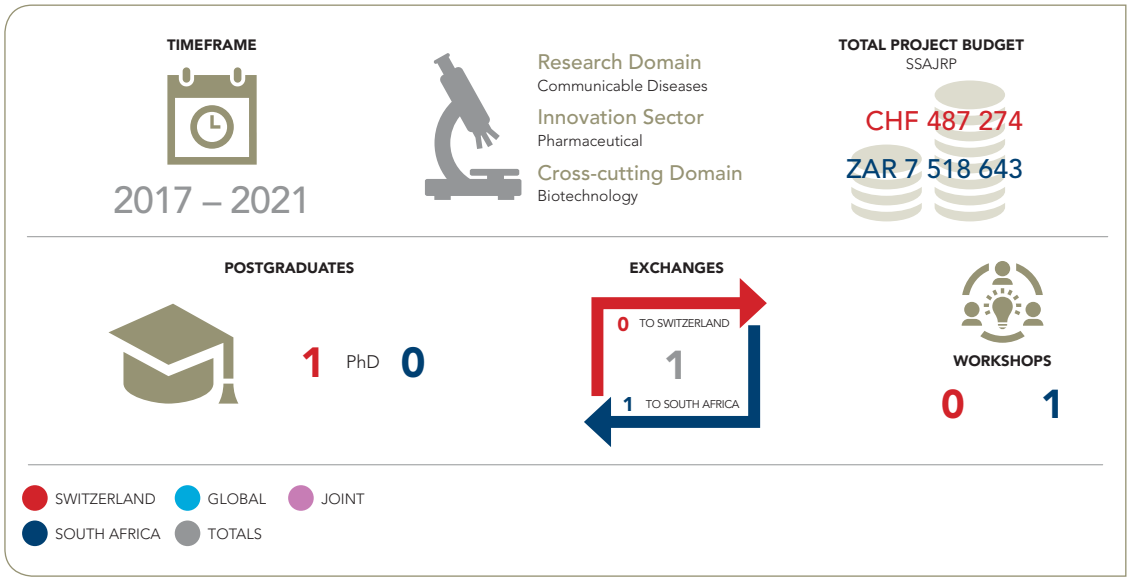
An inoculation wire loop is sterilised in preparation for lab experiments.

Professor Anne von Gottberg and Thabo Mohale, an MSc graduate, at the National Institute for Communicable Diseases laboratory.

children. It has been shown, however, that when these normally colonising pneumococci invade the body, they tend to cause particularly severe disease. Consequently, certain serotypes are clinically relevant depending on their invasiveness and the severity of disease they cause. Additionally, previous publications by the research group in Switzerland have shown that the pneumococcal capsule may play an important role in the severity of disease. These publications form the basis of this project.

The GERMS-SA enhanced surveillance program in South Africa and the expertise of the group in Switzerland in basic research, will contribute towards understanding the relationship between serotype and severity of disease. The knowledge gained from the project is important to help inform the design of future vaccines and will also contribute to the understanding of pneumococcal virulence in general.

The challenge involves coordination of 15 different GERMS-SA enhanced surveillance sites for CSF collection and organisation of transport logistics to ensure stability of inflammatory markers.



Role of TRIM5 and CypA in the HIV-1 transmission and pathogenesis of a well-characterised South African cohort

UNIVERSITY PARTNERS

University of Geneva
Professor Dr Jeremy Luban
University of KwaZulu-Natal
Professor Thumbi Ndung'u

A study of HIV-1-infection-prone individuals has revealed several genetic factors that protect some individuals from infection and disease progression. The research team investigated mechanisms of natural regulation of the HIV-1 restriction factors and HIV-1 cellular co-factors. Elucidation of these mechanisms will enable scientists to create novel vaccines and therapeutic interventions against this disease.

When these novel vaccines are rolled out into the global market, it could result in a significant global decrease in the infection rate. The innovation of novel HIV therapy will represent a major advance on a global scale.

During a study of the roles of CypA (cyclophilin A) in HIV-1 regulation, the research team discovered the tripartite interaction motif containing protein 5 (TRIM5) as an additional factor that could explain this disparate clinical phenotype. While searching for such factors among a specific cohort, they generated evidence to indicate that differences in TRIM5 and CypA correlate with different rates of infection, or different rates of disease progression in this cohort. The collaborators investigated the causes of the different clinical outcomes of HIV-1-infected people in this specific cohort with respect to the variants in the TRIM5 and CypA proteins.

The contribution of type 1 interferons (IFNs) as antiviral factors to HIV pathogenesis is not completely understood. The researchers carried out investigations to determine if the increased expression of a select type 1 IFN and TRIM isoforms is associated with a significantly lower likelihood of HIV-1 acquisition and viral control during primary HIV-1 infection. They found concordance between type 1 IFN (INF-1) and the TRIM22 isoform, the latter which is thought to act as an antiviral effector *in vivo*.

To test the hypothesis of the dysregulation of TRIM E3 ligases (TRIM5, 11, 19, 22, 36), CypA and IFN-1 factors upon HIV infection, they tested the peripheral blood mononuclear cells (PBMC) of HIV-positive subjects (within one year of infection) against those of HIV-negative subjects.

They also tested the hypothesis that there is a reduced likelihood of acquiring HIV-1 if innate

HIV PCR preparation workbench.

Members of Professor Thumbi Ndung'u's research group: Dr Kavidha Reddy and Sharon Khuzwayo.

Professor Thumbi Ndung'u

Preparation of reagents for whole genome HIV PCR.

and intrinsic immunity factors such as TRIM E3 and IFN-1 are expressed in increased quantities. Matched samples, i.e. PBMC from non-seroconverter subjects versus subjects who were recruited while HIV-negative and who later contracted the disease, were used. Conversely, they hypothesised that the likelihood of HIV contraction is increased by a high baseline expression of CypA. Results have shown that the expression of these factors indicates the progression of the disease (viral load and CD4+ T-cell counts).

This project gave answers for a number of emerging questions, some pertaining to the relative susceptibility of a well-characterised cohort of high-risk South African individuals to HIV-1 infection being due to expression levels of factors such as TRIM E3 ligases, cyclophilin A, and type 1 interferons in PBMC, and whether these factors correlate negatively with viral loads and positively with CD4+ T-cell counts. Insight into the HIV-1 target cells that express TRIM E3 ligases, and cyclophilin A and a positive *in vitro* demonstration of enhanced HIV-1 replication upon knockdown of particular TRIM E3 ligases, were also questions that pave the way for novel vaccine and therapeutic intervention creation against the disease.

TIMEFRAME

2008 – 2012

Research Domain
Communicable Diseases

Innovation Sector
Pharmaceutical

Cross-cutting Domain
Biotechnology

TOTAL PROJECT BUDGET
SSAJRP

CHF 407 599

ZAR 6 289 254

PUBLICATIONS

2

POSTGRADUATES

0	MSc	1
0	PhD	2

HDI

1	MSc	0
1	PhD	0

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

INNOVATION
No innovation was achieved during the project period but had the potential for the creation of novel vaccines and therapeutic interventions against the HIV-1 pathogen.

Analyses of geographical patterns of malaria transmission and mortality in Africa using Bayesian spatio-temporal modelling

UNIVERSITY PARTNERS

Swiss Tropical and Public Health Institute
Dr Penelope Vounatsou
University of the Witwatersrand
Professor Kathleen Kahn

Photograph courtesy of Paul Weinberg

Fieldworkers collecting Geographic Information System and mortality data at the MRC/Wits-Agincourt Health and Demographic Surveillance System (HDSS) site.

In South Africa, mortality in most age groups has been increasing. Estimating the geographical patterns of mortality and assessing spatio-temporal trends is important in identifying vulnerable population sub-groups, introducing interventions, evaluating the effectiveness of interventions and progress in achieving the Millennium Development Goals.

Malaria, caused by *Plasmodium falciparum*, the most severe of the parasite species to infect humans, is the most prevalent human parasitic disease. The geographical distribution of malaria is not well defined in South Africa, and the risk of contracting malaria varies across the risk areas. It is thus essential to determine the transmission of malaria to define the areas with greatest risk and to facilitate appropriate control strategies for these regions. Key factors affecting the transmission of malaria should be identified. A map outlining the malaria transmission in South Africa can help with intervention strategies to optimise human and financial resources.

This project enabled South African scientists to acquire the relevant skills and training in disease mapping and risk factor analysis of geographical data in order to contribute towards efforts to understand determinants of mortality and to reduce malaria risk. It builds on the long-standing collaboration between the Swiss Tropical and Public Health Institute (Swiss TPH), Wits School of Public Health and the South African Medical Research Council (SAMRC) in Durban. The partnership drew on data available within the three institutions, and expertise in Bayesian spatio-temporal modelling, malaria epidemiology and mortality, to address key research questions of major concern across much of Africa.

The first objective was to investigate mortality by identifying risk factors related to cause-specific mortality for defined age groups, producing maps of cause-specific mortality and assessing long-term temporal changes of all-cause and cause-specific mortality. The second objective was to investigate malaria transmission. This was achieved by estimating and mapping malaria seasonality in Africa, assessing spatio-temporal patterns of malaria transmission and producing regional- and continent-wide transmission maps adjusted for

Location of the MRC/Wits-Agincourt HDSS site.

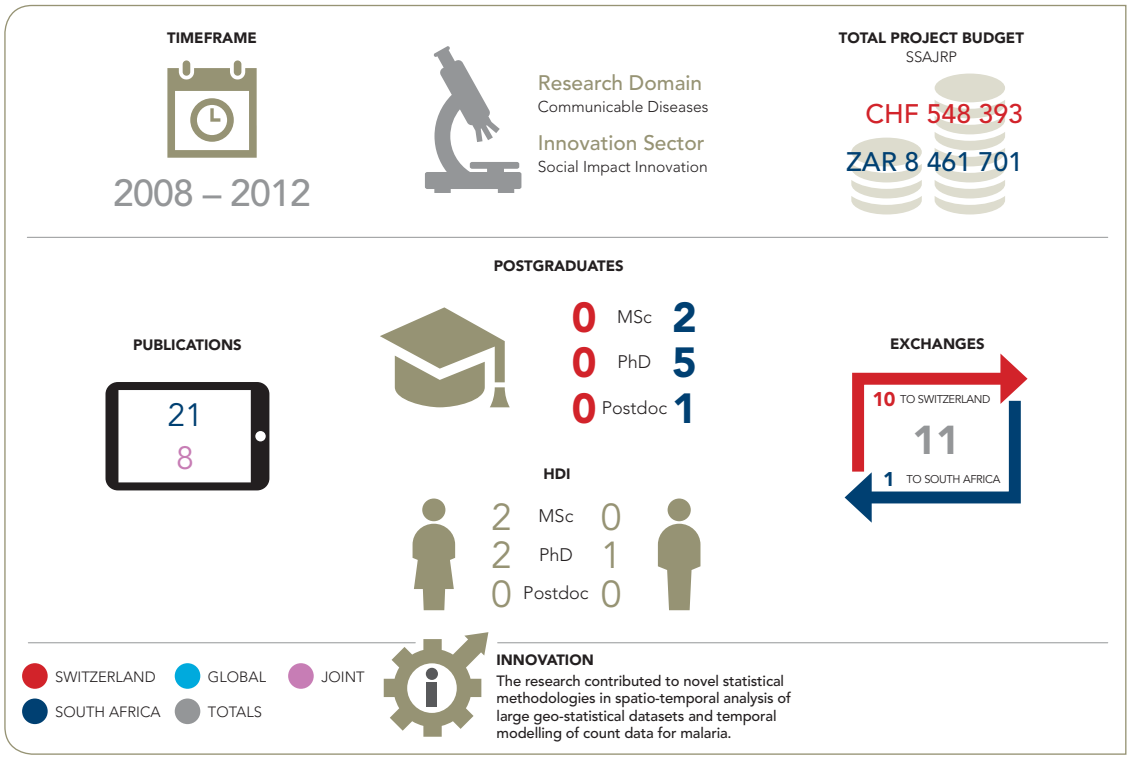
Drawings courtesy of Mark Collinson

Professor Kathleen Kahn

age, seasonality and climate factors and to develop models for forecasting malaria case data.

This research contributed novel statistical methodologies in spatio-temporal analysis of large geo-statistical datasets and temporal modelling of count data. Application of this work to mortality and malaria data from Africa, together with state-of-the-art existing Bayesian modelling approaches in the analysis of spatio-temporal data, will contribute to understanding the risk factors, geographical patterns and spatio-temporal changes of mortality; maps of malaria seasonality and malaria transmission; and malaria forecasting models. This provided estimates of burden of disease and its distribution, which will contribute to public health policy and programmes and evaluation of interventions.

This project assisted with capacity building in South Africa. Statistical capacity was developed by nesting doctoral students and postdoctoral fellows from both South Africa and Switzerland within this project. The project supported South African doctoral students to be trained on Bayesian spatio-temporal modelling, disease mapping, Markov chain Monte Carlo simulation methods, and mathematical modelling of malaria transmission.



Medicines from marine microbes

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Jörn Piel
University of Western Cape
Professor Marla Trindade

The objective of the project was to employ metagenomics technologies to identify and characterise novel pharmaceutically applicable prokaryotic biosynthetic pathways and to use gene transfer technology to express the biosynthetic pathways identified in easily cultured bacteria for the production of larger quantities of the compounds necessary for the preclinical and clinical phases.

In South Africa the project obtained 940 extracts from 479 marine invertebrate-associated bacteria that were screened on various platforms for activities against a number of pathogens and diseases. The genomes of the 20 most promising bacteria were sequenced. The sequence information was used to link antimicrobial activities to biosynthetic gene clusters and to establish heterologous expression systems. Three biosynthetic gene clusters were transferred into either *E. coli* or *Pseudomonas putida*. An NPRS cluster expresses in *E. coli* and confers antimicrobial activity against *B. cereus* and *S. epidermidis*.

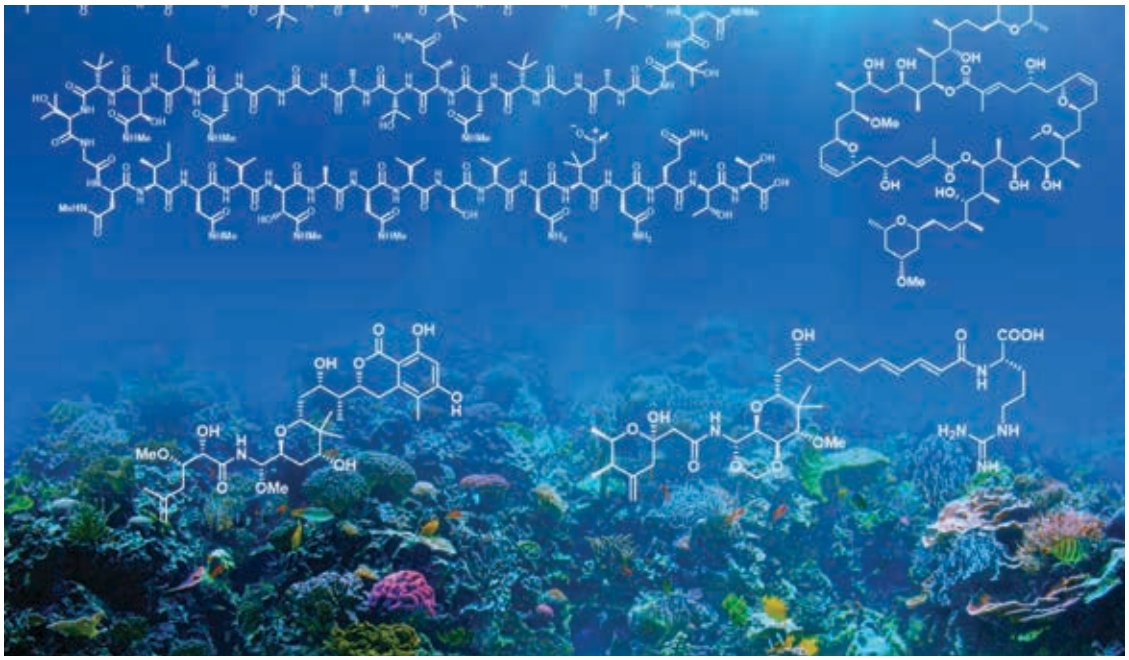
Ms Shanice Adams, SA MSc student and Professor Marla Trindade.

Professor Jörn Piel

The compound was isolated and is currently being characterised. A rhamnolipid pathway was successfully expressed in *P. putida*. Rhamnolipids have antibiotic bio-surfactant properties that make them suitable for application in a number of different industries. The integration of a rhamolipid pathway on a GRAS-status bacterium genome has never before been successful, which is required for industrial development.

Jointly, the Swiss and South Africa laboratories investigated two *Thalassomonas* species through bioactivity-guided fractionation. Initial fractionation indicated bioactivity against *P. putida* and a highly multidrug-resistant *E. coli*. These efforts, combined with electron microscopy, indicated that these two species produce tailocins with antimicrobial activity, and further analyses are underway to complete the investigation.

The Swiss laboratory focussed on the sponge-associated bacterium which produces a new antibiotic with nM activity against Mycobacterium tuberculosis. The compound is structurally novel and can be synthesised in a straightforward way. MoA studies and generation of analogs are underway to further evaluate its potential for TB therapy. In studies on uncultivated producers of sponge



Photograph courtesy of Prof Piel

Representative bioactive natural product families isolated from the marine sponge Theonella swinhoei, *which are produced by a bacterial symbiont.*

QPix robotic colony picker, for the high throughput screening of marine metagenomic libraries for bioactive compounds.

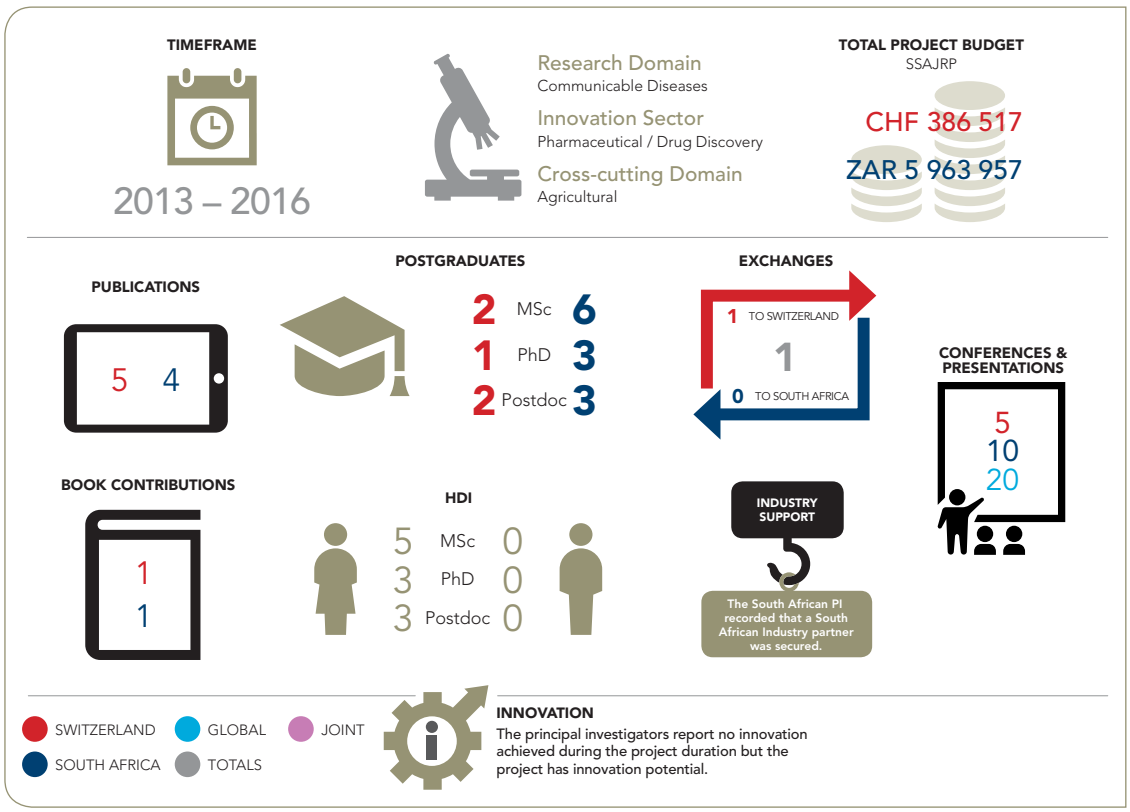
pharmaceuticals, uncultivated symbiotic producers from five different sponges were identified and genomically characterised. These belong to at least five different candidate genera, thus validating the chemical potential of uncultivated microbes. Dozens of biosynthetic gene clusters are now available. For one of these, encoding biosynthesis of the highly cytotoxic and complex polytheonamides, a new bacterial expression platform was established that produces these compounds within one to two days and also generates engineered variants.

The project presents novel opportunity to evaluate the mode of action, chemistry and the development of pharmaceutical products in the South African marine invertebrate isolates. The project has partnered with the H3-D centre in collaboration with Dr Digby Warner to further screen the libraries against TB.

The project enabled the potential for the discovery of completely novel structures with potentially valuable bioactivity properties for pharmaceutical development. Beyond drug discovery is the economic opportunity for bio-surfactants and pigments to be used in cosmetics and other personal medicines, antifungals for agricultural pesticides, and as antioxidants and additives in foods. This project therefore has both a social and economic impact as many enzymes and compounds from marine sources are being used as the basis for many biotechnology applications, a multi-billion dollar industry. This, however, is a long process but proves that the South African biodiversity is "hot" and holds much promise for future commercialisation objectives.

Photograph courtesy of ETH Zurich

Transmission electron microscopy of tailocin preparations from T.viridans.



Gene engineering HIV-resistant cells

UNIVERSITY PARTNERS

University of Zurich
Professor Roberto Speck
University of Pretoria
Professor Michael S Pepper

The project objective was to identify and target host elements in order to render CD4+ T-cells (cells that play a major role in instigating and shaping the adaptive immune responses) resistant to HIV and to prevent viral escape.

The collaborators' gene engineering approach was assessed *in vivo* in humanised immune system (HIS) mice infected with HIV as pre-clinical proof-of-concept. They directed their work at optimising techniques to expand haematopoietic stem cells for use initially in the HIS mouse model and ultimately for Phase I clinical trials. Subsequent work has been directed at optimising the microRNA approach (not part of the projects funded by the SSAJRP).

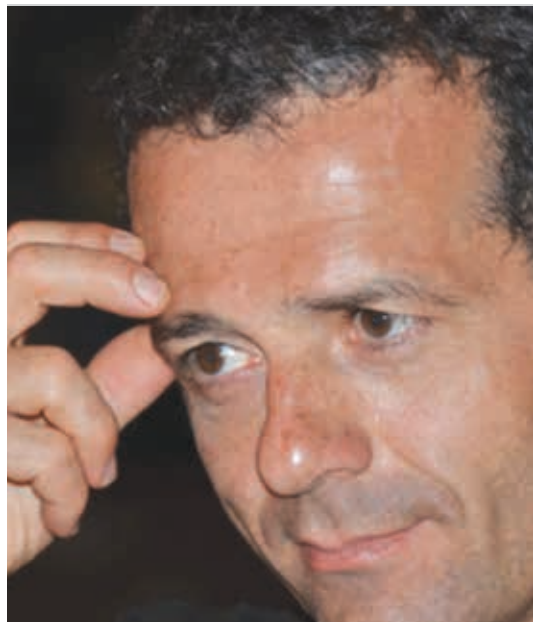
The Swiss research team was in charge of testing whether the microRNA to CCR5 – as generated by the team of Professor Karl Heinz Krause from the Geneva-based laboratory-generated an HIV-resistant immune system *in vivo*. Key findings and expertise gained were: efficient delivery of the lentiviral construct into haematopoietic progenitor and stem cells (HSPCs) demonstration of multi-lineage haematopoiesis of gene-engineered HSPCs; and functional cure of HIV achieved when humanised mice transplanted with gene-engineered HSPCs were generated (pre-clinical proof-of-concept).

The work in the South African laboratory has focussed on optimising techniques for expansion of haematopoietic stem cells, and on establishing the susceptibility of human haematopoietic stem cells (HSCs) to HIV infection. With regard to the first, a combination of *in vitro* experiments and *in vivo* experiments in NSG mice – one of the most immune-deficient mouse strains – have confirmed the effect of stemregenin-1 on expanding the primitive sub-population of HSCs.

In addition to the above, all three groups are preparing for a Phase I clinical trial based on the data generated over the three years of the project.

As the team gets closer to utilising the technology they have developed in patients, initially as the Phase 1 clinical trial, there is likely to be a significant impact on patients (society) and on industry, the latter initially in the form of a start-up biotechnology company.

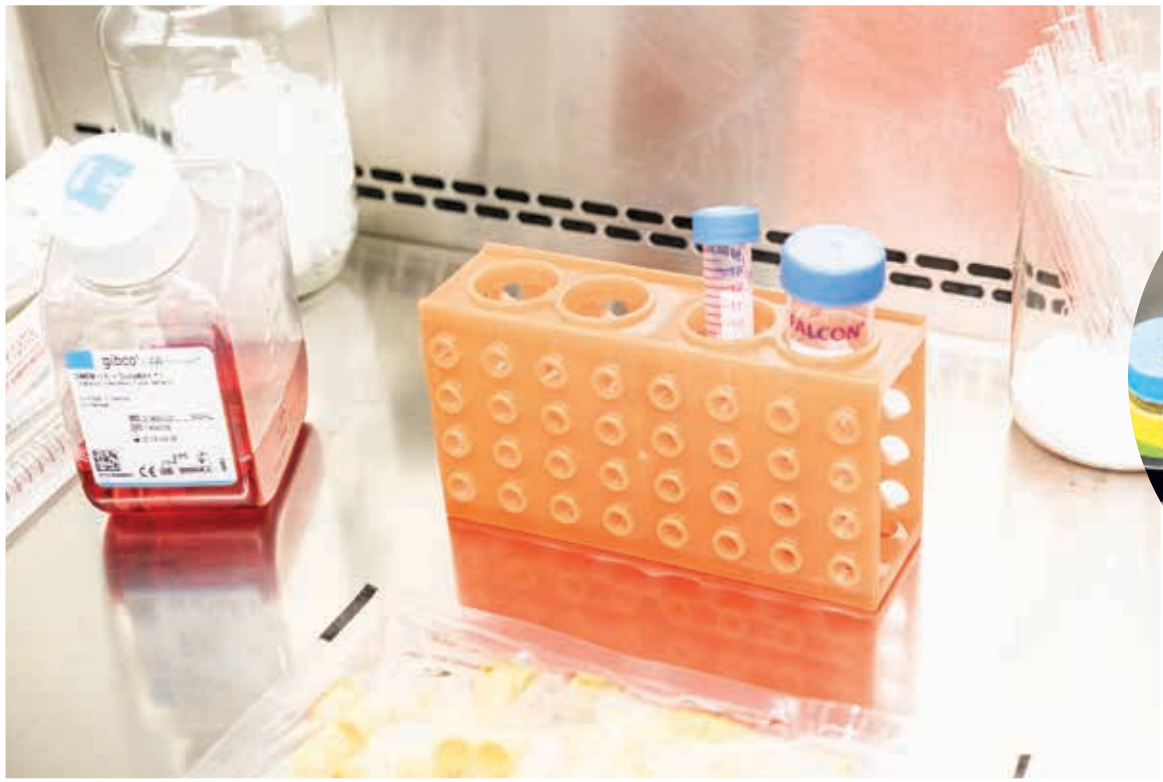
Professor Michael Pepper



Photograph courtesy of University Hospital Zurich

Professor Roberto Speck

Pipettes used for laboratory work.



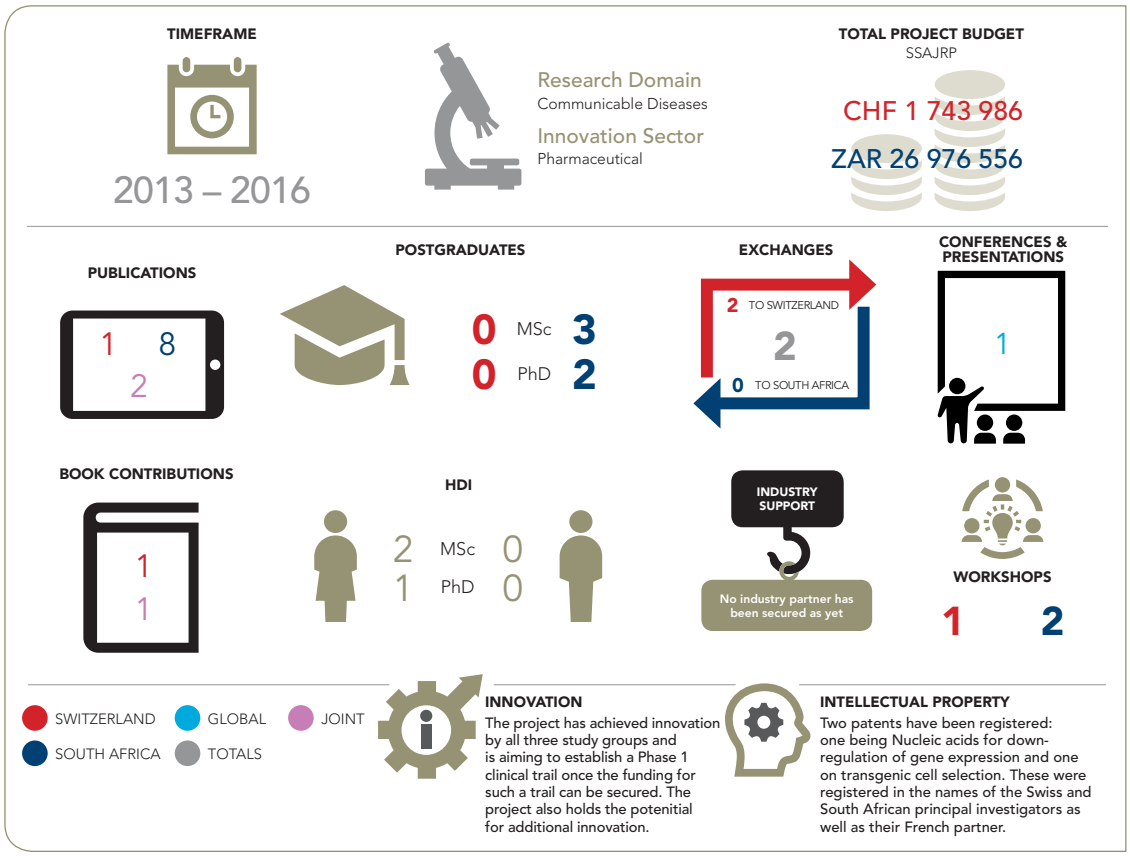
Centrifuge for research work.

Tissue culture setup.

The project has cemented a very strong relationship between the University of Geneva, University of Pretoria and the University of Zurich participating groups. The funds provided by the SSAJRP have allowed for an excellent and ongoing collaboration between these universities. Very importantly, the approval of this project intensified the collaboration between Switzerland and South Africa with yearly workshops either in Switzerland or in South Africa.

The funds provided by the SSAJRP established a platform from which additional funding was obtained from two competitive calls released by the SAMRC. The first was the prestigious SAMRC University Flagship Programme; the second was the SAMRC Extramural Unit award for Stem Cell Research and Therapy.

Finally, two patents emanated from this project, with one of them forming the core element of a start-up company that is registered in Switzerland.



Cultivation of marine algae for the development of valuable pharmaceutical agents

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology in Lausanne
Professor Jean-Paul Schwizgübel
University of Western Cape
Dr Rolene Bauer

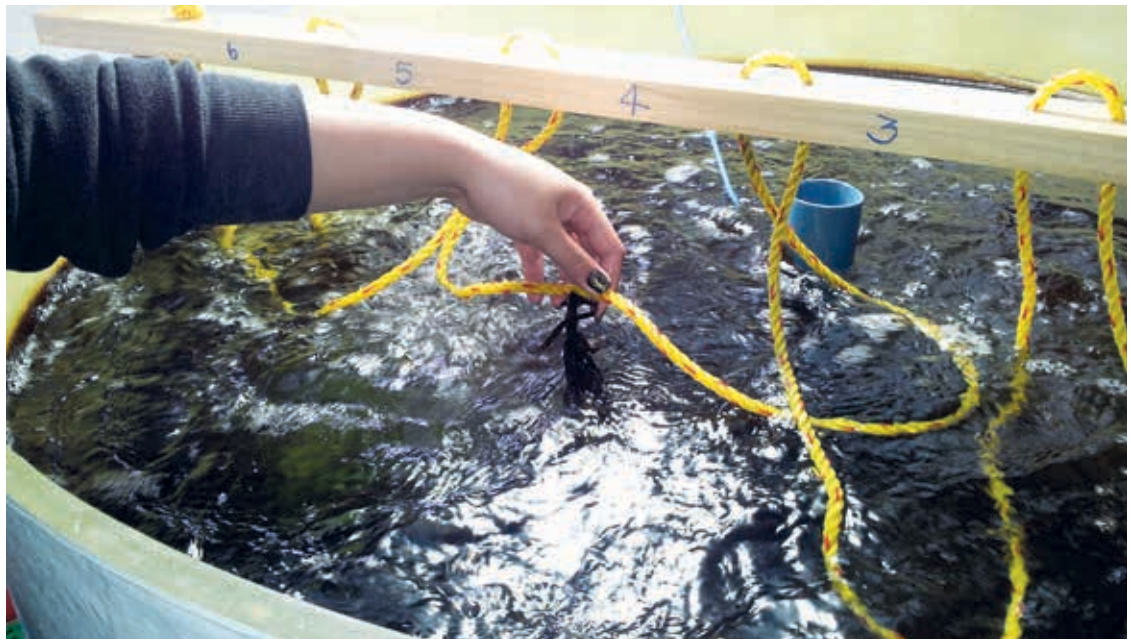
Algal extracts have been shown to exhibit potential pharmacological actions in mammalian systems, many with novel complex structures. Marine algae have a very high protein and/or polysaccharide content making them ideal for biomass production. The study was aimed at establishing cultivation platforms for micro-algae (Switzerland) and macro-algae (South Africa). Potentially valuable pharmacologically active molecules produced by these algae were targeted.

Numerous macro-algal species, endemic to South Africa, were implicated in production of polysaccharides with activity against breast cancer cells. Of particular interest was a brown algae (Splachnidium sp.) characterised by cylindrical branches filled with mucus (cellular bags of highly valuable fucoidan). Sulphated polysaccharides, such as fucoidan, have potent anticancer and antithrombotic activities due to the ability to imitate patterns of sulphate substitution.

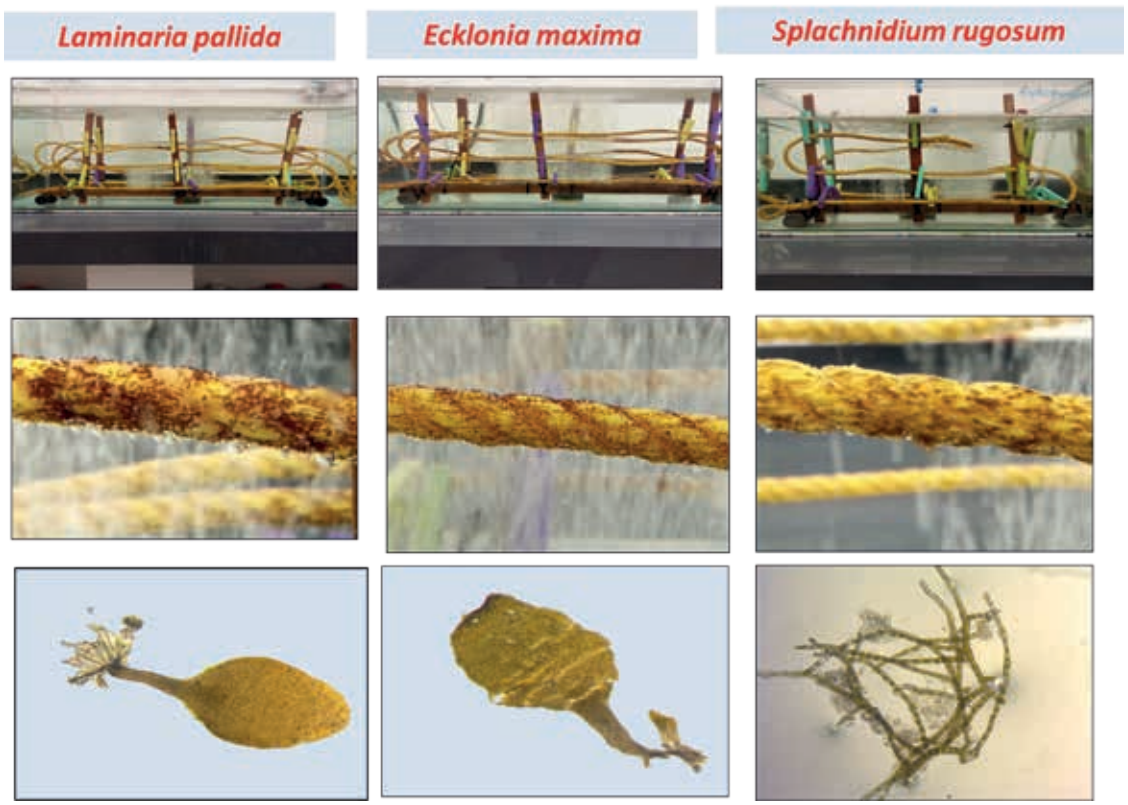
Short-term objectives of the project included cultivation of algae under controlled conditions and the elucidation of the structure of purified bio-active molecules. A long-term objective included bulk production of pure pharma-compounds for clinical trials and bio-medical applications.

The project resulted in the establishment of a cultivation platform for selected species of macro-algae endemic to South Africa in the open ocean (West Coast) and is now used and maintained by the algal research team of the Department of Agriculture and Fisheries (DAF). Collaboration with researchers at EPFL (Lausanne) and student exchange (Stephen Mackay, PhD) resulted in one joint high-impact publication.

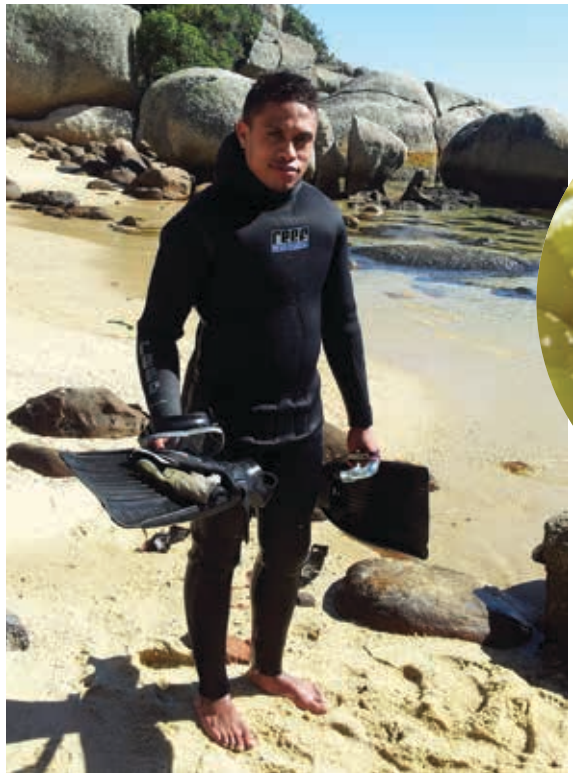
Micro-algae are a valuable source of high-value products, lipids and biomass. However, several energetic limitations restrict sustainability. One of the major limitations to micro-algae large-scale production in open ponds has been the harvesting of micro-algae which can make up 50% of the operational cost. Stephen Mackay published a joint study on a newly described lichen co-culture that shows potential for application as an energy-efficient harvesting method. The method is based on bio-flocculation of filamentous fungal pellets that form large dense lichen pellets with micro-algae that could be easily harvested.



Development of marco-algal spores on ropes in tanks.



Dr Rolene Bauer



Grant January (MSc student) harvesting macro-algae.

Splachnidium rugosum.

All photographs courtesy of Rolene Bauer

Growth of macro-algae on ropes in the open ocean.

TIMEFRAME

2011 – 2012

Research Domain
Communicable Diseases

Innovation Sector
Pharmaceutical - Micro-algal cultivation

TOTAL PROJECT BUDGET
SSAJRP

CHF 102 962

ZAR 1 588 700

PUBLICATIONS

2
1

POSTGRADUATES

0	MSc	3
0	PhD	1
0	Postdoc	2

EXCHANGES

3 TO SWITZERLAND
6
3 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS

13
3

INDUSTRY SUPPORT

Received funding and collaboration support from Swiss and South African Industry.

WORKSHOPS

1 2

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

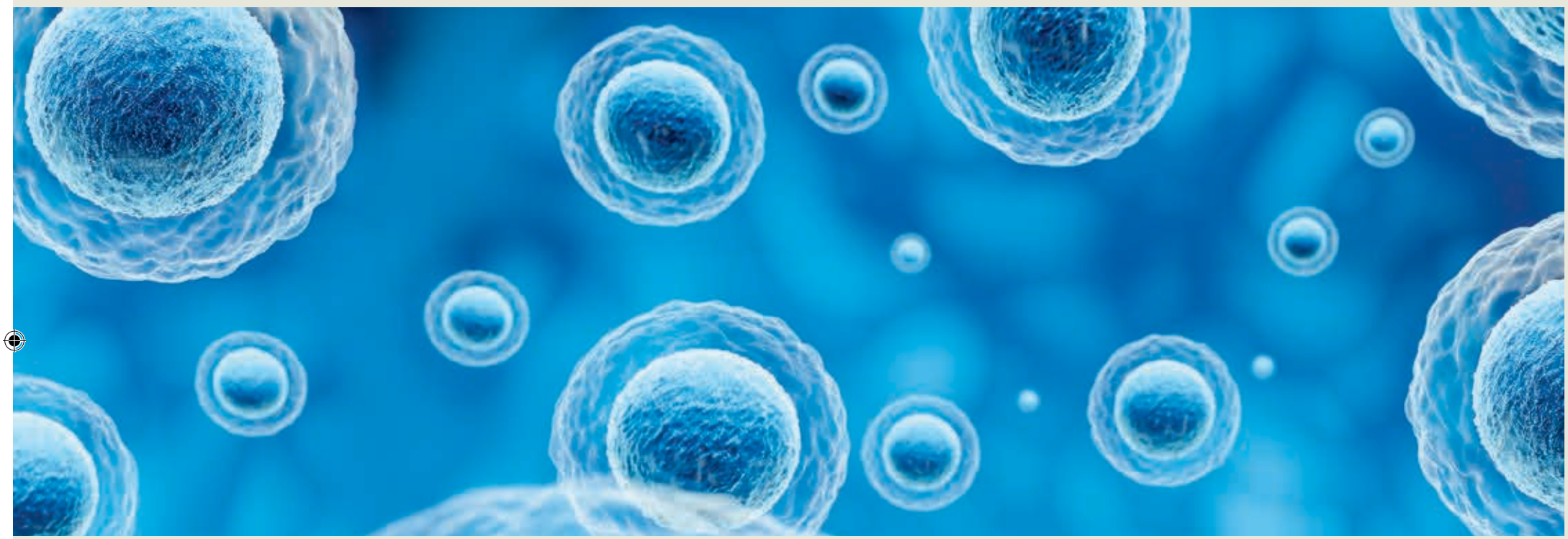
INNOVATION
Yes

INTELLECTUAL PROPERTY
IP protected in Switzerland.

3

JOINT RESEARCH PROJECTS

NON-COMMUNICABLE DISEASES



Human cell

According to a review article in the *New England Journal of Medicine* (2013), non-communicable diseases (NCDs) will be the predominant global public health challenge of the 21st Century. The main goals of health policy will be to prevent premature deaths due to non-communicable diseases and reduce related healthcare costs. For clinical medicine, the main goals will be to improve detection and treatment of non-communicable diseases and prevent complications and catastrophic events. To achieve these goals, the primary mission of public health is a multilevel approach that integrates policy actions, regulations, health education, and efficient health systems. All countries can benefit by sharing experience and pooling expertise to prevent and control NCDs.

NCDs, also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behaviours factors. According to the World Health Organization, these diseases kill 41 million people each year, equivalent to 71% of all deaths globally.

The main types of NCDs are cardiovascular diseases (like heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma), and diabetes.

People of all age groups, regions and countries are affected by NCDs. These conditions are often associated with older age groups, but evidence shows that 15 million of all deaths attributed to NCDs occur between the ages of 30 and 69 years. Of these "premature" deaths, over 85% are estimated to occur in low- and middle-income countries. Children, adults and the elderly are all vulnerable to the risk factors contributing to NCDs, whether from unhealthy diets, physical inactivity and exposure to tobacco smoke, or the harmful use of alcohol.

These diseases are driven by forces that include rapid unplanned urbanisation, globalisation of unhealthy lifestyles and population ageing. Unhealthy diets and a lack of physical activity may show up in people as raised blood pressure, increased blood glucose, elevated blood lipids and obesity. These are called metabolic risk factors that can lead to cardiovascular disease, the leading NCD in terms of premature deaths.

Socioeconomic impacts of NCDs
NCDs threaten progress towards the 2030 Agenda for Sustainable Development, which includes a target of reducing premature deaths from NCDs by one-third by 2030.

The rapid rise in NCDs is predicted to impede poverty reduction initiatives in low-income countries, particularly by increasing household costs associated with healthcare. Vulnerable and socially disadvantaged people get sicker and die sooner than people of higher social positions, especially because they are at greater risk of being exposed to harmful products, such as tobacco, or unhealthy dietary practices, and have limited access to health services.

In low-resource settings, healthcare costs for NCDs quickly drain household resources. The exorbitant costs of NCDs, including often lengthy and expensive treatment and loss of breadwinners, force millions of people into poverty annually and stifle development.

Prevention and control of NCDs
An important way to control NCDs is to focus on reducing the risk factors associated with these diseases. Low-cost solutions exist for governments and other stakeholders to reduce the common modifiable risk factors. It is thus important to monitor progress and trends of NCDs and their risk to guide policy and priorities.

To lessen the impact of NCDs on individuals and society, a comprehensive approach is needed requiring all sectors, including health, finance, transport, education, agriculture, planning and others, to collaborate to reduce the risks associated with NCDs, and promote interventions to prevent and control them.

Investing in better management of NCDs is critical. This includes detecting, screening and treating these diseases, and providing access to palliative care for people in need. High-impact interventions can be delivered through a primary healthcare approach to strengthen early detection and timely treatment. Evidence shows such interventions are excellent economic investments because, if provided early to patients, they can reduce the need for more expensive treatment.

South Africa
The accumulated losses to South Africa's gross domestic product between 2006 and 2015 from diabetes, stroke and coronary heart disease alone are estimated to have cost the country US$1,88 billion (Abegunde DO, Mathers CD, Adam T, Ortegon M, Strong K. 2007). Employers face additional costs in the form of high staff turnover and absenteeism, because these conditions are not only a source of morbidity but a leading cause of death in our working-age population (Collins D L, Leibbrandt M. 2007).

Obese workers cost their employers 49% more in paid time off than their non-obese colleagues. Workplace wellness programmes are growing and show promise, but the urban poor, who are particularly vulnerable, have little access to them (Van Nuys K, Globe D, Ng-Mak D, et al 2014). The NCD epidemic in SA is an even greater burden because it is occurring concurrently with an ageing HIV-positive population.

Switzerland
Switzerland faces a growing burden of chronic NCDs. Currently, 2,2 million of a population of eight million is affected by NCDs, and this is responsible for 80% of health costs and nearly 60% of premature mortality. In early 2013 the Federal Council – Switzerland's highest executive authority – approved a comprehensive healthcare strategy entitled "Health 2020".

In 2016, a National Strategy for the Prevention of Non-Communicable Diseases was adopted after a year-long consultation process. This strategy has four overarching long-term objectives: "to control the global burden of disease due to NCDs; to contain rising costs in the health sector; to reduce premature mortality; to maintain and enhance the productivity and social participation of the population". More specifically, the NCD strategy aims to "reduce behavioural risk factors; improve health literacy; develop a health-promoting environment; improve equity in access to health promotion and prevention; reduce the proportion of the population at increased risk of disease; improve the quality of life and reduce the need for care" *(New England Journal of Medicine, 2013).*

In 2017, specific measures were adopted to ensure a reduction of risk factors for chronic NCDs and a reduction of the burden of disease due to these conditions. The long-term success of this strategy will require the commitment of the many stakeholders in the health sector as well as cooperation between federal and cantonal authorities (Mattig T, Chastonay P. 2017:1002).

OUTCOME OF THE NON-COMMUNICABLE DISEASES DOMAIN: ECONOMIC VALUE

More than half the research projects in this domain demonstrated innovation potential, which is important to curb the prevalence of NCDs and reduce the healthcare burden.

INNOVATIONS	TOTALS	%
Projects achieved innovation	4	20
Impact innovation achieved	2	10
Projects have innovation potential	11	55
Innovation potential beyond projects	3	15

INDUSTRY LINKAGES	TOTALS	%
Research support from industry	2	10
Industry funding	3	15
Industry partner SA	3	15
Industry partner CH	2	10
Industry interested	3	15
SA Industry funds received	2	10
Swiss Industry funds received	1	5

INTELLECTUAL PROPERTY	TOTALS	%
Swiss IP	2	10
SA IP	1	5
Swiss IP protected	2	10
SA IP protected	1	5

Joint Research Projects

Outcomes of the Non-Communicable Diseases Domain (15 projects)

RESEARCH DOMAIN: NON-COMMUNICABLE DISEASES

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:
CHF 4 972 386 ZAR 74 430 031

UNIVERSITY PARTNERS

University of Geneva
University of Bern
Swiss Federal Institute of Technology Zurich
University of Lausanne
University of Zurich
Lausanne University Hospital
University of Applied Sciences for Southern Switzerland
Rhodes University
Stellenbosch University
University of Cape Town
North-West University
University of the Free State
University of Pretoria
University of the Witwatersrand
International Centre for Genetic Engineering and Biotechnology
Cape Peninsula University of Technology
University of Johannesburg

SEED FUNDING
PHASE 2008 – 2012 5 projects
PHASE 2012 – 2013 2 projects
PHASE 2013 – 2016 7 projects
PHASE 2017 – 2020 1 project

Phase III projects have not as yet reached full-scale scientific outputs.

BENEFICIATION

ECONOMIC
20% Technology development
27% Economic platform
33% Industry development
14% Africa economy
73% Knowledge economy

GLOBAL CHALLENGES
15% Africa challenge
5% Lifestyle diseases
10% Cancer

NATIONAL OBJECTIVES
15% Policy beneficiation
15% National strategies in South Africa
50% HCD of historically disadvantaged
10% Gender balance redress in SER

PUBLICATIONS
23 55 22
100 TOTAL

POSTGRADUATES

9	MSc	39
13	PhD	25
9	Postdoc	9

104 TOTAL

CONFERENCES & PRESENTATIONS
63 49 71 183

BOOK CONTRIBUTIONS
4 2 7
13 TOTAL

HDI

8	MSc	10
3	PhD	8
1	Postdoc	4

34 TOTAL

EXCHANGES
41 TO SWITZERLAND
78
37 TO SOUTH AFRICA

WORKSHOPS
41 25

APPRECIATION

COLLABORATION
45% Alignment of PIs objectives **55%** Joint knowledge **75%** Mutual beneficiation **20%** Joint publications **35%** Joint exchanges **20%** workshops

HUMAN CAPITAL DEVELOPMENT
70% Appreciate Swiss contribution **55%** HCD in general **50%** Should demonstrate South Africa research excellence

RESEARCH FACILITIES
20% Opportunity for applied research
10% Access to world-class infrastructure in CH

GENERAL APPRECIATION
10% Leverage funds from other grants

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
5% BRICS COUNTRIES
15% EU COUNTRIES
15% AFRICAN COUNTRIES
5% OCEANIA COUNTRIES

UNIVERSITIES AND NETWORKS
20% SOUTH AFRICAN UNIVERSITIES
15% SWISS UNIVERSITIES
20% CONTACTS AND NETWORKS ESTABLISHED
10% EXTEND COLLABORATION TO INTERNATIONAL NETWORKS

BENEFITS OF LINKAGES
35% NEW RESEARCH TOPIC
35% EXTENT COLLABORATION WITH SWISS AND SOUTH AFRICAN PARTNERS
5% GOVERNMENT INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
5% Exchange and transfer of research material to and from CH

GENERAL
5% Decrease in ZAR value - decrease in project funds
5% Lack of follow-up funding
5% Stated no challenges

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Phthalocyanine-based smart probes for the molecular imaging disease-related proteolytic activity

UNIVERSITY PARTNERS

University of Geneva
Professor Dr Norbert Lange
Rhodes University
Professor Dr Tebello Nyokong

This collaborative project has had a significant global impact due to its influence on the accuracy of disease diagnosis in the early stages. The project was based on the fact that the presence of disease-associated proteases can be detected via activation of specific fluorescence probes by the specific protease. The researchers developed novel phthalocyanine-based smart probes, inspired by previously optimised smart probes, by using unique complementary expertise of both the Swiss and South African researchers.

The inept nature of the human eye in detecting tissue deviations from the normal state poses a particular problem in disease imaging. Initially the manifestation of cancer led to the adoption of detection techniques that were both intrusive and cumbersome. These techniques involved procedures such as biopsies or explorative surgery, followed by histopathological analysis. The advent of imaging techniques such as ultrasound, whole body scans, CTs (CAT scan) and MRIs (magnetic resonance imaging) often averted these time-consuming and cumbersome techniques though they lacked the ability to detect internal tumours with diameters measuring less than two millimetres.

The need emerged for detection techniques that combined rapid results, high sensitivity and accurate disease identification. Molecular imaging, which is the biological process imaging in living organisms at the molecular and/or cellular level, addressed this need. Endoscopic fluorescence imaging uses the combination of genetic information, proteomics (the large-scale study of proteins), and new synthetic strategies in order to form new imaging probes, allowing the development of novel imaging techniques. The non-invasive nature coupled with high resolution and sensitivity make endoscopic fluorescence imaging ideal for treating patients suffering from cancer, ensuring that they can live as comfortably as possible.

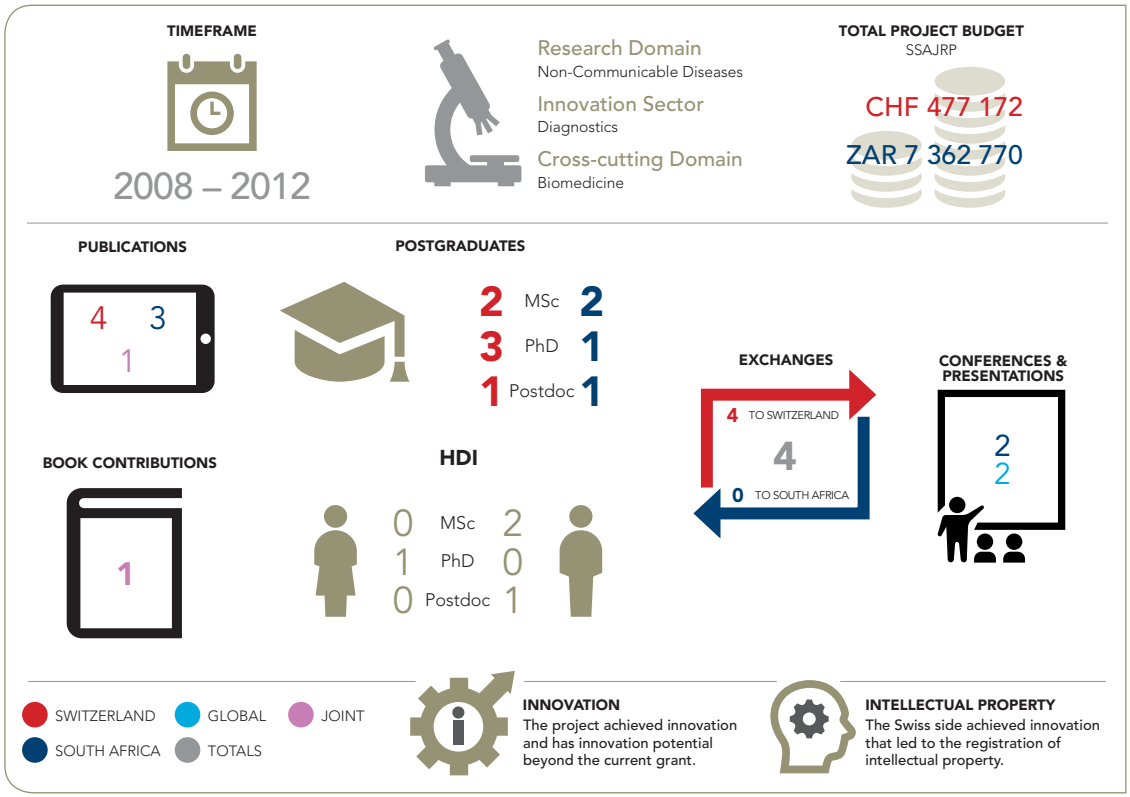
In this study, researchers developed the synthesis and purification of a suitable, slightly water-soluble, mono-substituted phthalocyanine dye (fluorescent reporter) for the innovative smart probes that were being developed. These were then coupled to a polymeric carrier and quenched, with optimal quenching resulting from the strong interaction of phthalocyanine dyes when multimerised on a polymeric carrier.

Professor Nyokong's laboratory and students.

Photograph Courtesy Prof T Nyokong

Professor Tebello Nyokong

In vitro and *in vivo* disease-associated proteolytic activity investigations were carried out in order to activate, characterise and optimise the probes. The response parameters at which the smart probes were aimed, for the purposes of optical fluorescence imaging, were the ability to absorb and emit light in the near-infrared region (NIR) of the light spectrum; produce strong extinction and high fluorescence quantum yield; and a high versatility with respect to the target protease while possessing a very high specificity for the target tissue.



Production and application of terbium radionuclides as a potential cancer diagnostic and treatment tool

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Dr Roger Schibli
The Cape Peninsula University of Technology
Professor Tjaart Nicolaas van der Walt

This collaborative research project developed the technology to produce radioactive isotopes useful for medical purposes. It aimed to venture into the uncharted waters of the production and application of two extremely attractive tumour-labelling molecules in the form of the Terbium radionuclides Tb-152 and Tb-155.

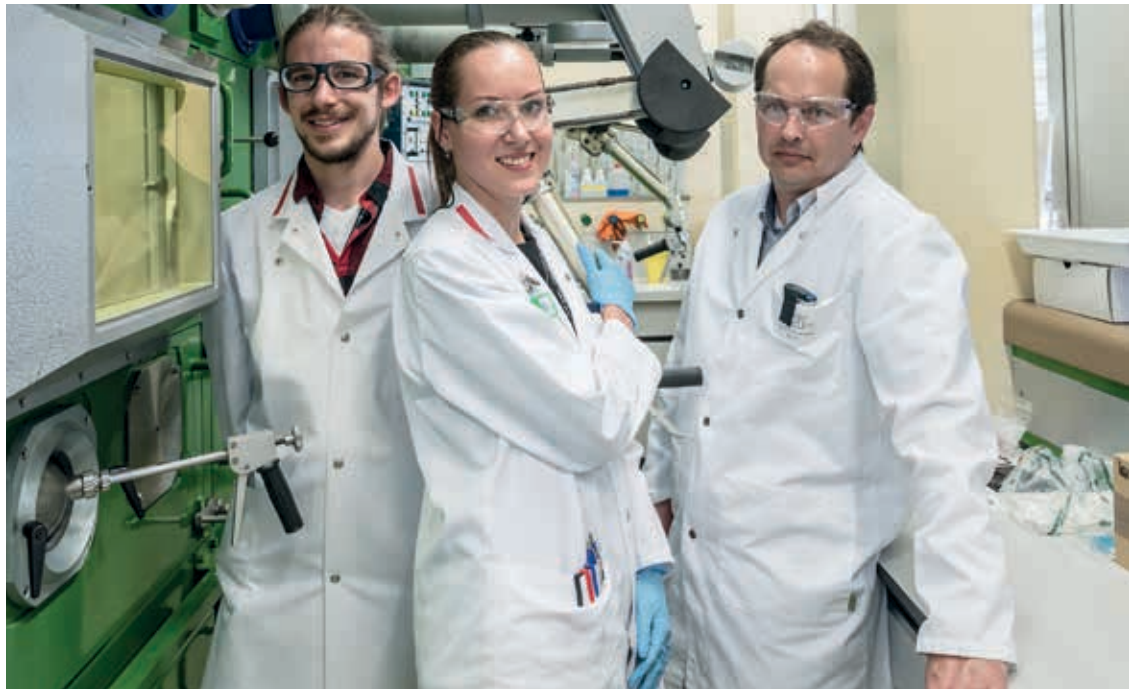
According to the WHO, 20% of deaths worldwide are as a result of cancer. Early detection and diagnosis, followed by effective treatment, is paramount to the increased quality of life provided to cancer patients. The use of radiopharmaceuticals in the cancer diagnostic tools of single photon emission computed tomography (SPECT) and positron emission tomography renders them non-invasive, and their ability to satisfy the abovementioned life quality enhancers makes them indispensable and increasingly used in oncology.

The results of the project are contributing towards the development of new and effective radiodiagnostics and therapeutics for the management of cancerous diseases.

The researchers used state-of-the-art facilities that presented an outstanding environment to tackle this highly relevant, though thought-provoking, scientific endeavour at both the unique cyclotron facilities at iThemba LABS (South Africa) and the Paul Scherrer Institute (Switzerland). The studies mutually profited from capabilities of these unique sites and the know-how of local experts in the field of radiochemistry and radiopharmacy.

Terbium (Tb) is an element that has a number of radioisotopes that emit specific particles which can potentially provide a new dimention to the avenue of cancer therapy. This element also has potential use in positron emission tomography and SPECT diagnostic methods due to the radionuclides it possesses, and this necessitates the need to find effective extraction methods of these radionuclides from Gadolinium (Gd). The establishment of effective methods to acquire the radioisotopes Tb-152 and Tb-155 for potential cancer diagnosis, and Tb-161 for therapy, can have a significant impact globally in the treatment of cancer.

This project used ion exchange chromatography and other extraction methods to separate and



Members of the Radionuclide Development Group in front of a hot cell at PSI: Roger Hasler (Technical Specialist), Nadezda Gracheva (PhD student) and Dr Nick van der Meulen (Group Leader).

Chemical separation system for Tb radionuclides.

Professor Dr Roger Schibli

Close-up view of a mechanical hot cell manipulator.

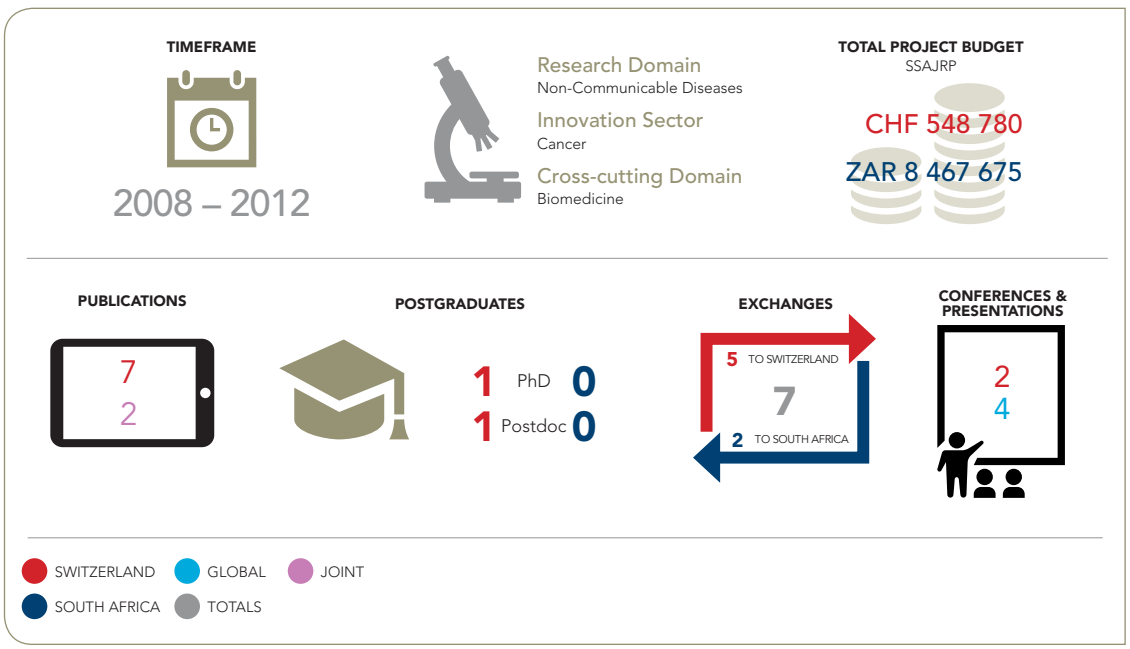
PSI's Radionuclide Development Group perform a Tb chemical separation from Gd target material.

obtain radioterbium nuclides from lanthanide elements such as Gadolinium and Dysprosium (Dy). Radioisotope separation from the lanthanides – a series of 15 metallic chemical elements that form part of the rare earth elements – required the compilation of a highly shielded tight casing in which highly radioactive substances could be remotely handled, called a hot-cell, and the instalment of the required equipment in a hot-cell at iThemba LABS. The researchers investigated the labelling of organic compound macromolecules, including monoclonal antibodies and peptides.

Significant advances in the field of radiotherapy were made with this project. Moreover, it served as a vehicle to capacitate Master's and Doctoral level students and junior faculty in the areas of radiochemistry, chemistry and biology. These scientists will serve to address the increasing demand of experts in these fields.

During the project, two key staff members left the Paul Scherrer Institute (PSI) in 2011 and 2012, thereby preventing development of chemical separations and preclinical work over this period. The issue was subsequently resolved when Dr N van der Meulen moved from iThemba LABS to PSI to cover this shortfall in 2013.

Much work was done to ensure preclinical success, with the data gained being used for a first-in-man injection of 152Tb-DOTATOC into a patient at Zentralklinikum Bad Berka, Germany, in 2016. This is currently paving the way for the introduction of the therapeutic 161Tb into clinics.



Imaging and therapy for cancer and other diseases using radioisotopes of rhenium and technetium compounds linked to biologically active molecules

UNIVERSITY PARTNERS

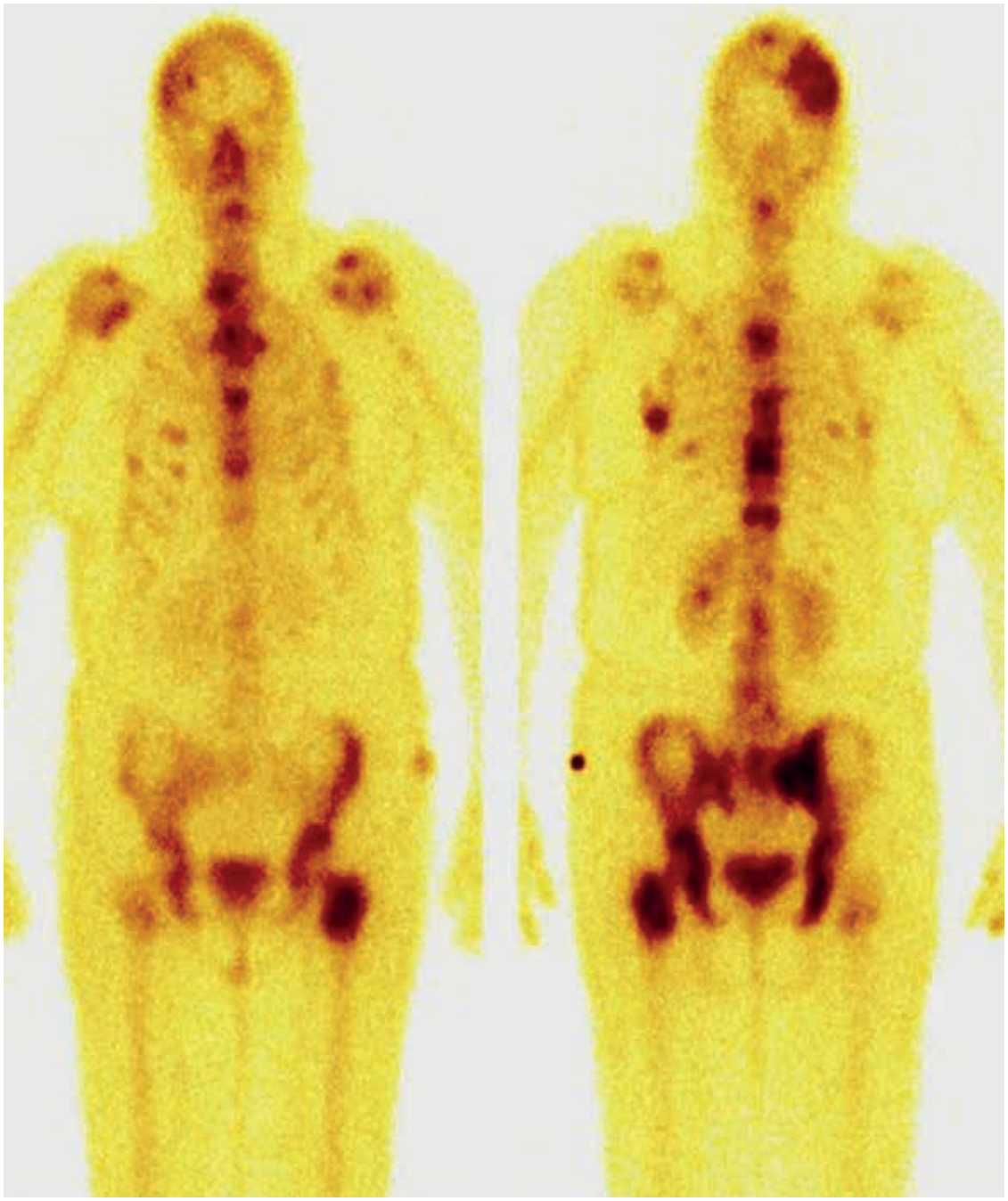
University of Zurich
Professor Roger Alberto
University of the Free State
Professor Andreas Roodt

Researchers participating in this project aimed to bring together South African and Swiss expertise in fundamental nuclear medicine related to technetium (Tc) and rhenium (Re) to expand the drive in this complex field.

A fundamental principle of diagnostic nuclear medicine is to have a suitable radionuclide that is attached to a director-group system aimed at a specific target (disease-affected organ) in the body. Selected uptake of this compound is then evaluated via a detector, similar to normal X-rays, which produces an image from which physicians can plan future treatment.

Imaging with bioactive compounds comprising technetium-99m (99mTc) is the most important modality of diagnostic nuclear medicine. To direct complexes of 99mTc towards a targeted site (organ), e.g. cells with increased densities of particular receptors, compounds must be conjugated to a molecule with the corresponding biological recognition properties. Tc and Re belong to the same triad and, if homologous compounds are synthesised, the option of therapy arises wherein minute quantities of 99mTc can be used for diagnosis and macroscopic amounts of Re for therapy. The researchers expanded the project successfully to include gallium coordination chemistry for potential radiopharmaceutical development.

The collaborative project formed part of the larger drive in South Africa towards creating a national collaborative platform, called the Nuclear Technologies in Medicine and the Biosciences Initiative (NTeMBI), to implement new strategic initiatives relating to R&D on nuclear technologies in medicine and the biosciences. NTeMBI was aimed to be managed by the South African Nuclear Energy Corporation (Necsa), as part of its legislative mandate and to function as a high-level Research, Development and Innovation (RD&I) initiative providing a framework to consolidate expertise and to implement new strategic initiatives relating to R&D on nuclear technologies in medicine and the biosciences. This overarching project with Switzerland was earmarked to form part of this broad initiative.



Courtesy Prof A Roodt

Scans of patient with bone cancer.

Courtesy Prof A Roodt

Professors Roger Alberto and Andreas Roodt.

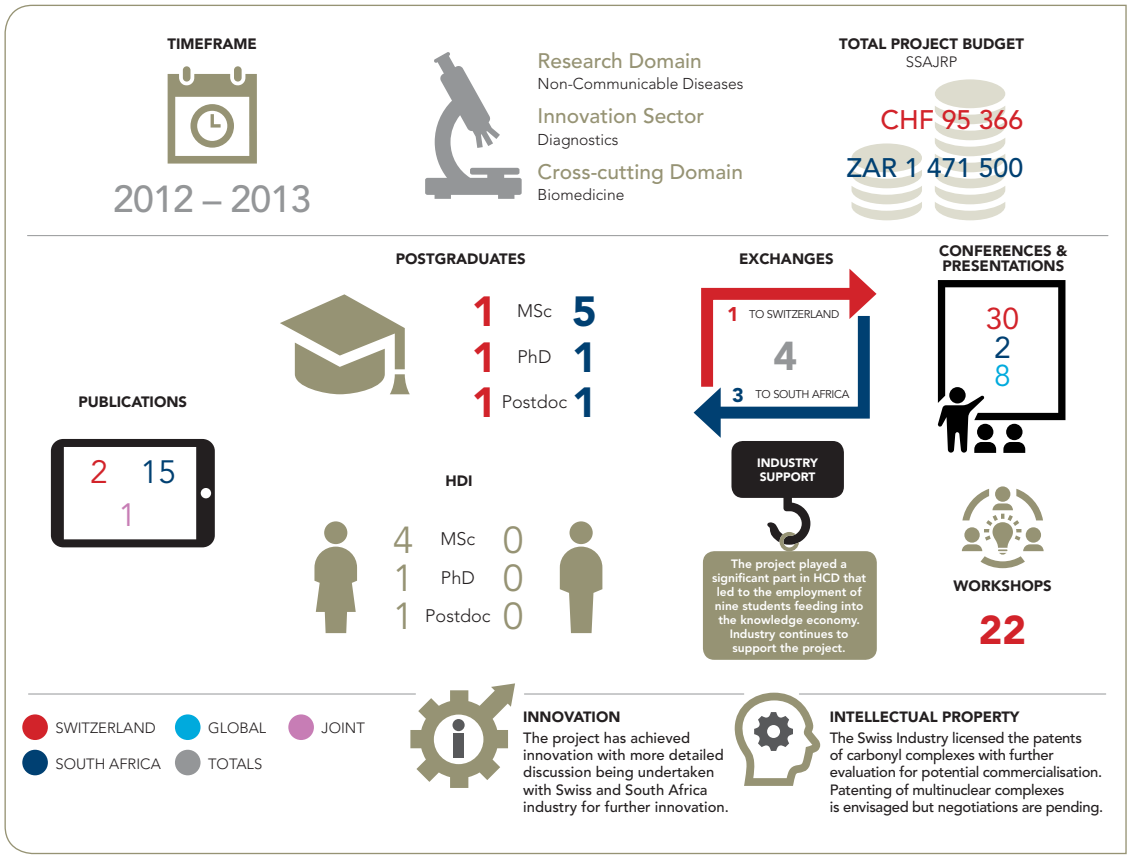
Photographs courtesy of Andreas Roodt

PhD students of the University of the Free State of which three are from SSAJRP.

A main outcome of the project was providing assistance to expand and/or establish international collaboration to routinely assess compounds containing Tc and Re for potential imaging and therapy respectively. The group arranged a Swiss-South Africa symposium, with a wide range of topics that included assistance via international networks to further the studies at South African Chemistry Departments, specifically at the University of the Free State and Nelson Mandela University as Centres of Excellence, to train students in radiopharmacy and nuclear medicine development. Major industry collaboration was established and is still being experienced under the project.

This project contributed significantly to expanding interaction between research groups from South Africa and Switzerland, and also established interaction with three African countries, India and Europe. It has consolidated the research cooperation between the groups beyond the actual project. The scientific accomplishments are mirrored in the human capital development and the scientific publications. A significant number of South African students benefitted from research visits to, and interaction with, the Swiss Principal Investigator and his students. Swiss students to South Africa experienced similar benefits.

The impact of this collaboration is far-reaching, and some outputs are still emerging. The project not only led to a substantial research output, but also enriched this field of science to pursue further. It resulted in significant interaction with industry in South Africa and research counterparts in other European countries and Africa.



Exploring the molecular basis of phenotypic spectrum of reproductive disorders in South Africa

UNIVERSITY PARTNERS

Lausanne University Hospital
Professor Nelly Pitteloud
University of Pretoria
Professor Robert P Millar

Broadly, this collaborative proposal aimed to build a cohort of well-phenotyped South African GnRH-deficient patients to perform genetic studies using cutting-edge technologies and to examine the biology of the identified variants in appropriate *in vitro* models. A multidisciplinary strategy was employed that combined human genetics, bioinformatics, clinical studies, molecular biology and pharmacology.

Patients with rare diseases face a number of health disparities, including challenges in finding appropriate access to expertise and timely diagnostics. The project has been effective in developing links and collaborations between groups in South Africa and Switzerland with expertise in rare reproductive endocrine conditions. These increased capacities are expected to benefit patients by enhanced approaches to timely diagnosis, as well as consultation with clinical experts.

Through this collaboration, two previously undescribed mutations of the Luteinizing hormone receptor (LHR) and one follicle-stimulating hormone receptor (FSHR) mutation have also been identified. LHR and FSHR both play critical roles in human sexual development.

The researchers have characterised one of these mutations *in vitro* and confirmed its non-functionality, and are working up the others. Mutations in other hypothalamic GPCRs (G protein-coupled receptors that are of central importance in endocrine regulation) have also been identified. An MSc student is exploring these in more detail to confirm whether they are non-functional. This is a very exciting sub-project that has potential to identify novel genes and confirm whether they are non-functional. A member of the group at an academic hospital in Pretoria, South Africa, has collected blood from 15 South African patients suffering from reproductive dysfunction of unknown aetiology. Swiss participants in the project are exome sequencing these with the aim to identify further mutations of interest.

The collaborators have raised awareness of this project in South Africa and have set up collaborations with the relevant endocrinologists who are most likely to see these rare-disease patients. The collaboration has been most productive with the reciprocal skills (South African receptor expertise for characterising GPCR mutations and rescue of function with pharmacochaperones and provision of patient DAN) and Swiss skills in whole exome sequencing. These novel discoveries position the partners to apply for international funding.

The impact on the patient community has primarily taken the form of raising awareness and creating avenues for patients to have consultations with experts in rare diseases. For the scientific community, the experiments involving the small molecule chaperones represent an important step forward in developing novel potential therapies for infertility. These scientific activities are likely of interest to industry, as they are unique pharmacological targets for an identified health need.

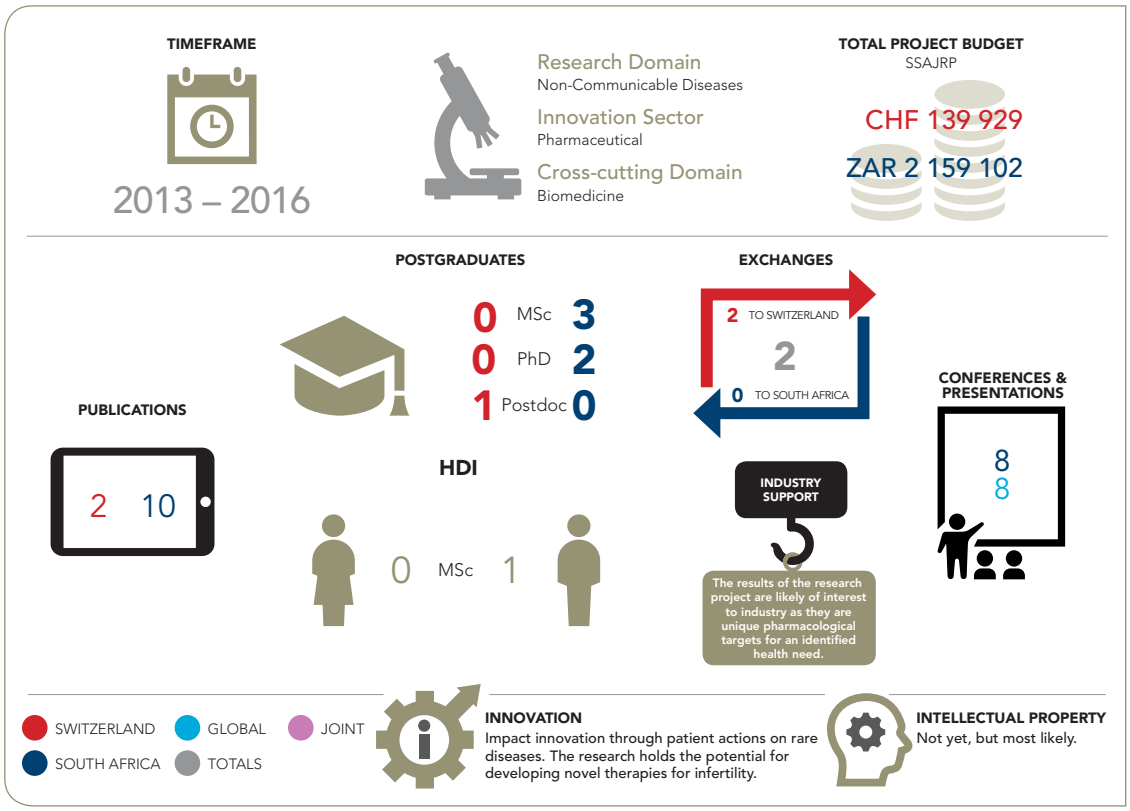
A number of female students and students from historically disadvantaged backgrounds are involved in the project.

Photograph courtesy of LMNA

Professor Nelly Pitteloud

Photograph courtesy of University of Pretoria

Professor Robert P Millar



Investigating the synergistic effect of Tat-RasGAP$_{317-326}$ in combination with hypericin-photodynamic therapy (hyp-PDT) on melanoma skin cancer cell death

UNIVERSITY PARTNERS

University of Lausanne
Professor Christian Widmann
University of Cape Town
Professor Lester Davids

The project used a novel approach by using a two-pronged strategy for the treatment of skin cancer. The first involved the pre-sanitising of the melanoma cells to death, which is achieved through exposure to the RasGAP-derived peptide, followed by the application of photodynamic therapy-induced cell death.

Specific objectives were to identify the mode of cell death induced via the combination therapy and the associated molecular and cellular mechanisms involved, and to investigate the effect of the optimised combination therapy (Aims 1) on melanoma cells and the role of the pigment, melanin, in cell death resistance.

The researchers previously performed a genome-wide CRISPR-Cas9 screen in order to identify regulators of hypericin PDT-induced cell death in A375 melanoma cells. While they did not identify any gene encoding protein involved in hypericin-PDT cell death, they highlighted FRYL (Fury Like Transciption Coactivator) as a putative gene involved in the resistance mechanism to this treatment.

Findings showed that FRYL does not independently modulate the manner by which hypericin-PDT exerts its anti-skin cancer effects.

The team did not manage to identify new regulators of hypericin-PDT-mediated cell death in A375 melanoma cells. Hypericin-PDT has been described to trigger different modes of cell death. Hence even if one death pathway is blocked, there is the possibility that another one can still be engaged to trigger cell death.

An African postdoctoral fellow, Dr Ajuwon, was given a Swiss fellowship and will work under the guidance of Prof Widmann. The Tat-RasGAP peptide does not enhance cell death triggered by the combination of the photo-sensitiser hypericin and photodynamic therapy (PDT). Dr Ajuwon will determine whether PDT synergises with the anti-cancer drug Cisplatin in a variety of skin cancer cell lines. This will bring important information on the usefulness of PDT in treating skin malignancies.

The study on the effect of photodynamic therapy as an adjuvant therapy for melanoma and nonmelanoma skin cancers was potentially pertinent and applicable to industry. However, the project team's work determined that there is no benefit in combining PDT with the TAT-RasGAP peptide. This information is important for the private sector as it indicates that it would be unsound to invest funds to develop a therapeutic combination of PDT with TAT-RasGAP$_{317-326}$. Rather, other combinations should now be investigated to try to improve current treatment of skin cancers.

The original objective of the project was modified because the Tat-RasGAP peptide did not enhance cell death triggered by the combination of the photo-sensitiser hypericin and photodynamic therapy (PDT). The team decided to take advantage of the CRISPR-Cas9 technology to perform a genome-wide screen to decipher the molecular mechanisms of hypericin-PDT mediated cell death.

The joint project between the South African and Swiss collaborators has helped acquire additional funds (a Swiss Government Excellence Scholarship to Dr Ajuwon) to support this work on PDT in the context of skin cancers.

Photograph courtesy of Prof C Widmann

Professor Christian Widmann

Photograph courtesy of Prof C Widmann

Professor Lester Davids

TIMEFRAME
2013 – 2016

Research Domain
Non-Communicable Diseases
Innovation Sector
Cancer
Cross-cutting Domain
Biomedicine

TOTAL PROJECT BUDGET
SSAJRP
CHF 230 109
ZAR 3 550 580

POSTGRADUATES
0 MSc 1

INDUSTRY SUPPORT
The innovation objective was not achieved which is relevant to the private sector indicating that it would be unwise to exlore a therapeutic combination of PDT with TAT-RasGAP$_{317-326}$.

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Stem cell activity in the adult human hippocampus

UNIVERSITY PARTNERS

University of Zurich
Professor Dr Hans-Peter Lipp
University of the Witwatersrand
Professor Amadi Ogonda Ihunwo

The formation of nerve cells in the adult hippocampus, a brain region mediating memory and behaviour, is one of the most rapidly growing topics in neuroscience. Adult neurogenesis defies the previously held notion that the human body is unable to generate neurons after birth. The need to replace damaged or destroyed neurons propels the need to investigate why these neuron-producing stem cells are generated and if it is at all possible to stimulate neurogenesis.

Since researchers have obtained most data thus far by studying mice and rats only, studies in other species are of high importance for recognising the physiological and, with it, the potential clinical role of such newly-generated nerve cells.

The proliferation of these cells during the lifespan of an individual is paramount in this investigation since studies have indicated that cell formation and proliferation rate decrease with age. Another challenge is the significantly shorter lifespan of mice and rats, which are commonly used as laboratory animals, when compared to humans. This renders them inapplicable as animal models for the human conditions under investigation. However, some rodent species in South Africa have a lifespan of up to 20 years and may prove to be more accurate animal models for the adult human brain condition.

The Swiss-South African collaborators collected an interesting data set from a multitude of South-African rodents, documenting neuroanatomical and behavioural data.

In the quest to find an animal model for human adult neurogenesis, the researchers found that the common mole rat is the animal species that exhibits adult neurogenesis in regions of both the hippocampus and the cerebral cortices. This species would therefore be able to best represent an animal model for human adult neurogenesis. This study involved the four-striped mouse, common mole rat and the greater cane rat.

The South African researchers conducted the immunostaining in rodents. A postdoctoral fellow involved in the study stained the hippocampi of over 70 mammalian species, finding adult hippocampal neurogenesis to be present in all but two cetacean species.The pre-immunostaining of human brains

From left: Drs Ajao, Meskenaite, Ola and Prof Amadi.

Mr A Becker from Zurich dissecting a brain in Pretoria.

protocol for this study was reviewed in Zürich and approved for use in the Johannesburg laboratory.

The researchers believe the study can be further optimised by employing a combination of the study of the postmortem brain stem cell proliferation time course of children and young adults, and the use of the advanced modern stem cell activity visualising and quantification methods available in the Zürich laboratory.

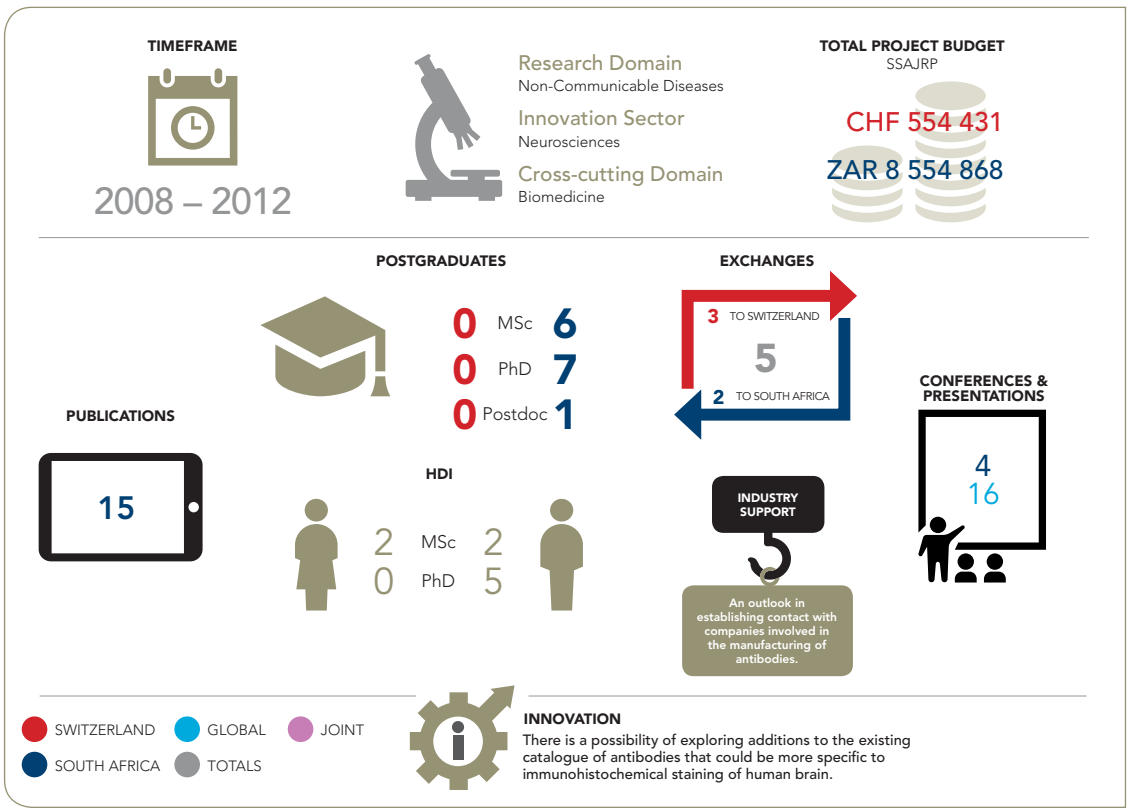
The urgency for drugs that promote cognition or memory and restorative process has sparked interest in obtaining these by application of neuropsychology and neuroscience in studies of adult hippocampal neurogenesis (AHN). The distinct locality of the AHN has made it the prime focus in adult stem cell studies. AHN mechanistic studies have been performed in rats and mice, primates and humans with decreasing frequency in the mentioned order. Due to the high proliferation levels in rodents, the results are presently extrapolated to the human condition. In addition to the low AHN levels in monkeys and humans, the paucity of their use in studies is caused by expenses incurred in colony maintenance of monkeys due to their long lifespan, the toxicity of the stem cell proliferation marker substances injected into human subjects, and the lack of expertise in using postmortem brain stem cell proliferation and differentiation indication antibodies.

Studies using immunological markers at a Swiss laboratory have demonstrated the absence of AHN in many bat species and that there are remarkable AHN neuroanatomical and regulatory differences even among rodents living in the wild. The proliferation rate of AHN decreases monthly by 40% in standard laboratory mice. The danger in extrapolation to humans cannot be ignored. This has necessitated the need to find alternative rodent or entirely different species with AHN time course and age levels as close to that of the human condition as possible. Adult human neurogenesis is also amenable to future cell replacement therapy in the central nervous system repair.

The mutual benefits of the projects were many: there was a successful transfer of technology and know-how from Switzerland to South Africa; a close and ongoing cooperation between ecologists and neuroscientists from both countries; Swiss Master's students could experience the fascinating sides of South Africa both in the laboratory and the wilderness; and the Swiss partner could profit from the availability of native South African species that would have been inaccessible otherwise.

All photographs courtesy Amadi Ogonda Ihunwo

Professor Amadi Ogonda Ihunwo



Epigenetic cross-talks and novel therapeutic strategies to prevent disease progression in ERG fusion-positive prostate cancer

UNIVERSITY PARTNERS

Institute for Oncology Research at University of Applied Sciences for Southern Switzerland
Professor Dr Carlo Catapano
University of Cape Town
Professor Luiz Zerbini

By combining and integrating the expertise at the two leading institutions, progress is being made in understanding the mechanisms involved in prostate cancer progression. Their goal is to discover novel therapeutic approaches for a specific and highly frequent subtype of prostate cancer, called ERG fusion-positive tumours.

Cancer of the prostate is a leading cause of cancer deaths in men worldwide. While localised prostate cancer is highly curable, nearly all patients with metastatic disease progress to castration-resistant prostate cancer for which there are limited treatment options presently. Identifying factors and pathways that lead to tumour progression and castration-resistant prostate cancer is therefore critical. It can lead to the discovery of novel and more effective therapeutic strategies based on the molecular and biological characteristics of the tumour and improve the survival rate of prostate cancer patients.

The two groups have recently discovered a novel mechanism leading to oncogenic activation of ERG and contributing to prostate cancer progression.

Gene fusions involving ERG are found in about half of prostate cancers. This genetic rearrangement determines overexpression of full-length ERG in prostate epithelial cells. Both pre-clinical and clinical evidence indicate that multiple cooperating factors and cross-talks with signalling pathways are involved in the progression of ERG-positive tumours. However, the molecular details of these interactions are not defined yet. Understanding these mechanisms would be important to develop more effective therapies.

This project seeks to address the role of ERG in orchestrating and remodelling the transcriptional and epigenetic landscape in prostate tumours by examining the network of co-regulatory factors co-opted by ERG to activate the pro-tumorigenic and pro-metastatic programme. To this end, researchers from the two institutes are integrating molecular, genomic and functional studies *in vitro* and *in vivo* with human patient data to understand the events involved in the cross-talks between ERG, epigenetic effectors and transcriptional co-regulators and to examine their biological and clinical consequences. They will furthermore examine strategies aimed at reversing this pro-tumorigenic/pro-metastatic

Photograph courtesy of Carlo Catapano

Professor Dr Carlo Catapano *Professor Luiz Zerbini*

Photograph courtesy of Zerbini Group

Professor Luiz Zerbini (back) with students at an international workshop in October 2018.

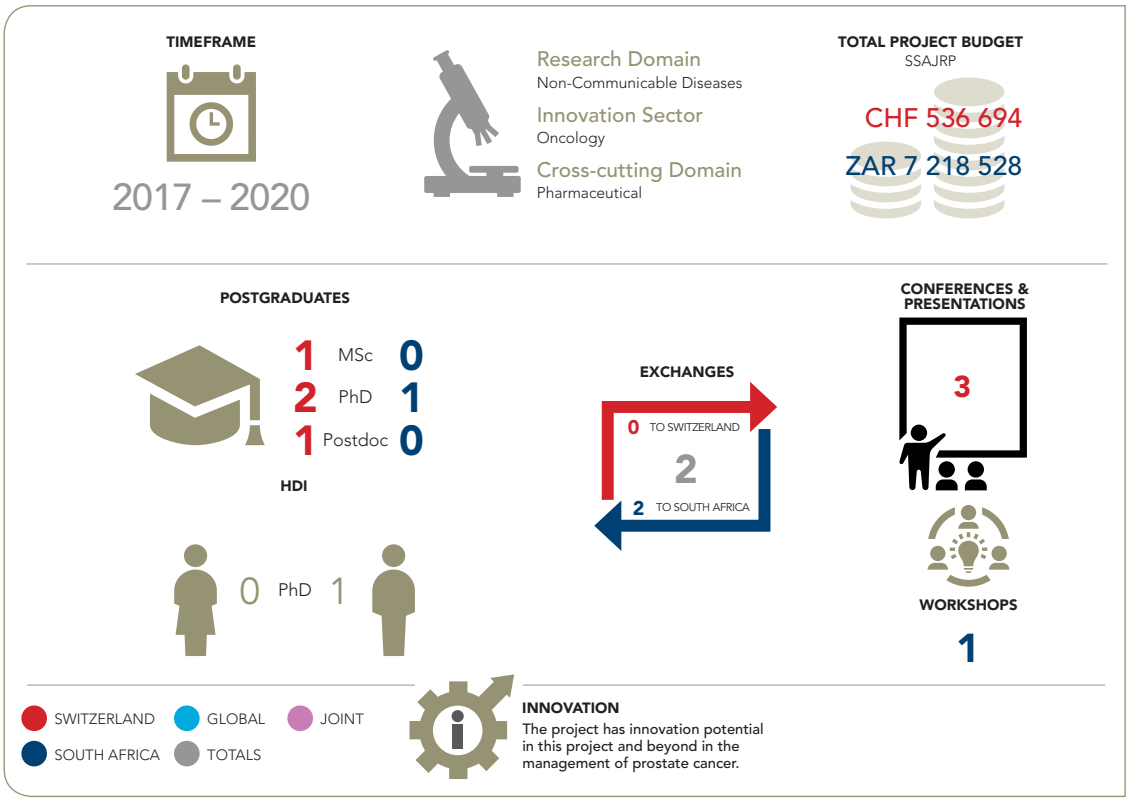
Photograph courtesy of Zerbini Group

Professor Pina Catapano, Mmboneni Muofhe from DST, Professor Carlo Catapano and Professor Luiz Zerbini.

programme by targeting the key components of the ERG-orchestrated epigenetic network.

During the first phase of this project they have combined molecular, genomic and functional studies in cell line and mouse models. They are dissecting the molecular events and identifying additional partners of the ERG epigenetic network. Both in cell lines and ERG transgenic mice they have found that epigenetic drugs such as inhibitors of EZH2 and other epigenetic effectors counteract the consequences of ERG-induced transcriptional deregulation and revert the tumorigenic and metastatic phenotype.

Ultimately, these studies will elucidate fundamental mechanisms leading to transformation and progression in ERG fusion-positive prostate cancers and will identify therapeutically actionable pathways whose modulation could have a broad impact on the management of prostate cancer.



Flower code and cell competition: Understanding its role in cancer initiation, proliferation and tumour therapy

UNIVERSITY PARTNERS

University of Bern
Dr Eduardo Moreno
International Centre for Genetic Engineering and Biotechnology (ICGEB)
Dr Luiz Zerbini

Cancer is a complex disease that places significant burden on individuals, families, health services and society. Early detection and treatment is still the best therapeutic option. In order to provide clinical significance, benefits to patients and society, along with high-tech advances in basic science, the collaborators in this project realised the need to foster cancer research that is relevant and translational.

Cell competition plays a major role in the initiation and progression of oncogenic stimulus in mammalian organs. Cancerous cells are super-competitive (winners) and they out-compete surrounding healthy cells (losers) for nutrition and extracellular growth signals, resulting in their death. Since cell competition between normal and transformed cells occurs from premalignant stages, the researchers exploited their knowledge of the cell competition molecular mechanisms to improve premalignant detection and treatment of cancer. They identified the Flower gene as a critical regulator of cell competition that, together with other cell competition regulators, can be used as a biomarker of cancer and for therapy purposes.

The collaborators analysed the importance of FlowerUbi and FlowerLose isoforms as regulators of cell competition in human cancer. Since Flower is a putative calcium channel, they hypothesised that the extrinsic signal that triggers cell competition via Flower might be calcium.

They found that the growth of cancer is significantly enhanced alongside a marked increase in the metastatic potential of cancer if FlowerUbi isoforms are overexpressed in the cancer tissue. On the other hand, over-expression of FlowerLose isoforms in the cancer tissue results in restricted tumour growth and metastasis. In addition, the Flower gene isoforms play a critical role in determining the aggressiveness of the cancer tissue.

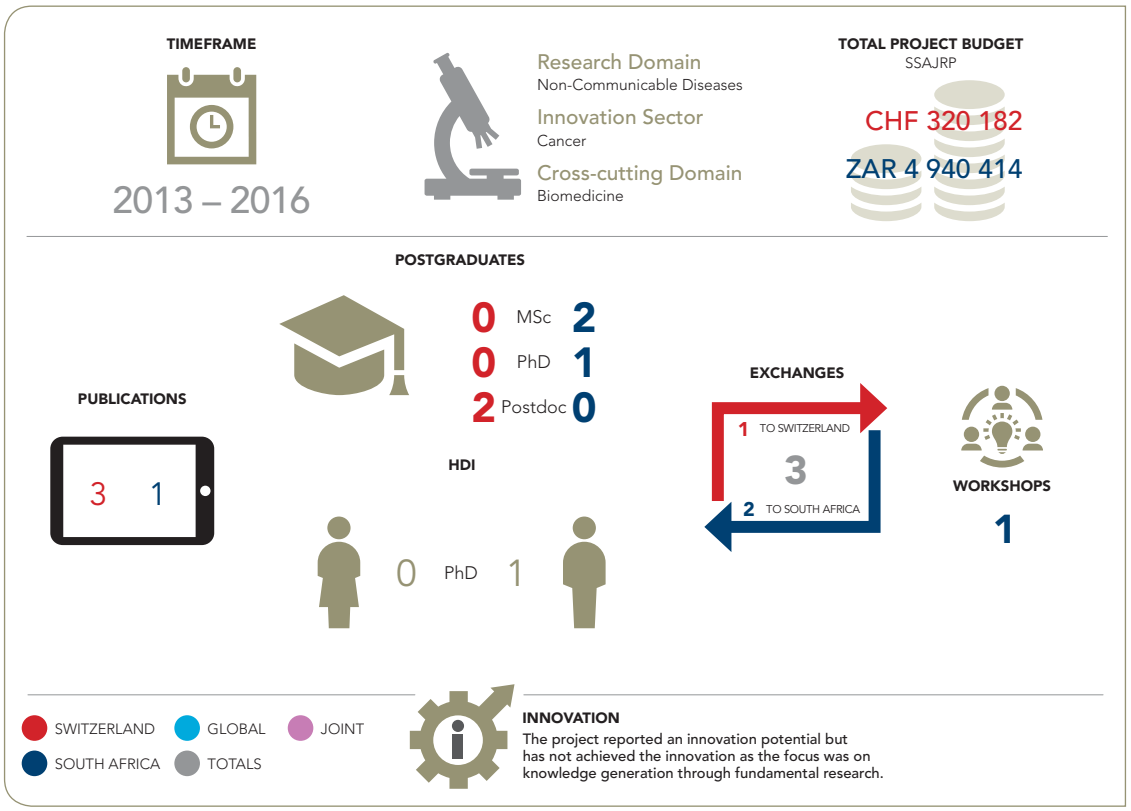
The researchers also tried to address how these cells kill each other, i.e. on what the molecular mechanism of this cell competition is based. They identified a set of novel genes, which may play an important role in the regulation of cancer.

The Swiss team's research focuses on stable cell societies, cell competition and genetics, while the South African team has expertise in genomics and proteomics approaches as well as translational cancer research. This laboratory has used cutting-edge technologies to address important questions in disease development and progression. Through the collaboration of these two groups, knowledge, expertise and resources were shared between Switzerland and South Africa, leading to a wide range of applications in both basic and translational research. Students and young scientists were also trained in an international setting and a high-quality research environment and increased infrastructure in both countries. The funding has greatly enhanced the exchange of knowledge and resources among the Swiss and South African laboratories.

The project trained and prepared team members for a future in this vital field of research and opened opportunities for the team members to pursue new research ideas. Interactions of young scientists help strengthen the current and future relationship and cooperation between South Africa and Switzerland.

Photograph courtesy of Champalimaud Foundation

The Moreno laboratory team.

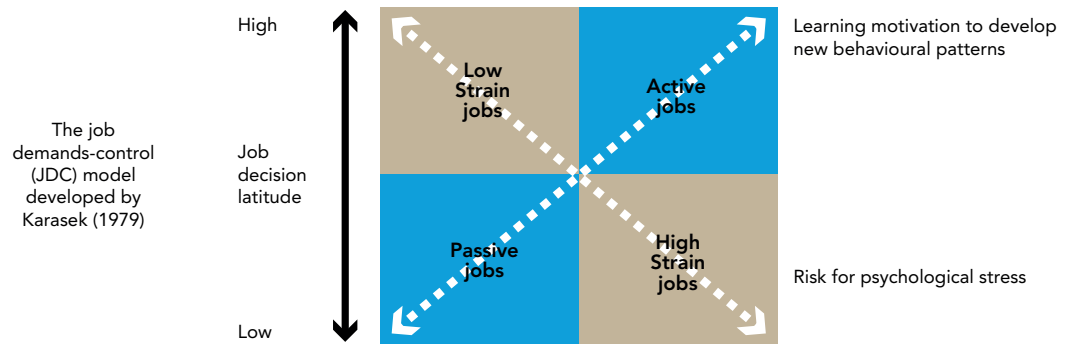


Relations of the job demands-control-support model of job strain with personality attributes: A cross-national study in Switzerland and South Africa

UNIVERSITY PARTNERS

University of Lausanne
Professor Jérôme Rossier and Dr Koorosh Masoudi
University of Johannesburg
Professor Gideon de Bruin

The research team's objectives were to examine the moderating effects of personality - as described in the Big Five model of personality - and culture in the demands-control model of job strain. The model posits three principal causes of job strain, namely high job demands, low job control or autonomy, and poor social support in the workplace. Hence, the model is successful in explaining when or under what conditions people are likely to experience job strain. However, the model is less successful in explaining who will be most likely to experience job strain.



The job demands-control (JDC) model developed by Karasek (1979)

The research team expected the findings of this project to shed new light on the cross-cultural validity of the demands-control model, which may serve to identify cross-cultural universalities and cultural specificities in the experience of job strain. In addition, they expected that the findings would show that individual differences in personality will either augment or diminish the effects of job demands, job control and social support on job strain. This would lead to a better understanding of who is most likely to experience high levels of job strain.

They hoped that the joint study of personality and culture within the context of the demands-control model would open up new avenues of research in the job strain domain.

Results indicated that equivalence cannot be assumed and that steps need to be taken to establish equivalence before cross-national comparisons can be made. The results showed that partially equivalent measures can be obtained by employing latent trait theory methods; however, full equivalence is difficult to achieve.

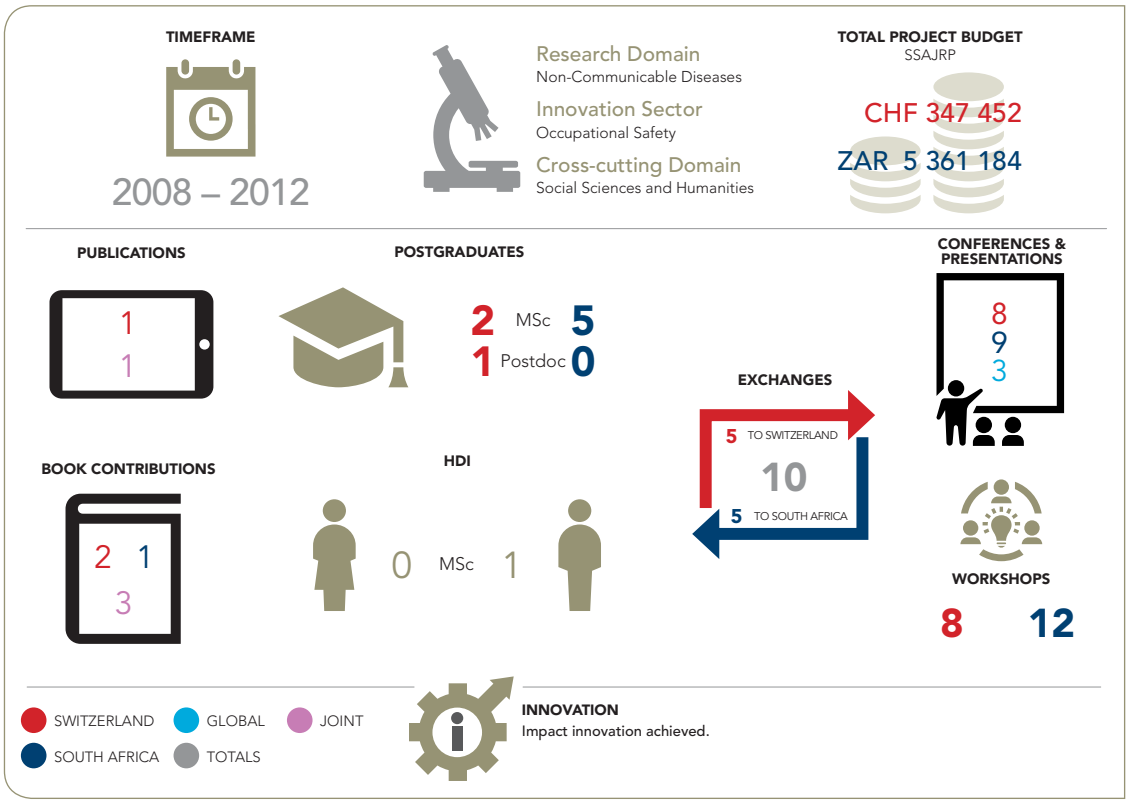
Another result they reported was that personality traits indeed moderate the relationship between job characteristics and strain outcomes. Overall, the results were similar across the two countries and in line with theoretical expectations, but some interesting anomalies appeared that require further investigation.

Footnotes:
1. https://doc.rero.ch/record/305061/files/Gy_rk_s_C.-Impact_of_Personality-20170830.pdf
2. Christina Györkös1, Jurgen Becker2, Koorosh Massoudi1, Gideon P. de Bruin2, and Jérôme Rossier
3. Diagram sources Toolshero

The demands-control model the researchers used was developed in North America and has been mostly studied in America and Europe. Little was known about the cross-cultural validity of the model. In particular, almost no research had been done in the African context.

The project allowed for theory testing and theory building in a cross-cultural context. This is likely to stimulate further research in the important areas of job stress and occupational well-being, which in turn might lead to the development of innovative interventions aimed at the treatment and/or prevention of job strain and the facilitation of job growth.

Moreover, a review article on the topic of this joint research project was published in a special issue about personality and culture of the *Swiss Journal of Psychology*, co-edited by Prof Jérôme Rossier.



Using novel nano- and Pheroid-technologies to enhance calcium delivery for food and nutrition applications: production, characterisation and *in vivo* efficacy

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Dr Michael Zimmermann
North-West University
Professor Anne Grobler

The project entailed the synthesis, characterisation and optimisation of nanostructured calcium (Ca) oxides, phosphates and carbonates (NCCs) by flame spray pyrolysis (a process that produces nanoparticles), the packaging of the nanostructured Ca oxides in different Pheroid carriers, and the evaluation of the effect of both in an *in vivo* study.

A Pheroid is a vehicle responsible for delivery and can be used to package a number of applications such as medicines, lotions and creams, food supplements and cosmetics. Pheroids also assist with absorption. NWU is the patentholder of the technology.

During the course of the project, the following were investigated: various factors that contribute to optimal synthesis of the nanostructured calcium compound; the various types of Pheroid carriers that can be used; the stability of the formulated Ca; and the compound:carrier ratios. *In vivo* studies were used to evaluate the value of Ca phosphate and Ca phosphate entrapped in Pheroid as intervention for bone density diseases. The researchers also tested to what extent customers would accept such formulations through sensory testing of the different Ca compounds/delivery systems in different foods.

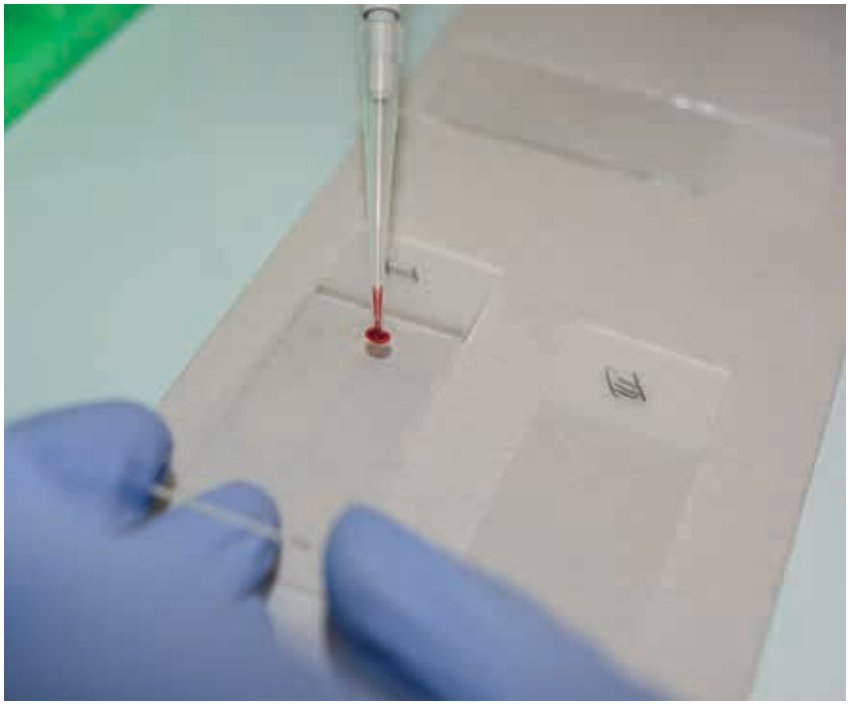
The bioavailability of nanostructured Ca versus micron-sized Ca, including Pheroid/biomineralised Pheroid structures, were also evaluated in an animal model, with concurrent assessment of potential toxicity in histopathology studies using a rat feeding study.

Even though the project started out with negative results due to the inability to produce the raw materials that would have been investigated, it enabled intensive sharing of knowledge about analytical methods and experimental procedures and knowledge transfer between the two participating institutions. It further involved a plant nutrition research company with equal shareholding by German and South African shareholders. The inclusion of a study leader from New Zealand further broadened the research linkages.

Since the problems with the production of nanopowders could not be solved in a reasonable

Photograph courtesy of Prof A Grobler

Desktop manufacturing for the novel liquid capsule dosage form of a Pheroid®-containing product now commercially available.



Photograph courtesy of Prof A Grobler

Photograph courtesy of ETH Zurich

Professor Dr Michael Zimmermann

Photograph courtesy of Prof A Grobler

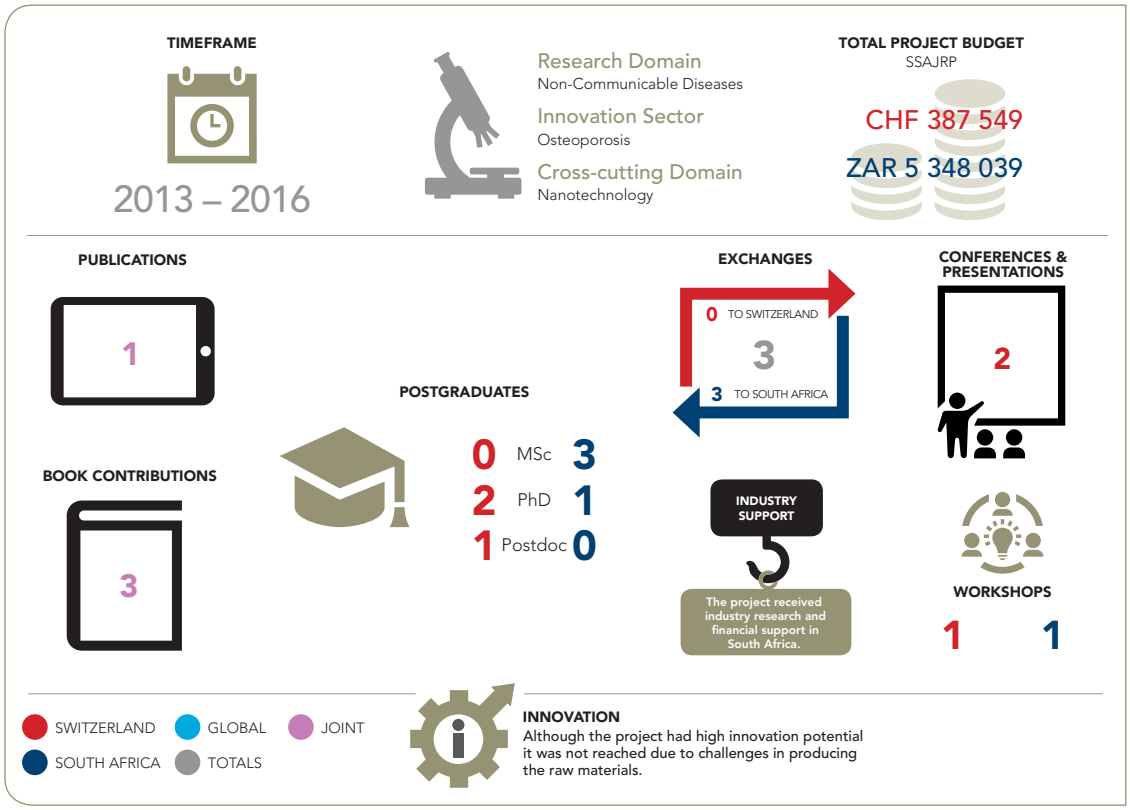
Professor Anne Grobler

Research conducted in the Grobler laboratory.

timeframe, commercially available compounds with the desired composition and specific surface area were used for compound carrier studies. Size and composition effects were investigated in a rat balance study and the results were compared to a previously published dissolution method for Ca to compare both *in vitro* and *in vivo* experiments.

The project contributed to knowledge on flame-assisted spray pyrolysis (FASP) as a promising new approach to produce nanopowders and has stimulated the search for a more suitable dissolution method with a possible correlation with *in vivo* absorption. The results of the studies also highlighted the possibility of an alternative Ca uptake mechanism in the animal model used, which needs to be further investigated.

This project enabled intensive sharing of knowledge about analytical methods and experimental procedures, as well as knowledge transfer between the Human Nutrition Laboratory at ETH Zurich and the Preclinical Drug Development Platform at NWU. The methods used to determine the effect of compound administration on harvestable yield was transferred to Dr Jesper Knijnenburg of ETH, who has since continued his career in this discipline.



Genetic analysis of the role of Hsp70-Hsp90 organising protein in the development of cancer

UNIVERSITY PARTNERS

University of Geneva
Professor Didier Picard
Rhodes University
Professor Adrienne Edkins

The Swiss and South African research groups aimed this collaborative, three-year study at analysing the role of the putative oncoprotein, Hsp70-Hsp90 organising protein (Hop), in mammalian cell and cancer biology using a combination of genetic and molecular techniques. The overall purpose was to determine whether Hop is involved in fundamental cellular processes that underpin cancer biology, analyse these processes at the molecular level and evaluate whether or not Hop may be a drug target for cancer.

The role of Hop was evaluated by depleting the levels of the protein by ribonucleic acid. RNA is one of three major macrobiological molecules essential for all forms of life, interference or through CRISPR/Cas9 mediated deletion of the gene. CRISPR is widely used to disrupt gene function by inducing small insertions and deletions. Hop was either depleted or knocked out of several established cancer cell lines and the effect on the biology of the cell evaluated. From the knockout lines, it was clear that Hop was not required for any essential cellular functions. Similar to the knockout lines, depletion of Hop by RNA interference (RNAi – a process used by organisms to regulate the activity of genes) did not result in a major growth defect. However, global analysis of proteins in Hop-depleted cells provided an insight into biological pathways that were perturbed and may account for the adaption of Hop-depleted cell lines.

The group's analysis did identify new roles for Hop in the cell. Taken together, these studies increase the fundamental understanding of Hop in mammalian cell biology and indicate that Hop may have important cellular functions. Some of the findings suggest that Hop may be a putative drug target and therefore there is the potential for future translation of the group's fundamental research findings. Research into the mechanisms by which Hop affects the cell is ongoing.

The project has made a substantial contribution towards the human capacity pipeline through the training and involvement of a number of postgraduate students who will receive advanced degrees through this training, and postdoctoral/emerging researchers. In addition to the students trained during the grant, the project generated

Professor Didier Picard

Professor Adrienne Edkins

Kaushik Bhattacharya

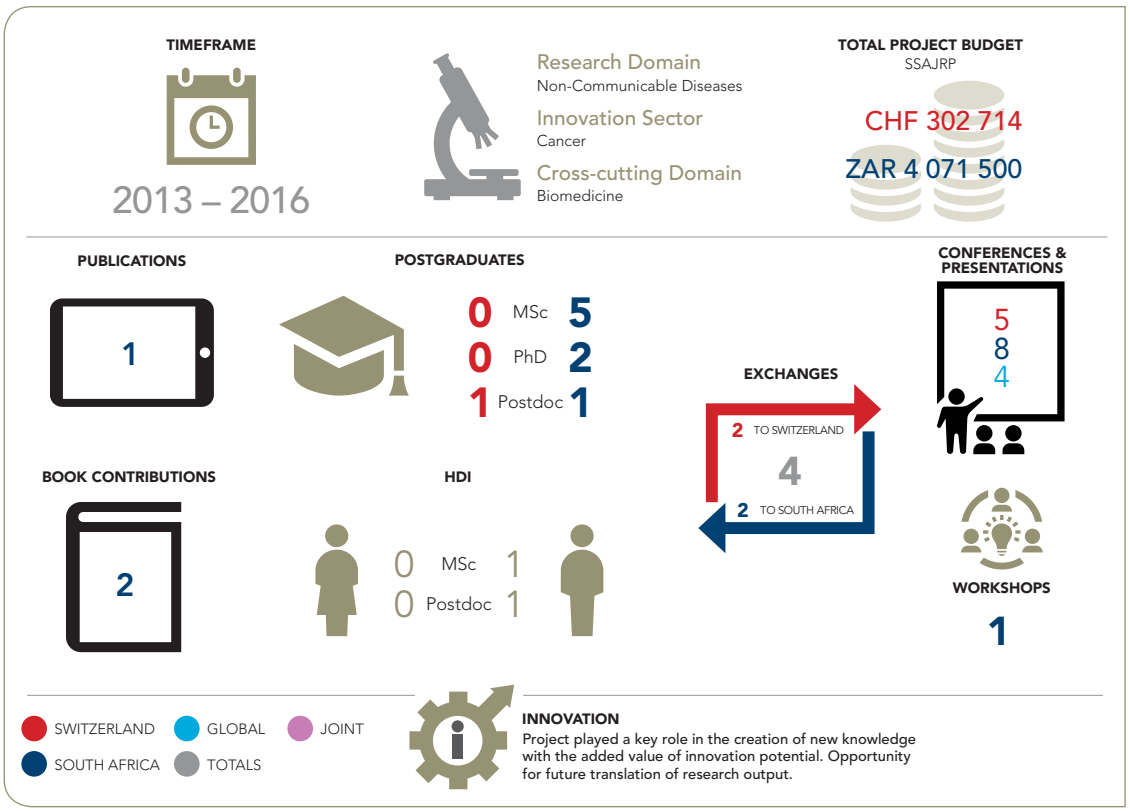
Photograph courtesy of Didier Picard

Professor Edkins with her laboratory team.

new avenues of research for training of other postgraduate students beyond the funding cycle. The postgraduate students of the South African partner are almost all female and a number of them are from historically disadvantaged groups, which makes a major contribution towards promoting redress in terms of equity from a student training perspective.

This project has also involved mentoring and developing postdoctoral and emerging researchers who have recently been appointed in independent academic positions. In addition, the South African Principal Investigator is a young female scientist whose research trajectory has been developed through the mentorship of her Swiss counterpart.

This project led directly to the establishment of a new collaboration between the South African and Swiss research groups. Due to the joint research interests, sharing of resources and complementary research expertise the collaboration is proposed to continue beyond this grant.



Investigation of natural and synthetic high-density lipoproteins as a therapeutic vehicle for cardio protection

UNIVERSITY PARTNERS

University of Geneva
Professor Dr Richard James (retired)
Dr Miguel Frias
Professor Nicholas Vuillemier
University of Cape Town
Professor Dr Sandrine Lecour

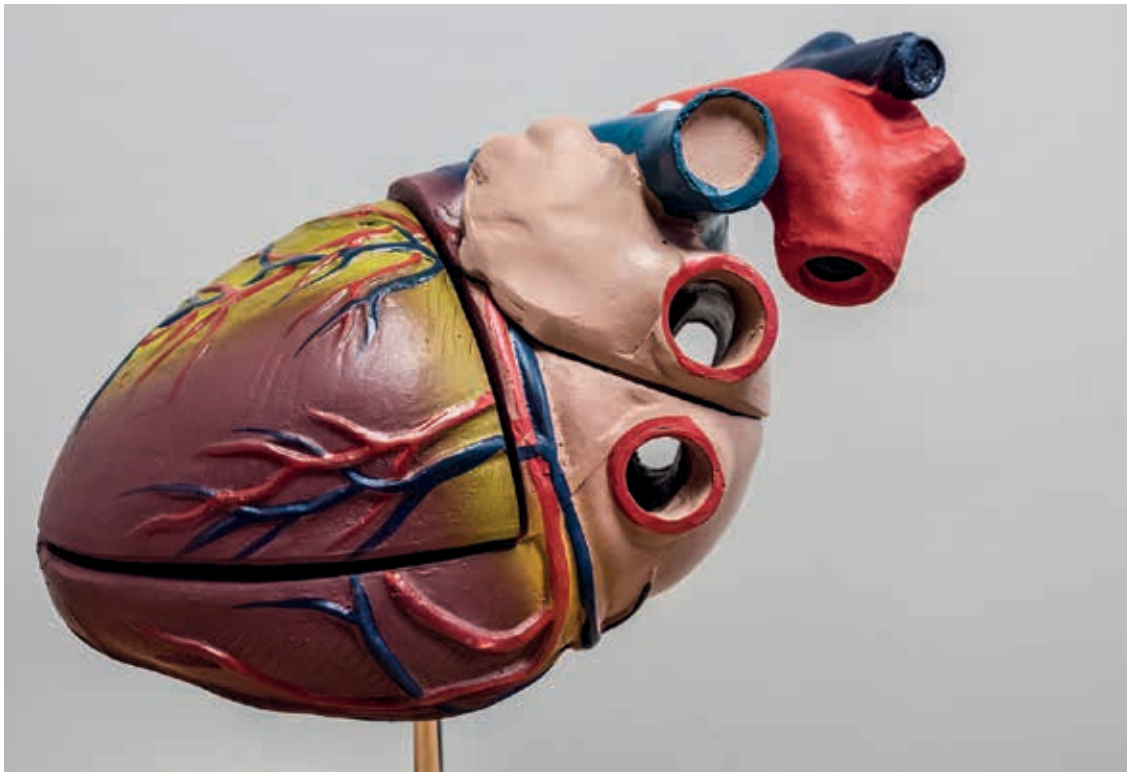
The researchers involved in this project investigated the therapeutic potential of natural and artificial high-density lipoprotein (HDL), commonly referred to as the good cholesterol, and explored the mechanisms that they could undertake to use synthetic HDL for cardioprotection in a clinical setting. As the risks of cardiovascular diseases are increased by decreased plasma HDL levels, the development of an effective synthetic HDL will benefit patients affected by myocardial infarction, diabetes, obesity and other associated pathological conditions worldwide.

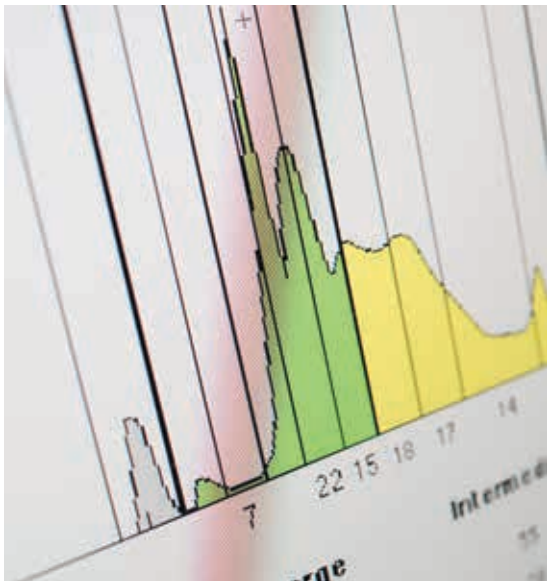
Underutilisation of high-density lipoproteins (HDL) as a therapeutic target against cardiovascular disease is of particular concern. It appears that HDL offers a wide range of cardiovascular benefits ranging from modulation of lesion development to cardiomyocytes and eventually that of heart function.

The researchers used an isolated mouse heart model to show that HDL administered in a dose-dependent manner protected the animal from myocardial infarction. Genetically modified animals that lacked tumour necrosis factor (TNF) and the cardiomyocyte transcription factor signal transducer and activator of transcription 3 (STAT3), allowed them to confirm the means by which HDL is protective.

The replacement of HDL with its major component, sphingosine-1 phosphate, yielded similar results. They noted a significant increase in the cardioprotective nature of HDL when they used a specially designed sphingosine-1 phosphate-enriched synthetic HDL in the animal models in place of the native HDL.

The data researchers obtained through this collaboration brought novel insight into the knowledge of cardioprotection with HDL. The design of their synthetic HDL as a novel therapy for cardioprotection is promising. Furthermore, their data clearly suggest the relevance of measuring HDL subclasses rather than total HDL as a more sensitive approach to measure cardiovascular risk in the clinical practice.





Lecour laboratory research tools and results.

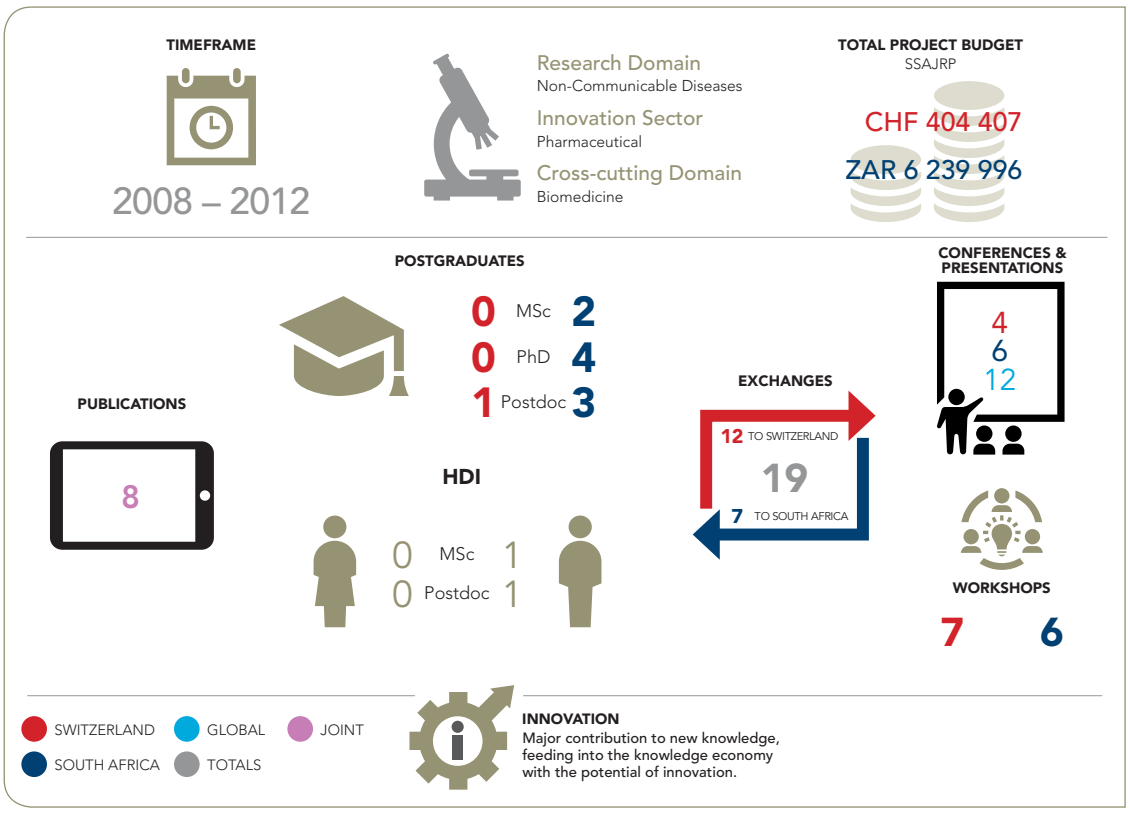
PhD student with Professor Sandrine Lecour.

This project has assisted in the capacity building of previously disadvantaged students and the acquisition of new research skills in South Africa. In collaboration with the Swiss partners, novel techniques to assess HDL sub-fractions, composition and functions were successfully established in South Africa. In return, the Swiss partners learned the isolated heart perfusion technique from the South African partners and managed to establish this technique in their laboratory in Switzerland.

A major impact of the collaboration has been the raised awareness and potential of South African medical research among Swiss scientists. South African students participated in the Swiss national meetings of the Cardiovascular Research and Clinical Implications Network that bring together young Swiss scientists working in the cardiovascular domain to present and discuss their studies. This underlined that fruitful scientific exchanges with South Africa are possible beyond those promoted by focused programmes.

Over the years, the collaboration has been extended to additional Principal Investigators and research facilities in both Switzerland and South Africa, and researchers from the Stellenbosch University and the University of Lausanne are involved in the continuation of this project.

"The SSARJP has allowed us to build a successful collaboration between South Africa and Switzerland. However, it has been challenging to grow this collaboration at the end of the programme due to lack of funding. Luckily, the excellent relationship between Swiss and South African partners has allowed us to pursue this collaboration with minimal funding (via a joint PhD student) and we also managed to extend it to other collaborators in Switzerland, South Africa and Germany," said Professor Dr Sandrine Lecour.



A translational model for the role of amygdala in fear behaviour

UNIVERSITY PARTNERS

University of Lausanne
Professor Ron Stoop
University of Cape Town
Professor Jack van Honk

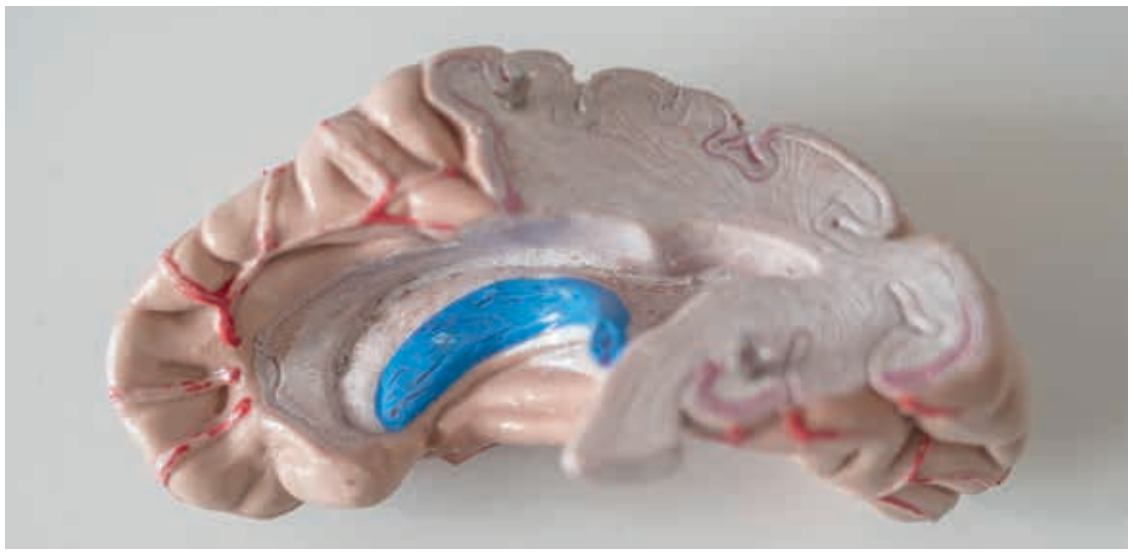
The participants in this project aimed to initiate translational research on rodents (in Lausanne) and humans (in Cape Town) to investigate the role of the amygdala in fear behaviours. The amygdala is an almond-shape set of neurons located deep in the brain's medial temporal lobe, shown to play a key role in the processing of emotions such as fear. In humans, the amygdala has been and still is being investigated and discussed as a single unit. Rodent research has, however, clearly demonstrated that the amygdala has structurally and functionally separate subdivision, with even antagonistic properties.

The researchers showed selective bilateral basolateral amygdala (BLA) damage in a group of subjects from the Northern Cape, South Africa, caused by a rare fault of the EMC1 gene (Urbach-Wiethe Disease (UWD), a rare recessive genetic disorder). Using neuroimaging techniques, the South African group showed that in these subjects the central nervous system (CNS) remains functional. Moreover, data on these UWD subjects correspond to animal models in showing that instrumental behaviours (subserved by the BLA) shifted to impulsive (subserved by the central-medial amygdala - CMA). These findings broadly agree with recent rodent models of the Swiss group at the University of Lausanne, but there are many unknowns requiring joint research to bridge the translational gap. In this bilateral project, the researchers for the first time used a truly translational approach in a project to construct a translational amygdala-centred neurobiological model of fear.

The researchers at UCT started new neuroimaging experiments with UWD subjects. Together with the Swiss collaborator, new translational tasks (for fear and socio-economic behaviours) were developed for further testing and translational research with amygdala patients and hormones. Several peer-reviewed papers were published in top scientific journals.

The project resulted in capacity development in terms of expertise in psychophysiological, neuroimaging and neuroeconomic research, which is evidenced in high-impact publications and international collaborations. The South African Master's and PhD students who worked on the

Professor Ron Stoop



A plastic model of the right hemisphere of the human brain, with the amygdala on the left (anterior) of the hippocampus (in blue).

Professor Jack van Honk

Photograph courtesy of Prof J von Honk

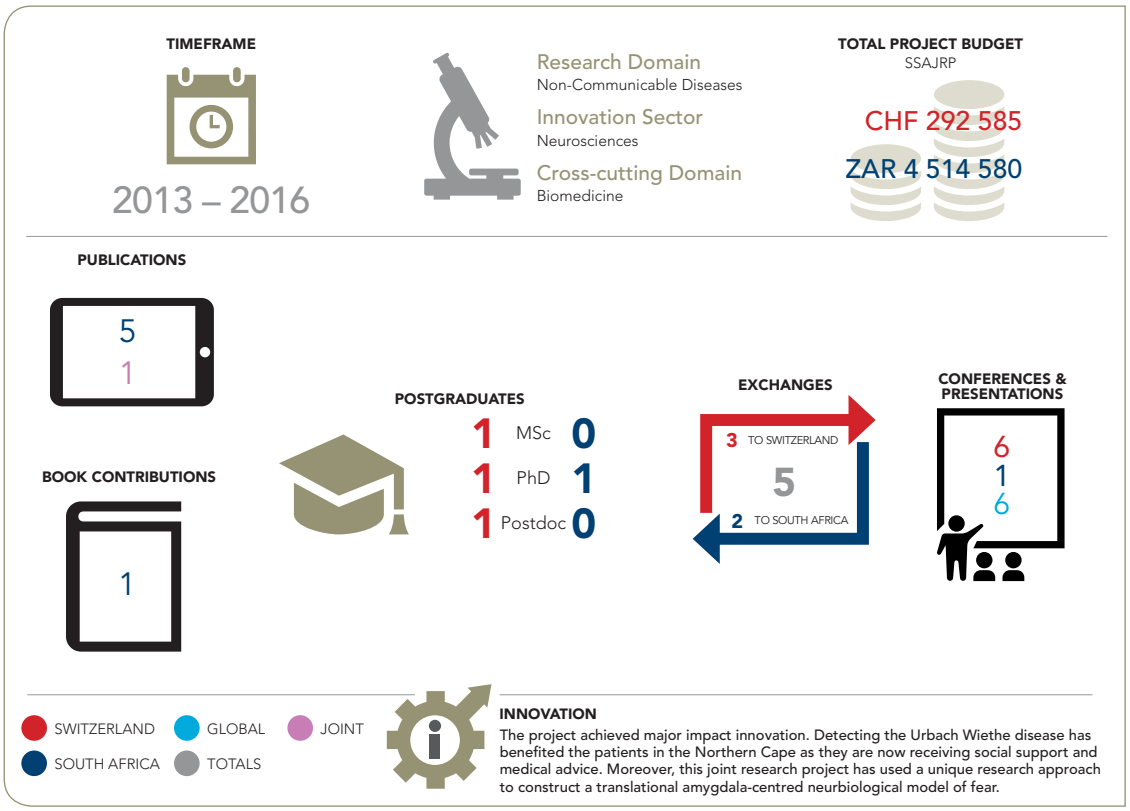
Entrance to the Center for Psychiatric Neurosciences of Lausanne University Hospital.

Yvonne Blake, graduate student from South Africa, financed by the Swiss-South Africa programme.

project were trained at top universities in Europe (Lausanne and Utrecth).

A new collaboration with Professor Michael Naeff, an expert in neuroeconomics at the University of London, supported the experiments on UWD.

Research on UWD has benefitted the patients and also some of the control subjects in the Northern Cape in that they received social support and medical advice and support. Most patients are now supported by disability grants. Children suffering from UWD, and control subjects in the Northern Cape, received support and small scale funding for education.



Multi-functional cyclopentadienyl and carbonyl complexes for theranostic applications

UNIVERSITY PARTNERS

University of Zurich
Professor Roger Alberto
University of the Free State
Professor Andreas Roodt

Photograph courtesy of Andreas Roodt

Supervisors in UFS RadioLab.

Imaging with bioactive compounds comprising Technetium-99m (99mTc) is the most important modality of diagnostic nuclear medicine. To direct complexes of 99mTc towards a targeted site (organ), e.g. cells with increased densities of particular receptors, the complex must be conjugated to a molecule with the corresponding biological recognition properties. The complex itself must be stable under physiological conditions, i.e. not trans-metallate to other sites or be metabolised by enzymes. If the attached biological molecule is cytotoxic, the metal-containing compound can be used for therapy. Technetium and Rhenium (Re) belong to the same triad. If homologous compounds are synthesised, the option of theranostics arises: minute quantities of 99mTc for diagnosis and macroscopic amounts of Re for therapy.

The research teams participating in this collaboration aimed their work at the preparation and biological study of such homologues. Considering the demand for physiological stability and structural flexibility, they focused their study on two well-known classes of ligands: cyclopentadienyls (Cp) and Schiff bases. Besides the synthetic challenge, they were interested in ligand exchange kinetics and substitution mechanisms, since both parameters are decisive for the success of 99mTc labelling. The project thus encompassed fundamental organometallic and coordination chemistry aspects, as well as physicochemical studies in solution and biological investigations.

Experiments with radionuclides such as 99mTc provided the project with special analytical and educative opportunities. They ultimately achieved their objectives of combining Re and 99mTc with functionalised ligands of both types; and accomplished complexes with two conjugation sites for binding one or two equal or different targeting/cytotoxic portions.

Through the intense mutual exchanges, discussions and collaborations, new innovative ideas emerged from this project. The two described tracks resulted in unexpected findings so far unknown in the inorganic medicinal and radiopharmaceutical community. The researchers will jointly develop these results, which will make an impact in the global community. The current project not only led to a substantial research output but also fertilised this field of science and makes it a necessity to pursue further.

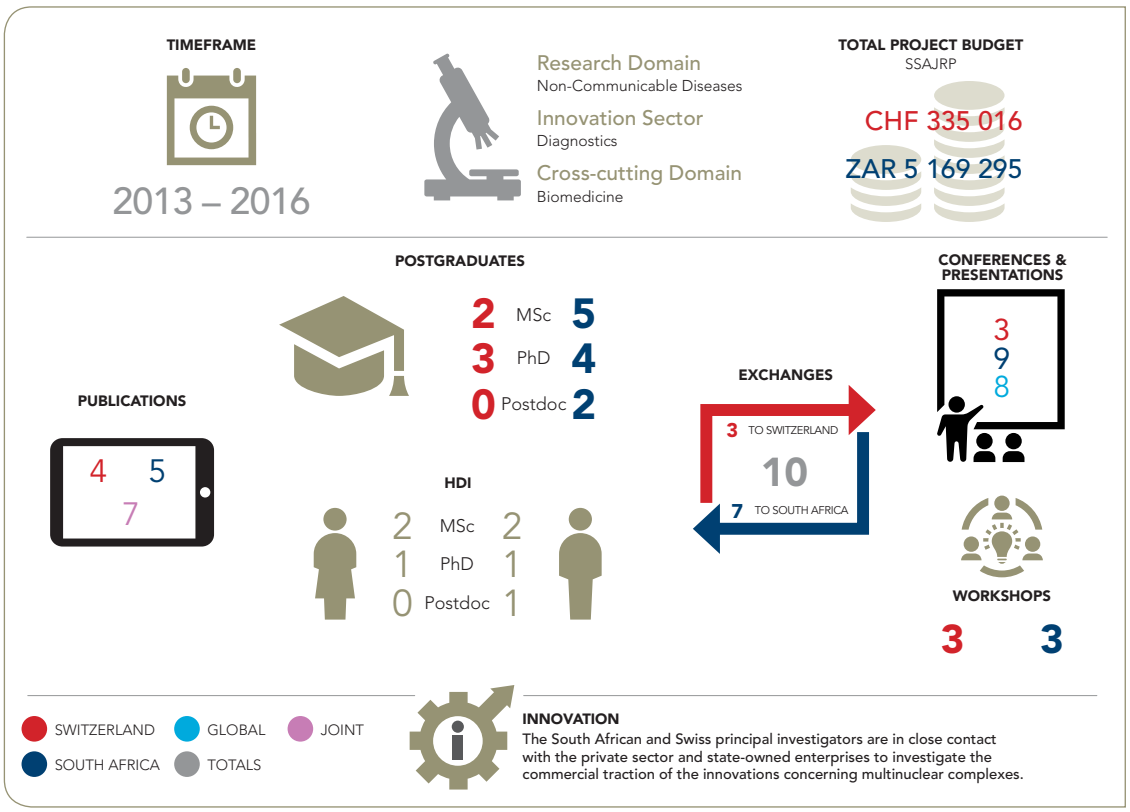
The SA students involved in this project are critical for the development of capacity in radiopharmacy, specifically from a fundamental chemistry point of view. Some South African hospitals employed students who were involved in the project.

The South African participants initiated significant interaction with industry in South Africa as well as with iThemba LABS under the overarching programme. Research interaction and expansion has been initiated with other countries and will be expanded further.

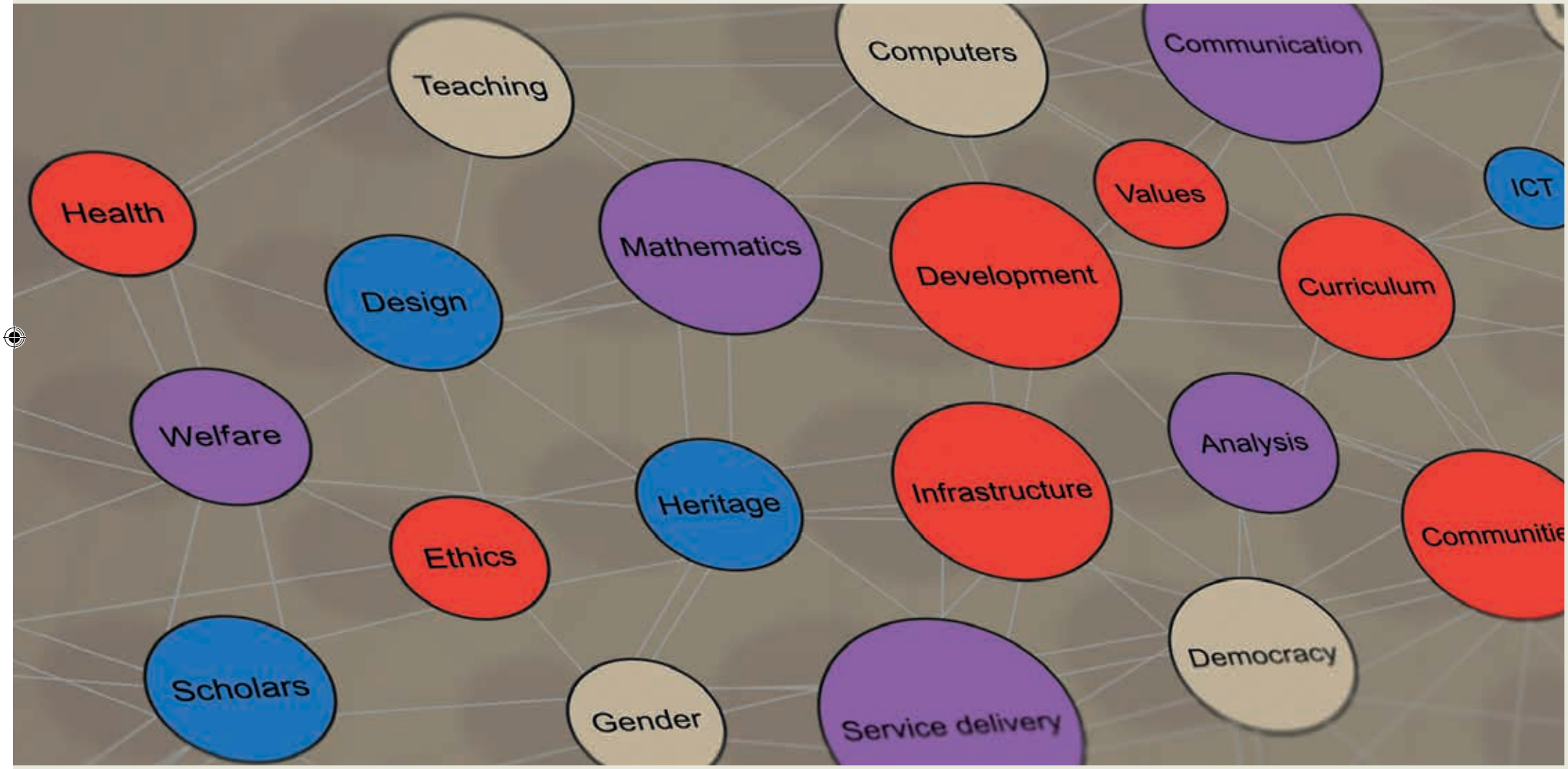
A number of compounds for theranostics (Re and 99mTc) prepared under the umbrella of this project were, or will be, subjected to biological studies at different laboratories in Germany and in France. The researchers are envisaging patenting multinuclear complexes, with negotiations pending.

Photograph courtesy of Andreas Roodt

Professor Andreas Roodt (right) with two students in the Fast Kinetic Laboratory.



4 JOINT RESEARCH PROJECTS
SOCIAL SCIENCES AND HUMANITIES



Switzerland
Under its new EU research programme, Horizon 2020, the importance of the social sciences and humanities has been formally recognised. Switzerland became fully associated with Horizon 2020 on 1 January 2017. Horizon 2020 has a number of innovative features, one of which is "to work beyond the 'silos' of different disciplines", in the words of EU Commissioner Máire Geoghegan-Quinn. More than €28bn is being allocated to tackle societal challenges, including energy efficiency, climate change, health, ageing, security, privacy issues and digitalisation.

The EU's integrative approach recognises the reciprocity of technological innovation and societal advancement: the more we strive for scientific and technological innovation, the more social innovation is needed. Science and democracy are never completely free of tension, but the social sciences and humanities can help to further mutual understanding on both

sides. These fields are the lynchpin for public engagement with science (Horizon 2020).

In Switzerland, the Academy for the Humanities and the Social Sciences is the umbrella organisation for the humanities and social sciences. It groups approximately 60 scientific societies which represent the broad spectrum of disciplines of the human and social sciences. Its mission is to represent the interests of the human and social sciences, to network the disciplines and to promote new subjects of scientific importance.

The Swiss Foundation for Research in Social Sciences (FORS) provides services to conduct research and to publish and disseminate research findings in the social sciences. FORS publishes a complete inventory of Swiss social research. It is located in the University of Lausanne.

The programme IRIS (Intégration, Régulation et Innovation Sociales) is a research and postgraduate education programme of the University of Lausanne, Geneva and of the EPFL. It represents scientists and researchers in human and social sciences. The Swiss National Science Foundation (SNSF) supports the research in humanities and social sciences (mySCience).

South Africa

South Africa's Human Sciences Research Council (HSRC) is a non-partisan, public-purpose organisation that generates scientific knowledge through its research and analytical work in the social and human sciences. It undertakes and promotes research that is often large-scale, multi-year, and collaborative in nature. It produces high-quality scientific evidence to inform further analysis, debate, advocacy and decision-making by role players in government, the media, academia, and community-based groupings. The HSRC responds to the needs of vulnerable and marginalised groups in society through its research. It develops and makes available data sets underpinning research, policy development and public discussion of developmental issues.

Through its work the HSRC aims to inform policy development and good practice, thereby making a difference to the lives of people in South Africa and in the mother continent (Human Sciences Research Council).

Research in the humanities and social sciences are funded by the NRF through the Human and Social Dynamics funding instrument, a discipline-specific funding instrument that supports basic research in HSS. The objectives of the funding instrument are to contribute to knowledge production in the HSS; support world-class basic research alongside the development of the associated human capacity; and to advance or develop paradigms, theories and/or methodological innovation in the disciplinary fields of HSS (National Research Foundation).

The value of the Social Sciences and Humanities domain lies in the excellent innovation that the projects achieved. Worth mentioning is the project on ethics and regulation of vaccine trials involving humans – an online training platform that is having a global impact. It has now become mandatory for researchers in South Africa to undergo these online training modules for clinical trails to ensure adherence to research ethics.

Three joint projects in the social sciences have focussed on education technology. The VITAL Maths joint research project has established an online training programme for maths in English, German and isiXhosa. This e-learning took ICT to the classroom of primary schools in disadvantaged areas where 120 primary school teachers in the Western Cape were capacitated to understand ICT and how it can be incorporated into the curriculum. The joint research projects on Wikipedia Primary School had a major impact on helping the South African education community create, assess and use Wikipedia content in the classroom.

Focus was placed on governance in the joint research project on organisational capabilities and the governance of utilities. The project investigated, among others, the interplay between policy decisions and competency-building in public utilities.

Joint Research Projects

Outcomes of the Social Sciences and Humanities Domain (7 projects)

RESEARCH DOMAIN: SOCIAL SCIENCES AND HUMANITIES

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:
CHF 2 338 885 ZAR 36 088 998

UNIVERSITY PARTNERS

- University of Basel
- University of Applied Sciences and Arts Northwestern Switzerland
- University of Applied Sciences and Arts Southern Switzerland
- University of Neuchatel
- University of Teacher Education at University of Applied Science and Arts Northwestern Switzerland
- University of Lugano
- Swiss Federal Institute of Aquatic Science and Technology
- University of KwaZulu-Natal
- Rhodes University
- University of Cape Town
- University of the Witwatersrand

SEED FUNDING

- PHASE 2008 – 2012: 3 projects
- PHASE 2012 – 2013: 1 project
- PHASE 2013 – 2016: 3 projects
- PHASE 2017 – 2020: No projects

BENEFICIATION

ECONOMIC
- **86%** Regional and rural
- **29%** Contribute to Africa

GLOBAL CHALLENGES
- **14%** Global disease
- **43%** Africa challenge
- **14%** Neglected tropical diseases

NATIONAL OBJECTIVES
- **15%** Policy beneficiation
- **25%** National strategies in South Africa
- **25%** HCD of historically disadvantaged
- **15%** Gender balance redress in SER

PUBLICATIONS

3 | 3 | 32

38 TOTAL

BOOK CONTRIBUTIONS

2 | 3 | 1

6 TOTAL

POSTGRADUATES

17	MSc	18
3	PhD	14
3	Postdoc	0

55 TOTAL

HDI

6	MSc	2
4	PhD	1
0	Postdoc	0

13 TOTAL

EXCHANGES

24 TO SWITZERLAND

52

28 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS

31 | 25 | 43 | 99

WORKSHOPS

22 | **26**

APPRECIATION

COLLABORATION	**40%** Alignment of PIs objectives **25%** Mutal beneficiation **20%** Joint knowledge **5%** Joint Publications **20%** Joint exchanges **25%** Workshops
HUMAN CAPITAL DEVELOPMENT	**20%** Appreciate Swiss contribution **20%** HCD in general **10%** Could demonstrate South Africa research excellence
RESEARCH FACILITIES	**10%** Access to unique research environment in South Africa **20%** Opportunity for applied research
GENERAL APPRECIATION	**20%** New research

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
- 25% BRICS COUNTRIES
- 15% EU COUNTRIES
- 10% AFRICAN COUNTRIES
- 5% SOUTH AMERICA

UNIVERSITIES AND NETWORKS
- 20% SOUTH AFRICAN UNIVERSITIES
- 5% SWISS UNIVERSITIES
- 35% CONTACTS AND NETWORKS ESTABLISHED
- 10% EXTEND COLLABORATION TO INTERNATIONAL NETWORKS

BENEFITS OF LINKAGES
- 5% NEW RESEARCH TOPIC
- 10% EXTENT COLLABORATION WITH SWISS AND SOUTH AFRICAN PARTNERS
- 5% GOVERNMENT INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
- 5% Difficulty reaching field research facilities
- 5% Inadequate infrastructure in the field
- 5% Access to information
- 15% Different admin and auditing procedures

FUNDING AGENCIES
- 10% Additional funds for HCD
- 5% Scholarships and busaries
- 5% Delayed project start

GENERAL
- 10% Decrease in ZAR value = Decrease in project funds
- 5% Lack of follow-up funding

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Wikipedia Primary School

UNIVERSITY PARTNERS

University of Applied Sciences and Arts of Southern Switzerland
Dr Iolanda Pensa
University of Cape Town
Dr Tobias Schonwetter

The research group involved in the Wikipedia Primary School project aimed to provide the information necessary to complete the cycle of primary education in South Africa on Wikipedia. More specifically, the joint applied research project focused on developing and evaluating a system to assess Wikipedia articles for primary education and to involve a wide network of scholars and expert contributors in the process.

Access to affordable learning materials remains a problem for many learners in South Africa, particularly in previously disadvantaged areas. Providing free information on Wikipedia to complete the cycle of primary education holds the promise of making learning materials more affordable and accessible, thus improving educational opportunities, especially for historically disadvantaged individuals.

Key activities of the project included developing the necessary framework to identify, address and involve key stakeholders (the Wikipedia community, partners, volunteers, scholars and experts in the field of education); selecting relevant articles that respond to curriculum-based questions; and facilitating the production of additional high-quality and assessed articles on Wikipedia linked to primary education.

Even though the researchers conceptualised Wikipedia Primary School to be scalable and international, it was designed to primarily address the needs of African countries. In addition, the content targets around 500 million Wikipedia readers who can access Wikipedia for free on their mobile phones and/or offline in around 30 countries.

The project has contributed to an analysis of the South African primary school curriculum and identification of relevant themes and content. The research team developed a review process and pilot launch and have drafted a pilot issue of the Wikipedia Scientific Journal. They furthermore developed a survey to involve teachers in the process and adequate evaluation criteria and identification of core data for evaluation purposes.

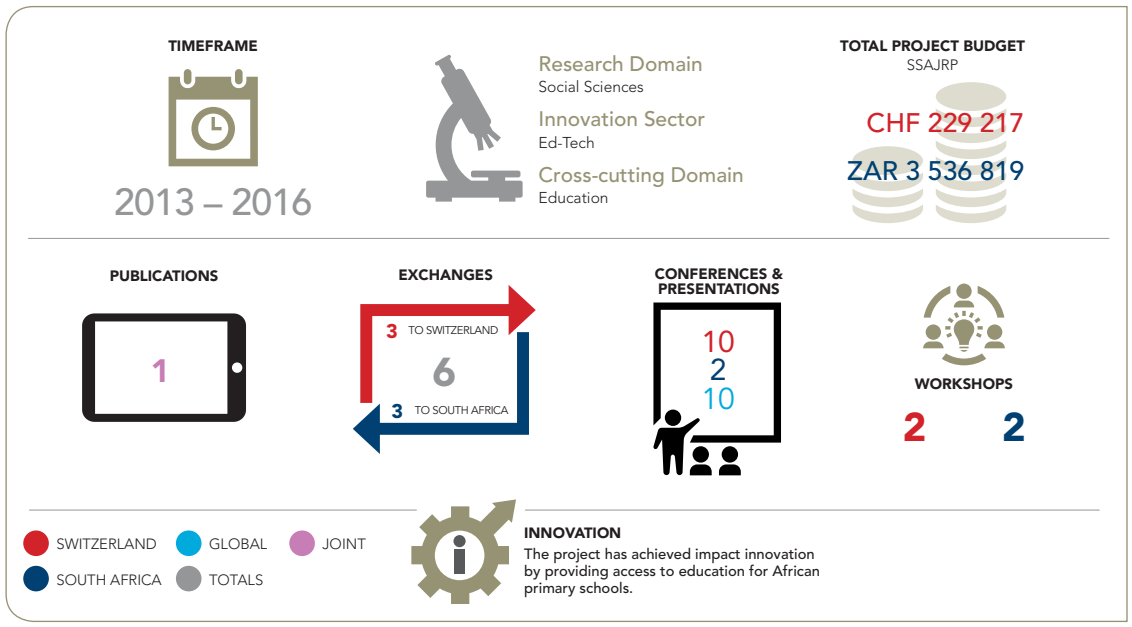
The research team trained South African students and librarians to produce and improve Wikipedia articles (identified through the involvement of South African teachers of two schools – Zimasa Primary and Moshes Primary) during three edit-a-thons, which were held at the Central Library in Cape Town.

Pucciarelli Marta, Giovanni Profeta and Iolanda Pensa.

Academic experts from five continents have provided scientific reviews to improve Wikipedia articles related to the South African primary school curriculum. Additionally, they facilitated content production through participation in and support of Wikimedia community offline and online events to reduce general gaps in African content production.

In addition to the research linkages created among the key participants of this project, the project has benefited from synergies with other networks: WikiAfrica, Kiwix, Kumasha Takes Wiki, Wiki Indaba, Creative Commons in Africa, and the Open African Innovation Research network.

The University of Cape Town in partnership with the Africa Centre held workshops in Cape Town and Johannesburg to discuss the project methodology and expected outcomes with around 15 stakeholders working in the education sector as well as 30 Wikimedia community members. In addition, they organised a series of so-called edit-a-thons to improve articles related to the South African primary school curriculum.



Ethics and regulation of vaccine trials involving humans: on-line training

UNIVERSITY PARTNERS

University of Neuchâtel
Professor Dominique Sprumont
University of KwaZulu-Natal
Professor Douglas Wassenaar

University of Neuchâtel

The project aimed to develop a free, open-access, high-quality, peer-reviewed online certificate-generating training module on the ethics and regulation of vaccine trials in humans.

To achieve this, the research team first conducted a literature and policy review to gather relevant resources. They developed an on-line peer-reviewed training module on the ethics and regulation of vaccine trials with humans before launching the online training module.

Researchers, students, members of research ethics committees and all other interested parties, including the general public, can now access and complete this peer-reviewed module free of charge, and download a certificate on completion.

The on-line training comprises two broad components: e-Learning and e-Resources. The main objective of the Training and Resources in Research Ethics Evaluation (TRREE) platform, including this specific module, is to provide basic training and to build capacity in the ethics of health research involving humans. The aim is for such research to meet the highest standards of research ethics and to promote the welfare of participants. The platform consists of a multilingual web-based training programme that includes reference tools.

Photograph courtesy of Douglas Wassenaar

Professor Douglas Wassenaar

Photograph courtesy of Dominique Sprumont

Professor Dominique Sprumont

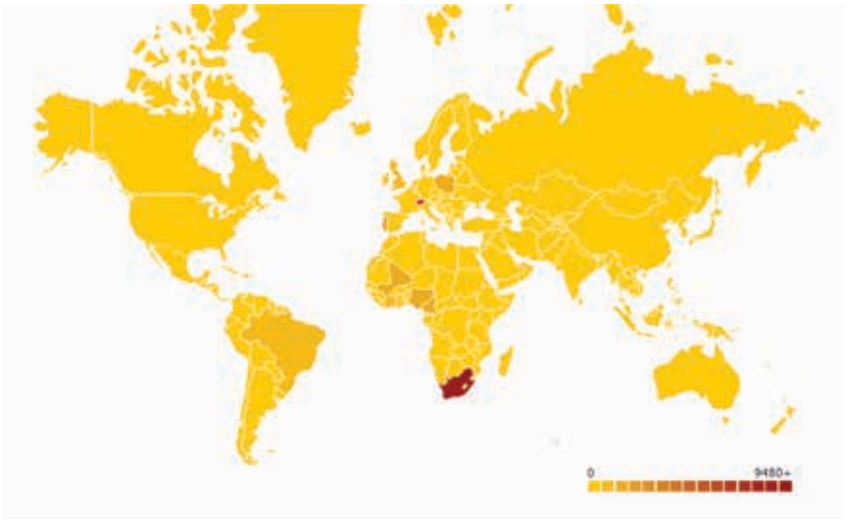


Illustration courtesy of TRREE

TRREE is a growing community. This is an overview of the origin of our participants.

Further, TRREE has obtained recognition for its training modules from the Swiss Medical Association and the Swiss Pharmacist Association. The project team also intended to seek the recognition of national and international bodies involved in continuing education programmes for healthcare professionals in general and those working in HIV prevention trials in particular.

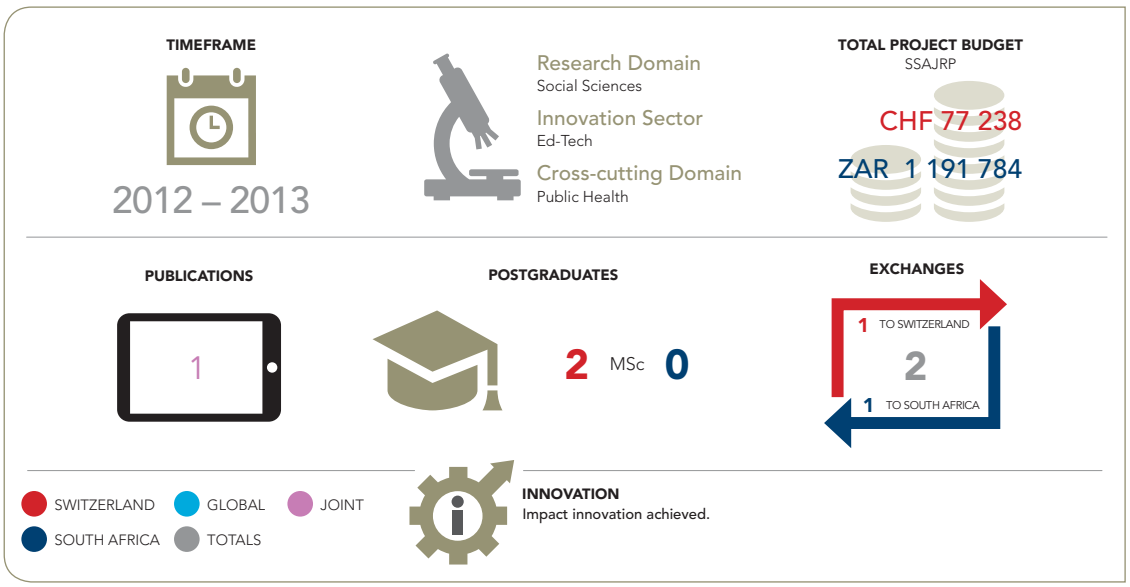
Members of several South African research ethics committees and ethics applicants are required to complete TRREE modules as evidence of basic training in research ethics. As at March 2018, 2 241 persons had completed the NRF/Swiss-funded online module and 1 984 certificates were issued.

The collaboration strengthened an already successful collaboration between the participating laboratories on research ethics, which led to further collaborative work on two more completed TRREE online modules – one on ethical issues in Enrolment of Adolescents in HIV Prevention Research, and a national module specific to South African health research ethics guidance and health law.

The philosophy of TRREE is to remain free with open access. Different TRREE modules have been funded by different funders, including the NRF and the Fogarty International Center of the US National Institutes of Health. In June 2017, TRREE introduced a moderate fee for participants from high-income countries (as per World Bank definitions). The fee is charged only for downloading the GCP module certificate.

As at the end of February 2018, 3 266 South Africans had completed TRREE modules and 2 345 certificates had been downloaded. South Africa has the second-most users of TRREE (8 008) after Switzerland (8 211), with 38 623 worldwide (including 1 665 on TRREE China).

By providing this open-access module on the TRREE platform, many users continue to be trained, and this number could be enhanced if the module, like others, was translated into other languages. TRREE is easily accessible using low-bandwidth internet, which makes training available to under-resourced areas. Professor Sprumont was invited to serve on the International Advisory Board of the South African Research Ethics Training Initiative (SARETI).

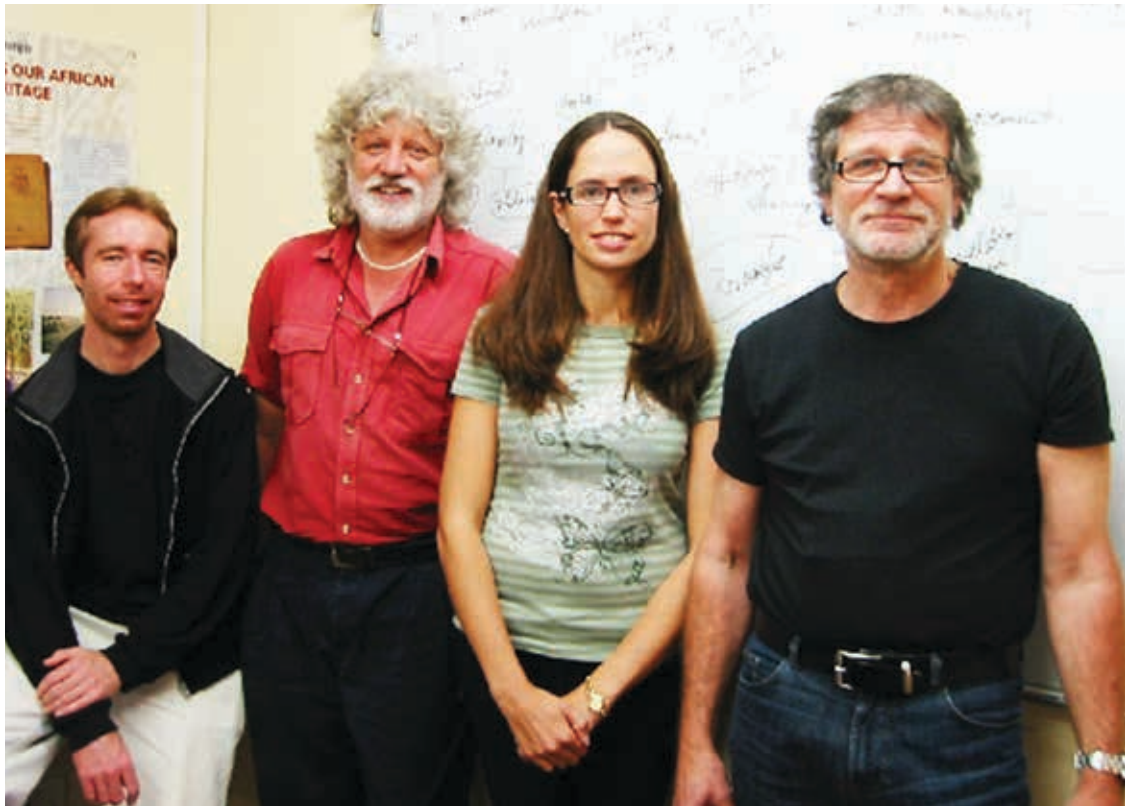


Visual technology for the autonomous learning of Mathematics 2 – learning in context ("VITALmathsLIC")

UNIVERSITY PARTNERS

University of Teacher Education
at University of Applied Sciences
Northwestern Switzerland
Professor Dr Helmut Linneweber-Lammerskitten
Rhodes University
Professor Dr Marc Schafer

Professor Dr Helmut Linneweber-Lammerskitten



Duncan Samson, Marc Schafer, Caryn McNamara, Helmut Linneweber-Lammerskitten.

Photograph courtesy of Marc Schafer

The VITAL Maths LIC project rests on the foundation of the VITALmaths project, which focused on the development of a bank of online video clips and the opportunities they offered for the mathematics teacher to use them as interesting and appropriate teaching devices and tools. These are used in conjunction with computers and mobile technologies such as tablets and mobile phones. The project had three main objectives: to produce a freely accessible databank of short video clips designed specifically for the autonomous learning of Mathematics; to maintain a dedicated website to house the video clips (http://www.ru.ac.za/VITALmaths); and to establish a research agenda around their use and efficacy.

With the new VITAL Maths LearningInContext project (VITALmathsLIC), the researchers aimed to establish how learning can take place in different learning, communication and contextual spaces. They designed teaching and learning support and scaffolding materials (such as "Arbeitsaufträge", worksheets and manipulatives) to align with the existing and a newly developed bank of video clips. They also created new video clips with a strong focus on language and communication.

Three underlying themes and associated research questions framed the VITALmathsLIC project:

- Enhance learning in a collaborative and social milieu,
- Enhance mathematical learning through encouraging an appropriate mathematical discourse and language,
- Encourage the use of physical manipulatives to enhance learning.

This research project lent itself to using questionnaires and focus-group interviews to explore how the videos encouraged selected learners to use physical manipulatives in conjunction with the videos to investigate mathematical ideas. The data for this project were generated through the use of worksheets and interviews where learners were required to engage with activities that lent themselves to a visual and/or abstract engagement. This engagement was analysed and characterised in terms of the extent to which it incorporated visual reasoning.

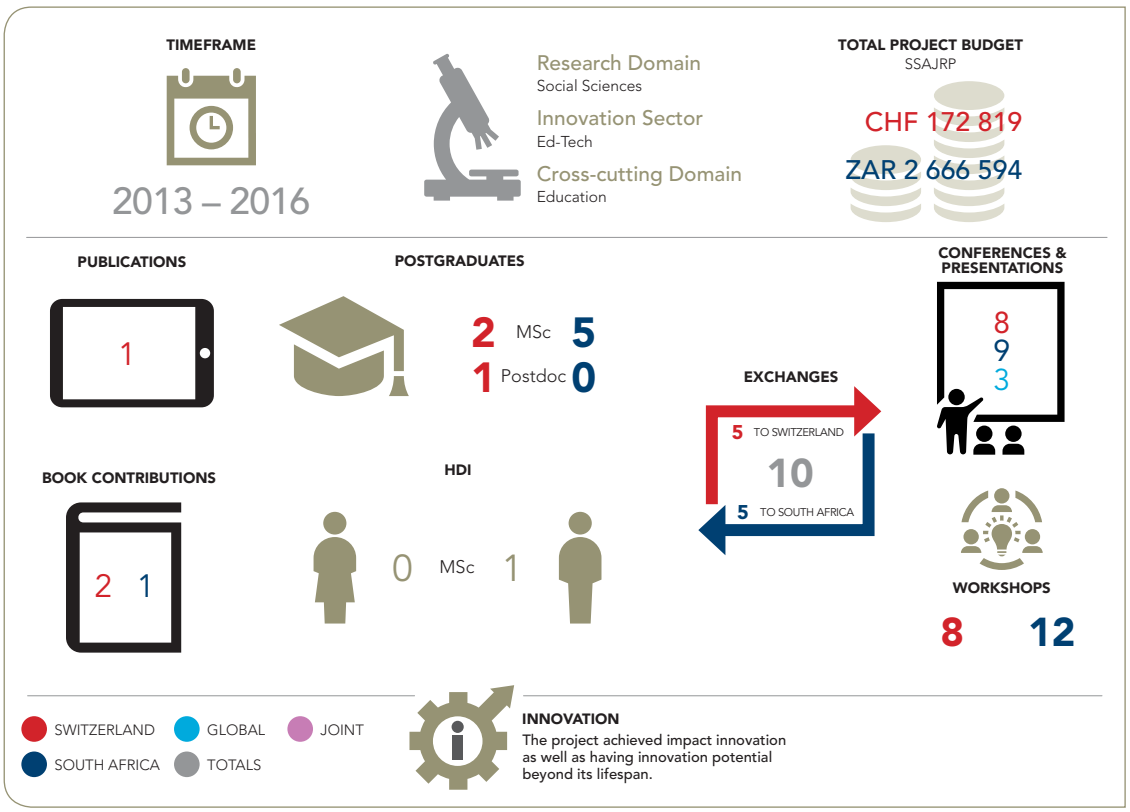
The findings of the research will continuously feed into the refinement of the design of newly developed video material. The resulting databank of videos thus continues to grow on the basis of this research, thereby ensuring sustained relevance. The project is committed to the principle of making educational materials and media available to learners free of charge, and to broadening access to quality material – this includes access in terms of language and culture. The videos are therefore made available in a diversity of languages.

The smooth transition and continuation from the

VITALmaths development tools.

VITALmaths project to the VITALmathsLIC project entailed, among others, the production of more than 50 new video clips (in English, German and isiXhosa), which are all available at www.vitalmaths.com and on YouTube. The new video clips differ from the old ones in that the mathematical situation is embedded in a specific dialogue. The dialogue is presented as on-screen text and models the kind of language that learners could make use of when expressing their own mathematical thoughts in a similar situation. Although the protagonists of the dialogue remain invisible to the viewer, what becomes visible to the viewer are their mathematical thoughts as modelled through language, manipulatives and sketches.

The collaboration that the grant has facilitated went beyond the Swiss and SA grantholders. The work of the VITALmaths project has brought people from all spheres of education together: academics, teachers, pupils, subject advisors, textbook authors, researchers and policymakers. It has also generated many new worthwhile research questions that will hopefully form the foundations of future research agendas and collaborations. The international networking that the grant has facilitated has been remarkable.



Measuring e-learning impact in primary schools in South African disadvantaged areas

UNIVERSITY PARTNERS

University of Lugano
Professor Dr Lorenzo Cantoni
University of Cape Town
Professor Wallace Chigona

University of Lugano

The goal of the MELISSA project (Measuring E-Learning Impact in primary Schools in South African disadvantaged areas) was to study the impact of information and communication technology (ICT) training on primary school teachers in the Western Cape Province, and to provide them with further training. The project trained 120 primary school teachers to understand ICTs and how to incorporate them in their curriculum. An experimental and a control group were incorporated in the project.

The research team believe that the integration of ICTs in education is essential to enhance learning practices and improve the quality of education.

Professor Dr Lorenzo Cantoni

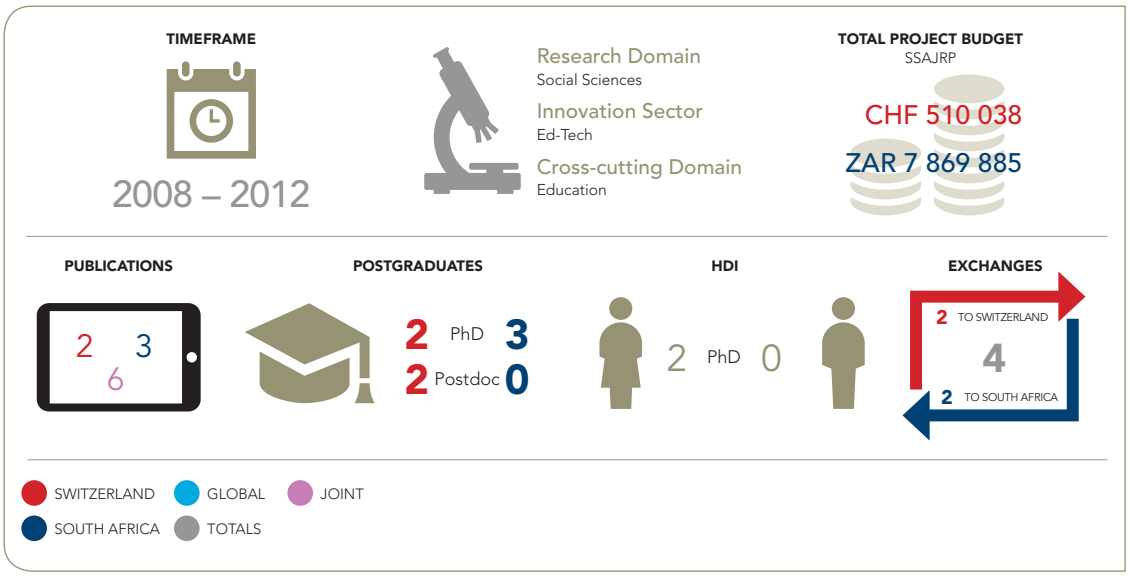
Professor Wallace Chigona

Photograph courtesy of Wallace Chigona

Initially, the lack of infrastructure in developing countries prevented the integration of ICTs in the education sector. However, a number of initiatives in South Africa have made the technologies available to schools and attempts were made to equip educators with the ability to use ICTs in the curriculum. Unfortunately, ICTs are still underutilised, even where the infrastructure is available. The researchers therefore attempted to identify and address factors resulting in the lack of efficient integration of ICT in the current curriculum.

The objective of the project was to help teachers understand the use of computers, their ability to use computers in their work and also their control over the impact of computers. Questionnaires and interviews were used to assess the groups. Teachers were assessed before and after the programme. The researchers then used the results to design effective, efficient and sustainable ICT training interventions, policy guidelines and also to evaluate activities. They further provided a framework for evaluating existing programmes. They believe this will allow for the optimal allocation of available resources.

The MELISSA project has helped school teachers to better understand and integrate ICT within their practices, making wise and sustainable use thereof. By becoming experts in using ICT, they have reduced the digital divide and are sufficiently prepared to introduce and guide their students into the knowledge society. The project design has allowed for a wider impact on practices, and ensures that not only the first cohort of students, but all future classes of trained teachers will benefit from it. In addition, teachers involved in the project will act as models, driving innovation in their respective schools and communities. They will also leverage ICT to ensure continuous building of skills and lifelong learning. The project will impact the concerned research communities, and help design more effective and sustainable intervention in the field, not only in South Africa but also in Switzerland. Improving the integration and use of ICTs in the South African curriculum contribute to effective and efficient growth of teaching abilities as well as improve the quality of education. The learners will benefit directly from this in terms of their performance and capacity building for the future. The outcome of the project was aimed at assisting in the effective design of efficient and suitable training interventions, and provide a framework to evaluate existing programmes.



Organisational capabilities and the governance of utilities

UNIVERSITY PARTNERS

Swiss Federal Institute of Aquatic Science and Technology
Professor Bernhard Truffer
University of Cape Town
Professor Anton Eberhard

Utility services – including electricity, water supply and sanitation – face many challenges, such as market liberalisation, organisational restructuring, massive investment needs and the introduction of new technologies. This project aimed to develop a deeper understanding of the role of competencies and skills in providing adequate utility services and to improve the performance of state-owned enterprises in infrastructure sectors, especially in the water supply, sanitation and electricity sectors.

Sustaining the functionality of infrastructure sectors is essential for poverty reduction, greater equality, accelerated economic development and growth, and for improving social welfare.

South Africa's electricity supply is inadequate as emphasised by the numerous blackouts and electricity distribution failures experienced since 2005. A deteriorating electricity distribution system was one of the causative factors identified. The Department of Environmental Affairs and Tourism further identified the deteriorating water quality and availability as one of the main challenges in South Africa. A survey completed by this Department revealed that 30% of all waste water treatment plants require intervention. Organisational capabilities are a key factor to provide effective and cost-efficient services and supply. Existing literature has addressed some of the challenges facing utility services in South Africa, but the role of organisational capabilities for managing utilities to ensure their long-term viability has not been explored.

Aspects the researchers investigated include how policy decisions influence competency building in public utilities; how utilities acquire and build adequate competencies and skills; and how the accumulation of competencies affects vertical integration and disintegration in infrastructure sectors.

The research team focused on the implications that competencies and skills have on effective public service provision, long-term viability of infrastructure networks and regulatory design. They believe better understanding of the impact of capabilities on the infrastructure sector may allow for the recommendation of adequate regulatory designs to policymakers. Insights from this project

Wastewater treatment plant.

Photograph courtesy of Infrastructure News

Eskom power station.

Photograph courtesy of Infrastructure News

Photograph courtesy of Bernhard Truffer

Professor Bernhard Truffer

Photograph courtesy of Hagen Worch

Professor Hagen Worch

Photograph courtesy of BAnton Eberhard

Professor Anton Eberhard

Photograph courtesy of Mundia Kabinga

Mundia Kabinga

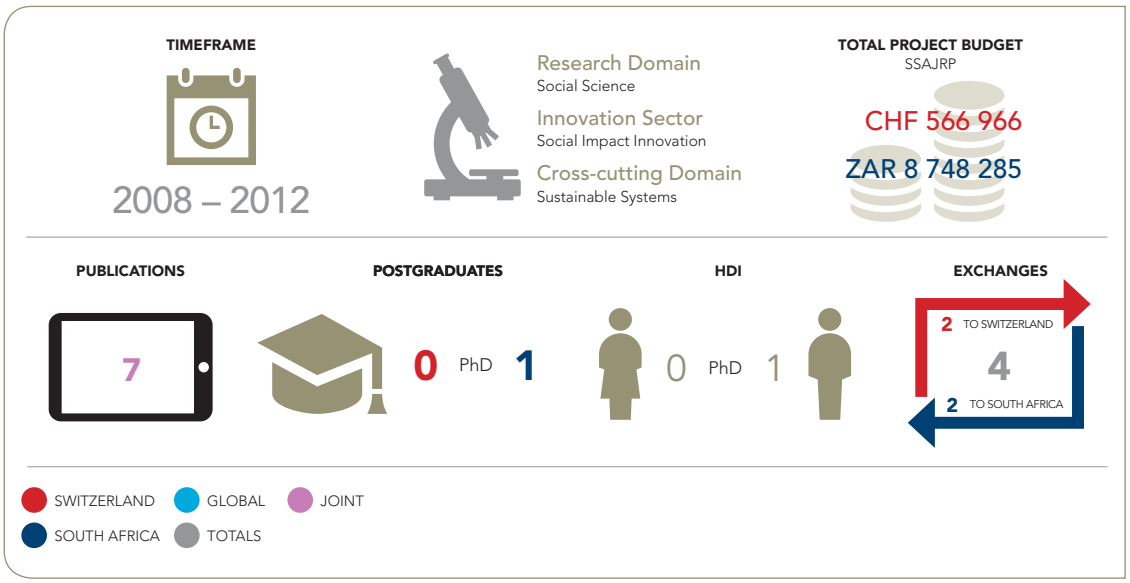
may also help utility managers in infrastructure sectors to develop and implement strategies to build and maintain sustainable organisational capabilities, and therefore improve the quality of public service delivery.

The project provided a set of recommendations to utility managers and policymakers on how to improve the quality of public service delivery. This can facilitate the process of setting up specific interventions for utilities to acquire the skills, technological knowledge and managerial capacities to improve the performance of public services and infrastructure networks. The results of this project were relevant for the improvement of the performance of public services and for securing infrastructure maintenance.

The project team had the advantage of comparing transformations and changes in infrastructure sectors in the Swiss and South African contexts (industrialised and emerging economies). The practical implications of the research are important, because previously there was no profound understanding of the unintended consequences of public and regulatory reforms on the loss and gains of competencies and skills.

Photograph courtesy of Infrastructure News

Hendrina power station.



Safeguarding Democracy and Concepts of Memory and Heritage

UNIVERSITY PARTNERS

University of Basel
Professor Dr Patrick Harries
University of the Witwatersrand
Professor Dr Sheila Meintjes

University of the Witwatersrand

This interdisciplinary project on the main challenges to democracy in South Africa and Switzerland provides an analysis that goes beyond conventional understandings of the consolidation of democracy.

The concepts and practices of democracy are not simply the results of a long process of historical struggle but are constantly challenged by parameters such as memory and heritage in different locales at different times. Democracy manifests are therefore understood and produced in different ways at local, regional and national levels.

In both South Africa and Switzerland, democratic ideas are translated into practice by employing the two distinctive political structures of representative and direct forms of democratic systems. The manipulation of the democratic systems by politicians, institutions, elites and civil society groups in order to impact the political processes, government-society relations quality and the response to political opportunity structures of stakeholder groups, provide a comparative perspective to investigate the quality of politics, the integrity of the different actors engaged and the approval or dissatisfaction levels with political outcomes.

Regardless of the variants governing the political and social settings of the two countries, it was plausible to undertake a comparative study of their democratic praxis and culture development to shed light on the varying facets of democratic politics. The researchers found it interesting that both countries disregard the deficiencies and threats to their democracy and view theirs as a model democracy.

The focal points of studies in this project included contests of memory, civic agency, citizenship and the nation through the prisms of slavery, gender, youth and education, nationalism and populism, the media and communication, and locality. In addition to providing fieldwork study exposure to both South African and Swiss scholars and unravelling political and social dynamics, they engaged in empirical research of specific areas of intersecting case studies, which enhanced perception of schemes used to obtain the desired results from political processes. This enabled them

to draw conclusions on the preliminary modulating factors of economic, social and political democracy.

The team deviated from previous projects, whose fieldwork studies entirely focused on Africa, and focussed on a number of issues and processes when an African gaze was turned to Switzerland and vice versa in order to enhance understanding of how their democratic processes are driven. Questions of the role and its efficacy levels of intellectuals, as well as disregard of their studies by powerbrokers, were addressed.

The project created a stimulating and motivating academic environment for both students and academics, and contributed to the bolstering of the democratic debates in South Africa and Switzerland. The Safeguarding Democracy project will promote the global North and South cooperation by deviating from the usual pattern of academic cooperation of Africa-based investigations. The comparative nature of the project exposes the democratic flaws in both countries.

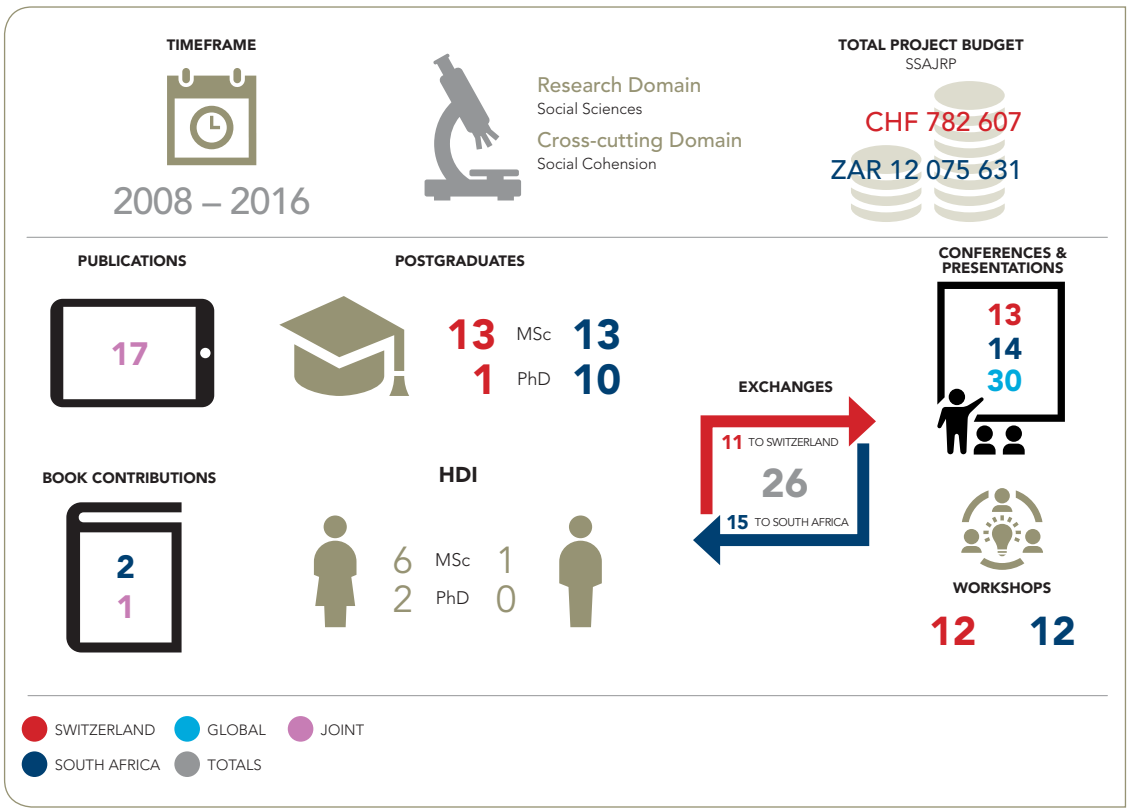
Nyonde Ntswana (PhD candidate, History Workshop), Noor Nieftagodien, Sekiba Lekgoathi (Prof and HOD of History) and Sheila Meintjies.

Contests of Memory and Heritage

The project in Phase II explored the question of how values are negotiated in different social and political contexts and what significance these have for knowledge production, policy development and, above all, for safeguarding democracy.

The case studies were based on South African and Swiss experiences. The view of the researchers is that all scientific and humanities knowledge production requires an enabling environment that only a sustainable democracy can provide. The research is therefore of vital importance to enable the two countries to understand the values that underpin their democracies and the threats that are posed to them by contentions that emerge from conflict in everyday life.

The sub-questions focused on the changes in the meaning of values that had taken place historically in each society. Researchers asked whether there are non-negotiable values, what they are, and how they came about. They also researched in what ways Swiss and South African democracies live up to the democratic values they promote and under what circumstances they do not honour the value that they promote.



5

JOINT RESEARCH PROJECTS

CLEAN TECHNOLOGY

Arabidopsis plants

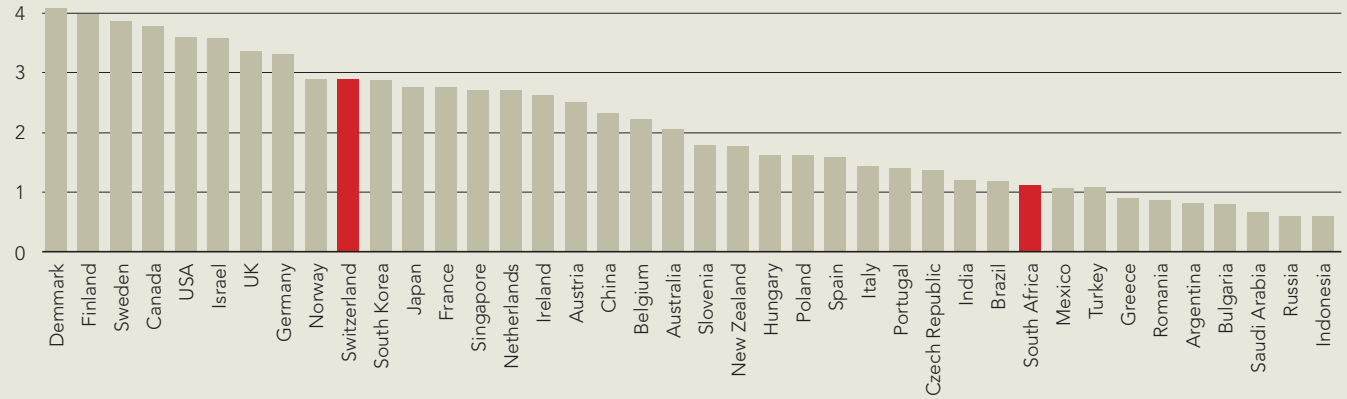
Technological progress is often associated with human action, which leads to pollution and therefore destruction. Fortunately this is not always the case, since clean and green technologies are specifically aimed at maintaining and preserving natural ecosystems by reducing the detrimental effects of human activity on the environment.

The topic of clean and green technologies was introduced into the SSAJRP Phase II call of the joint research projects that was launched in 2013, acknowledging that international collaboration is key in finding answers to global stressors on the environment. These stressors manifest through climate change, increasing environmental pollution, or the depletion of natural resources. Globally, there is an upward trend in the scientific discovery of green technologies that aim to prevent, reduce and/or reverse the negative impacts of human activity on the environment (Panwani, 2018).

Clean technology has the added benefit of economic growth and job creation to maintain and/or improve living standards. For example, the Swiss cleantech sector employs 5,5% of the total workforce and there has been a 25% increase in cleantech jobs over the last five years, adding 4,2% to the Swiss GDP. The Swiss 2017 Cleantech report put Swiss research and development in clean technologies at over $500 million in 2014, with the bulk of the funding from the private sector. The Federal Council issued the Swiss Cleantech Masterplan to encourage innovation in clean technologies in the private sector.

South Africa has made great strides towards a green economy with a focus on clean technology, spurred by its geographical advantage of enormous untapped renewable energy supplies. Notable is the Global Cleantech Innovation Programme (GCIP) for SMEs to promote clean technology innovation. The GCIP is implemented with the support of the Global Environmental

Cleantech Countries Innovation Index, (GCII, 2017)



Facility (GEF), the United Nations Industrial Development Organisation (UNIDO), and the TIA. An inventory of the South African Green Economy was undertaken in 2017, which stated that the robust vision of South Africa for a greener economy is underpinned by a total of 32 sub-frameworks, strategies, policies or Acts to achieve environmental sustainability (Dept of Environmental Affairs, 2017).

The Global Cleantech Innovation Index (GCII) 2017 was established to identify country-based success factors and barriers for entrepreneurial companies in developing sustainable solutions.

The GCII 2017 reiterated the 2014 findings that there are three pillars that facilitate cleantech innovations and uptake: addressing growing demand for renewable energy and other technologies; connecting startups with multiple channels to increase their succes rates; and international engagement across the cleantech ecosystem. Switzerland came in at number 10 and South Africa at number 31 out of 40 countries (see table above). The score of each country is established by looking at the average between inputs to innovation and outputs to innovation as being the country's ability to commercialise innovation (Global Cleantech Innovation Index, 2017).

OUTCOME OF THE CLEAN TECHNOLOGY DOMAIN: ECONOMIC VALUE

Many of the projects in this domain revealed robust innovation potential, which bodes well for the highly relevant Cleantech environment.

INNOVATIONS	TOTALS	%
Impact innovation achieved	4	20
Projects have innovation potential	7	35
Innovation potential beyond projects	5	25

INDUSTRY LINKAGES	TOTALS	%
Research support from industry	3	15
Industry Funding	2	10
Industry partner SA	2	10
Industry partner CH	3	15
Industry Interested	2	10
SA Industry funds received	0	0
Swiss Industry funds received	0	0

INTELLECTUAL PROPERTY	TOTALS	%
Joint IP	1	5
Swiss IP	0	0
SA IP	2	10
Swiss IP Protected	2	10
SA IP Protected	0	0
Joint IP Projected	0	0

Joint Research Projects

Outcomes of the Clean Technology Domain (10 projects)

RESEARCH DOMAIN: CLEAN TECHNOLOGY

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Swiss Federal Institute of Technology in Lausanne
University of Lausanne
University of Zurich
University of Bern
Global Indian International School
Swiss Federal Laboratory for Materials Testing and Research
Swiss Federal Institute for Forest, Snow and Landscape Research

Stellenbosch University
University of Pretoria
University of the Witwatersrand
University of Cape Town
University of the Free State
iThemba Labs / UNISA

SEED FUNDING PHASE
2008 – 2012 No projects
2012 – 2013 1 project
2013 – 2016 7 projects
2017 – 2020 2 projects

Phase III projects have not as yet reached full-scale scientific outputs.

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:

CHF 3 276 834 ZAR 49 504 062

BENEFICIATION

ECONOMIC
10% Mineral beneficiation
50% Technology development
30% Economic platform
40% Africa economy
10% Knowledge economy

GLOBAL CHALLENGES
80% Climate change
30% Energy storage
40% Mitigation

NATIONAL OBJECTIVES
20% Policy beneficiation
50% National strategies in South Africa
70% HCD of historically disadvantaged
60% Gender balance redress in SER

PUBLICATIONS

14 24 26
64 TOTAL

BOOK CONTRIBUTIONS

1 4
5 TOTAL

POSTGRADUATES

6	MSc	21
13	PhD	22
10	Postdoc	10

82 TOTAL

HDI

5	MSc	4
5	PhD	5
1	Postdoc	2

22 TOTAL

EXCHANGES

24 TO SWITZERLAND
47
23 TO SOUTH AFRICA

WORKSHOPS
9 9

CONFERENCES & PRESENTATIONS

13 14 46 73

APPRECIATION

COLLABORATION — **40%** Alignment of PIs objectives **90%** Joint knowledge **50%** Joint publication **70%** Joint exchanges **20%** Workshops

HUMAN CAPITAL DEVELOPMENT — **50%** Appreciate Swiss contribution **90%** HCD in general **10%** Could demonstrate South Africa research excellence

RESEARCH FACILITIES — **30%** Opportunity for applied research **20%** World-class infrastructure in CH **10%** Access to unique research environment globally

GENERAL APPRECIATION — **10%** Leverage funds from other grants **20%** Appreciation of project funding

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
30% NORTH AMERICA
30% BRICS COUNTRIES
50% EU COUNTRIES
40% AFRICAN COUNTRIES

UNIVERSITIES AND NETWORKS
20% SOUTH AFRICAN UNIVERSITIES
10% SWISS UNIVERSITIES
30% CONTACTS AND NETWORKS ESTABLISHED

BENEFITS OF LINKAGES
60% NEW RESEARCH TOPIC
10% EXTENT COLLABORATION WITH SWISS AND SOUTH AFRICAN PARTNERS
40% GOVERNMENT INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
10% Difficult to reach study environment
20% Exchange of materials and research samples

INNOVATION
10% Joint IP
10% Establishment of a NDA

GENERAL
20% Immigration rules in CH
20% Different university procedures

FUNDING
10% Decrease in ZAR Value = decrease in project funds
20% Inadequate funding for equipment
10% Lack of follow-up funding
20% High flight costs to Europe
20% Support for HCD and scholarships
30% Experienced limited challenges

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

ABB – A Swiss Private Company in the 4th Industrial Revolution

ABB Ability™ consolidates and expands all of its technologies to connect customers to the Industrial Internet of Things.

With the commercial launch of more than 210 solutions and services, ABB is unlocking value for customers in the Fourth Industrial Revolution. By combining ABB's deep domain expertise with network connectivity and the latest digital technologies and innovations, ABB Ability™ creates powerful solutions and services that solve real business problems and produce tangible business opportunities.

ABB Ability helps customers in utilities, industry, transport and infrastructure develop new processes and advance existing ones by providing insights and optimising planning and controls for real-time operations. The results can then be fed into control systems to improve key metrics such as factory uptime, speed and yield.

The offering builds on ABB's pioneering technology and more than four decades of industrial digital leadership and will enhance customers' ability to innovate and compete in the emerging digital-industrial marketplace.
The list of innovative and versatile solutions associated with ABB Ability™ includes such offerings as ABB Ability™ AssetInsight, ABB Ability™ Ellipse® Enterprise Asset Management software, and the ABB Ability Data Center Automation infrastructure management software. It will leverage the power of the digital revolution by enabling reduced maintenance costs, longer asset life, more efficient operations, reduced environmental impacts and improved worker safety.

ABB Ability's next-generation digital solutions and services are being developed and built on Microsoft's leading Azure cloud platform, based on a strategic partnership with the software company.

ABB Ability™ enables users to seize the opportunities presented by the Internet of Things. With the help of new ABB digital services and technologies, users can upgrade their existing systems to boost productivity through reduced downtime, greater efficiency and higher yields. The company's solutions and services tap into the benefits derived from rapidly expanding information and data flows.

The Internet of Things, Services and People expresses ABB's belief that human expertise will remain at the core of this new, more connected and digital world. Connected devices will enable new service models. Despite extensive automation, we will continue to rely on human collaboration and expertise. ABB's capacity to connect all that information and analysis directly to the control room, using it to make instantaneous operational decisions, is what makes ABB Ability™ truly powerful and unique.

ABB Ability™ is going to keep evolving and expanding to serve needs and solve new problems that our customers face. The fact that it can be constantly adapted for new applications is exactly why it is so important – both to ABB and to our customers around the world.

In South Africa, ABB signed a research, development and innovation partnership agreement with the University of Witwatersrand (Wits) with the view to support and tap into digital innovation to augment its own research, development and engineering work. This partnership with the Wits digital innovation hub, Tshimologong Precint, led by Professor Barry Dwolatzky, aims to support students, entrepreneurs and innovators with the view to leveraging global supply chains.

ABB (ABBN: SIX Swiss Ex) is a pioneering technology leader with a comprehensive offering for digital industries. With a history of innovation spanning more than 130 years, ABB is today a leader in digital industries with four customer-focused, globally leading businesses: Electrification, Industrial Automation, Motion, and Robotics & Discrete Automation, supported by its common ABB Ability™ digital platform. ABB's market leading Power Grids business will be divested to Hitachi in 2020. ABB operates in more than 100 countries with about 147 000 employees.

www.abb.com

Demonstrating the applications of Vanadium dioxide smart nano-scale material in the terahertz photonics spectral regime

UNIVERSITY PARTNERS

University of Bern
Professor Thomas Feurer
iThembaLABS, National Research Foundation and University of South Africa (UNISA)
Professor Malik Maaza

This project rests on the properties of Vanadium dioxide that is part of the smart-material family. Vanadium dioxide is gaining exponential interest in the research and development community as a promising technological application; it is considered as a promising material for oxide electronics. Complex oxide materials offer many characteristics that cannot be achieved with current electronics based on silicon.

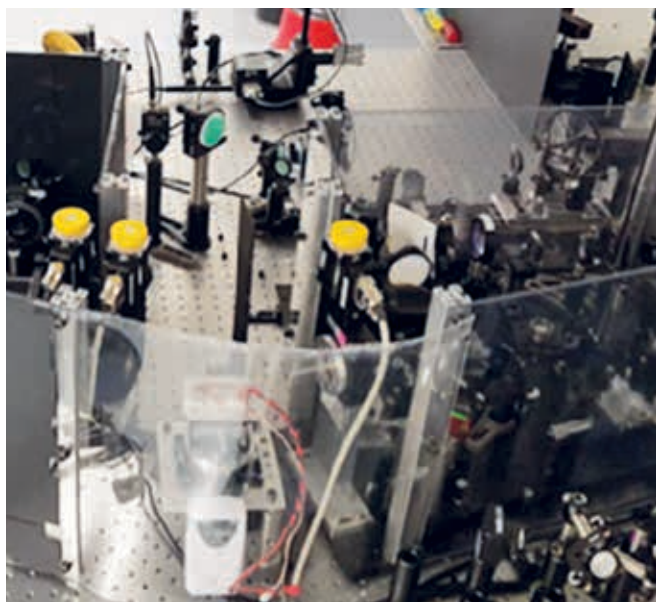
The Swiss-South African research proposal aimed to map for the first time the thermal variation of the carrier's density and its dynamics in nano-scaled V02 1-D type nano-rods by time domain terahertz spectroscopy (TDTS) that probes inter-molecular interactions within solid materials. It also intended to demonstrate the feasibility of a femtosecond photo-induced optoelectronic nano-gating. THz-TDS, is a spectroscopic technique for determining the properties of a sample probed by short pulses of terahertz radiation.

The joint research proposal was initially between iThemba LABS-UNISA and the University of Bern and, subsequently, collaboration with Empa through a Swiss Scholarship grant (ESKAS). During a visit to Switzerland, the project partners in collaboration with Empa, discovered additional technological application potential beyond the joint research project with a focus in the nanotechnology economy: upscaling of green biosynthesised oxides.

Although the objective to demonstrate the application of Vanadium dioxide smart nano-scaled material in the terahertz photonics spectral regime was reached to a certain extent, the device aspect is still to be finalised.

If the validation of the targeted devices/technology were finalised, there would be potential for mineral beneficiation in terms of Vanadium mineral usage as South Africa has the second largest Vanadium deposits globally.

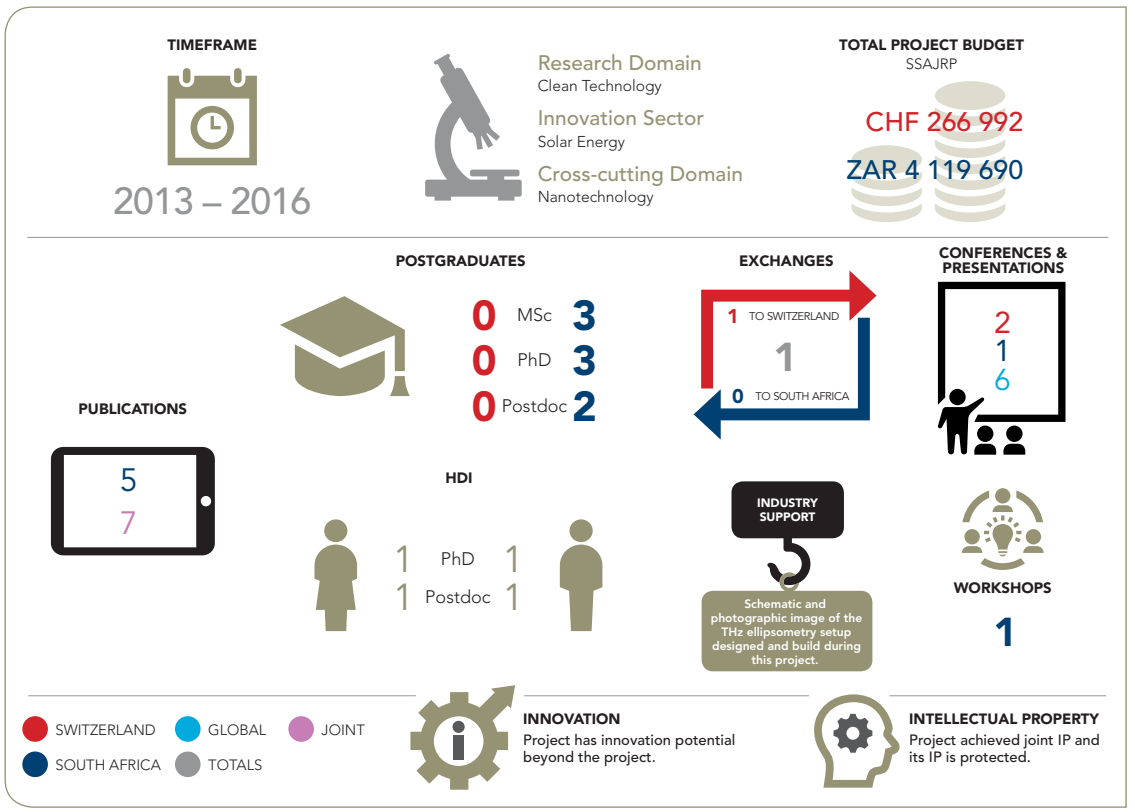
The South African senior and junior team members have gained insight into the Swiss R&D translation approach. They had an opportunity to access unique world-class infrastructure not available in South Africa and limited to very few international laboratories, such as the Ellipsometry Unit at the University of Bern.



Schematic and photographic image of the THz ellipsometry setup designed and built during this project.

Professor Malik Maaza

Photograph courtesy of Malik Maaza



The adoption of clean energy technologies in South Africa: the costs to adopting technology restrictions

UNIVERSITY PARTNERS

Graduate Institute Geneva
Professor Tim Swanson
University of Cape Town
Professor Mare Sarr

The overarching objective of the project was to identify the nature and extent of the costs of shifting toward new technologies, and the nature of the interventions that will be important to mitigating these. The project will deepen understanding of the cost and trade-offs required for a green economy.

This joint research project forms part of the "Innovation, Diffusion and Green Growth" project, located at the Graduate Institute in Geneva (GIIS). Collaborative partners are at the EPFL in Lausanne, ETH Zurich in Zurich and the London School of Economics. Fundamentally, the collaboration will contribute to a GIIS project by providing the perspective of a developing country and simultaneously provide insight into the reach of the South African green economy objectives and an opportunity to deepen international collaboration in these research areas.

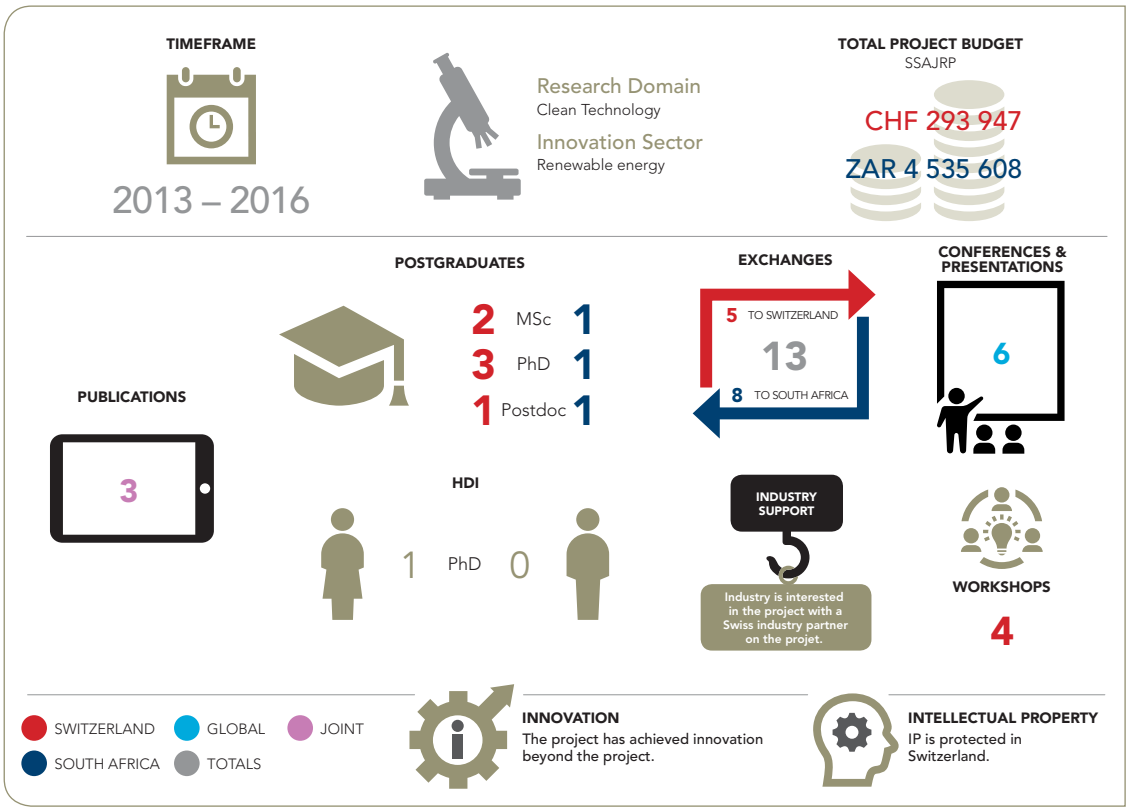
This project also examined whether governments are able to steer production towards a green economy, using only temporary policy interventions as is now commonly prescribed in the economic literature of directed technical change. The research shows that this might not be the case in an open economy that possesses abundant fossil fuel endowments and that is heavily invested in carbon-intensive production (such as South Africa). Indeed, if major trading parties to this resource-rich country care about potentially irreversible consequences of climate change, reductions in global emissions below catastrophic levels may require a resource buy-back policy over time to ensure the resource-rich nation will stop or at least seriously curtail production in the dirty sector.

Part of the project looked at the impact of policy shocks on the South African coal mining industry, using a field experiment in the Mpumalanga coal fields. The researchers explored how substantial changes might impact on mineworkers in the industry, based on their individual contractual status, unionisation and ethnicity. This allowed exploration of the determinants of cooperation or conflict among mine workers when faced with a shock to their industry.

The study aimed to uncover the effect of relative concerns (i.e. social comparisons between individuals) on public good provision, either by aggravating or alleviating the free-riding problem. Moreover, by changing the reference group at which individuals target their relative concerns – from national (local public good) to international (climate change mitigation) peers – they tested whether concerns within countries are different or similar to concerns between countries. The experiment was conducted in five of the top emitting countries: the United States, European Union, China, India and South Africa.

Key findings of the project were that the transfer of resource-conserving technologies for developing countries to reduce pollution could only be successful if accompanied by incentives. Temporary policy interventions towards a green economy prove challenging in an open resource-rich economy that relies heavily on carbon-intensive production. A possible solution is a resource buy-back policy.

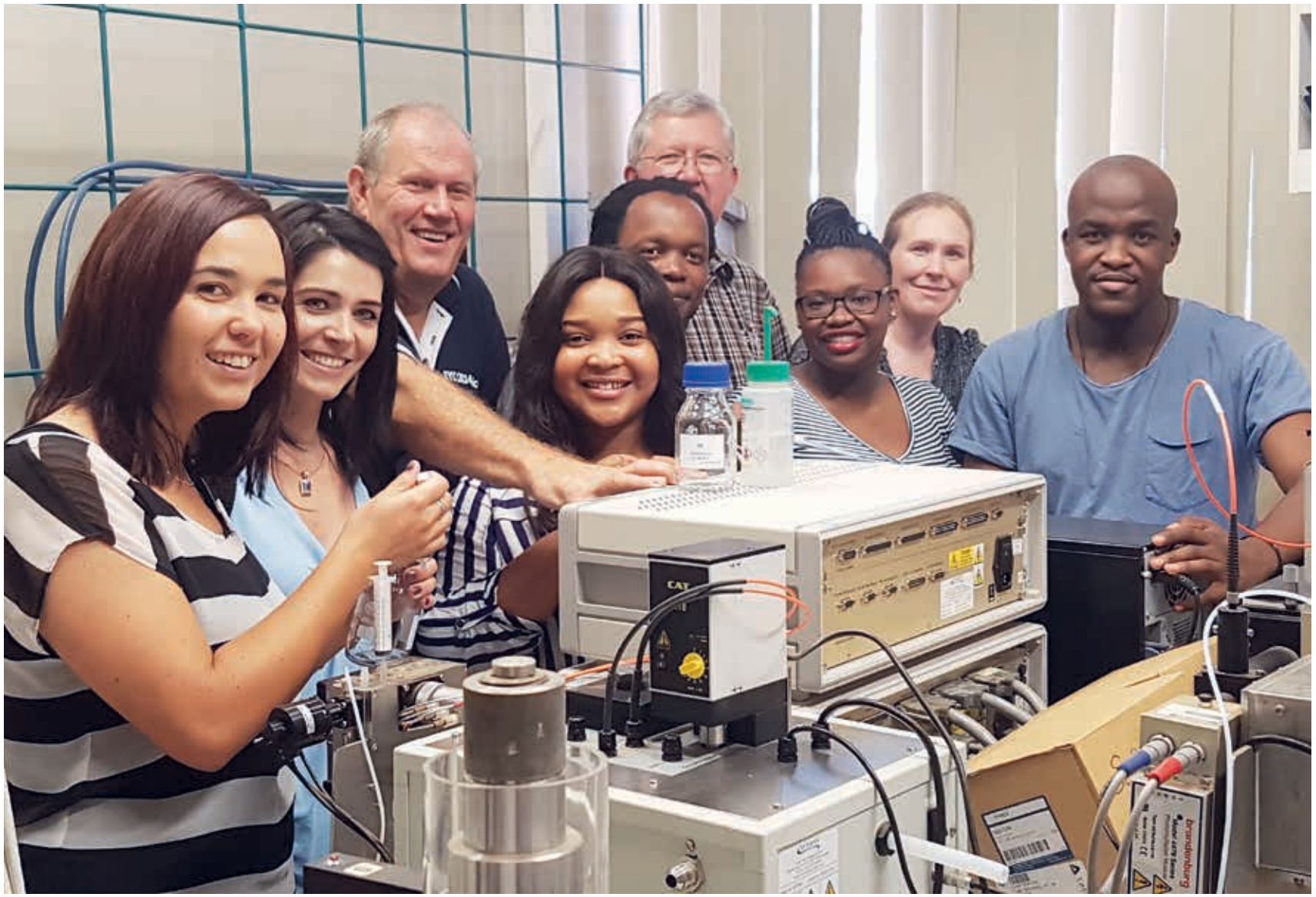
Professor Mare Sarr



Solar light-driven homogenous catalysis for greener industrial processes with H_2 as energy source and CO_2 as C1 building block

UNIVERSITY PARTNERS

University of Zurich
Professor Roger Alberto
University of the Free State
Professor Andreas Roodt



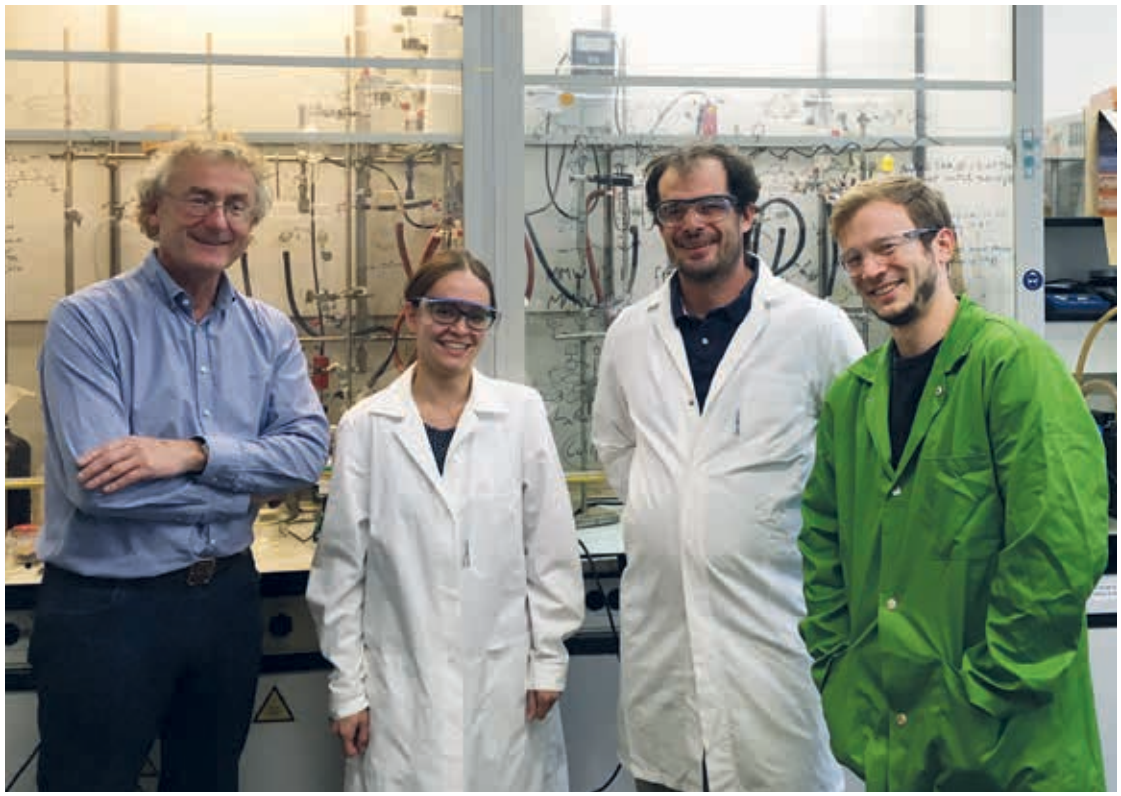
Photograph courtesy of Andreas Roodt

South African researchers at the UFS in Bloemfontein. From left: Drs Truidie Venter and Marietjie Schutte-Smith, Professor Andreas Roodt, Lindy Gantsho, Drs Dumisani Kama and Johan Venter, Nina Seitelo and Drs Alice Brink and Pennie Mokolokolo.

The overarching aim of this project is solar light-driven homogenous catalysis for a greener environment and industrial processes. The researchers are exploring two sub-projects: using hydrogen as energy source, and fixing or converting carbon monoxide as C1 building block for the synthesis of other useful chemicals.

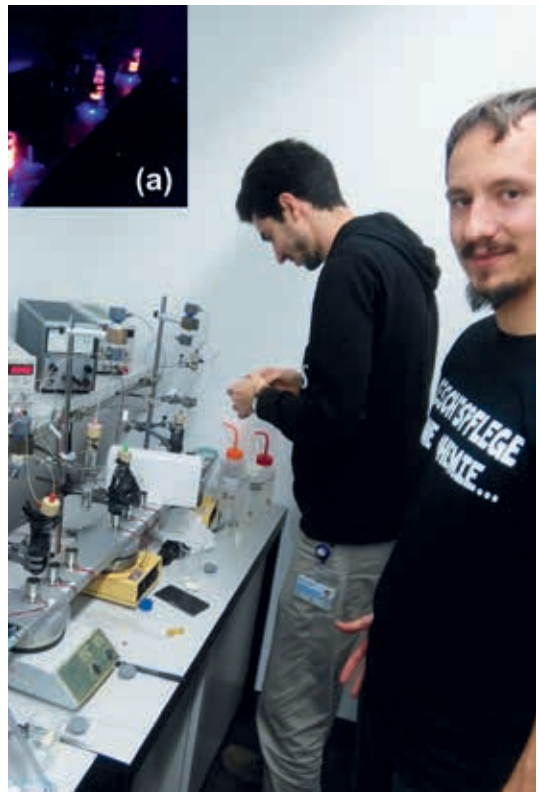
Currently, over 80% of Europe's energy use is based on oil, gas and coal. In South Africa, the value is estimated at over 90%. The South African National Development Plan and the Department of Trade and Industry underwrite the need for cleaner energy. Sasol, an important player in the petrochemical industry in South Africa, considered the research proposed within this broad project so important that they are providing additional support for research associated herewith.

The South African students involved in this overarching project are critical for the development of capacity on the overarching thrust of green chemistry,



Swiss researchers at the University of Zurich. From left: Professor Roger Alberto (Swiss PI), Franzsika Rahn (PhD student), Dr Benjamin Probst and Nicola Weder (PhD student).

Photograph courtesy of University of Zurich, Dept of Chemistry, Secretariat



Swiss PhD students Daniel Hernandez and Peter Müller set up photochemical experiments; Insert (a): Photochemical splitting of water to produce hydrogen gas.

Photograph courtesy of University of Free State, Prof Dr Andreas Roodt

cleaner environment and reduction of greenhouse gases, not only from a superficial, but specifically from a fundamental chemistry point of view.

The work initiated by the research teams is fundamental in nature, but they aim to apply the anticipated findings. It has consolidated the research cooperation between the Swiss and South African groups significantly, as well as beyond the actual project.

Following the plan as outlined in the proposal, the main research in the first 12 months was on the conjugation of water reduction catalyst or their ligands to the bis-arene scaffold to achieve key structures.

The results of this period of the project are promising enough to ensure that the team can enter a truly original track in the development of combined supramolecular frameworks for photocatalytic water reduction and carbon dioxide activation/ conversion. With these results in mind and ensuing further results, the submission of a proposal to a corresponding EU programme is foreseen. The ongoing cooperation in the project's field has led to parallel cooperation on other topics as well.

Top-notch results emerging from this project because of mutual cooperation are basic for future applications while inducing other cooperations at the same time.

TIMEFRAME
2017 – 2020

Research Domain
Clean Technology

Innovation Sector
Renewable energy

TOTAL PROJECT BUDGET
SSAJRP
CHF 602 735
ZAR 9 300 196

PUBLICATIONS
1 9
1

POSTGRADUATES

1	MSc	7
2	PhD	6
0	Postdoc	1

HDI

2	MSc	2
1	PhD	2
0	Postdoc	0

CONFERENCES & PRESENTATIONS
1
5

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

INNOVATION
The project has innovation potential beyond the project.

Understanding the impacts of climate change on Arctic, Antarctic and Alpine permafrost microbiomes (cryolink)

UNIVERSITY PARTNERS

Swiss Federal Institute for Forest, Snow and Landscape
Dr Beat Frey
University of Pretoria
Professor Don Cowan

Photograph courtesy of Don Cowan

Professor Don Cowan and NZ colleague Ian Hogg in the Antarctic Dry Valleys.

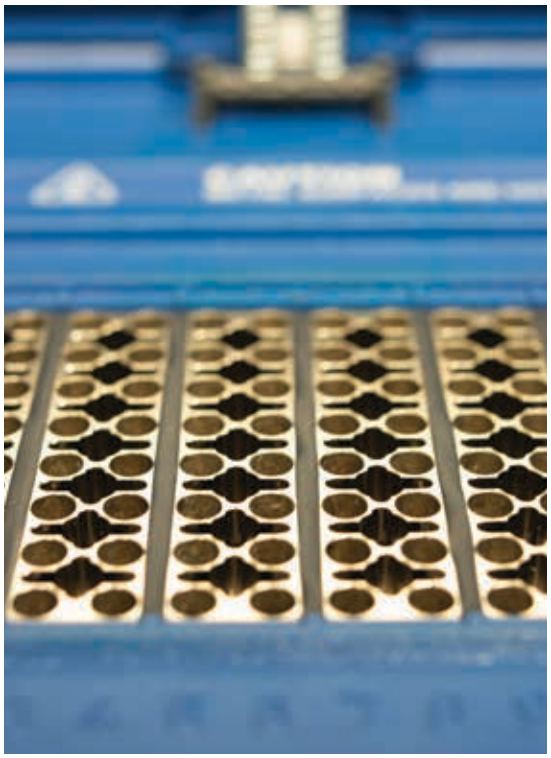
Swiss collaborators in the greenhouse (from left): Carla Perez Mon, (PhD student), Dr Aline Frossard scientific collaborator and Dr Beat Frey, principal investigator.

Various stones from glacial forefields to study bacterial biofilms on weathered mineral surfaces.

The research team proposed an extensive study to elucidate the ecology of microbial communities associated with permafrost systems and investigate comprehensively the diversity and functions of microorganisms in three bio-geographical areas: the Arctic, the Antarctic and the Alpine regions.

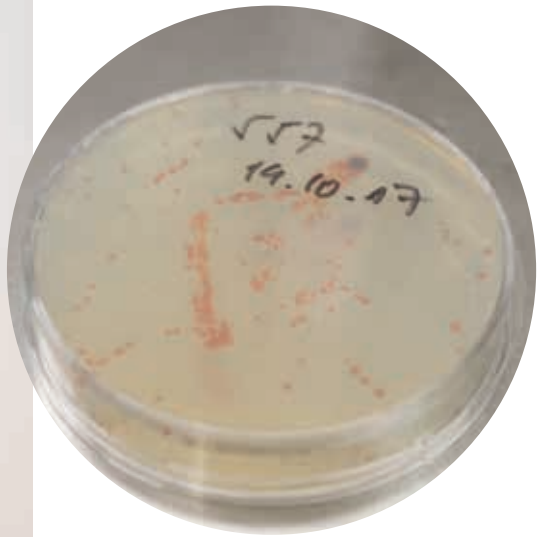
Cold habitats represent the majority of the Earth's biomes and permafrost, defined as the part of the soil frozen for at least two consecutive years, and are widely spread on land surfaces. Permafrost areas are considered "extreme environments" and harbour microorganisms with an ability to adapt, not only to sub-zero temperatures, but also to low water, carbon and nutrient availability. However, these habitats constitute a unique niche for cold-adapted microorganisms. Little information is available on the ecology of microorganisms in permafrost, despite their high importance in view of their high susceptibility to global change.

Nowhere is climate change more visible than in the Polar Regions. As a consequence, there is an increasing need to estimate the impact that global warming will have on the Arctic, Antarctic and worldwide. Polar Regions play a key role in



Laboratory device to amplify low DNA amounts extracted from mineral surfaces.

Photographs documenting glacier retreat in the last five years in the Swiss Alps.



Orange-colored bacterial strains isolated from 13 000-year-old permafrost soils to screen for interesting metabolites.

the Earth's climate system. There is considerable socio-economic interest in predicting how permafrost thaw and how the carbon balance of these ecosystems will respond to ongoing climate warming. Global warming unlocks an unknown microbial diversity in Arctic, Antarctic and Alpine permafrost soils with direct feedback on greenhouse gas emissions.

The research collaboration will provide value by developing the complementary skill sets of the two partner institutions. It will contribute to the capacity building of students and skills development through doctoral student training programmes. Furthermore, the collaboration will provide access for both institutions to Polar and Alpine sampling sites. Accessibility of sample sites is an ongoing challenge; for example, access to Antarctic permafrost sites is only available in the austral summer season. Since permitting for sample transfers is increasingly stringent, sample and material exchanges are a challenge.

In South Africa, this project is undertaken under the auspices of a long-standing collaborative relationship with researchers from the University of Waikato (New Zealand), through who access to Antarctic McMurdo Dry Valley soils is available.

TIMEFRAME

2017 – 2020

Research Domain
Clean Technology

Cross-cutting Domain
Climate Change

TOTAL PROJECT BUDGET
SSAJRP

CHF 559 519

ZAR 7 575 895

POSTGRADUATES

0	MSc	1
2	PhD	2
1	Post Doc	2

HDI

1 PhD 0

INDUSTRY SUPPORT

South Africa Principal Investigator has an industry partner.

CONFERENCES & PRESENTATIONS

2
6

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

INNOVATION
Project has innovation potential beyond the project.

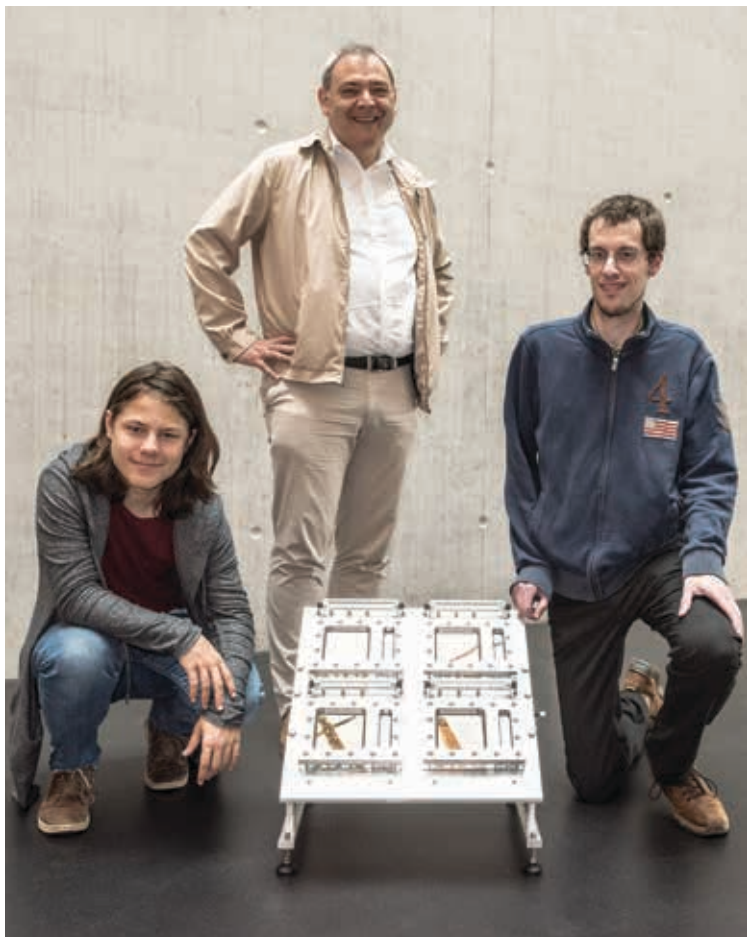
Production of liquid solar fuels from CO_2 and water using renewable energy resources

UNIVERSITY PARTNERS

Swiss Federal Laboratories for Materials Science and Technology
Dr Artur Braun
University of Pretoria
Professor Egmont Rohwer

Photographs courtesy of Artur Braun

Jospeh Simfukwe (left} won the poster prize at the Materials Research Society Fall meeting 2017 in Boston Massachusetts for his computational work on iron oxide photoelectrodes for solar fuel production.



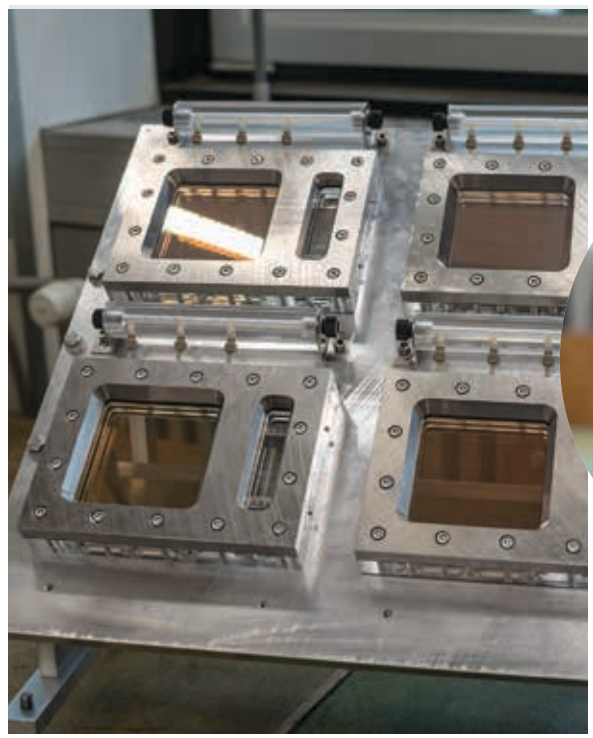
Dr Artur Braun and students with biomimetic PEC for solar hydrogen production with daylight.

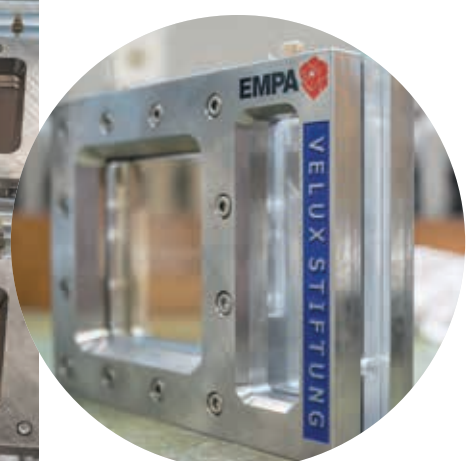
The objective of the project is to provide liquid fuels of the future without producing greenhouse gases during combustion as liquid fuels will continue to be an essential feature of, for example, air transport. The project therefore aimed at converting carbon dioxide to liquid solar fuels, addressing the broader challenge of sustainable energy production.

Batteries simply do not provide enough energy density (energy per mass) to replace aviation fuel for long-distance flights. Hydrogen produced from renewable energy sources has been proposed to fill this gap but the technical difficulties in storing and transporting hydrogen as a high-pressure gas or a liquid at ultra-low temperatures, are appreciable. Hydrocarbon liquids produced from renewable energy sources and CO_2 in the atmosphere, on the other hand, could produce direct substitutes for fossil-derived petrol, diesel and aviation fuel to serve the full transport sector in future. Only the same amount of CO_2 would be released from their combustion as that originally taken up from the air during production of the fuel. CO_2 and water would thus simply provide the building blocks for the synthetic liquid energy carriers, only to be released again after fuel combustion.

The successful production of such renewable liquid fuels could have immense consequences on, among others, the ability to store and transport large amounts of wind and solar energy with existing (fossil fuel) infrastructure. Such technology

Photograph courtesy of Prof E Rohwer





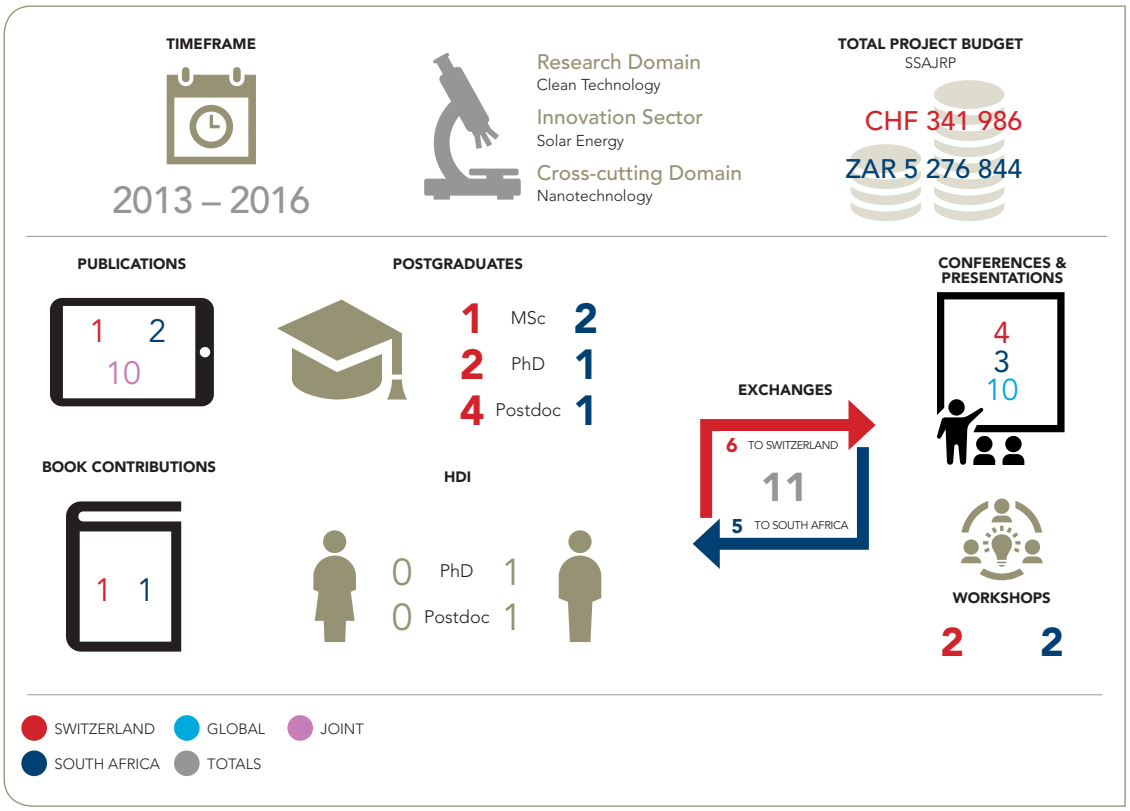
Professor Egmont Rohwer

could totally eliminate the combustion of fossil fuels and their associated contribution to global warming. A world-wide trade in renewable fuels could result, providing revenue to countries like South Africa that have immense potential in cost-effective production of solar and wind energy.

The researchers took two approaches towards the project's goal. One was aimed at a full artificial photosynthesis where the solar light harvesting and the chemical conversion happen in the same cell. Hematite was used as a novel light-harvesting system. The second approach used electrical energy, assuming it to be from conventional photovoltaic cells, and conversion was by co-electrolysis of water and CO_2 using a novel cathode catalyst.

The project was highly competitive and of interest at an international level. The project established the field of semiconductor photoelectrochemistry for solar fuel production in South Africa. The observation of the formation of methanol from formic acid is promising and of industrial interest, but has not yet reached the necessary level, and needs to be achieved with CO_2 instead of formic acid.

The team has presented the results in Africa, Europe, China, and in the United States.



Agricultural residue from sugarcane harvesting for the production of bio-energy and chemicals in biorefinery (enerchems)

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology in Lausanne
Professor Edgard Gnansounou
Stellenbosch University
Professor Johann Görgens

The project team aimed to develop biorefinery scenarios that utilise fibrous sugarcane material as feedstock for the co-production of bio-ethanol and valuable chemicals. These biorefineries could be developed in a manner that provides both economic and environmental benefits to stimulate interest in the policy and commercial spheres in their commercial implementation.

Key questions in the development of such biorefineries are the mix of products to be included and their optimal sizing and locations in the context of South Africa. The project was built on the assumption that such biorefineries will be integrated into existing sugar mills and first-generation bioethanol plants, which benefits conversion efficiencies and reduces costs. Both sugarcane harvesting residues and surplus bagasse from sugar mills or first-generation bioethanol plants will serve as feedstock to these lignocellulose biorefineries.

The project team rigorously investigated a number of biorefinery scenarios applicable to the South African sugarcane industry. Experimental work provided technical information that they subsequently used for simulation of these biorefinery scenarios. The outcomes of such simulation work demonstrated the potential environmental benefits of biorefineries, while also providing perspectives on commercial viability. The researchers communicated these outputs to policymakers as well as industrial partners in South Africa, providing further support for development of the bioeconomy of South Africa.

The simulations work completed in the project is also relevant to other sugarcane-producing areas, such as Brazil, India and China. The co-production of lactic acid or furfural with ethanol is highly novel in these contexts, and the project has certainly advanced understanding of these opportunities.

Research links were established with the South African Sugarcane Research Institute (SASRI) as well as the South African Sugar Milling Research Institute. These institutes provided some technical inputs required for the simulation of the scenarios and further techno-economic and life cycle assessments.

From left: Dr Jegannathan Kenthorai Raman, Postdoc Research fellow, Dr Pavel Vaskan, Postdoc Research fellow, Dr Elia Ruiz Pachon, Postdoc Research fellow, Juliette Brunet, MS student, Professor Dr Edgard Gnansounou, Director of the Research Group, Michael Agiovlasitis, MS student, Dr Daniel Tuazon, Postdoc Research fellow and Sabrina Martone, Administrative assistant.

Photograph courtesy of Edgard Gnansounou

Members of the research team at Stellenbosch University (from left): Professor Johann Görgens, Thapelo Mokomele (PhD student) and Dr Kathleen Haigh (postdoctoral researcher).

Control systems for pilot-scale bioreactor for ethanol production.

The project work has directly added to the strategic development of biorefinery plans in the industry. The anticipated project outcomes provide a basis for developing sustainable biorefinery systems, which allow highly efficient and cost-effective processing of biological feedstocks to a range of bio-based products.

The sugar industry is interested in the project and provided the feedstock (sugarcane trash and bagasse) for the study. The sugar industry needs to add more value to fibrous residues such as these as a means to revitalise the industry, which is presently in decline. The industry has major socio-economic impacts in a widespread part of South Africa.

The award of further funds by the South African Sugar Milling Research Institute to expand on the research and investigate potential biorefinery scenarios, demonstrated further interest in the potential to broaden the product range of sugar mills.

TIMEFRAME
2013 – 2016

Research Domain
Clean Technology

Innovation Sector
Renewable Energy

TOTAL PROJECT BUDGET
SSAJRP
CHF 264 108
ZAR 4 075 195

POSTGRADUATES

0	MSc	1
0	PhD	2
2	Postdoc	1

EXCHANGES
2 TO SWITZERLAND
5
3 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS
1
3
2

PUBLICATIONS
4 2
1

HDI

0	MSc	1
0	PhD	1

INDUSTRY SUPPORT
The project received research and funding support from industry. The project has an industry partner in Switzerland.

WORKSHOPS
1 2

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

INNOVATION
The project achieved innovation and also has innovation potential beyond this project.

Factors regulating carbohydrate storage in plants: implications for biotechnological improvement of crops for food and for clean, green technologies

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Samuel Zeeman
Stellenbosch University
Professor Jens Kossman

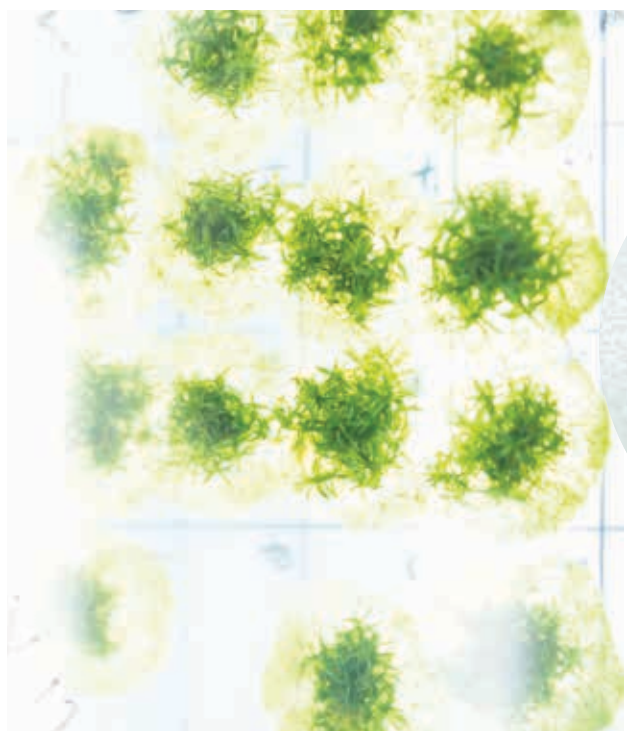
Arabidopsis plants.

Jonathan Jewell, Professor James Lloyd, Dr Paul Hills, and Professor Jens Kossmann.

The project work fundamentally addressed questions relating to building a bio-based economy as the researcher involved tried to manufacture crops that are more efficient and are a better resource for renewable materials. The Swiss group has written patents to protect their IP in terms of the new genes they have identified that are involved in starch metabolism and it is hoped that they will be used to improve industrial starches. The South African group has produced plants with improved industrial starches and hope that this will be used industrially in future.

The key objective of this project was to make new discoveries about how plants make the important storage carbohydrate, starch. Starch crops represent the cornerstone of human nutrition, and much of our arable land is devoted to their production. In this project, the research team used new information derived from the analysis of starch granule proteome – the proteins adhering to starch granules. This allowed them to identify previously uncharacterised proteins involved in starch biosynthesis. They used molecular-genetic and biochemical approaches to analyse the functions of

Petri dish with water droplets.

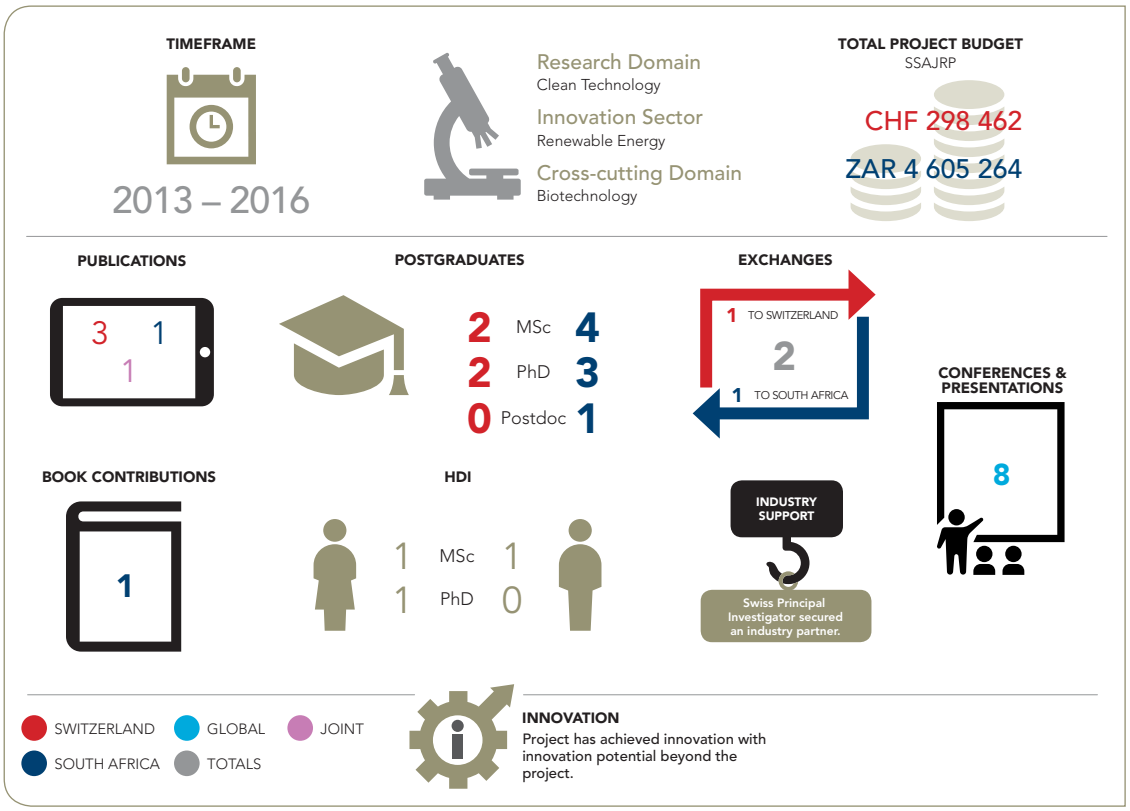


Physcomitrella patens plants.

the newly identified proteins both *in vivo*, primarily using the *Arabidopsis thaliana* model system, and *in vitro*. In addition, they altered starch metabolism in potato as this makes large amounts of starch in storage organs, and improved the industrial properties of that starch.

This project has been highly competitive on a global scale. It has led to the discovery of new genes involved in starch metabolism and the work describing this has been published in three papers within extremely high-impact journals. In addition, it has led to the discovery of a new mechanism to increase starch phosphate contents in plant storage organs. Work from the previous Swiss-South African grant was finalised, and led to a publication in a well-regarded scientific journal, with two more publications being prepared. The project also led to a publication in a high-impact review journal, *Current Opinions* in *Biotechnology*.

The ETH Zurich and Stellenbosch University signed an MoU for joint future projects on food security. They also hope to submit a successful grant application to a European Union call related to generating multipurpose crops using genome-editing technologies. The South African group has started collaborating with a group in France at Lille University due to contacts gained as a direct result of the project.



Development of crop plants with reduced requirement of phosphate fertilisers via the cisgenic regulation of PHO1 and GULP1 activity

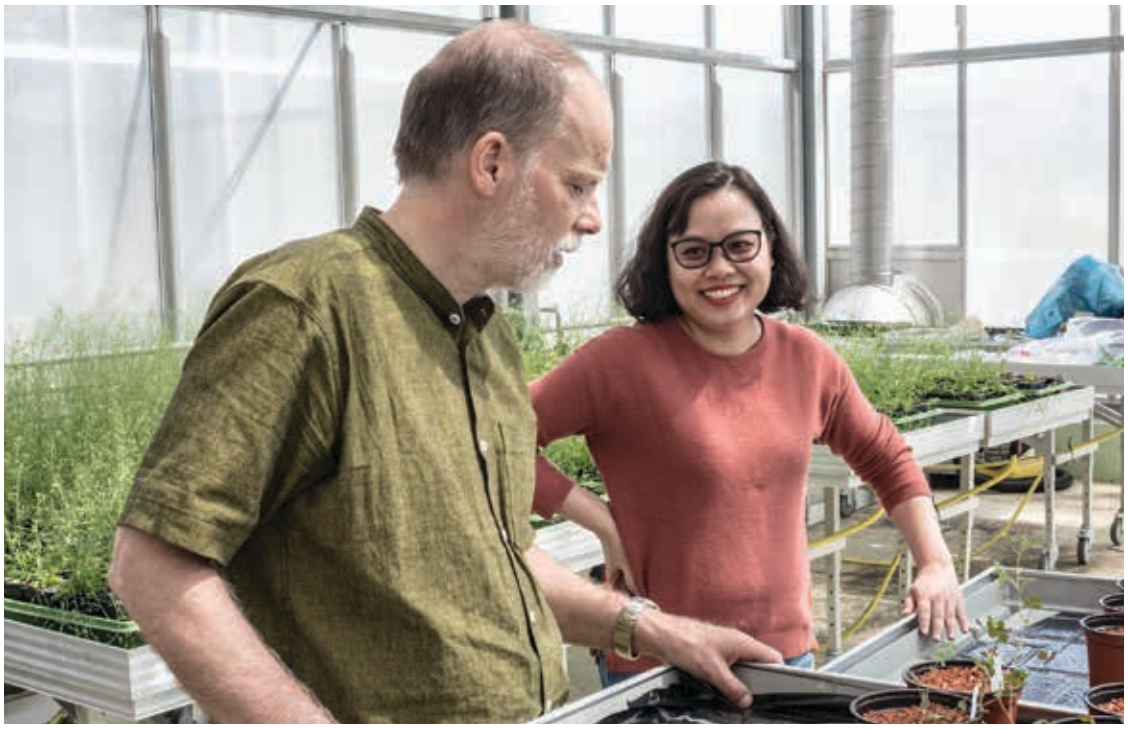
UNIVERSITY PARTNERS

University of Lausanne
Professor Yves Poirier
Stellenbosch University
Professor Alex Valentine

The primary aim of the research was to study and modulate the expression pattern of the PHO1 and the GULP genes in *Medicago truncatula* (a small annual plant in the legume family) and understand its implication in phosphate homeostasis and the adaptation of plants to phosphate deficiency leguminous plants, in particular under conditions of nodulation.

This project enabled the discovery of a novel role for the *Medicago* PHO1 gene in nodulation and nitrogen fixation, and also uncovered novel aspects of the adaptation of legumes to phosphorus deficiency. The success of this project was dependent on the complementary expertise of the South African and Swiss partners, as well as intense exchange of ideas and skills between them. Such interaction would have been impossible without this funding scheme.

The project has contributed immensely to capacity development in the South African group, since they gained new students from designated groups to work either fulltime or part-time on this project. This collaborative project also enabled both the South African and Swiss partners to gain knowledge



Professor Yves Poirier (left) and Dr Thi Ngoc Nga Nguyen from the University of Lausanne.

Growing Medicago *plants in the greenhouse under various nutrient regimes.*

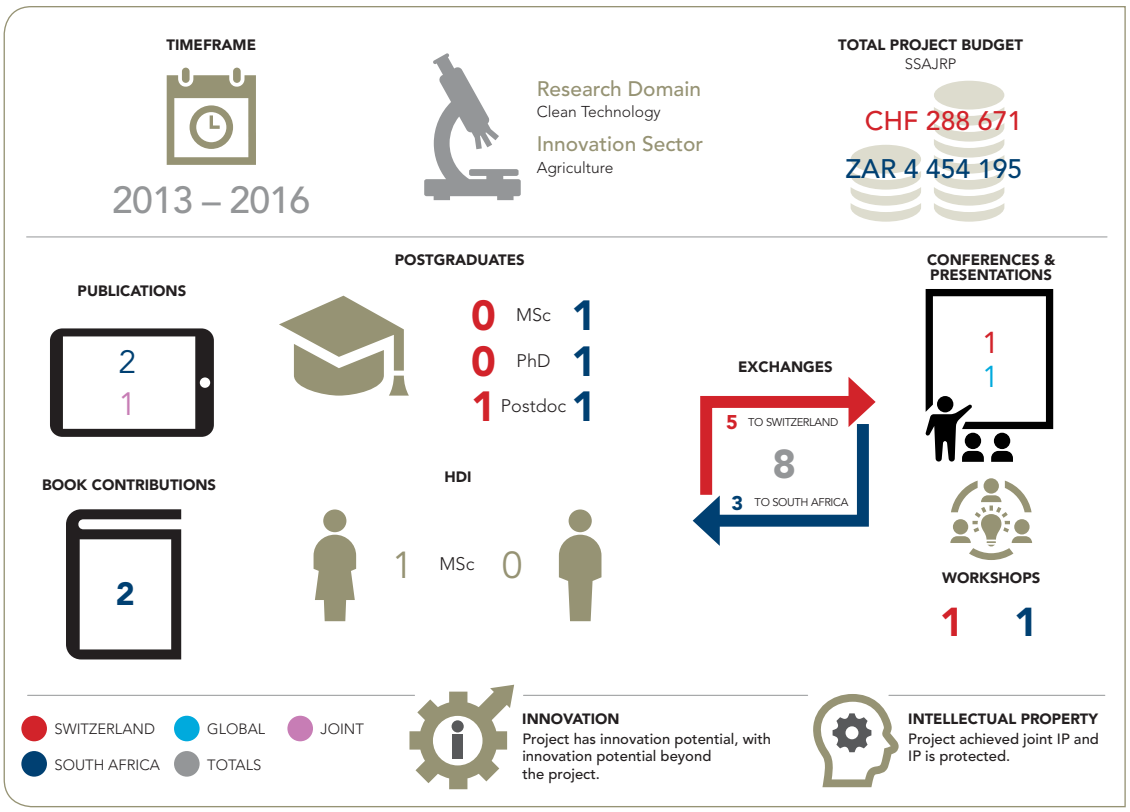
Growing Medicago *plants under* in vitro *conditions.*

and expand their expertise in novel areas of plant molecular biology, and particularly on legume and nitrogen fixation that will be key to a future research programme and ability to apply for new funding from national and international agencies.

This project received input from a collaboration with Dr Micheal Udvardi from the Noble Foundation in the USA whose group has unique expertise and resources related to *Medicago* genomics.

Reciprocal research visits took place to the South African and Swiss laboratories, where researchers were able to learn techniques and exchange valuable ideas for publications and future continuing work, as well as exchanges of research material (including from the USA lab). During the funding period, this project contributed immensely to technology transfer, capacity development, and international collaboration.

The research partners also used the expertise gained in this project to interact with the local community in two ways: they initiated an urban community vegetable garden project at a local school, where their knowledge on low-nutrient adaptations could be applied to crop production; and they engaged in a project with a poor farming community in the rural areas of the Cederberg, where knowledge from this project could be applied to rooibos tea production.



Development and transfer of a cassava transformation technology platform for industrial application

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology in Zurich
Dr Hervè Vanderschuren
University of the Witwatersrand
Professor Christine Rey

Transgenic cassava lines in tissue culture, developed for resistance to African cassava mosaic virus.

Photograph courtesy of Rey laboratory

This research proposal was aimed at implementing a cassava genetic transformation platform and exploring RNAi-mediated biotechnologies to generate cassava that is resistant or tolerant to cassava mosaic disease (CMD). The project also had as a goal to consolidate the collaboration between Switzerland (ETH Zurich) and South Africa (University of the Witwatersrand), whose interests in cassava aligned, and to share knowledge and transfer cassava transformation capacity from ETH Zurich to establish a high-throughput transformation biotechnology platform in South Africa.

Cassava *(Manihot esculenta Crantz)* is a major staple food of the poorest communities in sub-Saharan Africa and is also an important food security and subsistence crop. The attractive industrial use of cassava for starch and biofuel production is rapidly increasing the global demand for cassava. Cassava cultivation is also increasing in southern Africa. South Africa could become the leader in cassava starch technologies in Africa. In sub-Saharan Africa the major limiting factors to increased cassava production are CMD, caused by cassava mosaic geminiviruses (CMGs) and transmitted by whitefly *(Bemisia tabaci Gennadius)*, and cassava brown streak disease (CBSD), causing up to 80% loss in production.

The major constraint to improving virus resistance in cassava through genetic manipulation is the lack of a reliable and robust transformation method for cassava. The primary objective was therefore to expand existing technologies (RNAi).

Technology transfer from ETH Zurich to the University of the Witwatersrand (Wits) resulted in Wits becoming the first establishment to set up a robust cassava transformation and biotechnology platform on the African continent.

Exploration of the application of cassava starch in industry in South Africa was discussed at two successful workshops. The participants reached an agreement to initiate a cassava industry association, which was achieved in 2016.

The researchers also explored the possibility of conducting greenhouse and field trials in South Africa of ACMV-resistant cassava plants developed at ETH Zurich. A PhD student conducted greenhouse trials with several transgenic lines he developed, which led to capacity building in plant transformation and GM evaluation.

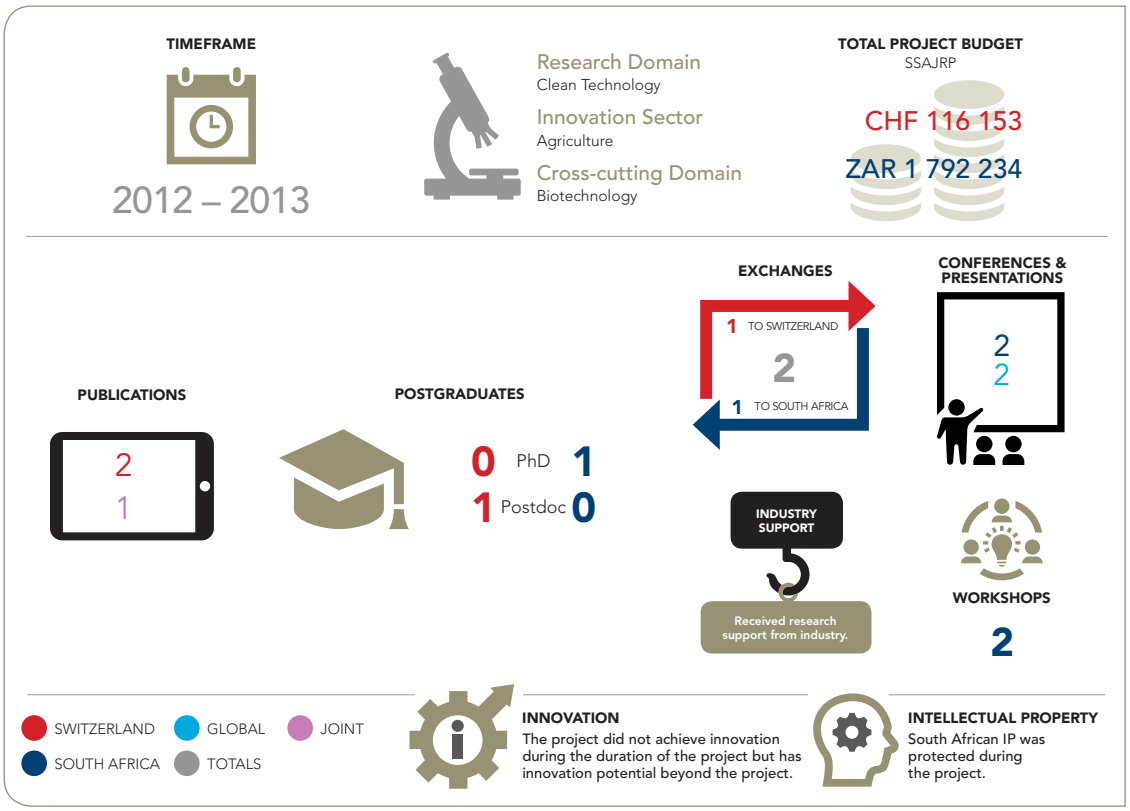
The research partners' engagement with Biosafety SA allowed them to explore the legislation required for GM trials in South Africa, which led to endeavours in initiating GM permit application and identification of a potential Agricultural Research Council (ARC) trial site in Mpumalanga Province.

Photograph courtesy of VIB - UGent

Dr Hervè Vanderschuren

Professor Christine Rey

This research collaboration was highly valuable. The Swiss partner was able to provide technical transfer of cassava transformation skills and is assisting in training capacity, which led to the establishment of a cassava transformation platform. The South African partner was able to provide the environment in South Africa where cassava can actually be cultivated and this is driven by starch industry needs and recognition in SA and the southern African region.



SAVUCA: South African Value-added Cassava

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Hervé Vanderschuren
University of the Witwatersrand
Professor Christine Rey

Close up of cassava leaves from cassava landrace T200.

This research was part of a larger initiative and framework to establish a cassava industry in South Africa and to promote cassava for small-scale farmers. In addition to genetic modification aims, the researchers worked with industry and government to establish cassava trials with small-scale farmers and to engage with industry and other stakeholders through the Cassava Stakeholders Meetings. Since the formation of the Cassava Association (CIASA), all stakeholders engage through this forum. The South African Principal Investigator continues to engage, advise and assist to promote cassava.

In 2016, the researchers continued to undertake national cassava germplasm trials initiated in three provinces in 2014. This was supported by the TIA and the ARC. Seven ARC cassava cultivators and four Ukulinga cultivars, which were part of the trials, were also established in tissue culture in the laboratory at Wits University. The researchers screened them for the presence of putative cassava mosaic resistance-associated genes in an honours project.

The ETH Zurich-Wits project was initially aimed at investigating biotechnological approaches to control viral diseases in cassava, including RNAi and peptide aptamers. As part of an effort to develop broad spectrum virus resistance, the project also developed cutting-edge approaches to investigate natural virus resistance (the so-called CMD2 resistance) in cassava leading to a detailed analysis of candidate resistance genes. The pioneer molecular work of Rey and Vanderschuren laboratories on CMD2 is particularly important as it remains a robust and broad spectrum resistance in the field.

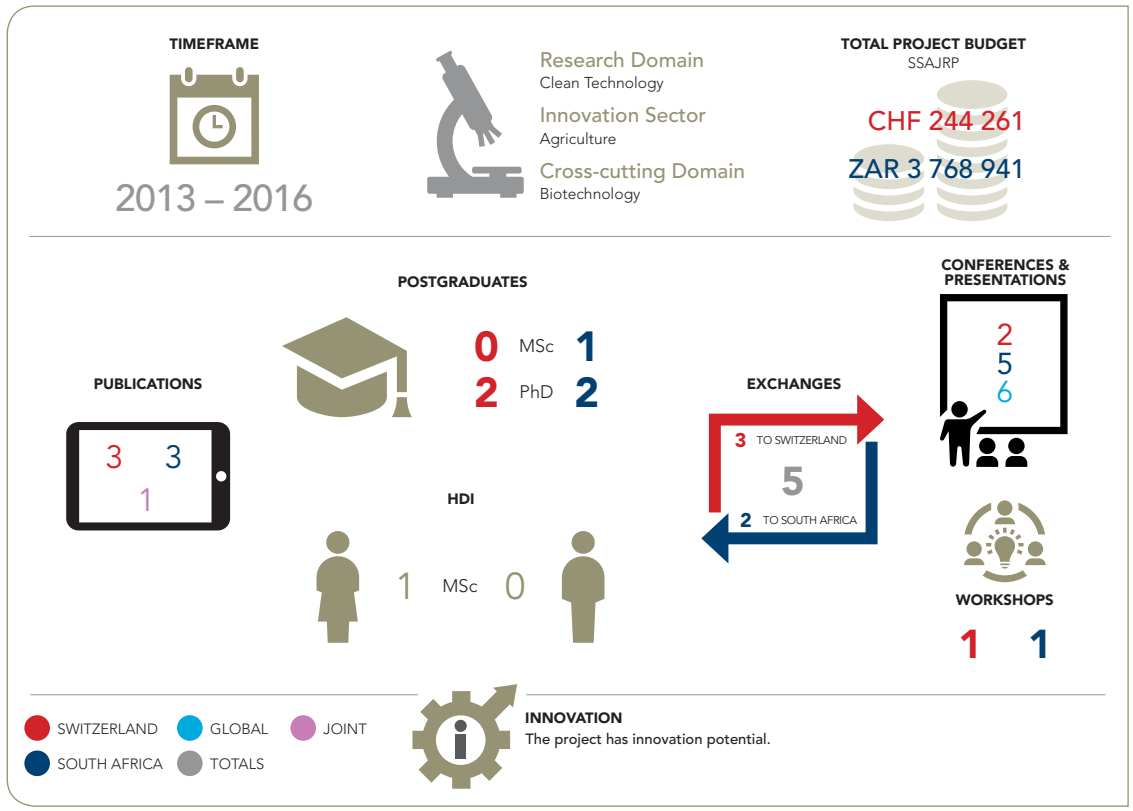
Several GM cassava lines displaying virus resistance phenotype have been characterised as part of the SAVUCA project and their assessment in the field will be carried out in ongoing collaborations between the Vanderschuren and Rey Laboratories. Both laboratories are also continuing their effort towards characterisation and utilisation of natural virus CMD2 resistance that was pioneered as part of the SAVUCA project.

Photograph courtesy of Hervé Vanderschuren

Swiss and South African researchers discuss cassava virus resistance assays in confined plant growth facilities (University of the Witwatersrand, Johannesburg).

The team drafted an application to obtain a permit to bring GM cassava from ETH Zurich into South Africa, with involvement of both the Swiss and South African partners. They secured a potential GM site, which they are leasing from the ARC. As part of another collaboration with African teams, ETH Zurich has shown in field trials in Kenya and Nigeria that, despite improved performance of several transgenic lines, immunity to virus infection has not yet been achieved. They decided therefore that the field trail application in South Africa should also include the additional constructs and transgenic lines generated as a part of the ongoing activities that have emerged from the SAVUCA project.

Other ongoing activities in both laboratories are targeting the development of cassava varieties with high value for industries, particular traits related to modified starch and disease resistance. Collaboration between the Vanderschuren (University of Liège, Belgium) and Rey laboratories has been continued through newly-funded projects.



6 JOINT RESEARCH PROJECTS
SUSTAINABLE SYSTEMS

Crop irrigation system.

Photograph courtesy of Peter Gonsalez on Unsplash

Ban Ki-moon, the United Nations Secretary-General from 2007 to 2016, stated that: "We don't have plan B because there is no planet B!" (United Nations, 2016).

Sustainable systems is an age-old concept, yet this concept was relegated to the background for many decades. In the 21st Century it is emerging as the most important approach in finding solutions to complex ecosystem questions.

The world's population is growing, and energy use and environmental pollution are on the increase. At the same time, natural resources such as fossil fuels and raw materials are becoming scarce. The effects of climate change are warning us that we need to reduce our output of greenhouse gases. Environmental challenges like these impact on both developed and developing nations, and they are compounded by increasing consumption pressures. The world needs innovative leaders and researchers who can help solve these complex problems and find sustainable solutions while addressing basic human needs such as mobility, shelter, water, food and communication.

The United Nations Sustainable Development Goals (SDGs), also referred to as Agenda 2030, were adopted in 2016. This was an historic decision on a comprehensive, far-reaching and people-centred set of universal and transformative goals. The main differentiating factor between the Millennium Development Goals, the predecessor of the SDGs, and the SDGs is that the new approach is looking into systems, and is not approaching the problems in silos. It is impossible, for example, to address food security without considering climate change, health issues, eco-systems and human behaviour.

If the platform of Big Data is added to the mix of sustainable systems, there should be a positive change in finding solutions to current-day challenges. The major challenge, though, remains human behaviour.

To change human behaviour, we have to prepare the next generation by moving away from subject-based teaching at school level to an integrated system-based and knowledge management approach to teaching and learning. Education for sustainable development, with its overall aim to develop cross-cutting sustainability competencies in learners, is an essential contribution to all efforts to achieve the SDGs. This would enable individuals to contribute to sustainable development by promoting societal, economic and political change as well as by transforming their own behaviour (UNESCO, 2017).

The adoption of the UN's Agenda 2030 has presented governments of both developed and developing countries with a challenge to align national policies with expansive global Agenda 2030 goals.

Switzerland

Switzerland is committed to working for the full implementation of the 2030 Agenda and to achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner. Implementation of Agenda 2030 provides many opportunities to advance sustainable development on a local, national, regional and global scale. However, contributing both nationally and internationally to the implementation of Agenda 2030 and the achievement of the SDGs, as well as measuring and reporting on progress in a meaningful way, will also present new challenges for the organisational structure and processes of the Swiss Confederation.

Switzerland's aim in the future is therefore to align its Sustainable Development Systems comprehensively with Agenda 2030 to secure its contribution to the achievement of the SDGs by 2030 (Swiss Confederation Report to the United Nations, 2016).

South Africa

"South Africa aspires to be a sustainable, economically prosperous and self-reliant nation that safeguards its democracy by meeting the fundamental human needs of its people, by managing its limited ecological resources responsibly for current and future generations, and by advancing efficient and effective integrated planning and governance through national, regional and global collaboration" (National Framework for Sustainable Development, 2008).

South Africa has done well in defining sustainability and sustainable development and the adoption of its National Framework for Sustainable Development (NFSD), which commits the country to a long-term programme of resource and impact decoupling. There is, however, still significant work to be done to reverse the many prevalent negative trends identified in the measurement of environmental performance. In response, government – in partnership with community organisations, business and academia – is putting in place structures and strategies to turn the situation around.

Policymakers also face the challenge to align the country's National Development Plan (NDP) with the SDGs. The NDP is South Africa's long-term development plan, which expresses consensus on societal challenges, focuses the national planning system and has the potential to implement development priorities in a more effective way.

The NDP seeks to address injustices, including improving the poor quality of education for black people, strengthening national infrastructure, uniting the country and creating employment (Brand South Africa, 2017).

OUTCOME OF THE SUSTAINABLE SYSTEMS DOMAIN: ECONOMIC VALUE

Most of the joint research projects in the Sustainable Systems domain started in 2017, which makes it difficult to quantify the economic value and social impact. Encouraging is that Jaeger et al, 2017 reported from the World Resource Institute that the achievement of the SDGs, intertwined with sustainable systems, has the potential to not only yield economic profit but to create jobs, especially in those countries with high unemployment. It is estimated that the economic yield of only four sectors – food and agriculture, cities, energy and materials, and health and well-being – could create a $12 trillion new market opportunity by 2030 and resource savings as high as $17 trillion. It is forecast that nearly 90% of all new jobs are expected to be generated in developing countries with 85 million jobs estimated for Africa.

Joint Research Projects

Outcomes of the Sustainable Systems Domain (7 projects)

RESEARCH DOMAIN: SUSTAINABLE SYSTEMS

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:
CHF 2 548 766 ZAR 35 927 560

UNIVERSITY PARTNERS

University of Basel
University of Applied Science and Arts Northwestern Switzerland
Zurich University of Applied Sciences
Agroscope
Swiss Federal Institute of Technology Zurich

North-West University
Stellenbosch University
University of Cape Town
Agricultural Research Council

SEED FUNDING
PHASE 2008 – 2012 No projects
PHASE 2008 – 2012 No projects
PHASE 2013 – 2016 3 projects
PHASE 2017 – 2020 4 projects

Phase III projects have not as yet reached full-scale scientific outputs.

BENEFICIATION

ECONOMIC
- **20%** Technology Development
- **15%** Economic Platform
- **15%** Contribute to Industry Development
- **20%** Regional and Rural Development
- **20%** Contribute to Africa Economy

GLOBAL CHALLENGES
- **5%** Climate Change
- **5%** Mitigation
- **10%** Addressing an African Challenge
- **30%** Applied Systems Thinking

NATIONAL OBJECTIVES
- **25%** Policy Beneficiation
- **25%** SA National Strategies
- **5%** HCD of Historically disadvantaged

PUBLICATIONS
8 6 5
19 TOTAL

BOOK CONTRIBUTIONS
3

POSTGRADUATES

5	MSc	10
0	Honours	1
3	PhD	10
1	Postdoc	3
33	TOTAL	

HDI

3	MSc	3
1	Honours	0
3	PhD	1
0	Postdoc	1
12	TOTAL	

EXCHANGES
9 TO SWITZERLAND
24
15 TO SOUTH AFRICA

CONFERENCES & PRESENTATIONS
9 4
35
48

WORKSHOPS
7 5

APPRECIATION

COLLABORATION	**10%** Alignment of PI's Objectives **25%** Joint Knowledge **10%** Joint Exchanges **5%** Workshops
HUMAN CAPITAL DEVELOPMENT	**15%** Swiss Contribution **15%** Technical Transfer from Switzerland **20%** HCD in general **5%** Could demonstrate SA research excellence
RESEARCH FACILITIES	**20%** Opportunity for applied research
GENERAL APPRECIATION	**5%** Leverage funds from another grant

RESEARCH LINKAGES AND BENEFICIATION

INTERNATIONAL
- 5% NORTH AMERICA
- 10% EU COUNTRIES
- 10% AFRICAN COUNTRIES

UNIVERSITIES AND NETWORKS
- 25% SOUTH AFRICAN UNIVERSITIES
- 5% COLLABORATION IN SWISS-SA JOINT RESEARCH PROJECTS
- 35% CONTACTS AND NETWORKS ESTABLISHED
- 30% EXTENT COLLABORATION TO INTERNATIONAL NETWORKS
- 15% INDUSTRY NETWORKS ESTABLISHED

BENEFITS OF LINKAGES
- 15% NEW RESEARCH TOPIC
- 5% ADDITIONAL INNOVATION OPPORTUNITY FROM PROJECT
- 5% RESEARCH SUPPORT FROM INDUSTRY
- 15% EXTENT COLLABORATION WITH SWISS & SA PARTNERS
- 10% SA GOVERNMENT TOOK INTEREST IN PROJECT

CHALLENGES

IN THE FIELD
- 5% Access to Information
- 10% Financial and Legal Administration of Project

FUNDING
- 5% Identification of suitable PhD candidates
- 15% Scholarships and Bursaries
- 5% Delayed Project Start

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Swiss Re and Sustainable Systems

While the South Africa Constitution enshrined a right of access to adequate housing, the country continues to experience a housing crisis. The numerous drivers for the housing crisis resulted in an estimated 2 700 informal settlements across South Africa. The challenge lies in developing a scalable, transparent and replicable model that addresses both real demand, market dynamics and municipal planning objectives.

In 2013 ETH Zurich teamed up with local NGO Ikhayalami to introduce an integrated approach to upgrading South Africa's growing informal settlements. The project is supported by the local architect firm Design Space Africa. By creating an interface between community, leading professionals and the state, the resulting Empower Shack project developed a pilot scheme that responds to the social, ecological and market dynamics of South African cities.

Targeting BT-Section Site C, a demarcated neighbourhood of 68 houses in Cape Town, this Swiss Re Foundation-supported project involved refining the housing prototype and reconfiguring the urban plan developed on the pilot.

Specifically, it:

- Developed new housing prototype designs, informed by current occupancy feedback, community engagement and on-site analysis of the first four pilot units.
- Developed and implemented a range of prototypes based on local construction techniques and materials, residents' spatial requirements and affordability.
- Developed a pilot legal framework with the City of Cape Town that allows for the approval of occupancy of the new units with clear pathways to formalisation and tenure security.
- Upgraded the houses in the BT-Section Site C within a new urban configuration based on participatory planning methodology.
- Designed and developed an income-generating urban agriculture scheme customised to the newly formed public spaces.

Empower Shack's overall objective was to offer a scalable methodology to reshape the informal settlement of South Africa by offering a methodology for the fair distribution of public space, a safer urban environment, improved service delivery and an urbanisation pattern that combines housing upgrades with new economic and social opportunities.

The 286 residents of BT-Section Site C benefitted directly from the project. Furthermore, employment opportunities were created through the facilitation and construction of the units, which included certified training programmes for the building industry and NGO sector. The Community Development Committees have benefitted from structured engagement

The Swiss Re Foundation has supported the Empower Shack project to develop a sustainable model for affordable housing.

on all levels of the project and should be able to exercise these skills in the further community urban management of the upgrade.

The results of this pilot have the potential to catalyse a productive new direction for South Africa's housing policy, potentially benefitting the millions of South Africans who presently live in informal settlements and are priced out of the formal housing market.

This integrated approach to planning follows principles of land re-adjustment by which a structured methodology for negotiation allows the interests of all stakeholders to be addressed. Customised digital planning tools have been developed to synthesise user inputs and preferences with micro-finance obligations and municipal planning frameworks. The building units are priced to meet meaningful financial contributions from recipients by designing generous but robust living space and service cores to meet building code obligations through fit-for-purpose bridge contracts. The long-term goals are to influence a new direction in housing policy and offer much-needed diversity and access to housing.

The resulting densification offers efficient land use to infrastructure ratio, provides cross-finance possibilities through additional rental and sales stock and, most importantly, fulfils the need to guarantee all residents the right to remain on site. Additionally, the re-adjusted building stock, new land plot sizes and allocation of public space are designed to integrate with municipal planning frameworks.

Understanding consequences of introgression of insecticidal transgenes from Bt maize into open-pollinating maize varieties

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Dr Angelika Hillbeck
North-West University
Prof Johnnie van den Berg

This grant enabled the researchers to start addressing the issue of safe and sustainable use of GM maize in Africa, since it directly addresses co-existence of Bt and non-Bt maize in Africa. The project has international significance in terms of its novel contribution to understanding the relationships regarding the effect of pollen flow between hybrid maize and open-pollinated varieties (OPVs).

The outcomes and findings of this project inspired the continuation of tracking transgene flow and its consequences for smallholder farmer communities, in particular those who aspire to capture premium prices and market access by following rules of organic production.

Genetically modified Bt-maize is widely used by commercial farmers in South Africa to control the African maize stem borer. While commercial farmers have to comply with stewardship guidelines for planting Bt-maize hybrids (i.e. adjacent refuge areas of non-Bt-maize) and are prohibited from saving maize seeds for further planting, these guidelines are impractical for small-scale farmers who mainly plant landraces, which are OPVs, and who recycle seed. Compliance with the stewardship guidelines is required to delay the evolution of pest resistance to Bt-maize.

Traditional small-scale maize farming could, unintentionally and unknowingly, become recipients of transgenes from Bt-maize fields. This "escape" and subsequent introgression of the cry1Ab transgene into local OPVs with unknown patterns of cry1Ab protein expression may, thus, facilitate the evolution of pest resistance.

The researchers elucidated the introgression of the cry1Ab transgene into OPVs and the functioning of the transgenes, and investigated the concentration of cry1Ab protein expressed and the effects thereof on the survival and development of the African maize stem borer. The collaborators did this under South African field conditions and under controlled conditions in climate chambers at ETH in Zurich. The researchers used the same varieties in the field trials in South Africa and in the climate chamber studies in Switzerland.

Professor Johnnie van den Berg (left) and Reynhardt Erasmus, a student on the project.

Bt and OPV maize grown in a greenhouse prior to making crosses.

Dr Angelika Hillbeck

Photograph courtesy of ETH Zurich

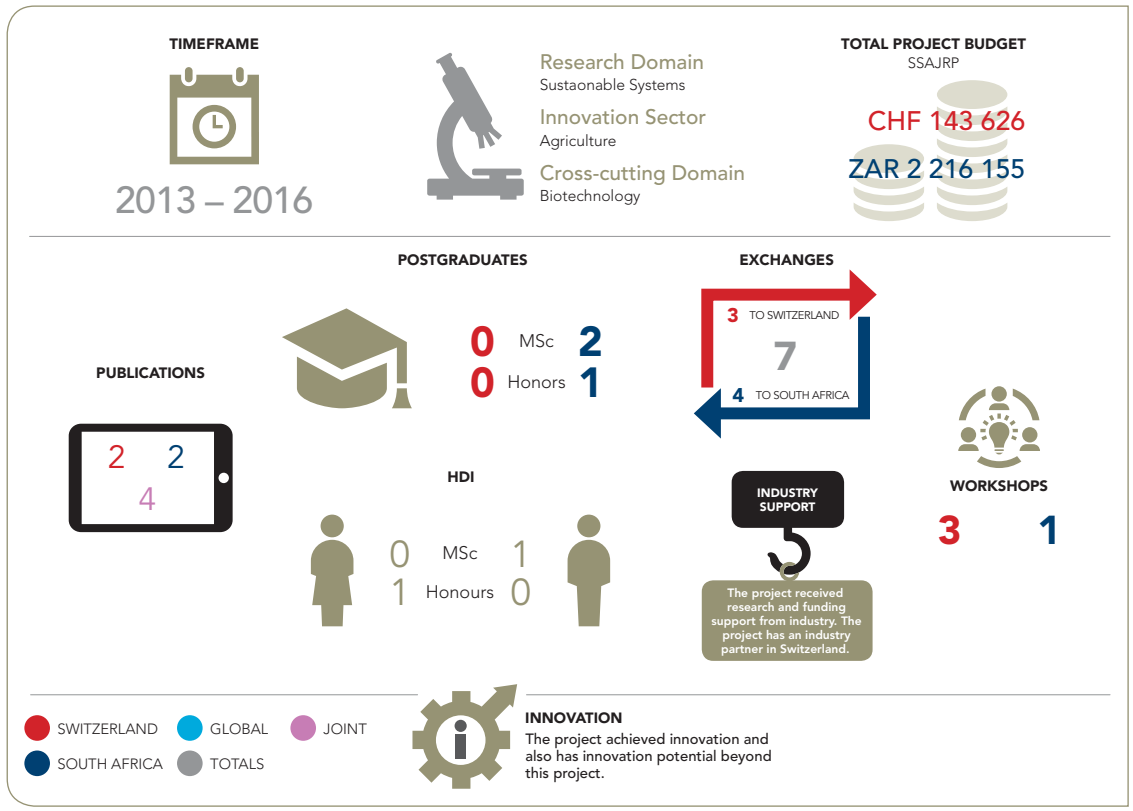
African maize stem borer larva damaging a young maize ear.

Larva of the African maize stem borer.

They determined the effect of pest damage (i.e. herbivore feeding) on cry1Ab protein expression in Bt-maize plants, and the concentration at typical stem borer feeding sites in Bt-maize plants including introgressed Bt OPVs.

The researchers showed that maize landraces and OPVs are vulnerable to foreign gene introgression. However, transgene expression did not systematically control Bt protein concentration and therefore transgene activity is no indicator for Bt concentration. Bt concentrations could be very low or nil, but were highest in outcrossed OPVs. Consequently, smallholder fields with outcrossed Bt OPVs will present themselves as highly diverse "landscapes" of maize plants with starkly fluctuating Bt concentrations and, thus, survival rates in susceptible pests.

A follow-up project was conducted with UCT researchers to study the seed selection behaviour of smallholder farmers more in depth. Linkages were established with small-scale farmers in South Africa, and collaboration linkages with the Agricultural University Uppsala in Sweden and the Centre for Gene Ecology in Norway. Follow-up funding was received from SDC to develop a larger trans-disciplinary project proposal involving smallholder farmers and researchers to allow farmer-led research with other enabling technology from ETH Zurich.



Impacts of land use patterns in South Africa (Ilupsa)

UNIVERSITY PARTNERS

Agroscope
Dr Stefan Mann
Stellenbosch University
Professor Nick Vink

From left: Siphe Zantsi, Kandas Cloete and Jan Greyling.

The research teams propose to adapt and expand the novel SWISSland approach to inform the best course of action to a country-specific, agent-based model of land reform in South Africa.

The importance of addressing the racially unequal agricultural land ownership patterns in post-transition South Africa is undisputed. However, more than 20 years after the first democratic elections, there is growing consensus that the land reform programme has failed to facilitate the intended transformation toward vibrant, equitable and sustainable rural communities. There is also consensus on a growing urgency for an expedited resolution of the "land question".

Stakeholders, while unified on the above, are not in agreement regarding the type of reform needed or the mechanisms through which these should be achieved. This has given rise to the implementation of poorly designed or unworkable programmes, and various unintended negative consequences. The apparent lack of success has also resulted in a plethora of proposals from various stakeholders, be it the state, individual farmers, organised agriculture or the academic community.

The development of a South African-specific, agent-based model could make an invaluable contribution. The proposed Integrated Land Use Plan for South Africa (ILUPSA) model would enable stakeholders to test the possible or probable outcomes of the various policies that are being

proposed in terms of their ability to transform the sector, benefit the rural poor and impact on aggregate production, employment, average farm size and land values.

The Socioeconomics research group in Tänikon has emerged as one of the leading centres for agent-based models. Its SWISSland model is the first agent-based model to make predictions about the farming sector of a whole country. It is not only regularly applied for ex-ante policy evaluations, but has also been used to explore several methodological innovations. These comprise, for example, sophisticated exchange modes for farmland and an evidence-based model validation through predictive analysis.

The Swiss experience has shown that a reliable model generates projections that enjoy a particularly high degree of credibility, providing a joint base for political discussions. Therefore, the expanded dataset on land reform, and the integration thereof with other statistical and spatial data sources, will provide the research community with an invaluable asset that will enable the testing of past and future hypotheses. More importantly, the development of the ILUPSA model will enable the quantification of the most probable outcomes of the various policy recommendations and proposed mechanisms. Such a perspective could help to direct the efforts and expenditure of several stakeholders toward the best-suited and most efficient mechanisms for realising the expedited creation of a vibrant and inclusive rural economy.

The ILUPSA model is a multiperiod agent-based model that allows for a ground-up approach to modelling complex systems such as land use patterns in South African agriculture. The eventual ILUPSA model will consist of about 2 000 sub-models that represent individual farms, both smallholder and commercial, which in turn are scaled to represent the entire sector. The physical attributes and farmer objectives of each of these farm sub-models are determined by survey and all of them are linked through codified behavioural rules. The model allows the researchers to test the long-term impact (> 5 years) of various land reform scenarios on land use patterns, as ownership patterns and farms size, by changing parameters such as the rate at which land becomes available for reform, the rate at which land is subdivided, or different government expenditure levels.

Collectively, these could bring about a new period of scientific discourse and enquiry on the subject, for which numerous academic publications and dissertations will see the light. It is expected that the decision-making process in the national government can be put on much more stable ground after the most relevant scenarios have been calculated, published and discussed.

The collaboration will result in a significant expansion in the domestic knowledge base through the training of PhDs and staff exchanges, especially since an already novel approach (SWISSland) will be adapted and expanded to inform the best course of action to a national imperative.

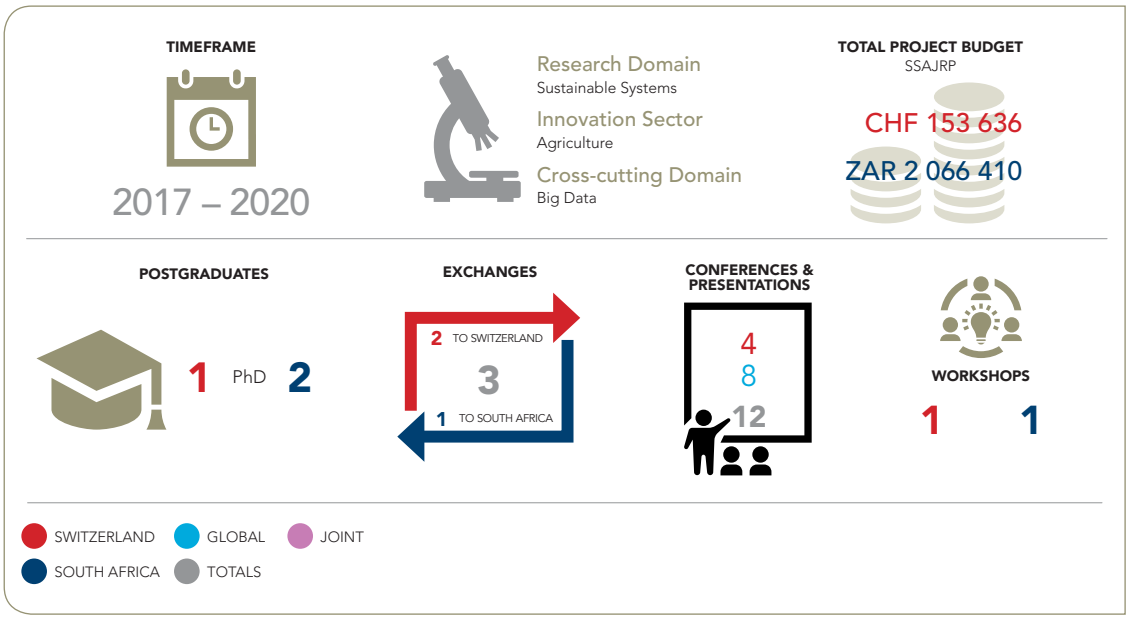
Considering that the ILUPSA model will be able to incorporate most land reform policy scenarios currently being discussed, it will serve as an invaluable resource for improved policy formation.

Photograph courtesy of Dr S Mann

Dr Stefan Mann

Photograph courtesy of Christian van Wechmar

Professor NIck Vink



South African cropland dust emission risks: physical thresholds, environmental and socioeconomic patterns

UNIVERSITY PARTNERS

University of Basel
Professor Nikolaus J Kuhn
University of Cape Town
Associate Professor Frank Eckardt

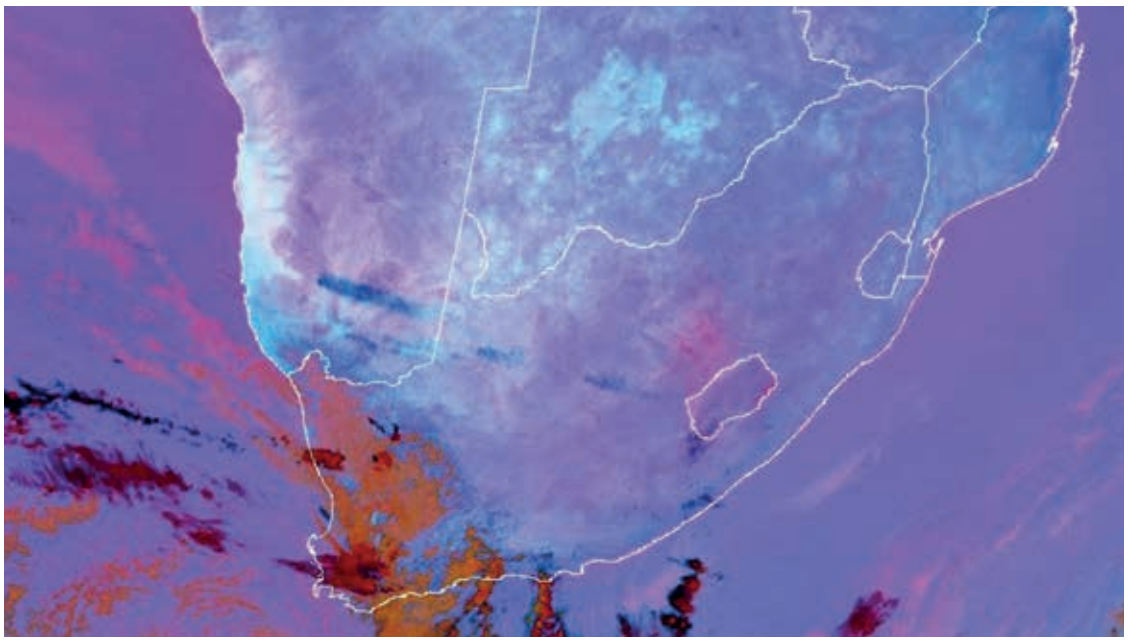
Dust emission is a growing issue affecting soil mass losses, ecosystem services, public health, and climate change. Understanding dust emission from farming in drylands is crucial not only to prepare and respond to the aforementioned impacts, but also to secure food production in the best possible conditions using marginal lands, a resource that is becoming increasingly scarce.

Southern African dust sources have been well documented, as they are among the world's dustiest regions, and disperse dust throughout the subcontinent and beyond. The west coast of South Africa produces dust from coastal pans, river valleys, and deltas in both the Namib and Northern Cape regions. Mine tailings in and around Johannesburg (Gauteng Province) are among the most studied dust sources in South Africa due to systematic monitoring efforts and immediate impact on urban air quality. However, few studies have drawn attention to dust originating from South Africa's extensive farmland. These areas appear to be most productive in early summer at the onset of the rainy season as part of cold pool outflows from convective storms over the Free State and Northern Cape.

Such ground level events have gone unmonitored due to their association with cloud and rain events. These associations are different from most other dust events that produce elongated plumes during the clear winter months, particularly in Namibia and Botswana, and disperse throughout the region. Nevertheless, the use of Meteosat MSG clearly suggests that southern African events are not infrequent and not insignificant in extent.

Exposed agricultural lands are thus important dust sources in South Africa, and the supply of fine dust material may be even more pronounced during drought cycles. Such events represent a loss of soil mass at the site of origin, but also impact ecosystem services further afield and, potentially, contribute to climate change. Microbial and chemical contaminants transported by dust from cropland add to the public health concerns when this dust originating from farms reaches urban areas.

The research questions of the proposed four-year project thus are: what are the environmental thresholds for generation of dust (wind, soil moisture, soil crust) in relation to farmland



Photograph courtesy of Imperial College London

False colour thermal Meteosat satellite image depicting purple dust plumes in the middle of South Africa. These plumes originating in the Free State are common in late winter and early summer imagery.

Photograph courtesy of Frank Eckardt

While spending time in the field the research team consisting of Nikolaus Kuhn from Basel, Anthony Palmer and Thantaswa Zondani from the Agricultural Research Council came across this road sign indicating that they are indeed getting close to the source of the dust in the Free State.

Heleen Vos from the University of Basel

University of Cape Town measuring atmospheric dust concentration and transport in a fallow field, a typical dust source for this region.

Photograph courtesy of Frank Eckardt

Wolfgang Fister from the University of Basel

Fence lines do not contain the mobile sand streaks which destroy surface crusts and crop stubble.This in turn promotes fine dust material essential to maintain moisture and nutrient content in agricultural soils.

Photograph courtesy of Frank Eckardt

management; and, to what extent do farmland dust sources impact ecosystem services, public health and, potentially, climate?

This research aims to fill this knowledge gap by using a holistic and interdisciplinary approach spanning geomorphology, land management, and microbiomics. A Swiss-South African partnership of four institutions (University of Basel, Agricultural Research Council, University of Cape Town, and University of Pretoria), which encompasses the necessary expertise, has been formed. They have divided activities and methods into four work packages. The results of these will be synthetised in a fifth one, leading to publication of holistic scientific contributions on South African cropland dust emissions, identification of farmland management best practices, and informing policy.

TIMEFRAME

2017 – 2020

Research Domain
Sustainable Systems

Innovation Sector
Social Impact Innovation

Cross-cutting Domain
Public health, Ecology, Climate change

TOTAL PROJECT BUDGET
SSAJRP

CHF 520 186

ZAR 6 996 497

POSTGRADUATES

2	MSc	2
1	PhD	1

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Sustainable honeybush plant-production - product nexus

UNIVERSITY PARTNERS

University of Applied Sciences Northwestern Switzerland
Professor Veronika Butterweck
Agricultural Research Council
Professor Elizabeth Joubert

Honeybush, an indigenous South African fynbos shrub endemic to the Eastern and Western Cape and commonly processed as a herbal tea, shows promise and opportunity for South Africa to capitalise on its biodiversity and capture niche markets. The tea is renowned for its rich flavour and high levels of antioxidants.

The participants in this study aim to enhance the sustainability of honeybush production in South Africa to reduce its vulnerability to risk. Sustainability focuses on both plant and product, addressing relevant aspects of sustainable production, consumption and value-addition in the form of a nutraceutical (having medicinal or health benefits) extract.

The collaborators anticipate that their research will provide improvements in the sustainability of honeybush (the common name for 23 species of *Cyclopia*) production and processing, which is urgently needed to reduce environmental impact and lessen dependence on scarce resources. Additionally, by demonstrating the herbal tea and nutraceutical potential of *C. pubescens*, the number of *Cyclopia* species suitable for cultivation and commercialisation could be increased, which will lower dependence of the honeybush industry on wild-harvesting. The dependence on wild-harvesting to meet demand results in significant stress on the *Cyclopia* species in the wild, to the point where extinction is possible.

Before commercial cultivation of under-exploited *Cyclopia* species, e.g. *C. pubescens*, assessment of their value-addition potential as herbal tea and nutraceutical is needed. *C. genistoides*, one of the major cultivated species, suitable for cultivation in sandy coastal areas, is prone to a bitter taste, limiting consumer acceptance. By identifying major bitter compounds, future selection of plant material for commercial propagation could be directed towards genotypes that have inherent low levels of these compounds, ensuring greater consumer acceptability as a herbal tea. The researchers will also revisit the energy-intensive, high-temperature oxidation processing step of conventional "fermented" honeybush tea with the aim to reduce energy use.

The team's investigation of the physiological responses and biochemical processes of honeybush

Plant Photograph courtesy of Agricultural Research Council

Cyclopia pubescens honeybush

Photograph courtesy of Prof Matthias Hamburger

Professor Veronika Butterweck

Photograph courtesy of Agricultural Research Council

Professor Elizabeth Joubert

Photograph courtesy of Prof Matthias Hamburger

Professors Joubert and Butterweck with their team.

Photograph courtesy of Agricultural Research Council

Joubert laboratory.

under drought stress as it relates to survival of the plants and ultimately also the quality of the final product, will provide much-needed information on the suitability of micro-climates and dryland cultivation for honeybush production.

Human well-being also comes into play as it is a main driver for honeybush production and consumption: it is rich in polyphenols well-known for their antioxidant and anti-inflammatory properties. The group will therefore investigate honeybush extract and isolated compounds, since they may represent a promising alternative to protect the gastrointestinal barrier against inflammation-induced side-effects, as well as their possible neuroprotective effects and prevention of brain ageing.

These experiments will not only enhance the scientific knowledge on the nutritional value of the honeybush, but will also enhance public health recommendations and, consequently, nutritional requirements.

The advantage of the proposed project is its multidisciplinary approach, combining agricultural, botanical, chemical, analytical, pharmacological, and biopharmaceutical knowledge. Therefore, it is of high scientific interest for each discipline itself but also for a broader scientific community.

TIMEFRAME

2017 – 2020

Research Domain
Sustainable Systems

Innovation Sector
Pharmaceutical

Cross-cutting Domain
Biotechnology

TOTAL PROJECT BUDGET
SSAJRP

CHF 537 188

ZAR 7 225 175

POSTGRADUATES

0	MSc	1
0	PhD	3

EXCHANGES

1 TO SWITZERLAND

2

1 TO SOUTH AFRICA

SWITZERLAND · GLOBAL · JOINT
SOUTH AFRICA · TOTALS

INNOVATION
The project has innovation potential and also beyond the lifespan of the project.

Applying life cycle assessment to mitigate environmental impacts of South African agri-food

UNIVERSITY PARTNERS

Zurich University of Applied Sciences
Professor Deborah Scharfy
University of Cape Town
Professor Harro von Blottnitz

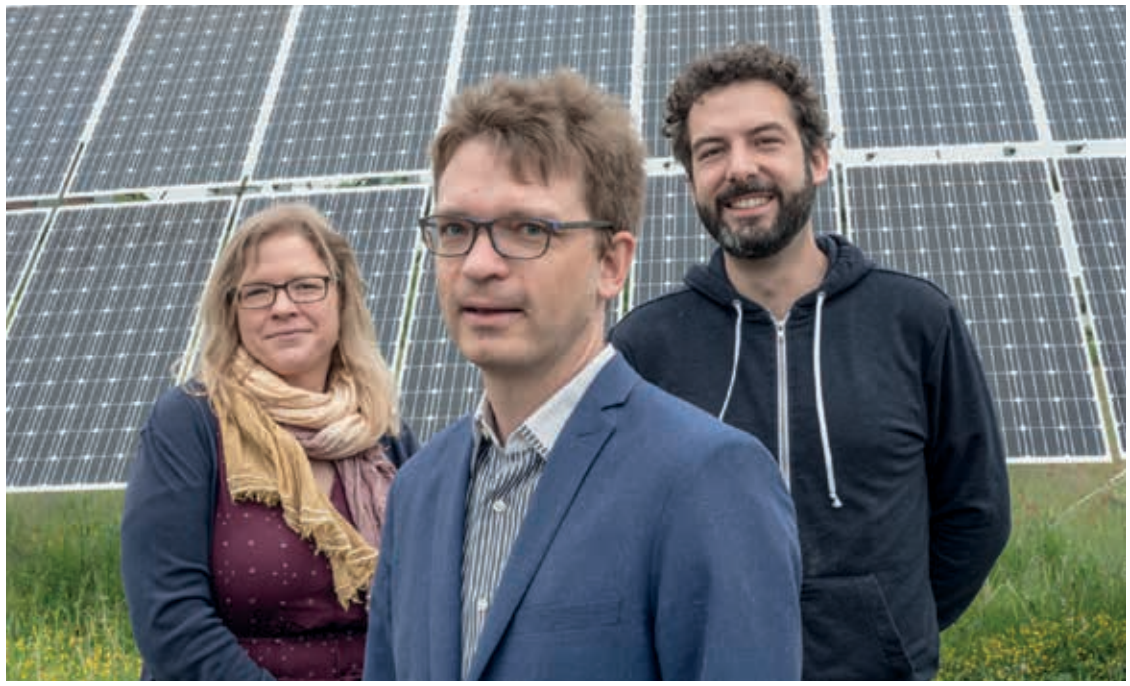
The project contributed to the important global question of how to reduce environmental impacts from food production, with a focus on South African food value chains.

Its goals were the identification of environmental hotspots in the life cycle of the most relevant agri-food products in South Africa; quantification of environmental mitigation potentials from applying green and clean technologies in the South African agri-food sector; development and dissemination of sustainable practice recommendations for public authorities and the agri-food industry; and the farm-stage and post-farm value chain for maize, dairy, beef, pork, pome fruit and soft citrus. They also gave some consideration to stone fruit, table grapes and animal feed. Life cycle datasets for South African agri-food products had to be developed, which they achieved through multiple student research projects to gather the data or model the systems in question.

The project team joined forces to ensure basic data collection for South African maize, dairy and fruit production, life cycle inventory generation, and subsequent environmental hotspot analyses. The main results generated were:

- Photovoltaic installations to generate electricity for irrigation in irrigated maize production would reduce the carbon footprint of such maize by 33%, making it comparable to the carbon footprint of dryland maize.
- Biogas production from feedlots and of slaughterhouse waste to generate electricity and heat could reduce the carbon footprint of beef by 10% and pork by 30%.
- Using feed additives as methane inhibitors potentially reduces the carbon footprint by 18% of raw milk from dairy cows.
- Renewable energy use, e.g. solar power, could effectively reduce the environmental impacts from South African fruits. They also quantified environmental benefits of other clean technology innovations, such as organic fertilisers, different forms of packaging and targeted pesticide application. Efficient water usage would have multiple environmental benefits in the fruit industry.

The project enabled data generation and modelling on a set of food production domains in



Researchers of the Life Cycle Assesment Research Group with agri-photovoltaics. From left: Karen Muir, Matthias Stucki and René Itten (all ZHAW).

The research team. From left: Dr Valentina Russo UCT, Lesley Sibanda UCT, Dr Philippa Notten UCT, Prof Deborah Scharfy ZHAW, Matthias Stucki ZHAW and Prof Harro von Blottnitz UCT.

Photograph courtesy of Prof Harr von Blottnitz

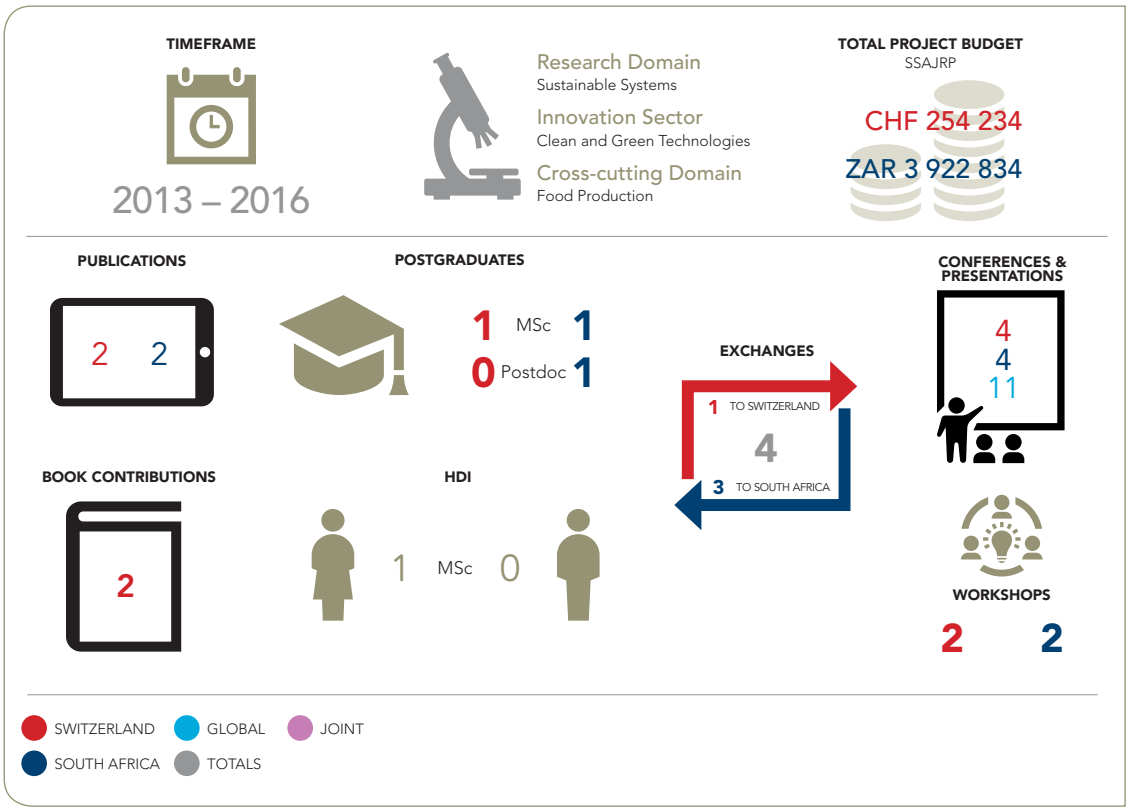
Fruit cultivation experiments.

Experimental greenhouses at the Zurich University of Applied Sciences campus in Wädenswil.

South Africa for life cycle assessments. This served to build significant capacity and opportunity and to discuss the value of such science-based, systems descriptions of food production with industry, societal actors and, to some extent, government.

The exchanges allowed Swiss researchers and students to understand the diversity and challenges of South African agriculture, and learn to view it as more than the carbon footprint of an apple or bunch of grapes in a Swiss university canteen. For the South African participants it served as a lens on how the science is practised and used, and facilitated interaction with global experts in life cycle analysis such as Prof Stefanie Hellweg and Dr Stefan Pfister.

Close interaction remained with the Swiss ecoinvent who has appointed UCT and the South African National Cleaner Production Centre to be the regional coordinators for a global life cycle data extension project funded by SECO. Close collaboration was established with WWF-SA and Woolworths as a retailer provided context for research and access to some farmers for project activities. Contributing to the outcomes of the project were the Confronting Climate Change in the fruit and wine industry project and Green-Cape with a focus on the green economy in the Western Cape.



Discovery of factors regulating carbohydrate storage in plants

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Zurich
Professor Samuel C Zeeman
Stellenbosch University
Professor Jens Kossmann

Professor Jens Kossmann laboratory.

The South African and Swiss laboratories instigated the discovery of novel genes involved in starch metabolism in plants. This work revealed a previously unknown link to human genes coding for glycogen dephosphorylating proteins that perform their task during glycogen metabolism.

Groundbreaking research into the mechanism by which glycogen and starch phosphorylation occur in bacteria, plants and mammals will strengthen the previous discoveries in this exciting new research field. The greatest impacts will be in demonstrating the biological importance of phosphate in glycogen metabolism in humans and in successfully controlling starch levels in crops.

Most living organisms store carbohydrates to provide an energy source. In humans the principal storage carbohydrate is glycogen, which is generated after meals and used during exercise or fasting. This carbohydrate storage process is essential to manage blood glucose levels and thus for a healthy lifestyle. Diseases resulting from faulty glycogen storage or blood sugar regulation, such as diabetes, are serious and debilitating.

In plants, starch is the ubiquitous form of carbohydrate storage. It is equivalent to glycogen in animals, though unlike glycogen it is insoluble. The starch granules found in the seeds, roots and tubers of crop plants form the basis of nutrition for humans. Starch extracted from these and other plant types is used as an industrial raw material and as feedstock for biofuel production. Increasing the starch content in plants and modifying starch properties are thus important biotechnological goals.

The novel genes discovered by the researchers involved code for starch phosphorylating and/or dephosphorylating proteins and enable the breakdown of the starch and subsequent use of the glucose products for the plant's own growth. To decipher the importance of carbohydrate phosphorylation and dephosphorylation, they are employing *Arabidopsis thaliana* and *Escherichia coli* – plant and bacterium model organisms that

accumulate starch and glycogen, respectively. These model organisms were selected because it is possible to conduct complete studies of gene function. Results can then be related to the metabolic machinery possessed by humans and relevant starch crops, which are themselves much more difficult to study.

They have successfully established a functional screen for identifying carbohydrate kinases in *E.coli*, along with a method for virus-induced gene silencing (VIGS) in plants. The latter has enabled functional characterisation of tobacco plants lacking carbohydrate dephosphorylating enzymes and other proteins that participate in the same biochemical pathway. This approach complements the work done with gene knockout mutants of *Arabidopsis*.

During the next phase of the project the researchers studied the role of putative glycogen phosphorylating genes from *E. coli* and identified genes playing the analogous role in humans. This is an essential process. Defects in the glycogen phosphorylation system in humans result in the debilitating and terminal syndrome, Lafora disease. Identification of the genes involved in glycogen phosphorylation and dephosphorylation in different organisms will shed light on the fundamental importance of this metabolic step, helping to explain Lafora disease and other glycogen storage disorders.

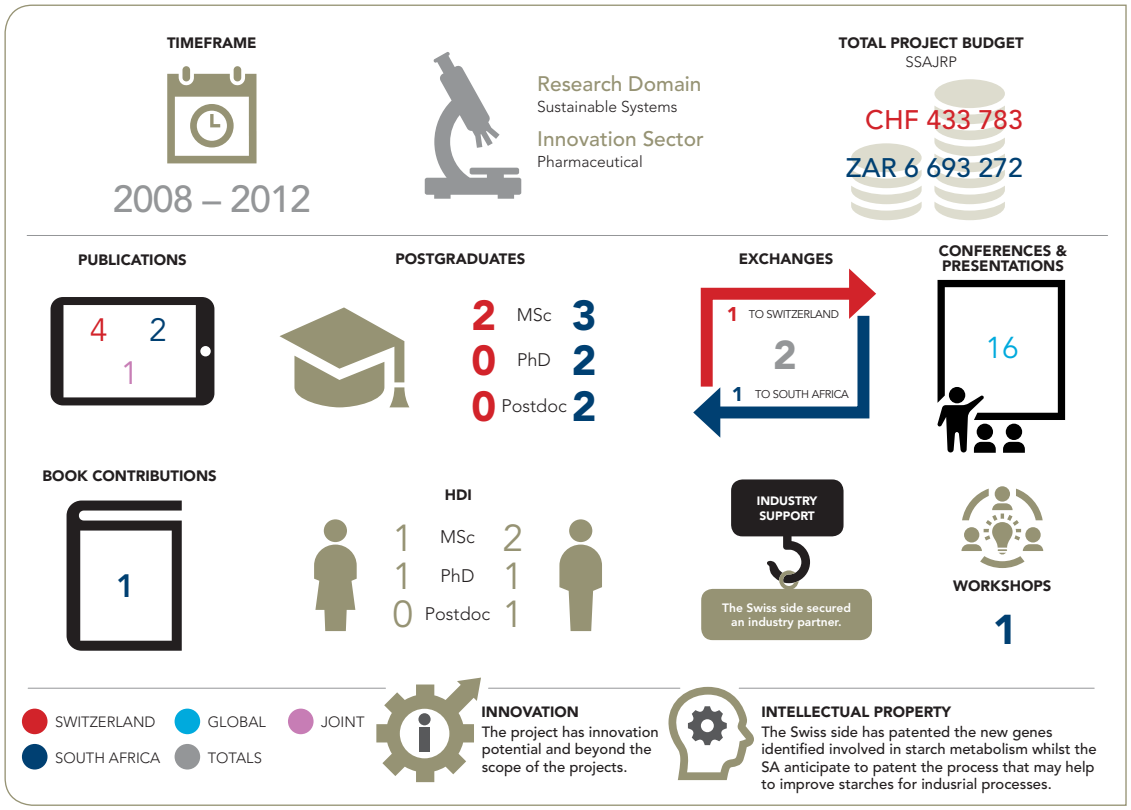
Work from the two laboratories has laid the foundation for complementary work to pursue a complete understanding of starch phosphorylation in plants. Its completion will explain at the molecular level the interdependencies between starch phosphorylation and its subsequent metabolism. Such a level of understanding will allow the rational control of starch levels and properties in plants. This is crucial to implement biotechnological improvements in starch crops.

A mechanistic understanding of the metabolism of glycogen will unlock the potential for biomedicines to treat energy metabolism diseases, the burden of which is increasing worldwide. It could also specifically aid in the development of a gene-therapy based treatment of Lafora disease. The interaction between world-class scientists and students facilitated by this joint research project will ultimately enrich the research environment of both countries and, in the longer term, could benefit the respective economies by taking research to the market.

The project also contributed significantly to capacity development in South Africa by promoting interaction between the research team members.

Photograph courtesy of ETH Zurich

Professor Samuel C Zeeman



Space in time: landscape narratives and land management changes in a southern African cross-border region

UNIVERSITY PARTNERS

University of Basel
Dr Giorgio Miescher
University of Cape Town
Professor Maano Ramutsindela

Historical Namaqualand in the South African/ Namibian border region is experiencing a new chapter in a long and complex history of changing land use and resource management. The area, which includes parts of the Northern Cape Province in South Africa and the Karas Region in southern Namibia, is dissected by the perennial Orange River (Gariep), a vital water artery in an otherwise semi-arid landscape. The region has seen a number of different land use and resource management systems over the past 200 years.

Currently, large-scale agriculture and nature conservation projects dominate land use. These are contested by people who claim their own rights to land and land use, among them formerly disadvantaged and often very poor communities living in Namaqualand.

The region provides an ideal starting point for an analysis of different narratives around land use and management. Placing these narratives in a broader historical and socio-political perspective furthermore allows for a more balanced discussion of land use that aims to transcend some of the antagonisms between the various stakeholders at local, national and international levels.

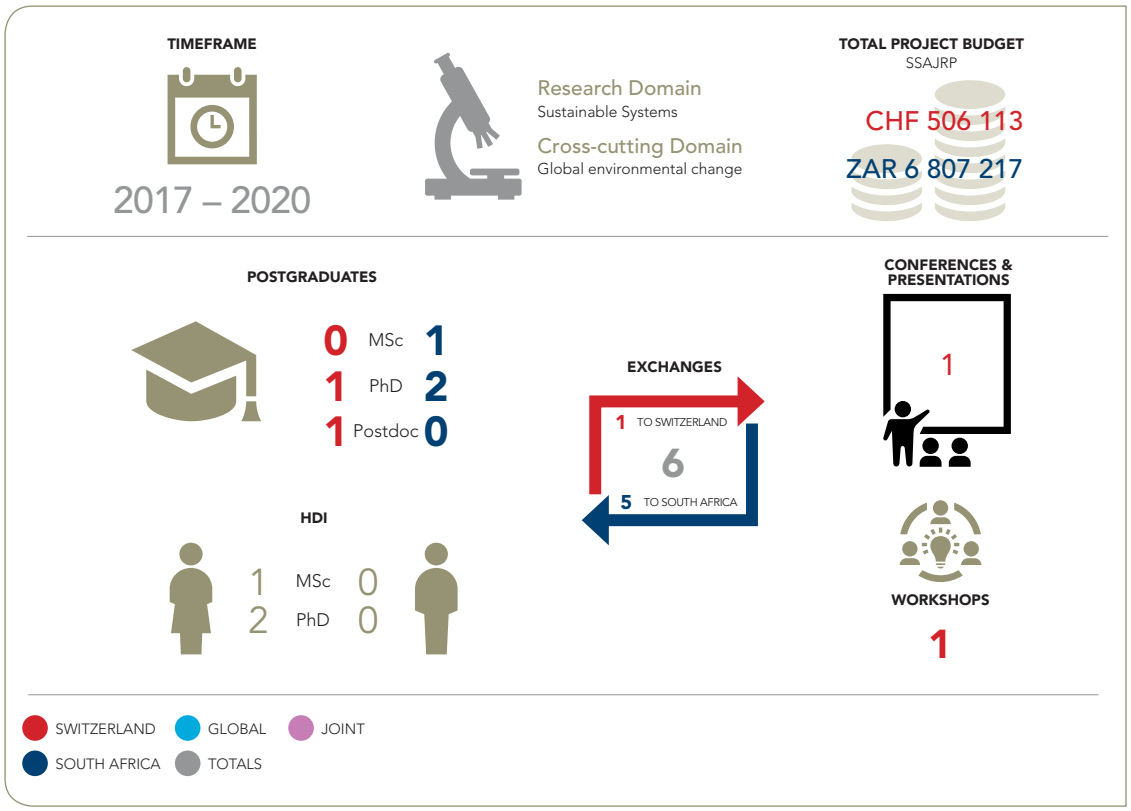
The researchers are aiming to develop a feasible, interdisciplinary methodology that merges different data produced by distinct research practices (history, geography, environmental science). They intend to, firstly, analyse the history of land use, land management and land claims and its changes. Then, how these changes inscribed themselves onto the landscape and how transformations of landscape reflected changes in land use. Pivotal are, for example, environmental changes, especially with regard to soils, vegetation and water resources. In order to account for these diverse short- and long-term transformations, and in an attempt to synthesise their analysis, the participating researchers will theorise so-called integrated "landscape narratives".

Central in this respect are interdisciplinary "landscape archives", a conceptual and practical tool that looks at evidence of landscape narratives and representations, the physical environment (soil profiles), archival documentation (written, visual and map material), oral recollections and local/ indigenous knowledge.

The collaborators propose that such an archive becomes an integrated research tool, for example as a (theorised) digital platform and database. The "landscape archive" could generate and supply scientific data gathered in close communication with selected local and regional stakeholders. They intend to design it as a tool applicable and accessible beyond the limitations of the research project itself and regard such a theorised "landscape archive" as a particularly innovative proposition and outcome of the overall research project.

Based on the findings of their research, they want to question and reassess current land and resource management regimes and challenge dominant "landscape narratives". Such a platform to different and differing claims (e.g. those of marginalised communities), can serve as a basis for future negotiations on sustainable and inclusive land use. This is of particular importance as recent initiatives, such as trans-frontier parks, generally justify their land use policies through references to the environmental and socio-political history of the cross-border landscape that are often rather based on imaginary than solid evidence.

Professor Maano Ramutsindela



Photograph courtesy of Wynand Uys on Unsplash

7

JOINT RESEARCH PROJECTS

ASTRONOMY AND BIG DATA

The Square Kilometre Array.

Photograph courtesy of SARAO

South Africa has a long history of excellence in astronomy, a sound high-tech infrastructure and clear skies. It hosts the Southern African Large Telescope (SALT), a 10 m optical telescope and the largest of its kind in the Southern hemisphere, at the South African Astronomical Observatory's Sutherland site. South Africa will also be hosting the majority of dishes of the world's largest radio telescope, the international Square Kilometre Array (SKA) project. The low-frequency array is to be constructed in Australia.

The MeerKAT radio telescope, which was officially inaugurated by the Deputy President of the Republic of South Africa, Mr David Mabuza, on 13 July 2018, is a precursor of the SKA.

Astronomy and Big Data go hand in hand. MeerKAT can, for instance, process up to 275 gigabytes per second. Signal transport and networks will be the backbone of the SKA telescope; they will interface with almost every aspect of the system and will ultimately represent the largest and most challenging network system in science. Approximately 160 Gigabits (10^9) bits per second of data will be transmitted from each radio dish to a central processor, meaning that the high-frequency dishes alone will produce ten times the current global internet traffic. The use of aperture array radio telescopes in the low- and mid-frequency ranges will further increase data rates to many Petabits (10^{15}) per second, which represent more than 10 times the current global internet traffic.

The Centre for High Performance Computing (CHPC) in Cape Town plays an empowering role for SKA partners in other African countries. It started when the CHPC unveiled the fastest computer on the continent in July 2016.

The Netherlands and South Africa have set up a data science partnership to establish national and regional data centres in order to tackle one of the most significant challenges presented by the SKA telescope: how to manage, process, and make accessible the immense amount of data the telescope will generate.

The SKA Africa's Big Data Africa Summer School aims to introduce fundamental data science tools and techniques to talented young science graduates across a range of disciplines, who have an interest to develop their skills and knowledge in

working efficiently on extremely large datasets in any research environment (Square Kilometre Array, 2018).

The SKA has been identified as one of the potential large-scale infrastructures in which Switzerland could participate in the coming years, and the country is investigating the best way to participate in the project.

Swiss scientists are not only interested in the observations the SKA will deliver but also in its sheer complexity, which is at the forefront of modern technology. The vast amount of data produced by the SKA will need to be digested and analysed. New hardware, software and advanced algorithms have to be developed to face the expected deluge of data.

Swiss SKA activities are led by a consortium in which more than 50 scientists are participating from different research institutes throughout Switzerland. From an engineering perspective, Switzerland is interested in contributing to work packages of the antennas, central signal processor, science data processor and Big Data, and is studying other packages too.

An example of recent technology that will benefit the SKA is the fast analogic-to-digital converter developed by scientists of IBM and EPFL that will help improve the ultra-fast ethernet network (EPFL, 2016).

But Big Data has uses in many areas other than in astronomy. Big Data is larger, more complex datasets, especially from new data sources. These datasets are so voluminous that traditional data processing software just can't manage them. But these massive volumes of data can be used to address problems such as help spot disease early and develop new medicines; maximise crop yields; predict and respond to natural and man-made disasters; and prevent crime (Oracle and Forbes, 2018).

Outcomes of the Astronomy and Big Data Domain (2 projects)

RESEARCH DOMAIN: ASTRONOMY AND BIG DATA

TOTAL FUNDS, INCLUDING THIRD-PARTY FUNDING:
CHF 829 267 ZAR 10 697 545

UNIVERSITY PARTNERS

University of Geneva
Swiss Federal Institute of Technology Lausanne

University of KwaZulu-Natal
Rhodes University

PHASE III
2017 – 2020
2 projects

Phase III projects have not as yet reached full-scale scientific outputs.

PUBLICATIONS

4 2
4

10 TOTAL

POSTGRADUATES

0	MSc	2
1	PhD	4
2	Postdoc	1

10 TOTAL

HDI

0	MSc	2
1	PhD	2

5 TOTAL

EXCHANGES

10 TO SWITZERLAND
19
9 TO SOUTH AFRICA

WORKSHOPS

2 2

CONFERENCES & PRESENTATIONS

4 2
6
12

SWITZERLAND GLOBAL JOINT
SOUTH AFRICA TOTALS

Addressing the Big Data challenge: developing transferable technologies and methodologies in the astronomy domain

UNIVERSITY PARTNERS

University of Geneva
Dr Martin Kunz
University of KwaZulu-Natal
Dr Kavilan Moodley

The project aims to develop technologies and methodologies to tackle the Big Data challenge in the astronomy domain by involving the investigators in a number of Big Data astronomy projects. These technologies and methodologies will be transferable to other scientific domains dealing with the Big Data challenge. The project is still at a very early stage.

Advances that the research team make towards tackling the Big Data challenges for the relevant astronomy projects will advance the platforms and architectures required to derive maximum scientific value from the data.

Swiss and South African collaborators bring novel opportunities to this project; for example, the involvement in the HIRAX, BINGO, MeerKAT, SKA and DES plus LSST projects (see glossary for descriptions).

The combined unique skills of the investigators in, for example, data analysis, computing architectures and machine learning, will bring excellent scientific value to the astronomy and broader community from this collaboration.

Capacity building has already occurred: students visited and worked at the ETH Zurich laboratory on drone technology for radio telescope calibration, and a postdoctoral fellow from UKZN visited the ETH Zurich group to work on models for the distribution of neutral gas in galaxies at high redshift, and on machine learning for radio frequency interference detection.

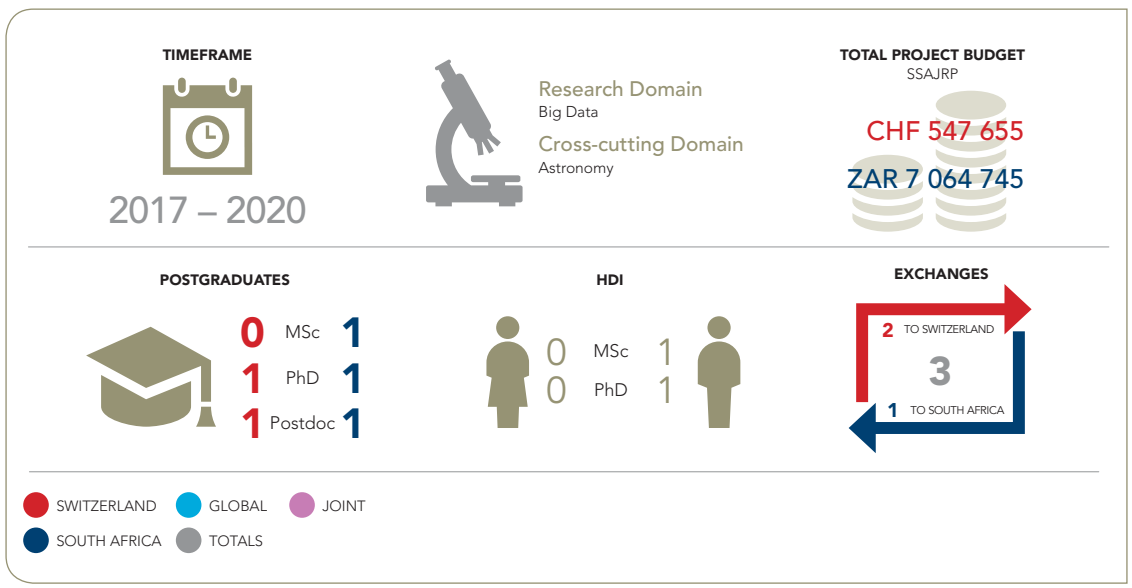
Photograph courtesy of Kavilan Moodley

Dr Kavilan Moodley

Photograph courtesy of Yasmin Hankel

Dr Martin Kunz

Members of the Astrophysics Research Centre at the University of KwaZulu-Natal, inspecting the PRIZM antenna at the astronomy instrumentation laboratory.



Wide-band imaging in the SKA era

UNIVERSITY PARTNERS

Swiss Federal Institute of Technology Lausanne
Professor Jean-Philippe Thiran
Rhodes University
Professor Oleg Smirnov

Radio interferometry (RI) allows the observation of radio emissions of the universe with great sensitivity and angular resolution. Aperture synthesis in RI correlates electric signals from pairs of antennae to produce the so-called visibilities which, under the simplifying assumptions of non-polarised monochromatic incoherent radiation on a small field of view, provide an incomplete Fourier sampling of the underlying two-dimensional sky brightness image of interest.

New radio telescopes, such as the future flagship SKA, are intended to provide images at a totally new range of resolutions and sensitivities, and on a wide frequency band. Data rate estimates for the first phase of development of the telescope only, are around a few terabytes per second. The massive amounts of data to be acquired will represent a great challenge for the infrastructure and signal processing, and the methods solving the inverse problem associated with the image reconstruction need to be fast and to scale well with the data volumes. The celebrated CLEAN imaging algorithm and its variants that have driven RI imaging so far, will simply not scale to the SKA Big Data regime.

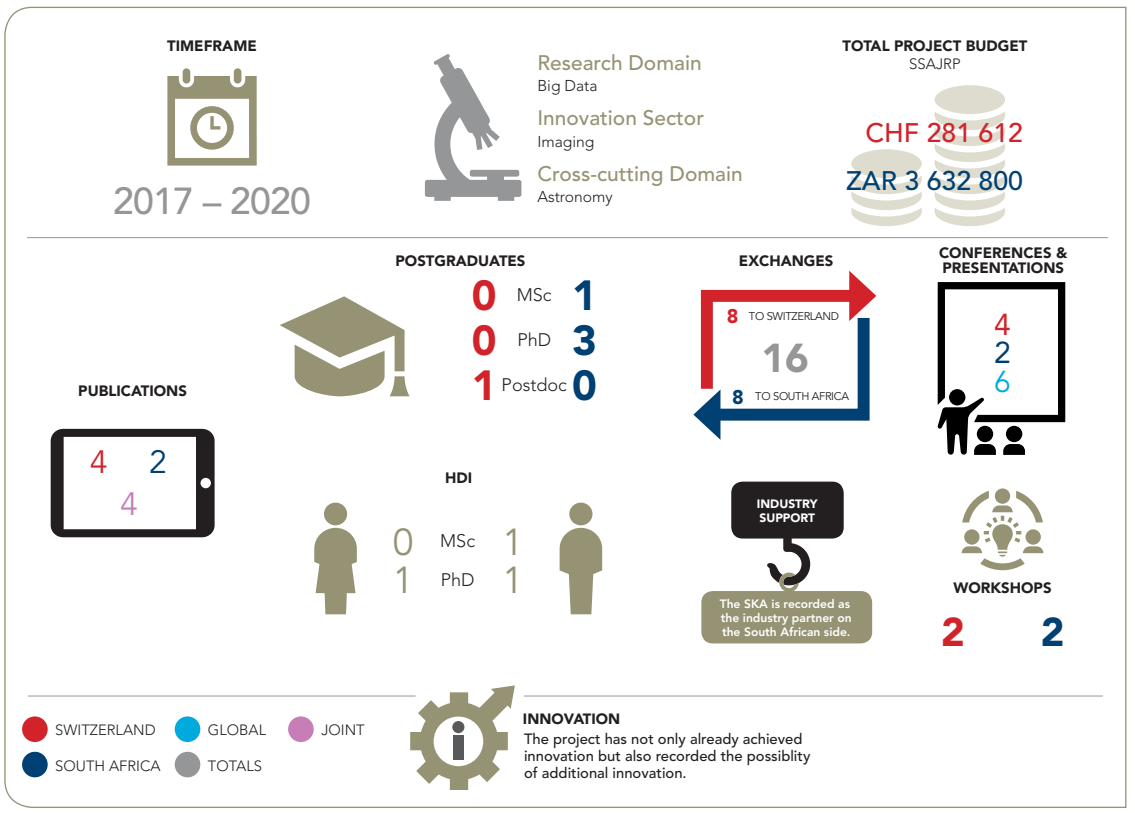
The project aims to tackle this RI imaging challenge in the wide-band setting – when a third imaging dimension is introduced to account for observation over a whole radio frequency band – by leveraging modern parallelised and distributed algorithmic structures in convex optimisation.

The researchers aim to define a new advanced wide-band signal model relying on low-rankness and average joint-sparsity of a matricisation of the wide-band image cube of interest. A convex optimisation problem will be formulated that encompasses multiple data fidelity terms and regularisation priors accounting for the signal model.

They will leverage a recently proposed primal-dual algorithmic structure to solve the optimisation problem, presenting the extreme advantage of full splitting of the objective function: the algorithm can split not only the data but also the image into a large number of blocks that can be processed in parallel at each iteration of the image reconstruction process. It is also shipped with a very powerful randomisation functionality, which enables a random selection of the data and image blocks to be updated at each iteration for lower computational requirement.

Photograph courtesy of SARAO

They will adapt the same algorithmic structure for Faraday depth synthesis when wide-band polarimetric data are considered. The team will perform algorithm validation with real data from the South African SKA precursor MeerKAT, of which first dishes came online simultaneously with the start of this project, as well as with simulated SKA data. They will also develop a high-performance computing (HPC) implementation.



8 DEEPENING RESEARCH COLLABORATION BETWEEN SWITZERLAND AND SOUTH AFRICA

Staff and Student Exchange

IN an interagency agreement signed in 2002, the Swiss and South African research support agencies, the Swiss National Science Foundation (SNSF) and the National Research Foundation (NRF), introduced support for student and faculty exchanges, mostly through workshops and seminars. Primary objectives are to generate new ideas, concepts and projects leading to the participation in broader funding instruments such as the European Framework Programmes, currently Horizon 2020. Student and faculty exchanges were well embedded in the Swiss funding allocations for Phase I of the SSAJRP through the Network Funding Instrument. On the South African side this was managed by the NRF through annual competitive calls. In Phase II this instrument was continued on the Swiss side on the basis of mutual financing (i.e. SA universities and third-party contributions).

During Phase I and II, 55 faculty exchanges and 47 student exchanges were funded by the Swiss Leading House. It is commonly appreciated that these face-to-face events are invaluable in growing and developing durable and sustainable cooperative networks. The exchange programme received particular mention at the SSAJRP mid-term workshop in Basel in October 2015, with participants emphasising that "it is more than simply a network of collaborators", especially as opportunities for inter-disciplinary work and that of sustainability of the collaboration beyond the funding term are explored.

International Scholarship Programme

Each year the Swiss Confederation awards Government Excellence Scholarships to promote international exchange and research cooperation between Switzerland and over 180 other countries. These scholarships are aimed at young researchers from abroad who have completed a master's or PhD degree.

While South Africa has been a recipient of these scholarships, the uptake among South African students has not met with the anticipated success, according to findings in the OECD report on Education at a Glance 2017 that highlights data on international student flows. It illustrates the strength of proximity factors, such as language, historical ties, geographical distance, and political framework conditions as key determinants for mobility (OECD, 2017, 295).

These determinants of international student mobility will inform how mobility programmes and scholarships should be designed between Switzerland and South Africa. Additional factors influencing student mobility include economics, such as high exchange rates and national university subsidies for postgraduates; immigration policies linked to visa requirements, and the lack of dual qualifications or badges. Those South African scholars who have benefited from the Swiss Excellence Scholarships have gained valuable experience and qualifications. These scholarships help the Swiss-South Africa Principal Investigators to enhance their current collaboration and to ensure that the collaboration continues beyond the project period.

Photograph courtesy of Don Cowan

University of Pretoria academics in Switzerland.

SWISS EXCELLENCE SCHOLARSHIP

Dr Itani Given Madiba

"Receiving the Swiss Excellence Research Scholarship strengthened my R&D portfolio, expertise and know-how. It also exposed me to world-class science facilities and helped me to manage various projects in the science and technology framework. In this regard I was able to accelerate my PhD studies through a wide range of platforms such as the use of and access to advanced world-class techniques at Empa, and participation in various science conferences hosted at Empa and other institutions in Switzerland. Through the collaborative measures of Dr Braun we were able to run a series of experiments successfully at The Physikalisch-Technische Bundesanstalt in Germany. We were also able to publish highly cited peer-reviewed papers in journals such as *Applied Surface Science* and *MRS Advances* in addition to completing my PhD in November 2017. I wish to thank Dr Braun and Prof Maaza for giving me the opportunity to work with them, recommending my Swiss Excellence application and for their excellent supervision."

PROJECT

Synthesis and thermochromic properties of Vanadium dioxide thin films as a thermal regulator in small satellites

UNIVERSITY OF SOUTH AFRICA

iThema Laboratory for Accelerator Based Sciences
Prof Malik Maaza

SWISS FEDERAL INSTITUTE OF TECHNOLOGY ZURICH

Swiss Federal Laboratories for Materials Science and Technology
Dr Artur Braun

Photograph courtesy of Prof M Maaza

Scientific Workshops and Symposiums

A number of joint workshops and symposiums were held between Switzerland and South Africa to exchange knowledge in existing research projects and develop proposals feeding into new projects. In addition to the workshops presented below, over 160 workshops took place among the joint research projects during 2008 – 2018.

The World Café was facilitated by RIIS, a boutique innovation consulting firm focused on building networks and consortiums that solve intractable business and social problems.

2012 Climate Change Workshop

Scientific workshops organised at official level promote and deepen collaboration in areas of global or national relevance. For example, the clean technology workshop held in 2012 was intended to build networks between Swiss and South African experts in preparation for the SSAJRP Phase 2 joint research call later that year that was earmarked to include clean and green technology.

2014 Nanotechnology Workshop

Within the framework of the Swiss-South African bilateral cooperation programme, the Swiss Embassy and the DST hosted the first Swiss-South Africa Nano Workshop via the UNESCO UNISA Africa Chair in Nano-sciences and Nanotechnology in 2014.

"Within the current global dynamics, Switzerland and South Africa have appropriately distinguished nano-sciences and nanotechnology as a main stream in their science, technology and innovation vision. In view of the related heavy cost investments, several nations have opted for bilateral, multilateral, and even continental joint programmes."

Prof Malik Maaza, 2014, UNISA.

2014 Social Sciences Workshop

In 2014 the Human Sciences Research Council (HSRC) and the University of Basel – supported by the DST, NRF and the Swiss Embassy – hosted a joint workshop in social sciences. The aim was to strengthen research across international networks in pursuit of shared goals in, for example, health, demographics change and well-being; smart, green and integrated transport; climate action and resource efficiency in a changing world; and leadership in enabling and industrial technology. Prof Olive Shisana, CEO of the HSRC, said at this event that "the organisation has always enjoyed a vibrant relationship with the Swiss, more specifically in the area of the social sciences and humanities", adding that the interested parties have jointly embarked on activities to support young researchers and common areas of research deemed as priorities.

2015 World Café

The Swiss Embassy, in collaboration with the Swiss and South African implementing agencies and the HSRC, has been implementing a novel approach in hosting collaborative workshops, the so-called World Café concept. This is a structured, facilitated dialogue in which the participants actively generate insights through the discussion process, which are then captured in graphic recordings during the workshop. It is therefore a generative process, based on multiple conversations, rather than the one-to-many process found in many conference proceedings.

A World Café workshop was held in 2015 with a specific focus on opportunities and challenges in the South African innovation system. Ninety-one participants from 43 organisations were present, representing a diverse range of sectors and backgrounds - academia, government, start-ups, large commercial organisations and industry bodies. This allowed for the widest possible set of views, across industry, age, experience, position, and influence.

2017 Nanotechnology Workshop

On 5 December 2017, the South African Agency for Science and Technology Advancement (SAASTA), through its Nanotechnology Public Engagement Programme (NPEP), an initiative of the DST, presented a symposium on the impact of nano-medicine on South African and Swiss health challenges. Presented together with the Swiss Embassy in South Africa, the University of Basel (UNBAS), and NABIO Consulting (Pty) Ltd, the symposium was part of the Science Forum South Africa. It provided a platform for researchers and industry to showcase ground-breaking academic and industrial research to policy-makers and promote collaboration in the areas of HIV/AIDS and tuberculosis treatment, and nano-medicine in South Africa and Switzerland. Over 200 delegates attended the symposium, which concluded with a networking event between Switzerland and South Africa.

Photograph courtesy of Steven Mufamadi

Attending the 2017 Nanotechnology Workshop are from left: Michael Ellis (SAASTA), Dr Rakeshnie Ramoutar-Prieschl (NRF), Dr Beverley Damonse (NRF), Prof Francois Venter (WHRI), Glaudina Loots (DST) and Dr Mthuthuzeli Zamxaka (SAASTA).

SSAJRP Joint Workshops

The scientific communities in Switzerland and South Africa often arrange among themselves networking and learning workshops in areas where they wish to establish institutional agreements. One such workshop was the ETH Zurich workshop with Stellenbosch University in 2014 that led to an institutional agreement on food security. A key feature of the SSAJRP joint projects is the hosting of project workshops, which have the added value of exchanging knowledge, developing joint project agendas and exploring future collaboration.

Delegates at the SSAJRP joint research programme workshop at ICGEB in October 2018.

Photograph courtesy of Zerbini Lab, 2018

Swiss-South Africa Academic Delegations

Photograph courtesy of J Kuster, ETHZ

South African days at ETHZ in 2016: From left: Prof Umezuruike Linus Opara, Distinguished Professor and DST-NRF Research Chair in Postharvest Technology, Stellenbosch University; Prof Gerhard Schmitt, Vice-President ETH Global; Prof Cheryl de la Rey, Vice- Chancellor and Principal of the University of Pretoria; and Prof Danie Visser, Deputy Vice-Chancellor, University of Cape Town.

Photograph courtesy of J Kuster, ETHZ

World Food System Center and Stellenbosch University delegates from ETHZ discussed plans to strengthen collaboration in 2016.

A key activity of the SSAJRP is to facilitate, host and promote mobility between academia and science councils from South Africa to Switzerland and vice versa. During the last 10 years the Swiss Embassy – sometimes with the participation of the DST, as well as the Swiss and South African implementing agencies – has seen a number of delegations to and from Switzerland. Swiss and South African officials and academics often undertake exploratory visits to either countries to ascertain the opportunity and appetite for collaboration in new domains.

The first mission to South Africa was the EAWAG Scientific Mission in 2010 with the objective to generate dialogue for cooperation opportunities in the area of water resource management.

One of the success stories is the visit of the EPFL maths students to South Africa from 10-24 July 2013, which included a visit to the site in the Karoo where a substantial part of the SKA telescope was to be housed. A group of these students has returned to South Africa each year after that to faciliate mathematics workshops at Scifest Africa, the science festival in Grahamstown in the Eastern Cape.

South African universities and organisations that have undertaken missions to Switzerland include the HSRC; the University of the Western Cape; various high-ranking academic officials; and a consortium of South African universities that visited Switzerland in 2014.

The Swiss Embassy hosted a roundtable discussion for the Swiss Federal Office for the Environment with South African stakeholders in 2014 to explore sustainable projects at the Cradle of Humankind, a unique UNESCO World Heritage Site, focusing on the Malmani Nature Reserve. Additional interactions were facilitated with the Water Research Commission, the World Wildlife Fund and North-West University.

A milestone visit was that in 2016 of Swiss universities to South Africa, with members representing the Swiss Universities of Applied Sciences (UAS) exploring collaboration in clean technology and energy. In the same year, a high-level delegation from the Universities of Pretoria, Witwatersrand, Stellenbosch and Cape Town visited ETH Zurich where they met with researchers to explore areas of collaboration between institutions.

Swiss Universities of Applied Sciences Fact-finding Mission to South Africa in 2016

In 2016, the UAS visited South Africa to explore collaboration opportunities in the domain of clean energy. An energy and power ecosystem workshop brought the Swiss and South African academia together with 65 participants in Gauteng and 30 participants in Cape Town. A novel addition to the World Café concept was the service of a team of local artists who recorded the discussions and outcomes through 'cartoon-like' images, providing a pictorial canvas of the voices of the delegates.

The Fact-finding Mission programme aimed to introduce the 11 Swiss delegates to key role players in the energy sector. This was complemented by a tour to over 200 individuals across more than 40 institutions representing the various stakeholders in the South African energy sector.

The tour was undertaken to strengthen collaboration in this field by facilitating the sharing of Swiss knowledge and technology, as well as establishing relationships to explore and benefit research partnerships in South Africa. The Embassy of Switzerland hosted a delegation from various UAS from 12-19 November 2016 in South Africa.

A direct outcome of the visit was the establishment of collaborations with the South African Institute for Advanced Materials Chemistry (SAIAMC) at the University of the Western Cape (UWC); the Faculty of Engineering at North-West University (NWU), which co-hosts the Hydrogen South Africa Infrastructure Centre of Competence; and a collaboration agreement with Stellenbosch University. Two members of the UAS 2016 delegation undertook follow-up visits in 2017 with a further project-based visit planned for 2019.

Delegates of the UAS fact-finding mission in 2016 visited the Standard Bank Centre in Rosebank to experience first-hand the excellent energy efficiency that was achieved in building the bank's new headquarters.

The 2017 FHNW study tour group to South Africa.

Photograph courtesy of JFHNW

EPFL EMBA Students.

Photograph courtesy of JEPFL

The Swiss University of Applied Science and Arts Northwestern Switzerland (FHNW) undertakes an annual study tour to South Africa to expose its master's students in Business Information Systems and International Management to opportunities in international collaboration. The tour provides a broad spectrum of visits covering many aspects of the economy – global enterprises, large companies, small enterprises, entrepreneurs and universities – from different regions. Through interviews with managers and university lecturers, the students are exposed to the latest trends and developments in business, technological innovations, entrepreneurial activities, and education in South Africa. Thus, they are able to understand South Africa's economic environment with due consideration for the country's specific cultural, social and historic situation.

Likewise, EPFL undertakes an annual visit to South Africa, giving its business and management students the opportunity to support and learn from the South African private sector and to also support the South African entrepreneurs who were part of the Swiss-South Africa Business Development Programme.

Academic Collaboration

In 2017 South African universities welcomed eight Swiss delegations, who were interested in the domains of nanotechnology; climate change and urban mobility; counterfeit drugs; agriculture; water-saving innovations; sustainable housing for the informal sector; and urban health. There was an equal interest from South Africa in strengthening the collaboration in research and innovation, with Switzerland welcoming delegations specialising in social science from the HSRC; and the visit of the Technology Innovation Agency.

University of Western Cape Fact-finding Mission to Switzerland in 2017

The University of Western Cape (UWC) visit to Switzerland from 2-5 October 2017, came about as a result of a meeting between the Deputy Vice Chancellor: Academic, Prof Vivienne Lawack, and the Swiss Ambassador, Ms Helene Budliger Artieda. UWC was the first official university delegation under the Swiss-SA Government-to-Government Agreement. The week was filled with discussions and considerations of collaboration opportunities. Highlights of the discussions included:

- Fribourg University of Applied Sciences and Arts at the School of Management created a vision for research collaborations in areas related to Fintech as well as entrepreneurship.
- Discussions at ETH Zurich took place with the Institute of Plant and Microbial Biology where they emphasised student and staff exchanges with the Department of Biotechnology at UWC.
- The World Food System Centre presented its opportunities for scholarships and project funding to the Centre of Excellence in Food Security at UWC.
- The Institute of Pharmaceutical Sciences suggested a student exchange programme with a common interest in novel delivery systems for cytotoxic marine natural products.
- The Forensic Pharmacology and Toxicology Department expressed interest to explore collaboration in forensic genetics, with UWC also expressing interest to gain technical skills in using virtual and augmented reality in forensic analysis.

The visit to École Polytechnique Fédérale de Lausanne (EPFL) focused on the establishment of incubators and a Massive Open Online Course. At the University of Bern, the Department of Economic Law expressed interest for a follow-up visit to UWC with a potential to develop a joint teaching module in International Trade Law and Economics.

The Swiss Research Institute of Small Business and Entrepreneurship at the University of St. Gallen expressed a wish to find a South African university to run the national survey on the entrepreneurial intentions of South Africa. Members of the UWC delegation also visited the Innovation Park in Biel where the model of "Discovering – Validating – Applied Research Development – Launching – Industrialise engineering – Growth" (an impressive and proven format in taking an idea to market) was presented.

Photograph courtesy of UWC

University of Western Cape.

The visit to Novartis also appeared fruitful, ending with the agreement to establish an integrated UWC-Novartis programme in training and research through existing linkages. The visit to the University of Bern, an institution that dates back to the 17th Century, gave detail on the history of Switzerland in higher education. Mr Christian Elias Schneider, Head of Innovation at the University of Basel (founded in 1463) presented the triple helix model in converting research results into practice. Information Systems and Big Data were discussed at the Zurich University of Applied Sciences (ZHAW) with the prospect of helping UWC develop a master's degree in Data Analytics. The delegation concluded with a visit to the Swiss Tropical and Public Health Institute with obvious links in the domain of public health.

Following this visit to Switzerland, UWC entered into an MoU with Lucerne University and also signed an agreement to do the Global Entrepreneurial Spirit Students' Survey (GUESSS 2018).

Swiss participation in Science Activities in South Africa

Swiss Participation at South African-hosted International Conferences

Luka Giovonetti from Swiss Contact at the Swiss Exhibition at COP 17.

South Africa hosts a number of scientific and innovation international conferences, congresses and forums, often for the first time on African soil. Switzerland prioritises its participation in these events through jointly hosting, representation and participation and often sponsorship. Such events are normally followed by a networking opportunity for the Swiss and South African scientific, official and politicial community. A few examples of Swiss participation in South African-hosted events follow.

Representatives from the Swiss Federal Office for the Environment and the Swiss Embassy participated in the **2011 United Nations Climate Change Conference** that took place in Durban from 28 November to 9 December. The conference also served as the 17th Conference of the Parties (COP 17) of the UN Framework Convention on Climate Change. The UN Framework Convention on Climate Change was adopted in 1995 and has 194 signatory councils, while the COP adopts decisions and resolutions. In the run-up to the Durban conference, parties (including Switzerland and South Africa) worked on the long-term global goal to limit the rise of global average temperature to below two degrees compared with pre-industrial levels.

Switzerland participated, supported and sponsored the **19th World Congress of the International Federation of Automatic Control** (IFAC) hosted in Cape Town in 2014. The first International Conference on Automatic Control was held at the University of Heidelberg in 1956 and nearly six decades later it was held on African soil for the first time.

Photograph courtesy of HSRC

Young scientists were sponsored to attend the 3rd World Social Science Summit.

The International Social Science Council (ISSC), the Council for the Development of Social Science Research in Africa (CODESRIA) and the HSRC hosted the **3rd World Social Science Forum** (WSSF) in Durban from 13-16 December 2015. The theme was "Transforming global relations for a just world". It was the first time that the WSSF was held on African soil.

South Africa and Switzerland jointly participated in the **6th World Sustainability Forum** in Cape Town in 2017. It was the first time that the World Sustainability Forum was held in Africa and it provided a platform for national and international debates on sustainability.

In February 2017, the **Urban Health in Africa Dialogue: *Advancing Multidisciplinary Approaches*** was held in Cape Town as part of the InterAcademy Partnership. The Urban Health Dialogue considered urban health challenges and opportunities in Africa and explored the frameworks required to promote research, education and policy actions in urban health.

Photograph courtesy of Novartis

Co-hosts of Urban Health Africa Dialogue are from left: Hedwig Kaizer, Helene Budliger Artieda, Jörg Reinhardt, Ann Aerts, Jo Boufford, Roseanne Diab.

Open Design festival booth.

Open Design Festival

The Open Design Festival is an annual event that attracts over 8 000 visitors. For Switzerland, the importance of Open Design lies in its programme's ability to engage entrepreneurs, managers, media, educators, students and members of the public to share design, innovation ideas and inspiration with each other. In 2016, Switzerland participated in the festival to demonstrate and promote Swiss innovation in architecture and the various housing solutions available from Switzerland. An innovation expert from Switzerland, Thomas Wittig, attended as a speaker at one of the most important side events, the Cape Town High Impact Series. The informal housing project of the ETH Zurich Urban Think Tank in Khayelitsha was exhibited.

Photograph courtesy of Winstone Jordaan

Sasol Solar Car Race

The Sasol Solar Challenge takes place every second year, and sees teams from across the world design and build their own solar-powered vehicles to drive across South Africa. The 2018 event was an eight-day challenge from Pretoria to Stellenbosch, with nine participants. Together with Sasol, the TIA is a major sponsor of the solar cars. In 2016, the Sasol Solar Car Challenge introduced the Legacy Projects with support from the Swiss Embassy. The Embassy participated, firstly, to support the notion that projects related to solar energy will be implemented along the route of the Solar Challenge and, secondly, to lay the groundwork for the participation of the Swiss Solar Team in 2018. Legacy Projects support communities along the 2 500km route of the Challenge and encourage young people to achieve success in STEM subjects (Science, Technology, Engineering and Mathematics). In 2018, the Swiss Embassy and TIA joined forces to launch the Bright Ideas Challenge among high school children in 11 schools in Graaff-Reinet, which is along the route.

Solar Car Race 2018

Science Forum 2015 Swiss exhibition.

Science Forum 2017 Swiss exhibition.

Science Forum South Africa 2018. From left are Senisha Moonsamy Sakhile Dhlamini, Mmamoloko Kubayi-Ngubane and Helene Budliger Artieda.

Science Forum South Africa

Science Forum South Africa is an annual event with high-level representation from scientific communities in South Africa and around the world. The 2017 event was attended by over 2 600 delegates.

During the 2015 Forum, Switzerland participated in four sessions. The Public Health Advancement session was jointly implemented by the Swiss, German and Italian Embassies and chaired by Prof Olive Shisana and Christina Stefan from the MRC. Another session focused on Massive Open Online Courses (MOOCs) and the challenges and opportunities for education in Africa. The session titled "Harm Reduction: Scientists Tackling Our Lifestyle Killers" was chaired by Prof Phillipe Gillet from EPFL.

In 2017, together with the Embassy of Italy, the Embassy of Switzerland's involvement included hosting an exhibition and participating in a panel discussion that was broadcast to over 50 000 listeners on a national radio.

The exhibition was done in collaboration with Ms Cara Fleitsch, an urban farming consultant, and Ma-khulong a Matala, a Johannesburg-based housing company that displayed their solution for food security to great acclaim. Their urban farming project emphasised the need for communities to be involved in food production, not only to feed their families, but also to address disparate social problems. This theme was displayed and communicated with great success, as indicated by the award for the best exhibition they received.

South African Scientific Dialogues

Representatives from the Swiss Embassy attended the 6th Research and Innovation Dialogue of Universities South Africa (USAf), held at Emperor's Palace in Gauteng, South Africa, from 31 May to 1 June 2018. The 80 delegates included vice-chancellors, deputy vice-chancellors and directors responsible for research and innovation from all South African public universities. This Dialogue is a platform from which senior academics, researchers, industry and other agencies engage on matters of priority interest and concern pertaining to research and innovation. The 2018 event focused on two themes: Postgraduate Training and Funding, and Internationalisation and Inter-institutional Collaboration.

Swiss Participation in the South African Innovation Summit

"The ultimate goal of the Innovation Summit this year is innovation acceleration – scaling and impact for SA-owned ideas," said Dr Audrey Verhaeghe, chairperson. "What better way to help us bring this vision to life, than to partner with Switzerland, the world's leading country in terms of innovation?"

In 2016, Switzerland was the first international partner country of the Innovation Summit (SAIS 2016), which is South Africa's largest conference on entrepreneurship and innovation.

The Swiss collaboration in the Summit focussed on three streams: participation of Swiss experts in the thought leaders platform; a workshop hosted by a Swiss expert at the University of Western Cape on 'Shape Growth through Business and Innovation'; and the presence and participation of five Swiss entrepreneurs. Swiss participation in the thought leaders platform focussed on Massive Open Online Courses; a master class in nanotechnology; green innovation; key ingredients in linking innovation with industry; and angel investors.

Swiss representation at SAIS was further supported by the visit of State Secretary for Economic Affairs, Ineichen Fleisch, who spoke at the Summit and visited the Swiss booth where the Swiss entrepreneurs showcased their innovations and interacted with South African entrepreneurs.

Swiss booth at the Innovation Summit.

Photograph courtesy of Venture Leaders Team

Photograph courtesy of ETHZ-U-TT

Swiss-South Africa Innovation Challenge

A joint Swiss-Africa Innovation Challenge was launched in 2017, linked to the ETH Zurich Urban Think Tank (U-TT) housing project in Khayelitsha, Cape Town. The idea was to introduce innovations into the informal housing sector that could make a sound contribution to the Sustainable Development Goals. A highlight of the challenge was a sponsorship received from the private sector to establish a pilot house where these innovations could be tested.

The opportunity was used to showcase the Swiss-South African innovations at the South African Innovation Summit in 2017, while hosting a World Café for the Swiss and South African entrepreneurs.

Over 40 000 individuals were contacted, with over 300 telephonic contacts made during the process, to ensure submissions. The Challenge lasted for four weeks, after which the various proposals were evaluated and categorised according to both technical and institutional criteria.

ETHZ Urban Think Tank housing project in Khayelitsha as the test bed for the Innovation Challenge.

Booth at the NSW 2012 (pictured below right) with school children winning Nestlé hampers.

South African Science Promotion for the Youth

In 2012, Switzerland participated in the South African National Science Week (NSW), DST's annual countrywide event to create awareness in science. The launch of the 2012 NSW, with the theme of "The Role of Science and Technology in Economic Development", was attended by Minister Naledi Pandor and the Swiss Ambassador gave the keynote address to nearly 6 000 learners. Switzerland participated on a practical level through a climate change exhibition coupled with quizzes where learners competed to win Nestlé hampers. The Swiss Embassy also participated in the 2014 NSW hosted at the Science Centre in Venda.

Switzerland also participated in SciFest Africa in 2016 and 2017. SciFest Africa is an annual science and technology event hosted in Grahamstown in the Eastern Cape with support from the DST. The two-week-long event draws more than 50 000 visitors from southern Africa annually, and consists of nearly 70 science exhibitions, 638 events with 350 local and global contributors.

In 2016, a Maths programme developed by the EPFL Mathematical Humanitarian Project (EmaHP) was presented during their study tour to South Africa in 2013. The EPFL facilitated an interactive process with the students to explain mathematical principles using origami möbius strips and fractals, for example.

Switzerland also hosted an interactive energy and climate change game with the SciFest students.

The Swiss participants in 2017 included:

- CERN – they sent a South African-born physicist, Dr Claire Lee, who is involved in the ATLAS experiment, to present on the work being done by CERN. One of her talks included a virtual visit to the ATLAS control centre. ATLAS is one of the four major experiments at the Large Hadron Collider (LHC) at CERN. The name CERN is derived from the acronym for the French "Conseil Européen pour la Recherché Nucléaire", or European Council for Nuclear Research.
- EPFL – under the EmaHP banner, they returned to the festival with more members on their Maths programme team. They hosted workshops in rural community schools that could not afford to send learners to the festival.
- Swiss Embassy – the team presented the Swiss landscape on education, research and innovation through an exhibition and a multimedia stream.

Photograph courtesy of MSLA

Since 2016, the Swiss Embassy has been providing an opportunity for two to three students from the Maths and Science Learning Academy (MSLA) in Kimberley to experience job shadowing at the Embassy. This opportunity allows the students to interact with the scientific, business, diplomatic, consular and economic divisions of a foreign mission. They also experience the opportunity to visit science centres and interact with the South African political and private sectors. For example, in 2018 two girls had the opportunity to participate in the Ladies Ambassadors Luncheon where the key guest was Maria Ramos, CEO of ABSA Bank. The two girls also visited the laboratory of Prof Mmantsae Moche Diale, as the newly appointed DST-NRF SARChI Chair in Clean and Green Energy at the University of Pretoria. A highlight of the Swiss Embassy MSLA collaboration was when CITRA, a Swiss-based housing innovation technology, involved MSLA scholars in a research study to explore the opportunities for the construction of houses in South Africa. These scholars could experience first-hand the research methodologies as well as the real-life context of their communities. The MSLA was established in 2006 by Anne Maclean to address the challenges in Maths and Science in South Africa.

Class of 2017 learners from the Maths and Science Learning Academy (MSLA) show their gratitude for the generous support they received. Front row: Lesedi Montwedi (3rd from right) and Alexis-Rae Shushu (5th from right) participated in the 2016 Swiss Embassy job shadowing programme.

Bright Ideas Innovation Challenge Winners.

iSTEM, the Innovation in Science, Technology, Engineering and Mathematics Youth Indaba, is a not-for-profit organisation that promotes sciences to young people in South Africa. Indaba is a South African vernacular word for "conference". The Indaba, which took place in June 2017, brought together more than 400 young people to the event that was organised by the DST and its key partners, the NRF and the TIA.

The Swiss Embassy also participated in the Bright Ideas Challenge in 2018, an innovation challenge among 11 schools. Fellow collaborators were the TIA, the Research Institute for Innovation and Sustainability (RIIS); the Saartjie Baartman District Municipality; and the Dr Beyers Naude Local Municipality. The Bright Ideas Challenge was coordinated and implemented by the offices of the District and Local Mayors as well as the Department of Basic Education. The Challenge encourages students from Grades 10 and 11 to identify the challenges in their community and to provide innovative solutions. The Bright Ideas Challenge was followed by a World Café entrepreneurship workshop for 50 scholars where they had the opportunity to learn more about, and explore, the world of innovation and entrepreneurship. The World Café event was followed by a prize-giving ceremony on 25 September 2018 where the scholars each received a tablet and the participating schools received a laptop.

The Bright Ideas Challenge encourages students from Grades 10 and 11 to identify the challenges in their community and to provide innovative solutions.

Networking Events

Swiss-South Africa networking events are used to forge potential new partnerships between Swiss and South Africans from the education, research and innovation landscapes. Networking events are normally hosted as part of the high-level visits of Swiss academics and others to South Africa. For example, the International Conferences on Research Infrastructures (ICRI) is a well-established international forum encouraging global cooperation and providing a unique opportunity to share views on matters of international relevance in the research infrastructures domain. The ICRI 2016 conference, which took place in Cape Town from 3-4 October 2016, was co-organised by the DST and the European Commission. The Swiss Embassy organised a Swiss-South Africa networking event for participants at the ICRI Conference.

World Sustainable Forum networking event in Cape Town in 2017.

Media Exposure

Both Swiss and South African participants in the SSAJRP work with the media to enhance the visibility of Switzerland in South Africa. Promoting joint activities and informing the public on research and innovation projects is key to all partners. In 2017, for example, the Swiss participation at the Science Forum was broadcasted on a national radio station.

Professor Dr Uwe Pühse, University of Basel, being interviewed by a national radio station.

Alumni Events

The objective of alumni and networking events is to foster ties and exchanges among Swiss and South African researchers who are, or have been, active in collaborative Swiss-South African research projects. The focus falls on:

- Swiss researchers active in South Africa
- South African researchers working on Swiss-South African research projects
- South African students who had previously received a Swiss scholarship
- Representatives from South African institutions active in the SSJARP.

The first SSAJRP alumni event was held in 2012, followed by another two: one in Gauteng on 14 November 2013 and in Cape Town on 4 December 2013. The alumni events were successful, with over 120 alumni and partners attending. Another successful alumni event was held in 2014, and in 2016 the alumni event took the form of a workshop in collaboration with the NRF and the DST, which focused on the SSABDP.

The SSABDP constantly strives to bring the successes and challenges of the programme to a wider audience. A workshop titled "Swiss-South Africa Celebrating Innovation Success" was held at the CSIR International Convention Centre on 29 June 2016 at which the SSABDP successfully hosted 150 participants. The event was co-hosted with TIA and the NRF.

The Antarctic Circumnavigation Expedition (ACE) Project

The Embassy of Switzerland in South Africa teamed up with the Swiss Polar Institute for the Antarctic Circumnavigation Expedition (ACE) to ensure a safe departure in December 2016 and a warm welcome back in March 2017. The ACE project, which ran under the motto "Science has no borders", offered teams of distinguished scientists from more than 30 countries, including South Africa, an outstanding and unique opportunity to study the marine and terrestrial environment of the sub-Antarctic ecosystem.

It was the first expedition of the newly established Swiss Polar Institute (SPI), which specially chartered the research vessel and icebreaker *Akademik Treshnikov* for this occasion. The SPI is a consortium consisting of the Swiss Federal Institute of Technology in Lausanne (EPFL), ETH Zurich, the University of Bern and the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL) and was cofounded with Editions Paulsen. While it will take years for the different teams of researchers to fully analyse the gathered data, the expedition can already be labelled as a great success. ACE will definitely contribute to a better understanding of the climate change in Antarctica and the Southern Ocean. The Polar Regions are affected by climate change more than any other region on Earth and they play a key role as climate factors by providing oceans with strong underwater streams from the poles to the equator.

Together with the Consulate General in Cape Town, the SPI and Presence Switzerland, the Swiss Embassy led an information campaign in Cape Town about the relevance of polar research in general, the excellence of Swiss polar research and the ACE project in particular. While the "House of Switzerland", located in the midst of the V&A Waterfront, hosted an exhibition on ACE and polar research, the Embassy organised different events on and around the ACE ship for VIPs, underprivileged youths and the broad public.

Polar explorer Frederik Paulsen is proud to be involved in this initiative: "The Swiss Polar Institute will help drive research in extreme environments, contribute to progress in the field of polar science and promote cooperation among public and academic institutions, industry and private-sector partners."

The Swiss ketch,
Fleur de Passion.

Photograph courtesy of Foundation Pacifique

Fleur de Passion

The 33m-long Swiss research vessel *Fleur de Passion* is an old German World War II navy minesweeper that has been disarmed and redesigned for scientific research. The *Fleur de Passion* reached Durban Harbour on 6 October 2018 where it was docked until mid-November 2018. From November to mid-February 2019 it will be docked in Cape Town Harbour. The vessel and its crew are on a four-year Ocean Mapping Expedition around the world, tracing the footsteps of Ferdinand Magellan from the 16th Century but now measuring the impact of humans on the oceans and raising awareness for sustainable development. The Ocean Mapping Expedition focusses on four scientific domains – micro plastic, noise and air pollution as well as climate change – in collaboration with Swiss universities. In Durban, the crew was welcomed by a mayoral reception and representation from the Swiss community located in Durban. Scientific crew on the ship also attended a two-day workshop on noise and air pollution as well as climate change. The Cape Town leg will focus on the collaboration between the University of Geneva and UCT with the *Fleur de Passion* as a catalyst to deepen the collaboration.

Inter-Institutional Collaboration

An integral role of the Leading Houses and the Swiss Embassy is to deepen the Swiss-South Africa collaborations beyond the joint research projects in the SSAJRP. This is done through academic delegations, dialogue platforms, alumni events, university outreach and networking events. These instruments often result in outcomes such as institutional agreements, new partnerships, joint research projects and joint teaching degrees.

University Outreach

Photograph courtesy of Wits University

Visit to University of the Witwatersrand in 2015.

Establishing collaboration between Swiss and South African institutes of higher education remains a key objective of the SSAJRP. In 2014, the Swiss Embassy and the NRF undertook a joint roadshow to universities in the Western Cape to promote the SSAJRP as well as the Swiss scholarships. The Swiss Embassy has also undertaken numerous visits to the comprehensive universities and previously disadvantaged universities, such as Fort Hare, Venda and Limpopo.

Swiss experts often present lectures at South African universities during their visits to South Africa. Examples include Prof Edwin Constable from the University of Basel who presented a guest lecture at the Nelson Mandela Metropolitan University (NMMU) in 2017, and Prof Stephanie Clarke who presented on neurosciences at the ASSAf international lecture series on 28 September 2018 at UCT. Prof Clarke's presentation was followed by a workshop the following day to develop the framework for future collaboration as well as a joint proposal for the NRF Knowledge Interface and Collaboration grant.

The Establishment of Institutional Agreements

Photograph courtesy of Stellenbosch University

Prof Lino Guzzella, Rector of ETHZ, and Prof Leopoldt van Huyssteen, acting Rector and Vice-Chancellor of Stellenbosch University, at the signing of the Food Security research agreement.

In addition to the activities supported under the SSAJRP, institutional collaboration has been growing steadily between Switzerland and South Africa over the last two decades, demonstrating the keenness for scientific and technological exchanges among the researchers from both countries. For example, the HSRC concluded an agreement in Social Science with the University of Basel in 2014; Stellenbosch University and ETH Zurich concluded an agreement in Food Security, also in 2014 and the University of Basel and ETH Zurich concluded agreements with UCT in the domain of African Studies.

In response to why ETH Zurich has forged a Food Security research agreement in Africa, the institution emphasised that it "seeks strategic international collaborations that align with its expertise and advance its research and educational interests, while contributing to solving some of the world's biggest challenges," according to Prof Lino Guzzella, Rector of the ETH Zurich. "Stellenbosch, a well-established research-intensive university, ranks highly in the region and values international quality standards. Most importantly for the Swiss, it opens wider a network to African scholars and connections to other countries within the region."

Collaboration with Swiss universities on capacity building and training would be explored with the University at PhD level. As Swiss scholarships exclude travel costs, it was agreed that co-funding opportunities with the NRF would need to be explored.

A highlight of the Swiss Embassy's support for institutional agreements was the visit of the Director-General of the Swiss Federal Office of Agriculture, Prof Bernard Lehmann. He visited South Africa in 2017 with the view to establish collaboration between Agroscope and the South African Agriculture Research Council (ARC).

During the visit a number of areas were prioritised, which guided the follow-up steps. It was agreed to focus on:

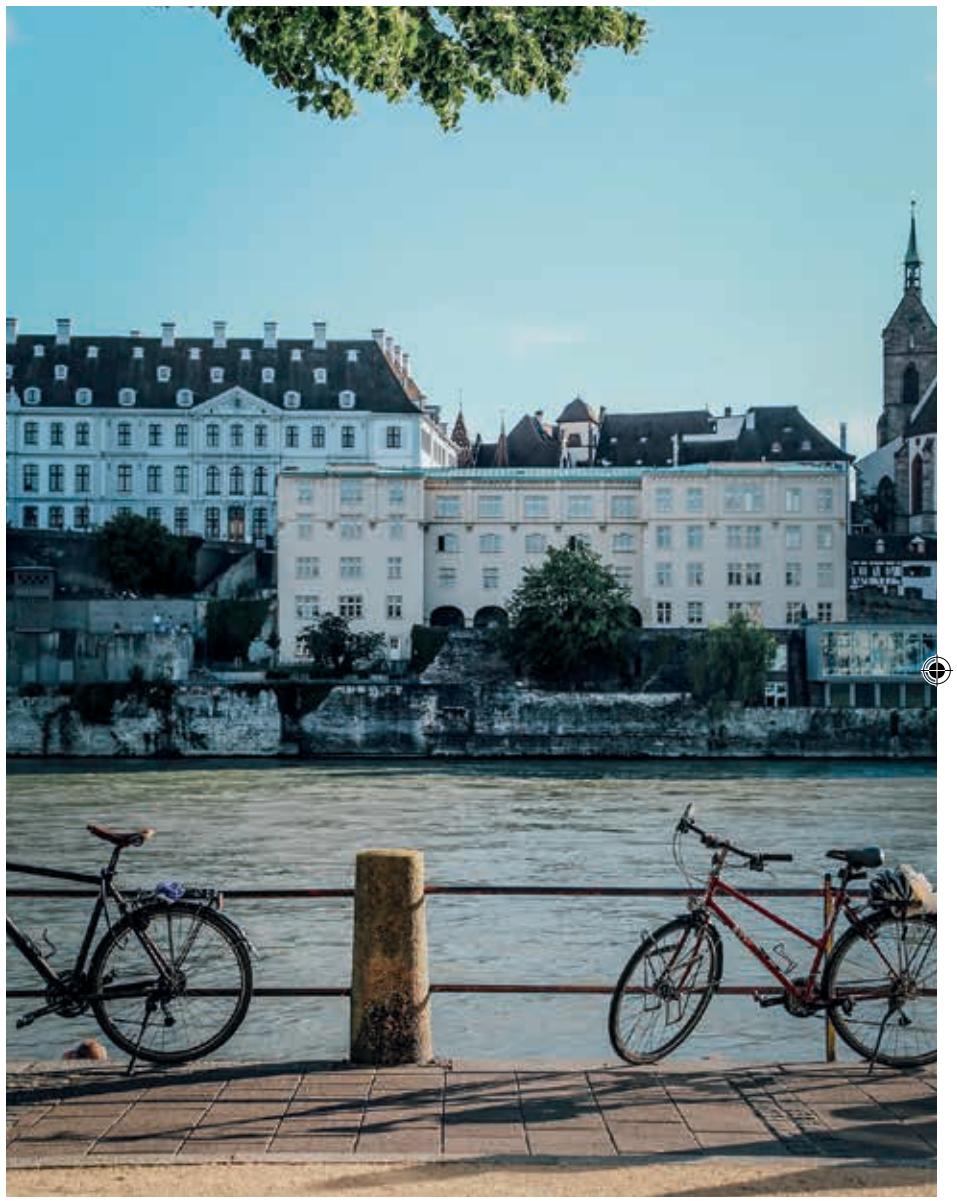
- Economic modelling to support smallholder farmers and add value to small enterprises (linked to land reform),
- Climate monitoring and modelling to develop decision-making support systems,
- Integrated pest management and biocontrol,
- Sustainable plant production systems, and
- Forages and rangeland utilisation and management.

Besides encouraging the exchange of scientists and technicians for capacity building and collaborating at international forums or on international projects, it was also agreed to work on development projects in Africa. The Swiss Embassy would share a list of ongoing projects in Africa to explore possibilities for ARC's involvement, and the ARC drafted an MoU for consideration.

Joint Degrees Collaboration

Photograph courtesy of UCT

University of Cape Town.



Photograph courtesy of Abi Hinchley on Unsplash

University of Basel.

Interactions between high-level delegations from the University of Basel and UCT led to a joint initiative to launch the master's degree in Critical Urbanism in September 2017. The course focusses on three state-driven housing development initiatives located in Paris, Abidjan and Cape Town. The aim of the course is to explore the role of national policy-making, local histories, social and ethnic dynamics, architecture and technology and transnational development in shaping the successes and failures of housing. The master's course provides for a semester of study and research at UCT supported by the UCT-University of Basel professorship at the African Centre for Cities. The joint collaboration is well under way and from 8-10 April 2018, students and staff of "Critical Urbanism" came together for an intensive research design workshop, where students were guided in developing their individual research strategies for their upcoming master's thesis research.

9 SWISS-SOUTH AFRICAN BUSINESS DEVELOPMENT PROGRAMME

The Science to Market (S2M) concept has worked exceptionally well for Switzerland and other OECD countries. S2M is planned, resourced and implemented along the "innovation chain", which is embedded in the Science Technology Innovation (STI) landscape supported by high-tech and industrialisation policies of these countries.

The creation of the Technology Innovation Agency (TIA) by an Act of Parliament in 2008 was a significant milestone in advancing the objectives of the NSI as proposed in the Science and Technology White Paper (1996).

During the first joint SSAJRP committee meeting in 2008, innovation was placed firmly on the agenda as an objective. This led to a number of initiatives, which resulted in the establishment of the Swiss-South African Business Development Programme (SSABDP) in partnership with the TIA and the Swiss Leading House, in 2010. The programme is implemented annually over three phases: Phase I is the basic course and fully funded by TIA; this is followed by Phase II, the advanced course, with costs shared between the Swiss Leading House and TIA; and, lastly, Phase III, is the Swiss Summer School hosted in Switzerland. The costs of Phase III are also shared between TIA and the Swiss Leading House. The SSABDP contributes to TIA's objectives of the Next Generation 100 Programme, which aims to encourage the establishment of technology start-ups. Beyond the SSABDP are initiatives such as the Innovation Challenges and the Swiss Academia Industry Training Programme. Key to the Swiss-South Africa Science to Market outlook is the innovation stemming from the joint research projects.

Swiss-South Africa Business Development Programme (SSABDP)

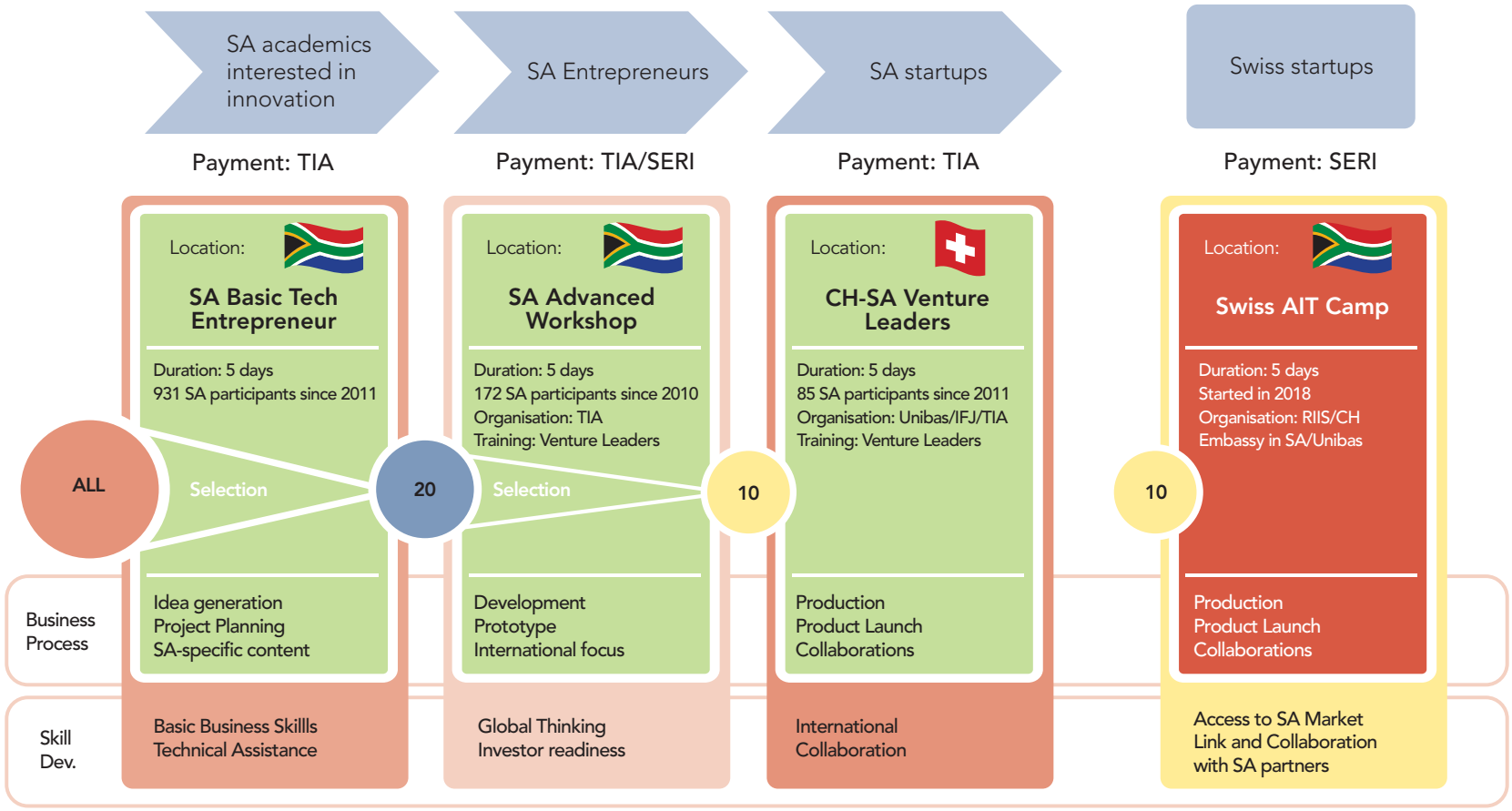


Illustration by Hedwig Kaiser, University of Basel.

Bringing innovation to market requires more than just a good idea or expert research. Launching a successful start-up depends on an understanding of topics such as intellectual property law, financing opportunities, business model dynamics and product development strategies. The launch of the SSABDP in September 2010 gave effect to the notion of innovation to market. An important milestone of the SSABDP was the partnership that was established between the University of Basel as the Swiss Leading House and TIA in 2011.

The SSABDP brings together emerging entrepreneurs from Switzerland and South Africa with the aim of nurturing an innovative spirit and of creating business networks across continents. The cycle commences in South Africa with the three-day SSAJRP Advanced Workshop and continues with the Swiss-South African Venture Leaders Week in Switzerland a few months later. It is a framework that provides motivation, entrepreneurial know-how and support to scientists while strengthening links and cooperation between the industries of South Africa and Switzerland.

SSABDP 2015 Advanced Workshop in Cape Town with Dorina Kühner and Hedwig Kaiser from the University of Basel, Switzerland, in front.

Photograph courtesy of Veronica de Bruyn

Since 2010, the SSABDP has trained 931 entrepreneurs in South Africa of whom 172 participated in the SA Advanced Workshop and 85 participated in the Swiss-South Africa Venture Leaders Programme.

In 2018, the Swiss Academia Industry Training (AIT) programme was added to the SSABDP. The AIT aims to connect scientists from top institutions in Switzerland with India, Brazil and South Africa, to promote an international network and enable access to promising markets and intellectual capital in applied research. The 10 Swiss entrepreneurs who attended a one-week market discovery programme in Cape Town, which ran parallel to the SSABDP Advanced Workshop, gained commendable experience in the South African business environment. The programme included workshops with local business experts, company visits and sessions with the South African start-ups.

Of the 85 entrepreneurs who reached the Venture Leader phase, 59% are still in business and a number of them were very successful in raising funding for their ventures. The start-ups raised more than R250 million by the end of 2017, of which 30 received funding from TIA and 17 raised funding from other institutions in the NSI. Two of the start-ups raised international venture capital investment and were invited to join venture capital accelerator programmes in South Africa.

Drivers of the SSABDP

The **Department of Science and Technology (DST)** has placed Science to Market high on the policy agenda, firstly with the Ten-Year Innovation Plan that was established in 2008 and with the new Draft Policy on Science, Technology and Innovation launched in September 2018. The main objective of the new policy is for South Africa to benefit from science, technology and innovation leading to economic growth, social development and transformation. The new Draft Policy places South Africa on a readiness alert not only for the 4th Industrial Revolution but also to deepen existing strengths in scientific areas such as ICT and localise resources, which is only possible through robust innovation. Recognising innovation as a catalyst for economic growth, societal benefit and job creation, the DST remains committed to supporting the NSI and their local and international partners in taking scientific output to market. The DST plays an enabling role in the SSABDP, ensuring that the necessary resources are available for the successful implementation of the programme by the designated agency, the Technology Innovation Agency (TIA).

The Technology Innovation Agency (TIA) is a national public entity that serves as the key institutional intervention to bridge the innovation chasm between research and development – from higher education institutions, science councils, public entities and the private sector – and commercialisation. The TIA Act established the TIA with the objective of "… stimulating and intensifying technological innovation in order to improve economic growth and the quality of life of all South Africans by developing and exploiting technological innovations". In giving effect to this objective, TIA recognises that it must straddle the gap between scientific research on the one end, where scientific or technological ideas originate, and established businesses on the other end.

The SSABDP falls under the Next Generation 100 Programme within the Innovation Skills Development Programme of the TIA. The Innovation Skills Development Programme aims to stimulate a culture of innovation thinking within the NSI, thus increasing the rate at which innovative ideas are translated into novel technologies, product and services. The programme provides focused and targeted training interventions to strengthen the entrepreneurial capacity of researchers and innovators to commercialise their research outputs. Next Generation 100 makes an impact by turning theoretical research and innovation into succesful technology opportunities. TIA is responsible for the organisation, facilitation and management of the SSABDP in South Africa.

The **State Secretary for Education Research and Innovation (SERI)** provides support for the SSABDP through the Swiss Embassy in Pretoria. The Swiss Embassy aims to enhance the innovation networks, linking entrepreneurs with the Swiss business community in South Africa, ensure ongoing interactions among the entrepreneurs and support the Swiss Leading House in organising the SSABDP. Recently, the Swiss Embassy has taken on the role of project management for the Swiss Academia and Industry Training programme that was launched in 2018. In this role the Swiss Embassy ensures targeted academia and industry meetings for the Swiss entrepreneurs where they explore potential market interest and/or the enhancement of their innovation through joint collaboration. The University of Basel received the mandate to implement the SSABDP on the Swiss side since 2008 and has been initiating focused academia-industry activities. Founded in 1460, the University of Basel is the oldest university in Switzerland and has a history of success going back over 550 years. Other programmes, even though not bilateral contributes significantly to the strengthening of Innovation collaboration between Switzerland and South Africa:

The University of Basel organises the SSABDP on the Swiss side. Thanks to its international reputation of outstanding achievements in research and teaching and its close ties to Africa, it received the mandate as Leading House for the SSAJRP in 2008 and has been initiating focused academia-industry activities.

Venturelab (Institute for Young Entrepreneurs) originally started in 2004 as a national start-up training programme mandated by the Swiss confederation to the IFJ Institute for Young Entrepreneurs, a company founded in 1989. IFJ further offers starting entrepreneurs an easy and efficient online incorporation service, online guides and checklists, courses, and business events. Together with successful founders, key academic and industry partners, Venturelab Ltd designs and operates programmes to bring the best startup talents to the next level of development. Its core mission is to support entrepreneurs to successfully raise funds and grow their business throughout their companies' evolution. Programmes include Innosuisse training, the Swiss national startup training programme that runs over 50 courses lasting five days for business creation and business growth; Venture Kick, a privately funded seed fund that has supported over 600 high-tech projects in the past 11 years, resulting in more than 450 incorporated companies that have cumulatively raised over CHF 2 billion of investment; and Venture Leaders, which offers international roadshows for startups to support them on their global expansion path.

The South African Venture Leaders

Although the SSABDP was initiated in 2011, the Swiss South Africa Pitch Battle was only introduced in 2014 for the participants of the SSABDP with the following results:

- In 2014, Swiss SA Venture Leaders took three of the five finalist spots and one was a winner at the Google PitchFest in Zurich. The South Africans competed against 31 Swiss Boston Venturelab and Swiss China Venturelab groups. Marlize Holtzhauzen walked away with top honours for her mobile app for emergency situations. The app activates the emergency services and notifies the families of the persons involved in the emergency situation. Rapid Response, one of the participants, went on to partner with ER24 (SA's biggest emergency response company), linked to the MediClinic hospitals. The organisation then signed contracts with Huawei and TomTom. Two fellow South Africans, Drew van der Riet (University of KwaZulu-Natal: Advanced Prosthetics Engineering), and Gavin Jones (a technology commercialisation practitioner working on the rehabilitation of stroke patients), also made it to the top five.
- The Google PitchFest, which took place in Zurich in 2015, saw 13 South African entrepreneurs compete against Swiss start-ups from the Swiss Venture Leaders programme. The SA Venture Leaders won five of the six finalists' spots and took the honours of the winning pitch.
- In 2016, the PitchFest was organised at startup space for the first time. Ten SA Venture Leaders and 10 Swiss start-ups pitched their projects to an audience of 40 guests with an expert jury of four from large Swiss companies. The winner was Moses Kebalepile for his project Asthma Grid.
- In 2017, the PitchFest was again a major networking opportunity and a great visibility event for the 10 South African Venture Leaders and the 10 Swiss start-ups who pitched their projects to an audience of 45 guests. The winner was South African Venture Leader, Ian de Vries, with BalanCell, an energy battery management solution.
- In 2018, the winner of the PitchFest was Murendeni Mafumo for his project Kusini Water, which locally manufactures low-cost, high-quality water filtration systems that use Macadamia nut shells as carbon filter as well as nanofibre membranes.

2011 - 2018

These success stories represent the power of science and innovation in ordinary lives and make science so relevant for our society. I am proud of our winners, they represent a new generation of knowledge workers that is being produced through our investment in the creation of a National System of Innovation."

Minister of Science and Technology, Naledi Pandor

2011 Venture Leaders

Photograph courtesy of Venture Leaders Team

Venture Leaders 2011

KYLE GOETSCH

Lab39

In vitro cell models are being used for drug discovery and screening within the biotech and pharmaceutical community. However, many of the cellular assays use cell lines or tumour-derived cells that are "abnormal" and differ substantially from *in vivo* tissue. As a result, data derived from these models are often difficult to translate into animal and human drug trials, which contributes to the current high attrition rate of drug trials. The model developed in 2011 involved the use of both animal and human stem cells to bioengineer functional 3D skeletal muscle *in vitro*. Minimal modifications to stem cells are made prior to *in vitro* tissue formation. Mechanical and electrical systems for muscle stimulation are also being developed to ensure optimal skeletal muscle formation.

JOHANN GÖRGENS

Stellenbosch University, Cellulosic ethanol

Stellenbosch Biomass Technologies (SBMT) aimed to produce bioethanol from cellulosic material and to develop process technologies for local feedstocks. On 2 July 2010, *Engineering News* reported that cellulosic ethanol can be used in the production of second-generation biofuels from non-food lignocellulosic plant material sources, including wood and agricultural residue such as sugarcane bagasse. The value of this innovation is that the technology could be custom-made for local feedstocks and thereby unlock the value from underutilised lignocellulose. SBMT was launched in 2010 and participated in the SSABDP in 2011. A provisional patent was filed in 2014. Innovus, the innovation hub at Stellenbosch University, reported that the invention is a major step towards the large-scale production of ethanol from plant biomass and will put South Africa at the forefront of alternative fuel creation.

ROLENE BAUER

New-generation carbohydrate-based conjugate vaccines for viral infection and thrombotic disease

Dr Rolene Bauer is taking nanotechnology to new depths – of the ocean, that is. Her research, which probes the fascinating world of marine life, is targeted at finding prospective drug candidates from marine algae. In work that cuts across several disciplines, combining molecular biology with chemistry and high-resolution imaging coupled with nanoscience and nanotechnology approaches, her research could hold the key to harvesting new antimicrobials and other bioactive compounds from the deep. Her research makes extensive use of nanoparticles to study the mechanism of action of new molecules isolated from algae. Crucially, Dr Bauer's work also entails creating platforms to cultivate algae, part of a larger programme of research aimed at promoting the development of an algal bio-based industry in South Africa.

MAUREEN LOUW

HaloBiologix

This bio-manufacturing company focuses on recombinant therapeutic peptides for the generic market with a reduced cost (10-30 times cheaper to manufacture). It is able to offer affordable, effective therapeutic peptide drugs for developing countries. This technology can be applied to generic production of highly effective pharmaceutical peptides; antigenic peptides for vaccine development; antimicrobial peptides as topical antibiotics; and antiviral precursor peptides for antiretroviral therapy.

2011 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

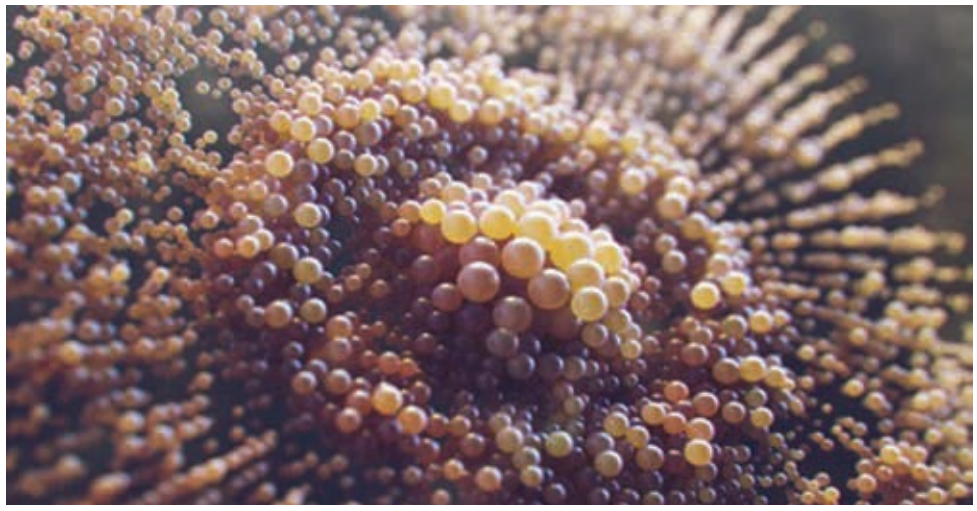
ANNE GROBLER

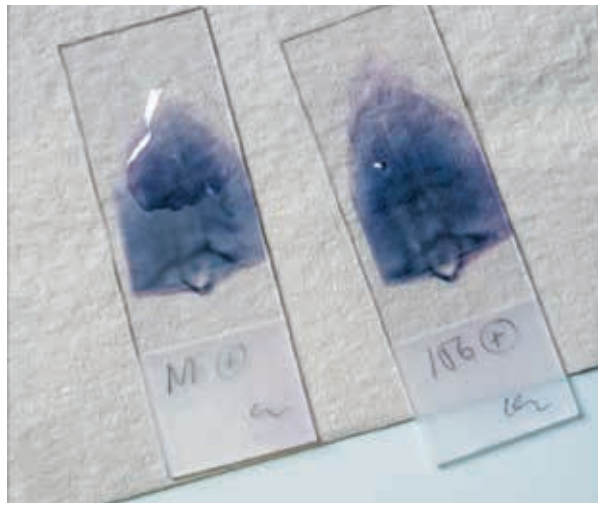
Enabling effective use of chemicals and biologicals through the use of bio-responsive Pheroid technology (Phertech).

This initiative aims to exploit Pheroid™ technology as a platform to administer and deliver active pharmaceutical ingredients (APIs), agricultural remedies and biologicals. This is done by entrapping the compounds/ molecules in the novel Pheroid-M carrier system reformulating this delivery vehicle into innovative dosage and administration forms and commercialising the developed products.

Anne Grobler, Director of the Preclinical Drug Development Platform South Africa and professor for Pharmacology at North-West University, is already leading her second joint research programme with scientists from Switzerland and South Africa. She participated in the inaugural Venture Leaders programme in 2011. Her experience in taking part in the 2011 SSABDP completely changed how she thought about her responsibility as a scientist and how she views her scientific results. She said that the SSABDP porgramme really opened her eyes to the importance of making the transition from science to market.

"Back then, one of the mentors asked me directly: 'Do you want to do business or don't you? First, you have to make that decision.' So I made the decision and that business has since flourished and we are today exporting our drug delivery system customised for plants to China, Namibia, Zambia and Turkey, among others. When it comes to commercialising biotechnology, South Africa can learn a lot from Switzerland – the Swiss are just incredibly good at it."





Photographs courtesy of Anne Grobler

2012 Venture Leaders

Photograph courtesy of Karen Eksteen

Venture Leaders 2012

NCEBAKAZI GALADA

Biophytoceutics© Labs

The innovation sought to exploit the rich biodiversity of indigenous medicinal plants by extracting bioactive compounds for drug discovery, the development and manufacturing of new and/or improved medicines, and pharmaceutical products using multidisciplinary scientific and indigenous methods. Ncebakazi works at the National Advisory Council on Innovation in Pretoria.

MAGDALENA MEUSBURGER

Patty: Genetic Test

This innovation aimed to develop a rapid paternity test through a point-of-care system for genetic analysis. The new technology aimed to be fast, accurate and affordable. The innovator, Dr Magdalena Meusburger, aimed to enter the paternity testing market in 2014. Her main reason for entering the SSABDP was to learn how to translate the idea into a convincing strategy, to network with entrepreneurs in Switzerland, and for personal development.

2012 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

FANUS VAN WYK

Agreenco Environmental: Bio-capping technology

Agreenco specialises in the remediation of mine soils and mine water, and also provides associated dust suppression solutions to the mining industry. Industrial waste stockpiles (such as mine tailings) are notorious for dust problems, which affect human and environmental health. The aim of the innovation is to develop the value chain service offering for a commercial biological dust suppression product (using soil algae and associated triggers) to apply to dusty sites. The dust suppressant is a combination of polymer and soil organisms with added nano-fibres, which provide additional durability to the product. It is applied to ground mine ore to stop dust emanating from the surface and this protects the surrounding communities and environment. Agreenco has since branched out into a number of sectors and industries, providing innovative solutions for a sustainable planet.

MARY MOGASHOA

ADVANze Biotech

The innovation aimed to provide novel antimicrobial compounds that could inhibit antibiotic drug-resistant micro-organisms and develop potent drugs for neglected diseases. The business model is based on a spinoff company or suitable special purpose vehicle approach to be developed at the University of Limpopo with other collaborative partners. This entity will commercialise products emanating from the University's research activities, in particular indigenous knowledge and biodiversity. Dr Mary Mogashoa remains active in the research and development sector as a lecturer at the University.

MIRABEL NYAMBOLI

Nanomedicine-based drug delivery systems for poverty-related diseases

The innovation aimed to develop nanomedicine-based, targeted drug delivery systems, to address the inadequate therapeutic management of poverty-related diseases like tuberculosis and malaria, by improving undesirable characteristics such as poor drug bio-availability, safety and efficacy. The aim was for the innovation to provide drug delivery systems that could efficiently release the drugs, at the right dose, place and time, anywhere in the body, with accuracy and precision. This could help patients adhere to treatment, result in better treatment outcomes, and reduce costs of disease prevention and treatment programmes.

GUY REGNARD

CryoCloud

Storing laboratory-generated samples can become a challenge if not effectively and efficiently managed. That is exactly the aim of CryoCloud, which caters for small/medium laboratories. The innovation aimed to provide an online database combined with the collection and storage of biological samples. The customer will interact with their biological collection online and can request samples for preparation and delivery the following day.

WENLONG CHEN

Karyonome Diagnostics

Karyonome Diagnostics aimed to provide specialised molecular genetics diagnostic services for cancer. Cancer is a disease of genetics and, by understanding the genetic aetiologies of cancer, patients can benefit from better treatment plans to ensure a better prognosis. In South Africa this service is extremely limited and very expensive. Karyonome Diagnostics aimed to change this by making this specialised service readily available and affordable to the public. In 2012, Karyonome Diagnostics estimated a market opportunity of around 80 000 clients per annum.

2013 Venture Leaders

Photograph courtesy of Karen Eksteen

Venture Leaders 2013

DAVE PONS

Agribiotech

Agribiotech manufactures a new-generation insecticide that uses fungi to kill insects, which reduces the toxin content of fruit and vegetables and results in better yields. The secondary aim of the company is to register a non-toxic method of controlling household pests such as flies, bed bugs and cockroaches. Dave Pons has since sold AgriBio to a Dutch competitor and has started another project "Ceiling in a Can" that offers a DIY, low-cost solution to affordable housing. For his next venture Dave received TIA Seed Funding to develop it further. Dave was a winner at the 2014 Global Cleantech Innovation Programme South Africa Awards in the Innovation for Social Impact section of the Special Awards category.

CHRIS RAFAEL

Winetecdirect

These stainless steel wine barrels have a mesh cartridge installed into the centre of the barrel. The cartridge contains oak wood chips and other ingredients to allow traditional fermentation to take place without the use of oak barrels. The system reduces the facile evaporation of the wine from the barrels; requires less wood to impart the same flavour in the wine (higher surface area); and the wood cartridges can be used in other industries such as brandy and sherry. The cartridges can be customised to the needs of the winemaker ensuring they are still able to impart the correct character to the wine by varying the recipe of ingredients used.

BURT RODRIGUEZ

BioDx

BioDx aims to reduce society's dependence on synthetic chemicals by harnessing the power of biotechnology, and enabling a better and healthier world. The company has raised more than R50m to date and has done successful field trials with Eskom. The company also has a Supply and Distribution Agreement with Westerblend (Netherlands). While previous generations of disinfectants and preservative solutions

Photograph courtesy of Venture Leaders

Jordi Montserrat from Venturelab, Burt Rodriquez from BioDx and Dorina Kühner from the University of Basel.

have often relied on synthetic chemical solutions, BioDx has used a natural citrus extract stabilised with an organic biodegradable compound, which contains no chlorine, ethanol or aldehydes. Called DECONT-X™, the formulation is non-corrosive and earth-friendly and rapidly kills 99,9% of many bacteria species.

MAURITZ VENTER

AzarGen

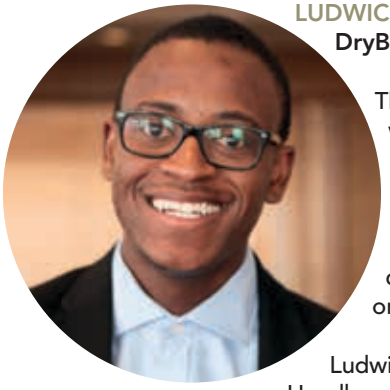
Azargen has received around R60m in funding to date. Milestones for this start-up include:

- A Freedom-to-Operate analysis conducted by one of the world's largest biotech legal advisory firms
- Novel synthetic biological components conferring enhanced protein expression capabilities
- Expression and purification of human target protein on a "proof-of-concept" scale, and
- Provisional patent applications (USPTO and PCT) for several technologies.

"Joining the ranks of a select few hi-tech companies as part of the prestigious Venturelab Swiss Programme, definitely elevated the profile of AzarGen on an international level. Exposure to executives from multinational companies and lessons learned from this programme allowed us to position AzarGen to attract strategic partners and investors. We have been successful in both, and this has allowed AzarGen to become a serious player in the South African and international biotech scene."

Mauritz Venter

2013 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR



Photographs courtesy of DryBath

LUDWICK MARISHANE

DryBath™ Bath-Substituting™ Gel

The DryBath™ product is the world's first Bath-Substituting™ skin gel. The product is applied to unsoiled skin, and acts as an alternative to bathing/showering. The product has been fully developed and is already available on the market.

Ludwick Marishane is the founder of Headboy Industries and the youngest patent-filer in South Africa. He sells close to 90% of his product online to the export market with more than half going to the USA. In 2013, the year that he attended the Venture Leaders Programme, *TIME* magazine named him as one of the 30 people under the age of 30 who are changing the world. He was one of only two Africans on the list.

As far back as Grade 11 Ludwick wanted to innovate and contribute to a societal challenge. He then realised that the shortage of sanitation and hygiene facilities, often an outcome of poverty, could be addressed by an innovation where water was not necessary for health and hygiene. He invented DryBath Gel™ that could remove odour and dead skin cells without a huge amount of water for rinsing. Today, Headboy is focussed on social impact innovation where ideas contribute to social challenges.
During his research, Ludwick found that over 2.5 billion people in the world live without access to clean water which exacerbates sanitation-related diseases. Of these, 450 million are in Africa and five million in South Africa. Notable is Trachoma, a disease that is caused by dirt getting into eyes, that affects 350 million people and leaves eight million permanently blind through recurring infection.

2014 Venture Leaders

Photograph courtesy of Karen Eksteen

Venture Leaders 2014

GAVIN JONES

reScribe

reScribe is a low-cost stroke rehabilitation device that aids handwriting rehabilitation in stroke patients. A functioning prototype is available. It features five actuated degrees-of-freedom on the thumb, index and middle fingers that are needed for a tripod handwriting grip. It fits over the wearer's hand and guides the movement as they trace an image on a computer tablet with a stylus, enabling coordination to be re-learnt.

KHILONA RADIA

Antrum Biotech

Antrum Biotech innovates new technologies in rapid diagnostics for infectious diseases. Their first research project under commercialisation is a point-of-care test based on a key biomarker that has been identified in diagnosing extra-pulmonary tuberculosis (EPTB). The TB test strip provides rapid testing for pleural TB. The test differs from normal lung TB/sputum diagnosis in that it is conducted at the patient's bedside where immediate medication could be prescribed. Today, this innovation is successful and available in the market.

WILLEM BOTHA

Cairo Suspension

Cairo Suspension is a South African innovation that revolutionised suspension systems and brought worldwide safety and profitability to commercial vehicles. It offers solutions that cater for all vehicles under all conditions, including off-road. Their Hydro-Pneumatic Suspension System provides extensive wheel articulation independent of axle articulation, resulting in a comfortable ride with minimum dive and squat.

LESTER DAVIDS

SkinCross™

SkinCross™ is an improved methodology to provide and upscale cloned human skin for direct clinical application to

all procedures that require skin replacement. It has perfected the harvesting and expanded clonal growth of both the upper epidermal skin cells from normal human skin grafts. It has further optimised the inclusion of the pigmenting cells as well as the third cell type, which they believe will help a wound heal more closely and restore the original skin colour with increased flexibility and elasticity. They have also optimised an improved biopolymer, synthetic matrix for the expansion of skin cells.

PHIYANI LEBEA

Point-of-Care Animal Diagnostics (PhiCo Labs)

Foot-and-mouth disease is endemic in the SADC region and therefore these countries cannot export livestock and livestock-derived commodities. The strains that affect these regions are vaguely known and the CSIR has developed the methods to detect them. The point-of-care diagnostics aim to detect viruses of economic importance in livestock. The service included total disease management for a fee to a variety of customer levels, such as government departments.

2014 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

MARLIZE HOLTZHAUSEN

Rapid Response

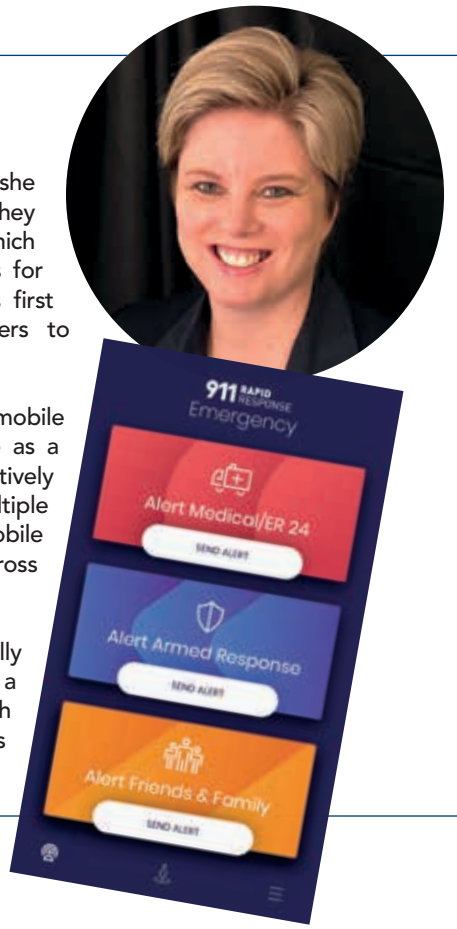
The Rapid Response applications are based on cell phone technology, designed to ensure rapid response from emergency services in the case of crime and emergencies.

Rapid Response was the winner in the International Labour Organization's first enterPrize Job Creation challenge (2013). The business idea was regarded as most innovative in the ICT category and resulted in its founder, Marlize Holtzhausen, winning this award. During the 2014 Swiss-SA Venture Leader programme, Marlize was the winner at the Google PitchFest in Zurich. In 2018, she was in the top three nominations in the Innovation and Impact Category of the MTN Women in ICT: Partnership for Change Awards.

The 911 Rapid Response mobile application was born of a personal traumatic experience. With 15 years of mobile technology and communication experience, Marlize was determined to build a solution that could stop the next family experiencing the same trauma, at just the push of a button. By using existing technologies (mobiles and wearables) to trigger an alert, she now gives people a voice when they can't speak for themselves, which reduces communication barriers for people in need and empowers first responders and family members to help.

The business has evolved from a mobile panic button to a full Software as a Service (SaaS) platform, effectively able to activate alerts in multiple industries, across multiple mobile electronic devices and across platforms.

Marlize's application started locally but is expanding overseas at a rapid rate into Canada, North America, Mexico and Europe as well as 18 African countries.



2015 Venture Leaders

Photograph courtesy of Karen Eksteen

Venture Leaders 2015

CEDRIC SCHEEPERS

Quainted

Quainted is an enterprise social network (ESN) that improves corporate productivity and profitability by addressing and resolving issues with regards to disengaged, unproductive and stressed employees. Quainted focuses on solving human capital issues to the benefit of employer and employee. The week after the 2015 Venture Leader workshop, Cedric pitched to TechnoGym and he was invited to join the H Farm Accelerator in Italy. Quainted received €80 000 (cash investment, incubation and technical partners). During the final phase of the accelerator programme, the Quainted team pitched at the demo day and received equity investment and returned to Europe for the next two years.

GERT-JAN VAN ROOYEN

Custos Media Technologies

The company brings the latest research in media security, management and distribution to content owners and providers. Custos attracted investment of R4m from a private SA investor and the New York-based Digital Currency Group (DCG). Its indie-focused web application, called Screener Copy, was launched commercially and sold as a custom white-label and video-on-demand platform. The company has successfully used the technology to detect and remove clients who were stealing feature film content, and joined forces with Digimarc to start doing ebook protection through its UK-based reseller, Erudition Digital. A US patent for bounty-tracked forensic watermarks

was granted and Custos is launching a document protection service for e-learning platforms.

ISMAIL HASSEN
CSR-Africa

CSR-Africa aims to be known worldwide for its high-tech cleaning, storage and repairing of box, road and tank containers. Bitu-Box, the innovation entered as part of the SSABDP, is a mobile storage or intermodal transport unit (sea, road or rail) for bulk bitumen with an integrated heating system that offers advantages over conventional drums. It allows for faster depot turnaround times with less labour, and eliminates environmental air pollution. Before Bitu-Box, the only solution available was from the Chinese market, which only offered them on a rental or purchase basis.

JEANINE ENGELBRECHT
Azimuth

Mining companies need accurate maps of unstable areas, that are regularly updated, to minimise loss of life and damage to assets. The Azimuth provides maps of unstable areas cheaper, faster and more reliably than can be achieved with current technologies. Azimuth innovation provides information on surface deformation, with current emphasis on mining-induced surface subsidence. Based on satellite imaging technology and underpinned by a mature ICT stack, Azimuth is unique in that, for the first time, continuous operational monitoring over an entire mine licence area can be achieved in a systematic, standardised way, thereby providing early warning capability.

BELINDA BERRY
Chitosan Manufacturing

In 2015, Belinda Berry stated that the chitosan market grows by approximately 16% per annum with the waste material producing a valuable raw material. She proposed the development of a production facility for chitosan produced from various crustacean shells sourced from southern African waters. Chitosan is applied in a wide variety of value-added applications such as water treatment, packaging and trauma care applications. Their chitosan is very low in heavy metals and presents an opportunity to provide the market with sought-after low-level heavy metal chitosan and derivatives.

2015 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

Jordi Montserrat, Bandile Dlabantu and Beat Schillig at the Innovation Summit 2016.

Photograph courtesy of Venute Leaders Team

BANDILE DLABANTU
Khepri Innovations

Khepri Innovations is a cutting-edge biotechnology company established in 2012. It combines principles and technologies from a multitude of spheres, including industrial entomology, engineering, agriculture and biotechnology. By merging such diverse yet specialised expertise, together with fresh entrepreneurial ideas and commercial creativity, the company strives to solve various problems in the agricultural, health and research sectors in an economically viable way.

Khepri Innovations uses technology to convert waste products into high-value products. The team has produced a low-cost method of waste management for food producers and abattoirs and designed a container unit that is able to process organic waste onsite using fly larvae. This method achieves a 40% reduction in waste products and the larvae are converted into low-cost animal feed protein.

Besides being the winner of the 2015 PitchFest, for patenting indigenous knowledge solutions, Bandile won the SAB Social Innovation Award with prize money of R1,2m. He was further selected as one of the three SA finalists of the South African 1776 Challenge, and won the GCIP-SA's winning cleantech innovation for 2017.

"The Swiss programme allowed us the opportunity to restructure our business and to articulate our value proposition. The travel to Switzerland linked us with researchers and other insect-based businesses in Europe. This allowed us to connect better and communicate with potential funders and collaborators. The Swiss programme allowed us to repackage our offering in a way that allowed us to better communicate with our potential clients. The participation and mileage received from the Google PitchFest allowed us to attract funding from TIA and other institutions. We are still realising the benefits from our participation."

Bandile Dlabantu

2016 Venture Leaders

Photograph courtesy of Karen Eksteen

Venture leaders 2016

IPELENG MATHEBULA

Boost Mechanics (Pty) Ltd

This startup company develops internal combustion engine components for aftermarket and Original Equipment Manufacturer (OEM) applications. The scalable products reduce the carbon footprint and operating costs of existing or new engine platforms. Large engines with high-energy densities are still competitive when compared with emerging alternative energy sources. Boost Mechanics is extending the efficiency of these engines to minimise the carbon footprint, reduce operating costs and extend the life expectancy of carbon-based fuel reserves. A patent pending for exhaust venturi developed by Boost Mechanics optimises the use of the turbocharger to reduce fuel consumption.

ROELOF SMIT

AgriPD

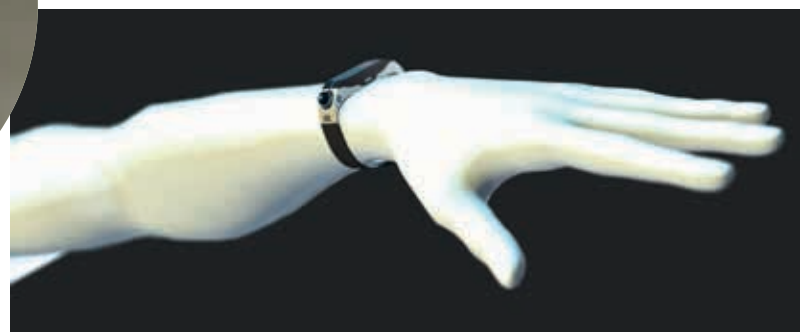
Available natural resources – water and soils – for agriculture are approaching their maximum capacity. Thus, the emphasis will shift from horizontal expansion of land towards vertical improvement of natural resources. AgriPD is undertaking the commercialisation of the EM38MK2 device used to improve the quality of information for soil and water management, which follows the principles of precision farming. AgriPD provides the service to produce soil and water management maps using cutting-edge technology. This technology will manage existing agricultural fields on a spatio-temporal basis to improve water and soil productivity.

SIOBHAN ASHMOLE

Bliss Herbals

Potentially the most underdeveloped industry in South Africa, our traditional medicinal plant trade is nearing crisis. In 2005 there were an estimated 28 million consumers of traditional medicinal plant products, 250 000 traditional healers, 20 000 tons traded per year at an approximate value of R270 million, and a growing international market. Yet, the majority of plants traded come from wild sources, are unsustainably harvested and in dwindling supply. Bliss Herbals is an innovative social-entrepreneurship venture that offers high-quality African botanicals grown ethically and sustainably in their habitat.

2016 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR



MOSES KEBALEPILE
Asthma Grid

Asthma Grid, winner of the 2016 PitchFest, is a wearable diagnostic device that provides clinically diagnosed asthmatics with an early warning of an imminent asthma attack. The technology originated from a PhD research study at the University of Pretoria in South Africa and subsequently led to a researcher exchange programme at the Swiss TPH, an associate Institute of the University of Basel in Switzerland.

Clinically diagnosed asthma patients exhibit different disease patterns and progressions that are caused by differing susceptibilities of biological systems, behavioural patterns and a broad range of environmental parameters. The complex mapping of these divergent parameters makes it difficult for the patient and/or primary caregiver to predict and respond timeously to imminent asthma attacks which regrettably leads to the deaths of approximately 58 500 asthma patients per year, in South Africa alone.

Since 2016, the Asthma Grid technology has evolved from the discovery phase into a prototype zero version that is undergoing clinical trials in South Africa. The clinical trials are evaluating the real-world performance of proprietary Predictive Personalised Models (PPM) algorithms as well as the data acquisition capability of the diagnostic device. The successful execution of the clinical study encompasses evaluating the accuracy of the PPM algorithms for mapping the disease patterns and progression for each asthma patient, and using real-time trigger factors that are measured by the device to issue alerts of imminent asthma attacks.

Kebalepile Technologies and Innovations (KTi) is aiming to advance the development of the wearable device to secure a share of the $4 billion beachhead market in South Africa, with further ambitions of disrupting international markets.

The project also contributed to human capacity development with one PhD African male student attending a conference, an exchange with Swiss TPH, and delivering a presentation. The project registered one provisional patent and established a spinoff company.

A clinical study is running in the Gauteng area, with four patients participating in a technology testing phase. Upon completion of this testing phase, a further iteration of the prototype will be completed. These further development stages are scheduled to begin in January 2019, and will be followed by further testing and certification processes for regulatory compliance. The product will be launched in the South African market, but will soon thereafter be launched in Europe with Switzerland as a soft-landing base. Strong relations with the Innovation Space at the University of Basel have been established, with great exposure to business development, mentorship and guidance on how to do business in Switzerland, and Europe in general.

"The business development programme was critical to validating my work, and this helped develop a strong sense of confidence and a vital belief in what I do. Being selected throughout the stages of the development from the initial stages to the final week in Switzerland also helped me to articulate my business ideas in a clear and consistent manner. Generally, translation of research to commercialisation of a product is a very abstract process, and the business development programme helped me to comprehend the process, and align my thinking with the steps necessary to develop an idea into a technology."
Moses Kebalepile

DAWIE DIAMOND

ARAMI

Expensive industrial assets (steam turbines, railway tracks) and rotating machinery (gearboxes) experience heavy loads and harsh operating conditions during their operation. If left unmaintained, these assets will fail, costing companies massive amounts of money in machine repair, production losses as well as possible loss of human life. ARAMI is commercialising several predictive maintenance and structural vibration measurement techniques developed at the University of Pretoria. ARAMI will provide information to industry regarding the health and optimal maintenance intervals for industry-critical assets through the use of remote vibration monitoring and predictive analytics.

ZUKO MANDLAKAZI

Senso

One of the main impacts of deafness and hearing loss is the individual's inability to communicate with normal hearing people or being able to hear life-saving sounds. The Senso innovation provides a wrist-wearable device and mobile application that communicates sounds to the user through vibration and colour-coded LED lighting. Senso successfully executed the prototype in June 2015 after almost two years of research, development and prototyping.

PASCAL NGIDI

Hlomuka Holdings

The Ngidi Klamper is a first-of-its-kind circumcision device designed to apply the bio-degradable sutures. This will eliminate the need for patients to revisit the hospital to remove the device. All other devices on the market are wearable devices that need to be removed after a week, so patients need to revisit the health facilities, which are already overstretched. The Ngidi Klamper solves that problem as bio-degradable stitches are applied during the procedure and it takes just two miunutes to do. Hlomuka Holdings have produced the prototype, and filed a patent.

Photograph courtesy of Venture Leaders Team

SSABDP Advanced Workshop billboard on William Nicol Drive, Johannesburg.

2017 Venture Leaders

Photograph courtesy of Venture Leaders Team

Venture Leaders 2017

GIFT BHEBHE
Settec (Pty) Ltd
Blockages in pipelines cost the mining industry millions of rands in downtime. Settec Mining and Industrial Solutions (Pty) Ltd, a CSIR spinout, developed and commercialised the Settled Bed Detector (SBD). This instrument detects settlement in pipes and sends information to a system to control the flow rate and avoid this settlement of solids. The SBD's novelty lies in its application of heat to the slurry at the overt of the pipe and using the rate of heat removal as an indicator of motion or stagnation at the invert of a pipeline. Settec services also include the supply of plant, equipment, spares, mine consumables and chemicals to the mining industry.

ANDREW COUDOUNARIS
Onyx Display Media
By using the glass front of display units, Onyx Display Media has solved the problems of displaying high-definition content in a fully stocked cooler-type environment. The technology displays the colour white and is self-illuminating, not relying on any other light source. Onyx's two primary focus areas are to deliver a disruptive and interactive media platform on glass to increase customer attention by up to 140 seconds, resulting in double-digit increases in sales. The second focus area lies in the collection and analysis of customer analytics, as their solution incorporates facial recognition and detection technology that provides for deep learning from big data, as well as intelligent signage that can adapt to the profile of the audience.

SHANA DERMAN
IntelliCred
IntelliCred aspires to create a safe and secure cyberspace by protecting what customers and businesses value most: their brand. They do this by providing a full-service brand protection offering using patented technology which detects, controls, protects and monitors company IDs, brands, images and more. IntelliCred has developed patented technology that is Cloud-based, built on the Windows Azure platform, and is the first of its kind in the world. The innovation addresses global problems of affiliate fraud, phishing, identity theft and copyright infringement.

LINDA MEYER
Mabu Casing Soils (Pty) Ltd
Mabu Casing Soils manufactures an eco-friendly mushroom casing soil for the button mushroom industry. The substrate is produced from sugarcane pith, a waste product of the bagasse paper-making process at Sappi, KwaDukuza. Pith mushroom casing is a 100% natural, cost-effective and eco-friendly substrate that allows for sustainable mushroom growing for the first time ever. Since August 2014, Mabu has been processing substrate on its own 22,8 ha site situated near Bapsfontein in Gauteng. Besides mushroom casing, Mabu started a plant and seedling growing medium development project in 2016.

PORTIA MNGOMEZULU
Portia M Skin Solutions
Portia M Skin Solutions is a skincare brand that researches, manufactures and distributes skincare products suited to the African climate and made from natural African ingredients such as Marula Tree oil. These products for uneven skin tone, dry skin, stretch marks and other skin ailments are supplied to over 700 retail stores countrywide.

Photograph courtesy of Portia M Skin Solutions

Portia Mngomezulu, Portia M Skin Solutions.

2017 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

IAN DE VRIES
Balancell

Photograph courtesy of Ian de Vries

Balancell has developed a comprehensive Battery Management System (BMS) that enables the ability to sell stored battery energy. At the same time it offers cost-effective battery management, maximises reliability and battery life, with online monitoring, smart alerts and analysis. The online monitoring and smart analysis or "AI learning algorithms" all enable effective remote battery maintenance and scheduling thereof. Their ultimate goal and vision is that battery energy storage will help convert the world to renewable energy sources, support the provision of electricity to the last billion people, and thus improve quality of life. Balancell believes that this is already feasible, but the business model for battery energy storage has to change from buying batteries to providing stored energy as a service. Balancell aims to provide the electronics, the communications and the power electronics on batteries that will enable this service, as well as derisk remote ownership and maintenance and make them more useful and cost-effective. Lithium Ferro Phosphate batteries improve dramatically on lead acid battery performance in several areas, including depth of discharge, lifetime (cycles), weight, recharge time and efficiency. Balancell operates across three continents and has many blue-chip companies as customers, including Toyota.

2018 Venture Leaders

Photograph courtesy of Venture Leaders Team

Venture Leaders 2018

FARHAD BHYAT

Farosian

Farosian is a specialist social media company that seeks to help customers better navigate the complexities of social media through staff training and reporting services. The company offers social media screening reporting services that can improve recruiting efforts by increasing the frequency of "first time fit", thereby reducing recruitment costs and improving staff retention. These screening reports can also be used to identify fraudulent insurance claims and streamline processes in the credit bureau market.

AARON CHIU

ION Water

The ION Water Device is the world's first and only non-electrical water ioniser. This simple SABS-tested ionisation device is easily retrofitted onto any tap to control bacterial infection in water and reduce the chemicals used to purify it. This technology is aimed at the healthcare sector in particular, but can be applied to the hospitality industry, private dwellings and educational premises. The company's mission is to provide a better quality of life through quality water by transforming ordinary tap water into ionised and energised water without the need for chemicals or electricity.

SAKHILE DHLAMINI

GAD Group

The Wi-World: Decentralised Data Platform is a mobile application that enables individuals with data to share wi-fi and receive payments for extending the service. This novel application, which can be downloaded onto any electronic device, widens the market, coverage and access of internet wi-fi for frequent business travellers seeking convenience on the road, as well as to lower-income individuals with limited connectivity due to infrastructural and economic challenges. The company's investment thesis is based on the underlying belief that digital assets will reinvent the way business interacts with the world, especially in developing economies, using block chain.

PORTIA MAVHUNGU
PRD Logical Solutions
PRD Logical Solutions is a social innovation company that focuses on ideas that are affordable and available to every economic class and allows everyone an equal chance to face simple daily challenges. It has created the PARA-Tube, a seating device that retrofits into a wheelchair, which has a built-in toilet and biodegradable bags to reduce upper body movement and strain for disabled individuals when using the toilet. Portia Mavhungu and her partner Darushna Chellan received funding from TIA to strengthen their innovation and to establish PRD Logical Solutions. In 2017, PRD Logical Solutions was a finalist in the Gauteng Accelerator Programme and walked away with the top award from among 500 entries.

ROBIN KOOPMAN
Cognitive Systems
The Artificial Mind Engine (AME) is a patented data-agnostic Cognitive Computing and Distributed Artificial Intelligence Engine that can be deployed to, and over, different Internet of Things sensors at the source. AME is able to ingest any data stream and offers seamless and intelligent real-time monitoring of data, objects and environments to empower clients to initiate immediate corrective or preventive actions from alerts and insights. AME mines through complex data to help industries monitor risks, harness opportunities and respond to emergencies.

2018 FLAGSHIP SOUTH AFRICAN ENTREPRENEUR

MURENDENI MAFUMO
Kusini Water

Kusini Water has developed an affordable water purification device that uses locally sourced macadamia nut shells and nanofibres to ensure water is safe to drink at source. The device does not need any electricity and can be plugged into any water supply at home, the office or in the hospitality sector. The filter is modular and can be expanded to supply communities with safe water.

The vision for Kusini Water is to ensure that everyone, regardless of background or location, should have access to quality, safe drinking water. Kusini Water is a black-owned water engineering company with over 10 years' experience in designing home, office and municipal water filters that make use of the latest technology in nano-tech. Murendeni Mafumo from Venda studied at CPUT followed by a career in water management at the City of Cape Town and Johannesburg respectively. He soon realised the need for clean drinking water and decided to explore a solution where he invented the mobile, solar-powered water purification system to provide safe drinking water. The portable system uses rain water and ensures the removal of 99,99% of pathogens and viruses. Kusini Water's business model is based on franchises where the profit is split between Kusini Water and the franchisee. Kusini Water funds 80% of the social franchising and the entrepeneurs have to come up with 20%.

Photograph courtesy of Kusisni Water

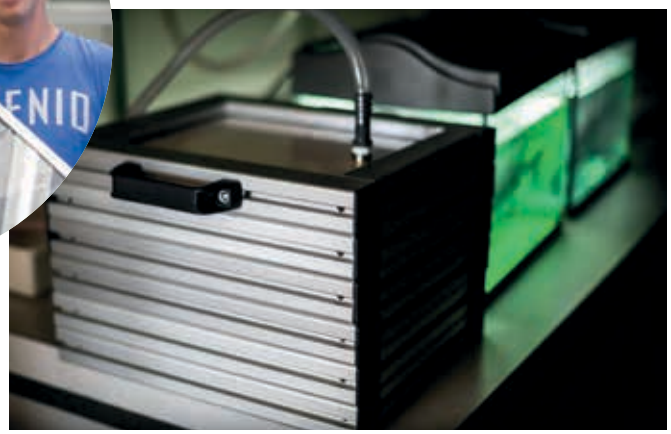
First Swiss Entrepreneurs to South Africa 2016

To ensure best impact and synergies, the Swiss Leading House scheduled the first part of the annual SSABDP Advanced Workshop back-to-back with South africa's largest conference on entrepreneurship and innovation, the Innovation Summit (SAIS 2016). This allowed the five participating Swiss entrepreneurs to join the event. One of the immediate successes was Endre Horváth's solar purification device for water, which received great interest and resulted in a joint collaboration with Stellenbosch University.

SWOXID

SWOXID technology is based on an innovative nanoporous photocatalytic ceramic aerogel composite membrane, which, upon solar irradiation, renders contaminated water safe. It does this by removing and inactivating infectious disease-causing biological agents such as bacteria, viruses, protozoa, worms and persistent bioaccumulative organic water pollutants such as pharmaceuticals, pesticides and endocrine disruptors. The Swoxid device uses sunlight to filter and sterilise contaminated water.

The zero-power, gravity-fed system does not require electricity or chemical agents, while laboratory tests predict that a 1m^2 panel can filter 70 litres of drinking water per day. This amount is equal to the average daily water intake of a small community.



The Swodix solar-thermal water purification panel was developed by researchers at EPFL, Switzerland.

Right: Assessment of the Swodix prototype in South Africa.

Photographs courtesy of Dr Endre Horváth

The project was showcased at the South African Innovation Summit in 2017. The patent-pending solar-thermal water purification panel has been developed at EPFL, and Swoxid came second in the category of "Innovative Research & Development – International Institutions" during the first cycle of the United Arab Emirates' Mohammed bin Rashid Al Maktoum Global Water Awards. "This award helped us finalise the validation process of our cost-effective and sustainable water-purifying solution by independent certified laboratories. It also received endorsements from third parties to distribute it in remote communities," says Dr Endre Horváth, who leads the project.

Along the road of a successful technology transfer, field test evaluation under real conditions is an important milestone. This is now being realised, thanks to the Visiting Fellowship Programme of the Swiss-South African Research Cooperation (SARECO). The first visit and the field tests in collaboration with Stellenbosch University Water Institute (SUWI) started in September 2018. The aim of the field test is to evaluate the sterilisation performance of the prototype filters in real conditions using contaminated, non-potable surface water resources. It will reveal the technology readiness level of Swoxid filtration technology. The short-term project outcome will be a microbiological validation of this technology under real conditions. The gathered data about functionality and operation during the field tests may be the basis of a future certification and approval procedure, ensuring that the future product meets regulatory standards and specifications, such as safety and technical requirements. The long-term outcome may be the successful implementation of Swoxid water filter panels to various drinking water filter units and waste water treatment plants (i.e. persistent and bioactive micropollutant elimination in a cost-effective and sustainable way). This project will provide a step forward for infrastructure improvements aimed at addressing environmental sustainability in water management and at health improvement under extreme poverty.

Note from Dr Endre Horváth to ZKS Foundation after his visit to South Africa: "This is my first time in Africa and this is the first time that I see how serious the water problem can be, especially in rural areas. The prototype made the journey to here, so that people could see and touch it. The interest was enormous.

"I have just come back from Stellenbosch University, where the field tests of the last generation of solar-thermal water filter prototypes started in September. On behalf of the Swoxid project team, I would like to thank you for all your support. There is no doubt about the crucial role the Swiss-South African Joint Research Programme has played in this social entrepreneurship endeavour."

Dr Endre Horváth

FLOWBONE

Flowbone® at the Laboratory of Biomechanical Orthopedics at the EPFL is the first all-in-one therapy specifically adapted for the minimal-invasive treatment of non-loadbearing and difficult-to-access bone defects. It can also be used to reinforce weak bone structures. Flowbone® comes as ready-to-use material in a syringe that can be applied to the human skeleton through small natural and artificial orifices. Another application of Flowbone® is for dental implants, as 10% of the implanted patients suffer from peri-implantitis, an infectious disease of the tissue surrounding the dental implant. Flowbone® can be used as a new drug-eluding biomaterial to repair bone defects caused by peri-implantitis. Flowbone® is a fully biodegradable, injectable biomaterial consisting of a hydrogen-matrix and mineral particles that act as "seeds" for new bone formation and carry an active agent.

SEERVISION

Seervision improves amateur video quality by imitating the rules of professional cameramen and reducing the relative movement of the camera and the target. Seervision was founded in 2016 and stems from research in the field of camera control at the Automatic Control Laboratory of ETH Zurich. Subsequently, the innovation has progressed to the development of software for self-driving cars. Seervision has analysed the motion sequences of cameramen in various scenarios and converted these into video analysis algorithms for real-time object recognition and scene segmentation. With this technology, multi-camera robot setups collaborate and can perform all tasks of traditional camera work autonomously, such that the result of the software-controlled camera can no longer be distinguished from that controlled by a human being. Seervision has innovated the world's first autonomous multi-camera robots for live production. The Seervision robot uses artificial intelligence to bring new levels of accuracy to production while minimising footprint and production costs.

SENSARS

SensArs restores feeling in amputations by targeting the peripheral nervous system through the revolutionary neuroprosthetic device Sensy. The idea behind the innovation is to provide relief to people who have lost a limb, like children who stepped on a mine, or victims of car accidents. Amputees struggle to perform basic manipulation tasks as the prosthesis is a cumbersome foreign body that presents a multitude of challenges, including psychological, which could result in them abandoning the prosthesis. The SensArs innovation restores feeling from the limb by making functionality similar to the healthy limb. Sensy is a unique device that provides the opportunity to "feel" again by restoring the natural-like flow of the neural sensory information. SensArs appeared on 101 innovative health start-ups in Switzerland, received financial support from the Horizon 2020 SME instrument and was listed as one of the best 100 Swiss start-ups.

STERILUX

SteriLux is an innovative solution for sterilising medical instruments in resource-strained environments, thereby decreasing sterilisation costs for hospitals while ensuring total safety and a quality process for every cycle. The goal of SteriLux is to innovate in the production of medical devices. Their patented technology revolutionised the way medical instruments are sterilised by offering an economic and ecological solution. SteriLux offers a unique solution for isolated clinics with limited water and electricity as the Steroxessential product is perfectly adapted to be used in these areas because it is transportable and completely autonomous. Thanks to the patented process using ozone, only one teaspoon (5ml) of water is necessary for a sterilisation cycle.

The Flowbone® project team from left: Dominique Pioletti, Pierre Boffy, Claire Delabarde, Ulrike Kettenberger, Sandra Le Penven, and Dr Martin Broome.

Photographs courtesy of Flowbone

Nestlé as a Swiss Private Company in Social Sciences

'Enhancing quality of life and contributing to a healthier future' is Nestlé's purpose that drives the organization to shape a better world and inspire people to live healthier lives. We bring this purpose to life through our Creating Shared Value business approach.

Creating Shared Value is our way of delivering long-term positive impact for our shareholders and for society. The clear articulation of this approach over a decade ago, helped us to identify, operationalise and manage strategies towards making sure our activities and products make a positive difference to society while contributing to Nestlé's ongoing success. Since then we have made significant progress globally, including:

- Nestlé for Healthier Kids reached 29 million children in 2018. Our ambition is to help 50 million children lead healthier lives by 2030.
- By total sales, 82.5% of our foods and beverages now have Nestlé Nutritional Foundation (NF) status, up from 82.1% in 2017, including 93.1% of our products consumed by children (compared with 92.5% in 2017).
- By the end of 2018, our fortified foods and beverages had reached 106 million children and families in eight countries.
- In 2018, we increased the amount of marketing expenditure on healthier categories by 30% (compared to 2016), to promote healthier cooking, eating and lifestyles among individuals and families.
- Over 26 000 job opportunities were offered to people under the age of 30.
- Nestlé needs YOUth continued to grow, reaching more than 300 partners.
- By 2020: 600 000 beneficiaries in local communities have access to water, sanitation or hygiene projects around our manufacturing facilities and key agricultural supply chains.
- At the end of 2018, 758 604 people around the world were benefiting from our WASH programs, and 316 474 people in local communities given access to clean water and sanitation through our partnership with the IFRC since 2005.

Innovation has a critical role to play in supporting the needs and challenges of our communities. It is also a key driver of economic growth. For example, the need for affordable and nutritious food, sustainable agricultural produce and environmental friendly packaging can be attainable through innovative scientific research and development.

At Nestlé, our goal is to accelerate the innovation of products and services that meet consumer needs and challenges locally. This means adopting a multi-faceted approach by collaborating with key external partners including NGOs, governments, universities and local start-ups to identify sustainable and scalable science and technology solutions.

Nestlé has several initiatives that are aimed at boosting local innovation such as the partnership with Ashoka and the Swiss Agency for Development and Cooperation to create the Social Investment Accelerator, which accelerates social entrepreneurship and boosts economic development of Africa.

Sustainability is also important to us as we aim to develop our business while improving our environmental performance. We want to ensure a more

sustainable supply of natural resources and the raw ingredients that go into making our products. We are also investing our resources in areas such as plant-based alternative proteins, while exploring environmentally friendly packaging solutions for our products. Upstream in our supply chain, our global team of over 1000 agronomists provide training to help our farmers improve their methods to help reduce losses and keep their land healthy and productive.

In South Africa, we have a dedicated agronomist team supporting our commercial & emerging farmers to build capacity on a holistic approach to sustainable production practices to maximise the yield of produce per hectare. The farmers are also supported financially for sustainability projects. An example of one of the tools for capability building is 'The Sustainable Dairy Handbook" developed in collaboration with Conservation South Africa which is provided to all interested parties, free of charge.

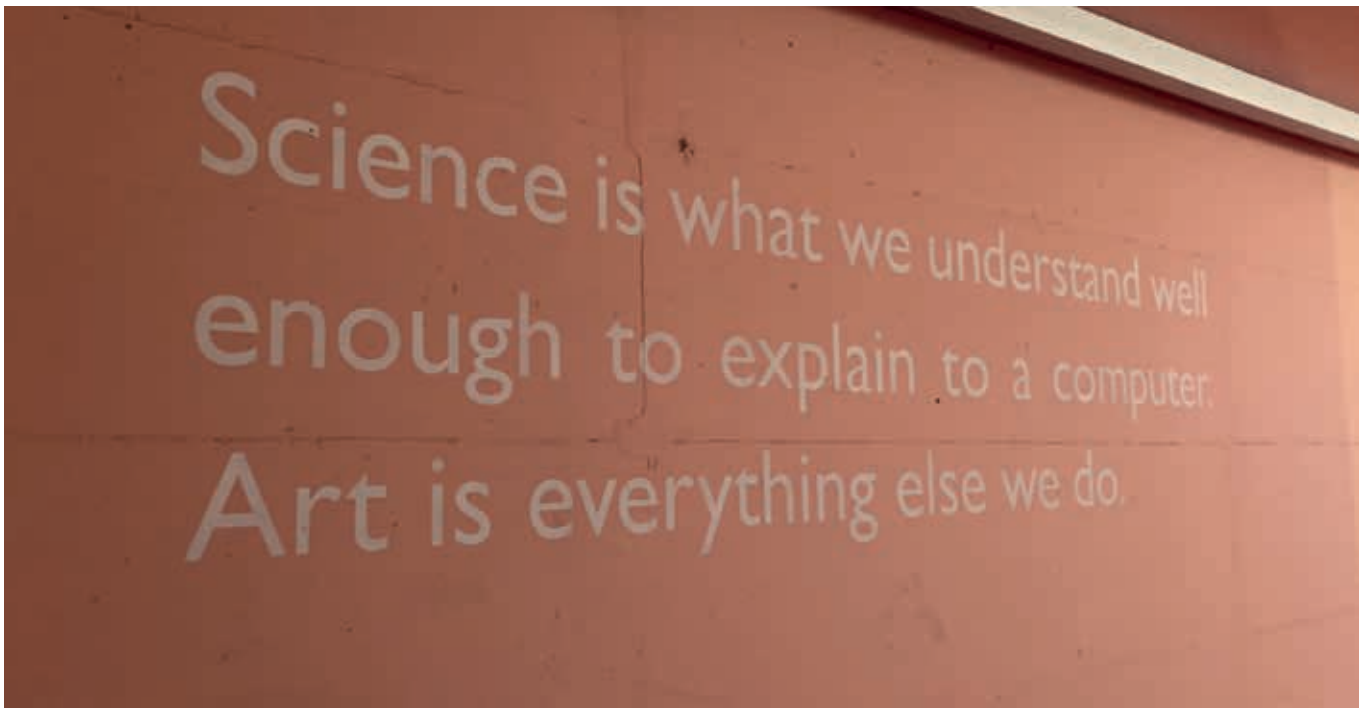
We also continue to play our part in helping to reduce food loss and waste. At our sites, we reduce, reuse and recycle with the ultimate goal of achieving zero waste for disposal at landfill. To date 20% of our operations are at zero waste to landfill with the remainder planned to follow suite within the next 2 years.

To further demonstrate our commitment to an eco-friendly environment, Nestlé recently signed the New Plastic Economy Global Commitment Pact. This has been adapted for Nestlé ESAR focusing on five key deliverables to achieve our 2025 vision that all of our packaging is recyclable or reusable with the ambition that none of our packaging ends up in landfills or as litter.

Swiss Academia Industry Training Programme 2018

In 2018, the Swiss Academia Industry (AIT) Camp was added as part of the SSABDP. By connecting scientists from top institutions in Switzerland and India, Brazil and South Africa, the AIT programme promotes an international network and enables access to one of the most promising markets and intellectual capitals in applied research. Ten Swiss entrepreneurs attended a one-week market discovery programme in Cape Town, which ran in parallel to the SSABDP Advanced Workshop. The programme included workshops with local business experts, company visits and sessions with the South African start-ups. The Swiss and South African start-ups competed with each other at a pitch battle in Cape Town, followed by a 'return' pitch battle in Zurich.

Winners of the 2018 Swiss-South Africa Academia Industry Training Programme



Photograph courtesy of Venute Leadess Team

DANIEL CHIUMA

Chiweto

Chiweto is a low-cost mobile application being developed to allow livestock farmers and the organisations working with them to access data collection and communication services. This allows organisations to improve their monitoring and evaluation of the farming process, and farmers to access information and trade in real time. Access to information is a chronic challenge among livestock farmers and organisations working with them in developing countries such as Malawi. This problem leads to poor extension services delivery to farmers, hence affecting farm production efficiency. Daniel views himself as a serial entrepreneur who is passionate about contributing to sustainable solutions through innovation that leads to societal beneficiation.

ETIENNE JEOFFROY

FenX

Current building thermal insulation materials are energy-consuming, flammable, pollutant, toxic or inefficient. FenX identified a huge need to find robust, environmentally-friendly and economically competitive materials that can efficiently insulate buildings. FenX exploits mineral waste and transforms it into highly porous foams that can be fabricated

OLGA DUBEY
AgroSustain

Dr Jean-Pascal Aribot (co-founder), Dr Olga Dubey (founder) and Dr Sylvian Dubey (co-founder).

Almost half of the fruits, vegetables and cut flowers sold in supermarkets get wasted each year, and a third of these losses are caused by fungal pathogens. Another challenge is the negative impact of fungi on human health induced by, for example, aflatoxin which is a poisonous carcinogen produced by Aspergillus. AgroSustain aims to develop and bring to market efficient organic treatments against broad ranges of plant fungal pathogens that have a strong negative impact on food production worldwide. The natural origin of AgroSustain's products allows them to be used pre- and post-harvest. The broad spectrum of activity and application of their products open up access to four major customer segments: storage facilities in food stores, foresters, gardeners and farmers.

South Africa is the lead market in Africa for the fast-growing and high-potential agri-business sector. Therefore, AgroSustain is exploring the South Africa market in order to conduct a product market validation, get feedback from key stakeholders, (including retailers and potential investors) about the potential of the product, and securing willingness to start collaborating with AgroSustain for a pilot. Long term, providing organic treatments for crop protection is a critical need for South Africa and Africa in general where agriculture has a big role to play in feeding a fast-growing population.

Photographs courtesy of Agrosustain

at ambient temperature, releasing no CO_2 emissions and are 100% recyclable. These foams are marketed to the property development and construction industries as non-flammable insulation products with conventional shapes (panels, bricks) and customised 3D-printed shapes.

SÉVERINE CHARDONNENS
IDUN Technologies

The electrical property between an electrode and skin or tissue is important when the human body is used as a conductive medium for communication performance of the transcutaneous communication system. The electrode needs to be accurate and comfortable in order to provide meaningful data over extended periods of time. Accurate electrodes can only be worn for a short period of time and the comfortable ones do not provide exact data. With stretchable conductive materials, IDUN Technologies now provides a gel-free electrode that has equal signal quality to that of clinical gel electrodes. IDUN Technologies is developing and producing soft and dry conductive electrodes for heart, brain and muscle (ECG, EEG, EMG) biopotential monitoring. These customisable wearable devices provide high-quality signals with skin-friendly materials without electrolyte gel or glue. The company is targeting home monitoring, preventive medicine, sports diagnostic, and brain-computer interface.

ALDO PODESTA
Learn to Forecast (L2F)

There are very few companies capable of designing complex predictive models that leverage on advanced machine learning techniques. L2F, thanks to a team of pure mathematicians, is enhancing the mathematical theory behind big data while pushing the most advanced techniques in predictive analysis into business. The scientific innovation behind L2F is the Topological Data Analysis. They believe that every data set has a shape and that only through the study of such shape are we able to make accurate predictions. L2F's talented mathematicians have a profound understanding of Machine Learning and Algebraic Topology used to create tailor-made predictive models for dynamic pricing, fraud detection, predictive maintenance, algorithmic trading, risk assessment and distribution systems. L2F also maintains a joint research programme with the Laboratory of Topology and Neuroscience at the Ecole Polytechnique Fédérale de Lausanne (EPFL).

AMIN KASIMOV
Oqtor

Creating designs (flyers, brochures, online adverts) is onerous for a lot of businesses as current design solutions are expensive and time-consuming. Oqtor provides an online design tool that uses artificial intelligence. Advanced computer vision algorithms and data scrapping techniques allow them to infer their customer's brand and generate eye-catching branding solutions. This allows companies and individuals to minimise the financial and time costs associated with the design of branding material from initial design to final publishing.

STEFANO GRASSI
Gilytics
Power grid operators (technically called Transmission System Operators – TSOs) still plan new powerlines by hand and they have to go through time-consuming steps to get permits and to communicate with local communities. Gilytics has created an interactive and automated web-platform to quickly identify and compare optimal routes of new linear infrastructures in distributed energy and transport systems. This innovation seeks to improve the interaction between authorities and local communities by combining GIS and satellite data to create 3D visualisations, as well as virtual and augmented reality that can be accessed through mobile devices.

DIMITRIOS TERZIS
MeduSoil
MeduSoil, an EPFL spinoff, has innovated a soil stabilisation solution geared at ensuring long-term stability of structures against earthquakes, landslides, soil erosion and rising sea levels. This technology is an enzyme-based liquid mix, which is introduced in the subsurface and turns soils into stones. The solution can be directly mixed with soils or used with geotextiles. MeduSoil is the world's first soil bio-reinforcement technology mainstream for construction problems. This innovation couples traditional construction practice with lab-developed biochemical carriers to reduce application costs, minimise equipment requirements and increase long-term resistance against failures and environmental threats.

BRUNO AZEVEDO
Thinkmilk
Mastitis is a global issue and plagues dairy cattle worldwide. While milk producers from economically developed countries are used to taking preventive actions to avoid epidemics, smallholder farmers from emerging countries have no money or technology to avoid losses and diseases. Thinkmilk innovated low-cost, automated in-line sensors for dairy cattle breeders to improve the health of the herd (cows, buffaloes, goats) in emerging countries, by getting information on milk substances rate, traces of antibiotics and animal diseases, which assures milk quality comparable to international standards.

South Africa is the most productive (in litres per cow) African country, with large herds (an average of 357 cows per herd) and intensive, relatively low-cost farming and is thus an important market.

GNANLI LANDROU
Oxara
The construction industry is facing major challenges: CO_2 emissions due to cement production, and resources depletion and scarcity due to billions of tons of sand and gravels mined to produce concrete, as well as billions of tons of excavation material earth that is dumped each year. Oxara has developed an innovative cement-free concrete technology that allows construction and recycling companies to produce concrete out of excavation waste from the construction site. This technology is geared towards building low-rise affordable housing while minimising the environmental impact in terms of CO_2 emissions and sand depletion.

By 2050, 2,5 billion affordable homes need to be built especially in Africa, while in South Africa, the government plans to build around 20 million affordable homes. This technology can help support the sustainable development goals in Africa and increase access to affordable housing.

Photographs courtesy of Gnanli Landrou

"In Cape Town, I was challenged to get out of my comfort zone, explore new realities, and understand the main issues such as water scarcity and the housing backlog. Contacts put together by TIA and the Swiss Embassy team helped us to explore strategies to implement the innovation in Cape Town within the South African context. It was a valuable experience that I would recommend to Swiss start-ups with an interest in the African market and South African startup ecosystem. Nevertheless, many aspects could be improved, such as community involvement in the programme as many projects are community-driven. I would like to thank Venture Leaders, TIA and all the supporting members."

Gnanli Landrou

ANNEXURE 1

SWISS-SOUTH AFRICAN SCIENCE AND TECHNOLOGY COOPERATION 1994-2018

Switzerland

SWITZERLAND and South Africa have diverse and close diplomatic relations. Both countries view each other as strategic partners with science and research as one of key areas.

In 1998 the two countries signed a Declaration of Intent on Joint Activities that provided for collaboration in areas such as democratisation and good governance, small arms and light-weapons non-proliferation, as well as promotion of conflict resolution and peace.

Ten years later, in 2008, a Memorandum of Understanding that provided for annual high-level consultations was signed. The Memorandum made provision for further cooperation in the fields of politics, business, development, peace, education and training, science and culture. Since 2008, there have been six further high-level consultations focussing on the enhancement of broad bilateral relations between the two countries.

South Africa

"A good head and good heart are always a formidable combination. But when you add to that a literate tongue or pen, then you have something very special."

Former South African President Nelson Mandela

Science and Technology Cooperation (2001-2007)

Photograph courtesy of University of Basel.

Dr Charles Kleiber, former Swiss State Secretary for Science Education and Research, and Dr Mosibudi Mangena, former Minister of Science and Technology for South Africa.

In early 2001 the National Research Foundation (NRF) and the Swiss National Science Foundation (SNSF) signed a research collaboration agreement.

In September 2003, the two organisations launched a first call for proposals to host joint scientific workshops or seminars either in Switzerland or South Africa. The first of a series of such networking seminars took place in 2004 with an additional four networking seminars co-funded in 2005. By 2006, in terms of the number of applications received across all disciplines, the NRF also facilitated unilaterally funded joint research projects that had evolved from these networking seminars. Although primarily for staff mobility, the NRF was able to fund the participation of postgraduate students in these seminars through its grant holder-linked instrument.

The decision for taking the collaboration between Switzerland and South Africa to that of a bilateral agreement was prompted by a number of diplomatic exchanges between the two countries during 2004-2007 with the intention of establishing a scientific and technological agreement. In 2004, a Letter of Intent formalising science and technology cooperation between Switzerland and South Africa was signed.

Subsequently in March 2007, an official delegation from Switzerland visited South Africa and Dr Mangena and Dr Kleiber signed a joint statement, which provided for the cooperation instruments, including major areas of cooperation, the establishment of leading houses, a joint committee, evaluation and financial resources. The joint Statement paved the way for the bilateral Agreement on Scientific and Technological Cooperation, which was signed at the University of Basel in December 2007.

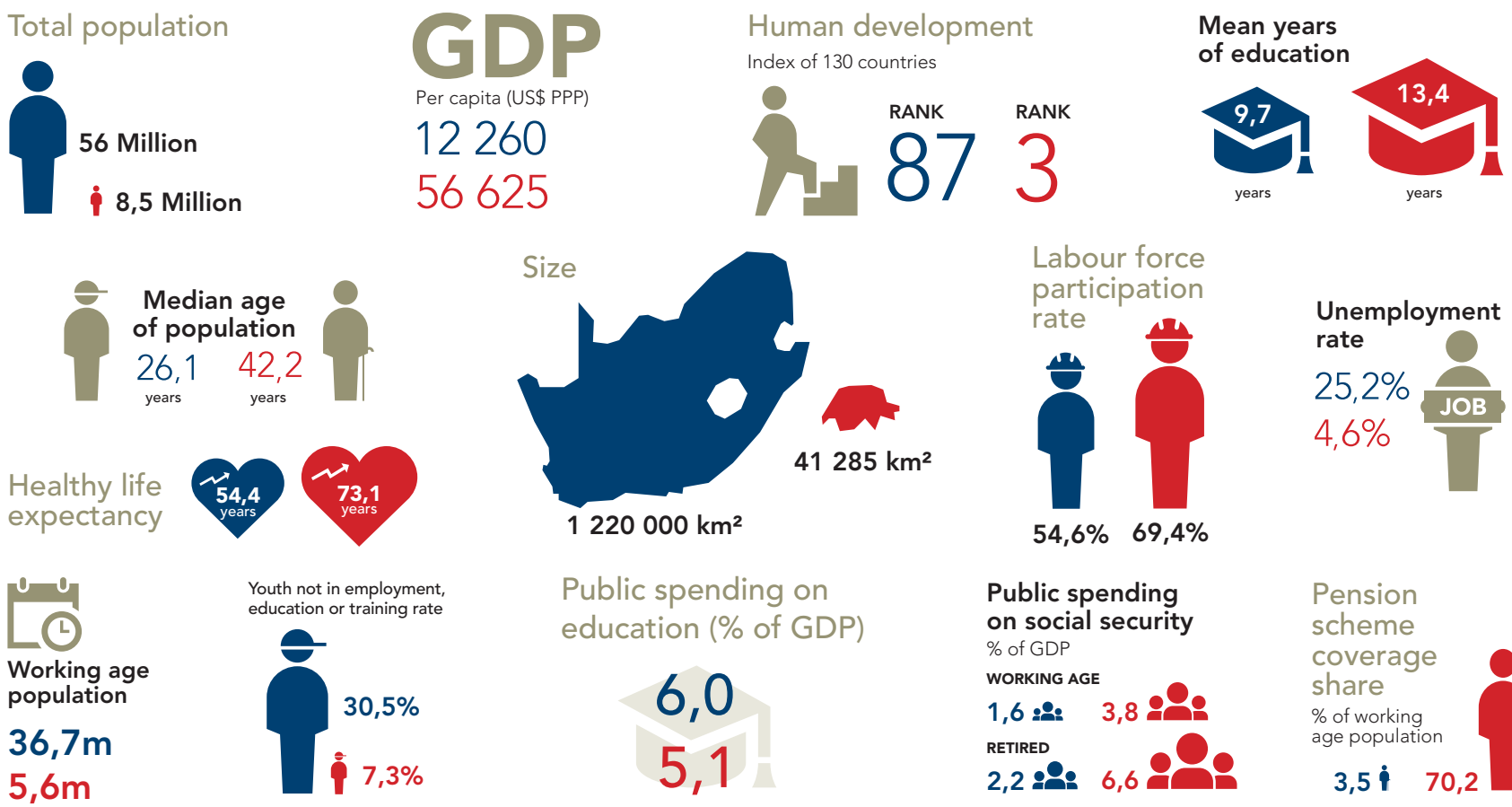
Science and Technology Cooperation (2008-2018)

The Agreement on Scientific and Technological Cooperation which was signed in 2007 formally established the Swiss-South Africa Joint Research Programme (SSAJRP). The first phase of the Joint Research Programme was implemented from 2008 to 2011, the second phase from 2013-2016 and the third phase which is currently in progress will be implemented from 2017 to 2020.

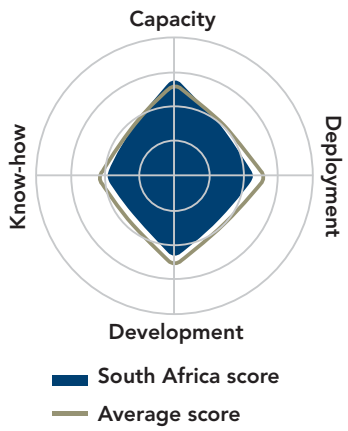
In the beginning of the joint research programme there was a low rate of application which saw the first joint call for research proposals in 2008 elicited only three applications. This has since improved in the following calls for research proposals where the third joint call for the period 2017-2020 saw nearly 90 applications. In ten years there have been 61 completed and ongoing projects, and this programme's enduring value comes from the research, training and innovation networks it has spawned. These networks connect researchers, entrepreneurs, companies of all sizes, and the public sector in a manner that allows ideas and opportunities to be shared across borders.

Country comparison: Switzerland and South Africa

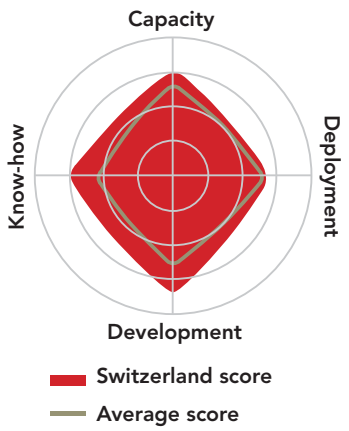
Key indicators from the World Economic Forum's Global Human Capital Report *show the value of scientific interactions between Switzerland and South Africa to address common problems facing humanity, as well as country-specific areas of concern.*



SOUTH AFRICA: SCORE AT A GLANCE



SWITZERLAND: SCORE AT A GLANCE



Source: Global Human Capital Report: World Economic Forum, 2017

Swiss Approach to International Scientific Collaboration

SWITZERLAND places the highest priority on ensuring the closest possible ties with global knowledge networks as a key objective of its approach to science diplomacy. European Union (EU) member states are among Switzerland's main partners for international cooperation in education, research and innovation. However, Switzerland also has ties – some of which are long-standing – with several non-European countries.

In line with their autonomous role, individual higher education institutions in Switzerland maintain their own international cooperation strategies. The Confederation also provides support for this, by attempting to create the best possible conditions for the internationalisation of university activities. Swiss research policy is intended to promote the appeal of Switzerland and its institutions in the area of science and innovation and enhance competiveness. This particular policy follows a bottom-up approach. If the Swiss scientific community concludes that an international research organisation or a supranational research programme can help Switzerland make significant scientific and technological progress, then the Confederation can enter into international agreements to ensure the participation of Swiss researchers.

Swiss Participation in International Research Programmes and Organisations

Switzerland plays an active role in various international research programmes and organisations. The international realm is important to Swiss researchers as it enables them to gain access to otherwise cost-prohibitive infrastructures that would be required for such fields as aerospace, astronomy, high-energy physics, or particle physics. In today's increasingly globalised world, international cooperation is also a means of overcoming obstacles and sharing information in areas that spill beyond national borders and that can only be effectively addressed through international programmes and joint cooperation projects. In both cases, international research cooperation strengthens national scientific and economic capacities through a more efficient use of resources, which also makes the country more competitive.

Swiss participation in EU multi-year framework programmes is particularly important as such programmes are the EU's main instrument for support in the areas of research, technological development and demonstration, as well as for implementation of Pan-European strategies, such as those of the European Research Area. Researchers from Swiss higher education institutions and the private sector have been participating in the Framework Programmes (FP) since 1987. Swiss researchers were among the most successful in securing EU funding in FP7 calls for project proposals (2007–2013). Horizon 2020, which runs from 2014-2020, is the EU's eighth generation of research framework programmes. From 2014-2016, Switzerland had partial associated status in Horizon 2020, but has enjoyed full associated status since 2017. Researchers in Switzerland are therefore fully entitled to take part in all calls for proposals in the programme, including coveted European Research Council grants, and if successful, receive funding contributions from the EU. For Swiss researchers, the EU's framework programmes are the most important source of public funding, second only to the Swiss National Science Foundation.

Bilateral Research Cooperation with Priority Countries Outside of Europe

Switzerland has broadened the scope of its international science policy beyond its traditional Eurocentric focus. Since 2008, the Federal Council has been actively working to develop bilateral research cooperation ties with countries outside Europe. In order to provide the best possible general conditions to encourage the international research cooperation efforts of researchers and their institutions, Switzerland has entered into bilateral agreements with various countries such as Brazil, Russia, India, China and South Africa. This has helped to foster cooperation and exchange in the area of scientific and technological research.

In 2007, the Swiss Federal Council, in consultation with the Swiss universities, drew up a list of priority countries with which Switzerland would pursue broader and deeper scientific policy relations. Corresponding bilateral research cooperation agreements have served as the basis to elaborate upon joint research programmes aimed at deepening scientific cooperation between Switzerland and the partner country in research fields of mutual strategic interest. These joint research programmes are also intended to encourage international networking activities among Swiss higher education and research institutions and raise their profile.

Cooperation is based on the principles of scientific excellence, mutual interest and reciprocity (matching funds). Since 2013, pilot projects have also received funding for the purpose of assessing the potential of cooperation with new countries.

swissnex – the Global Network for Education Research and Innovation

swissnex is the Swiss global network connecting the dots in education, research, and innovation. Its mission is to support the outreach and active engagement of its partners in the international exchange of knowledge, ideas and talent. The five swissnex locations and their outposts are established in the world's most innovative hubs. Together with around 20

Science and Technology Offices (STO) and Counsellors (STC) based in Swiss Embassies, they contribute to strengthening Switzerland's profile as a leading innovation hotspot. The core value of the swissnex network consists of:

- connecting its partners to thriving innovation ecosystems worldwide,
- advising on trends and opportunities in science, education and technology,
- promoting the visibility of Swiss higher education and research institutions, start-ups and other innovation-driven partner organisations,
- inspiring new ideas by promoting knowledge exchange.

The swissnex network is an initiative of the State Secretariat for Education, Research and Innovation (SERI) and is part of the Confederation's network abroad managed by the Federal Department of Foreign Affairs. The activities of the swissnex network are based on a collaborative approach, relying on public and private partnerships and funding.

The swissnex network collaborates with a broad spectrum of partners related to international research and innovation, supporting them in their outreach and active engagement in the global exchange of knowledge, ideas and talent. These primarily include:

- higher education and research institutions
- governmental and publicly funded institutions
- start-ups and innovation-driven companies
- non-governmental, non-profit organisations
- creative industries linked to education, research, or innovation.

Established in some of the world's most innovative hubs, there are presently five swissnex locations on four continents:

- **swissnex Boston (est. 2000)**
- **swissnex San Francisco (est. 2003)**
- **swissnex China (est. 2008)**
- **swissnex India (est 2010)**
- **swissnex Brazil (est. 2014).**

Source: SERI

Swiss Collaboration with African Countries

Switzerland is no newcomer to research collaboration on the African continent. A number of Swiss universities and universities of applied sciences hold close research and innovation ties with Africa. For example, in public health the Swiss Tropical and Public Health Institute (Swiss TPH) has field laboratories and research facilities in Côte d'Ivoire, Tanzania and Chad. The collaboration between the Swiss TPH and African countries is built on a culture of partnership and mutual trust. Development and innovation are key features. For example, the École Polytechnique Fédérale de Lausanne (EPFL) forged partnerships with emerging and developing countries through the Cooperation and Development Centre (CODEV). These collaborations are supported through a United Nations Educational, Scientific and Cultural Organization's (UNESCO) chair with a focus on global challenges. A recent instrument that is fostering Swiss-South Africa collaboration is the establishment of Massive Open Online Courses (MOOCs) that make education free and accessible. Another example is the University of Lausanne support for the VanThuyne Ridge Research Centre, an inter-disciplinary research centre in Botswana opened in 2014. Situated between the Okavango Delta and the Chobe National Park, the centre focuses on biology, geology and anthropology.

Equally, South Africa is providing a learning opportunity for Swiss students by, for example, hosting the annual training week of EPFL MBA students to gain experiential training. Nearly 40 students have been placed at South African-based companies, including those stemming from the Swiss-South Africa Business Development Programme. Switzerland also established other programmes such as the Southern African Research Cooperation (SARECO) and Research for Development (r4d) as highlighted overleaf.

South African researchers participate in four of the 57 projects.

Approved SARECO Joint Projects with South African Universities

TOPIC	COUNTRIES OF RESEARCH PARTNERS
Employment effects of different development policy instruments	Bangladesh, Ethiopia, Ghana, Madagascar, Vietnam, South Africa, Switzerland
The contribution of vocational skills development to inclusive industrial growth and transformation. An analysis of critical factors in six countries	Bangladesh, Cambodia, Ethiopia, Lao PDR, South Africa, Switzerland, Vietnam
Social mobile media to educate, connect and empower frontline health workers in Nigeria, Zambia and South Africa	Nigeria, South Africa, Switzerland, Zambia
Woody invasive alien species in East Africa, assessing and mitigating their negative impact on ecosystem services and rural livelihood	Ethiopia, Kenya, South Africa, Switzerland, Tanzania

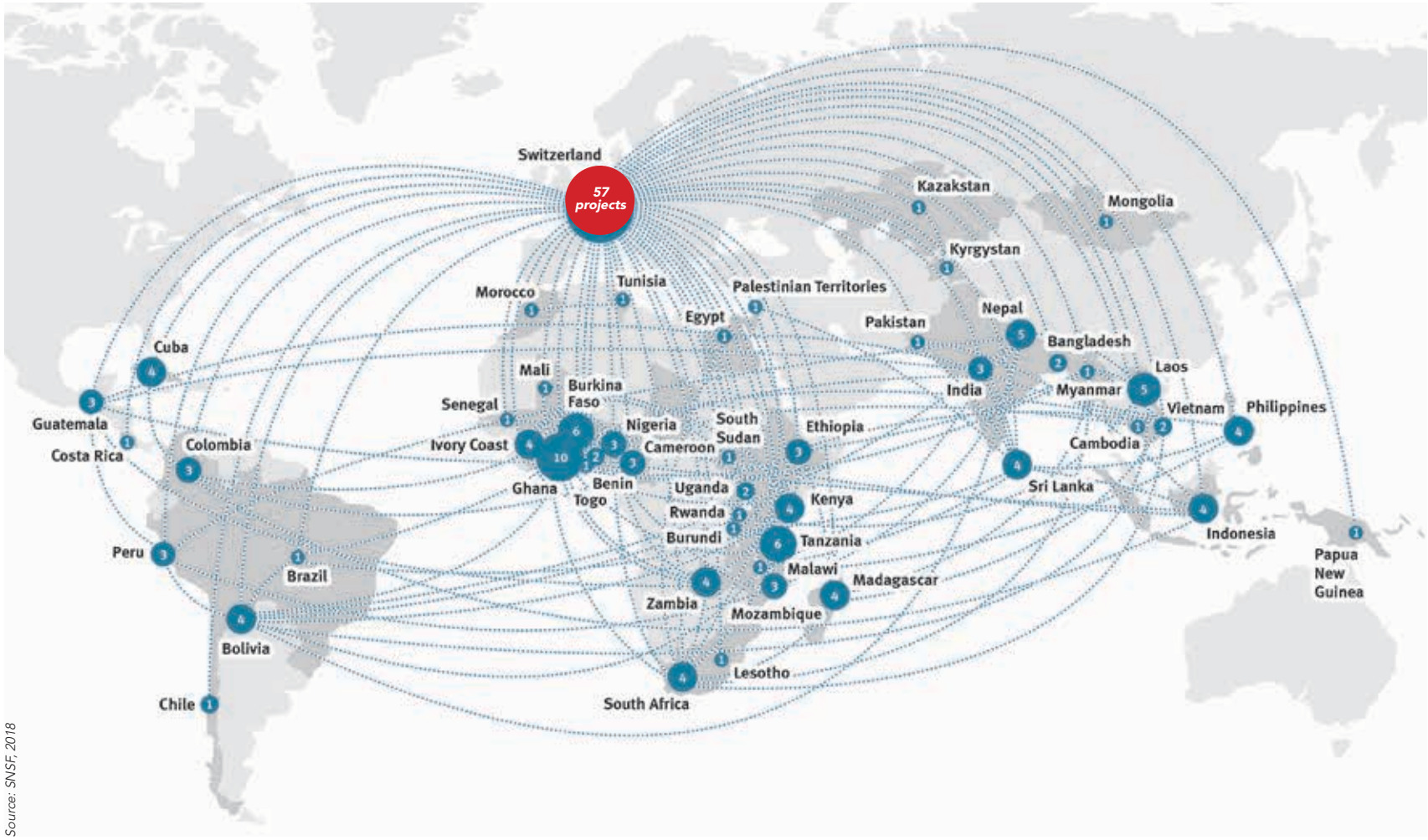
Swiss-Southern African Research Cooperation (SARECO)

The Swiss-Southern African Research Cooperation (SARECO), has been in place since 2013. In addition to existing ties with Côte d'Ivoire, South Africa and Tanzania, countries such as Cameroon, Ghana, Kenya and Uganda have also been identified as key countries to strengthen cooperation between Switzerland and Africa.. Close collaboration has also been established with the African Academy of Sciences. The collaboration further focuses on institutional hotspots in the designated partner countries to facilitate exchange visits, joint seminars and joint workshops, (SARECO, 2017). The sareco.org database provides information on collaborative research projects between Switzerland and African countries. The database aims to bring early career scientists together and to create a framework for exchange about funding instruments and project success stories, inviting peers to follow and thereby grow the Swiss-African research network. In 2018, SARECO received 23 proposals for visiting research fellowships for advanced PhD students and early postdoctoral researchers. Four of the 10 approved joint research projects were with South African universities as presented in the table below.

Research for Development (r4d) Programme

The r4d programme, a joint funding initiative of the Swiss National Science Foundation (SNSF) and the Swiss Agency for Development and Cooperation (SDC), aims to provide politicians and civil society with scientific knowledge and practical solutions in order to tackle global problems. It provides funding for inter- and trans-disciplinary research partnerships between researchers in Switzerland and in African, Asian and Latin American countries. Researchers working at research institutions in these countries are eligible to apply for an r4d grant. The responsible applicant must be employed at a Swiss research institution. The network map on the next page shows the reach of the research collaboration in the r4d programme since 2012. South African researchers participate in four of the 57 projects.

Research Networks



Source: SNSF, 2018

Swiss-South Africa Joint Collaboration in the EU Framework Programme

Switzerland and South Africa also collaborate in the European Union Framework Programme. In the 7th Research Framework Programme (FP7, 2007-2013), South African and Swiss research teams worked together in a total of 55 projects. Eighty-one different research teams from both countries were involved in these projects. The total cost of these 55 research projects amounted to €307 million, of which about €220 million was financed from the FP7 budget. Compared to all 127 countries with which Switzerland cooperates under FP7, South Africa is in 37th place and first among the African states. Swiss and South African researchers are currently cooperating in 12 projects under Horizon 2020. The total cost of these 12 projects is €97 million, of which a maximum of €79,5 million will be financed from the Horizon 2020 budget. Three projects each are located in the areas of climate sciences and research infrastructures.

The integration of South Africa into the EUREKA network in June 2014 took place during the Swiss Presidency (July 2014 to June 2015), which further enhanced the objective of science to market. South Africa supports cooperation projects in the field of innovation with all EUREKA member countries, including Switzerland. In EUREKA's network projects with Switzerland, the Department of Science and Technology (DST) sponsors project partners from South Africa while Innosuisse sponsors project partners from Switzerland. Since June 2016, South Africa has been supporting projects under the EUREKA Eurostar's programme for research-intensive SMEs.

South African Approach to International Scientific Collaboration

Photograph courtesy of SARAO

The Square Kilometre Array is one of South Africa's global partnerships.

SOUTH Africa's main international research priority is to be part of a vibrant African research and innovation system. To achieve this goal, South Africa's science diplomacy is aimed at attracting international investment into South African science, and securing research capacity development partnerships with international partners, such as training programmes and knowledge production partnerships abroad for South African researchers.

The DST is the lead Department for science and technology policy in South Africa. One of the DST's agencies, the National Research Foundation (NRF) is mandated by the DST to implement bilateral agreements through joint research calls and joint bilateral activities under the Science and Technology Agreements Fund. This mandate gives the NRF an active participatory role in the internationalization of science. The role of the NRF in promoting international collaboration is further evident in the publication of the NRF's funding opportunities that provide support for South African academia to participate in multilateral programmes and joint activities with international partners (NRF, 2017). The various national science councils and universities also participate in science diplomacy where they conclude inter-institutional agreements with their foreign counterparts.

NRF Overseas Cooperation, NRF (2017)

* Cooperation between the NRF and other international agencies
** Government to government cooperation

Multilateral

IBSA DST Trilateral
IBSA HE Trilateral
IBSA DST Nanotechnology
BRICS Formation (DST)
European Union

Strategic Projects

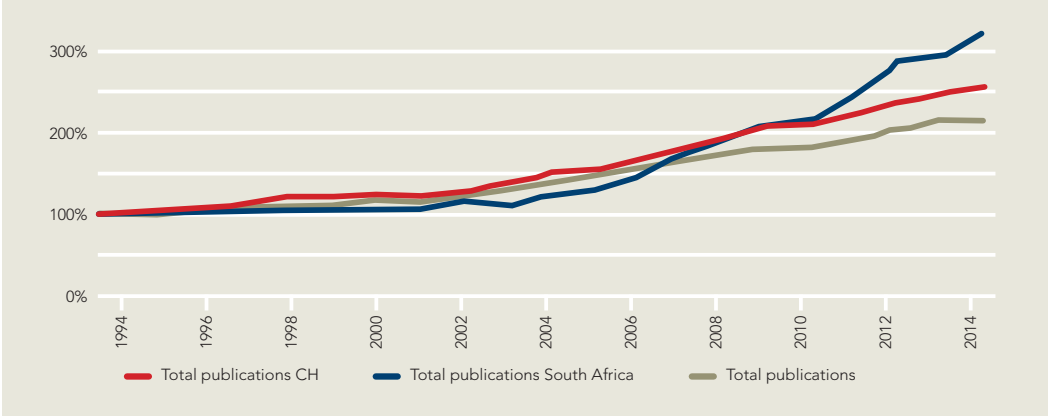
Newton Fund
NRF/TWAS Partnership
NRF/ERC Partnership
NRF/Canadian Research Chairs Partnerships
NRF/Embassy of Sweden Nobel Lecture Series
NRF/ICTP Infrastructure Mobility Fund

Swiss-South Africa Joint Publications and Domains of Collaboration 1994-2014

Peer-reviewed publications are well-known scientific indicators of a country's progress in building new knowledge. Both Switzerland and South Africa have experienced exponential growth in their publication outputs as illustrated in Figure 1.

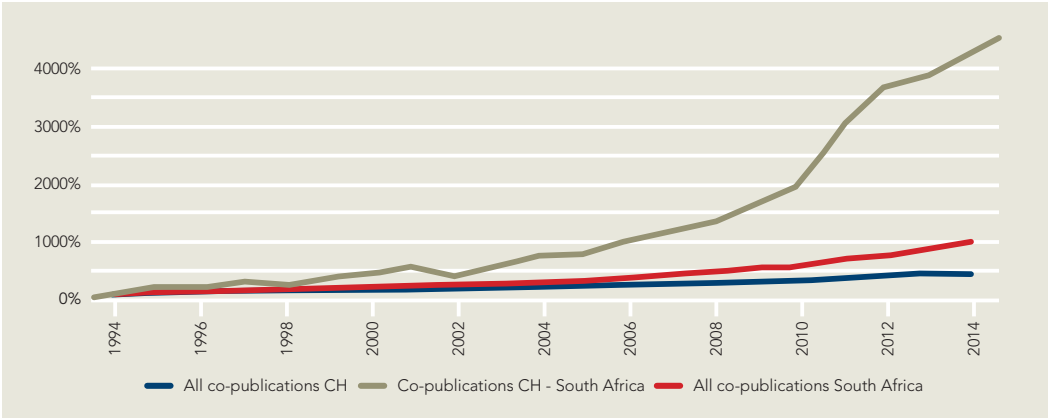
Measured against a peer-reviewed scientific output it can be concluded that the Agreement signed on that cold winter's day in Switzerland has truly led to growth in the scientific and technological collaboration between Switzerland and South Africa as illustrated in Figure 2. It is interesting to note that the overall co-publications (measured on the stone-coloured bar below) have experienced significant growth with a marked rise after the signing of the Swiss-South Africa Scientific and Technological Agreement in 2007.

Figure 1: Publication outputs for Switzerland and South Africa



Publications trends in %, in reference to 1994 (SNSF 2017)

Figure 2: Joint publication outputs for Switzerland and South Africa



Percentage publications between Switzerland and South Africa against the 1994 reference (SNSF 2017)

Co-publications have experienced exponential growth with a marked rise after the signing of the Swiss-South Africa Science and Technology Agreement in 2007.

Comparison of South African International Partners 1981-2013

Table 1 indicates South Africa's collaborative partners during a 40-year period. Switzerland occupied 12th position during the first two periods (1981-1983 and 1991-1993). It moved to 10th position during 2001-2003 and was at Number 8 for the 2011-2013 period. This demonstrates the successes in the science diplomacy initiatives.

The majority of research collaborations are all with developed economies (US, England, Germany, Australia, France, Canada, Netherlands, Switzerland, Italy and Sweden). In 2013, South African researchers published 84,1% of scientific papers with at least one author from these countries. This is an increase of 28,7% over the 2004 level. Since 2011, the other BRICS countries (Brazil, China, India and Russia) have overtaken the top 10 African countries as the research collaborating partners of South Africa.

Table 1: Ranking of countries collaborating with South Africa (Pouris 2014)

1981-1983		1991-1993		2001-2003		2011-2013	
Country	Record Counts	Country	Record Counts	Country	Record Counts	Country	Record Counts
USA	387	USA	669	USA	1848	USA	6457
England	194	England	334	England	1179	England	4086
FDR	108	Germany	268	Germany	684	Germany	2372
Australia	56	Canada	162	Australia	571	Australia	2258
Israel	54	Australia	121	France	471	France	2029
Canada	45	Israel	94	Canada	363	Netherlands	1719
Uruguay	43	France	88	Netherlands	348	Canada	1638
Scotland	41	Italy	78	Belgium	244	Switzerland	1360
France	38	Scotland	58	Italy	235	Italy	1207
Zimbabwe	24	Netherlands	49	Switzerland	198	Spain	1159
Denmark	22	Belgium	46	Scotland	194	Sweden	1143
Switzerland	22	Switzerland	45	Sweden	181	PR China	1083
Belgium	21	Brazil	33	Spain	166	India	981
Netherlands	19	Austria	32	Japan	155	Belgium	914
Sweden	16	Japan	30	Israel	135	Scotland	861

South African University Research Collaboration

Table 2 shows the countries with which the various South African universities collaborate. Switzerland is one of the top 10 countries with which South African Universities collaborate. The US and UK are the major collaborators, with Germany among the top five countries on the list of co-authoring countries. The Netherlands, Australia, France and Canada are also on the list of major countries that have co-authored with South African universities and Switzerland occupies the eight position.

Table 2: Top 10 countries collaborating with South African universities (2009 - 2013) (Pouris 2014)

Countries	University of Cape Town	University of the Witwatersrand	University of Pretoria	University of Johannesburg	KwaZulu-Natal University	Stellenbosch University
USA	2485	1965	911	541	1230	1027
England	2138	1139	436	415	811	680
France	900	566	205	326	403	327
Germany	876	637	264	370	334	542
Australia	825	741	318	360	298	360
Netherlands	713	455	327	329	212	330
Canada	675	470	182	348	327	269
Switzerland	634	496	138	0	254	218
Italy	574	0	0	320	0	0
Spain	503	0	0	0	0	0

ACRONYMS

AAQ	Agency of Accreditation and Quality Assurance
ABS	Access and Benefits Sharing
ACTs	Artemisinin-based combination therapies
AGP	Antibiotic growth promoter
AHN	Adult hippocampal neurogenesis
AIDS	Acquired Immune Deficiency Syndrome
AIT	Swiss Academia Industry Training
ALH	Associated Leading House
AMCS	African Centre for Migration and Society
APIs	Active pharmaceutical ingredients
AQ	Antimalarials amodiaquine
ARC	Agricultural Research Council
ARD	Applied Research and Development
ARV	Antiretroviral
ASSAf	South African Academy of Science
AU	African Union
AVQN	African Qualifications Verification Network
BINGO	Baryon acoustic oscilliations in neutral gas observations experiment
CAS	Certificate of Advanced Studies
CBOs	Community-based organisations
CD4+T	T-cell with CD4 receptor
CDC	Centre for Disease Control and Prevention
CERN	European Council for Nuclear Research
CGS	Council for Geosciences
CHE	Council on Higher Education
CHF	Swiss Francs
CHPC	Centre for High Performance Computing
CIASA	Cassava Association of South Africa
CIS4	Community Innovation Survey 4
CMA	Central-medical amygdala
CMD	Cassava Mosaic Disease
CNS	Central nervous system
CoA	Coenzyme A
CoCs	Centres of Competence
CODESRIA	Council for the Development of Social Science Research in Africa
CODEV	Cooperation and Development Centre
CoEs	Centres of Excellence
COHEP	Swiss Conference of Rectors of Universities of Teacher Education
COP 17	17th Conference of the Parties
CPA	Consolidated Plan of Action
CPUT	Cape Peninsula University of Technology
CQ	Chloroquine
CRU	Rectors Conference of Swiss Universities
CSEM	Centre for Electronics and Microtechnology
CSIR	Council for Scientific and Industrial Research
CTI	Commission for Technology and Innovation
CypA	Cyclophilin A
DAS	Diploma of Advanced Studies
DBE	Department of Basic Education
DCTB	Differentially culturable tubercle bacilli
DECs	Disease endemic countries
DES	Dark energy survey
DHET	Department of Higher Education and Training
DIRCO	Department of International Relations and Cooperation
DNDi	Drugs for Neglected Diseases initiative
DR-TB	Drug-resistant tuberculosis
DST	Department of Science and Technology (South Africa)
Dy	Dysprosium
EAWAG	Swiss Federal Institute of Aquatic Science and Technology
EC	Enzyme commission
ECTS	European Credit Transfer System
EDCTP	European and Developing Countries Clinical Trials Partnership
EDK	Swiss Conference of Cantonal Ministers in Education
EIS	European Innovation Scoreboard
EMaHP	Mathematical Humanitarian Project
EMF	Esperanza Medicines Foundation
EMPA	Swiss Federal Laboratory for Materials Testing and Research
EPFL	Ecole Polytechnique Federale de Lausanne
ERI	(Swiss) Education, research and innovation
ETH Zurich	Swiss Federal Institute of Technology
EU	European Union
FASP	Flame-assisted spray pyrolysis
FBOs	Faith-based Organisations
FDFA	Federal Department of Foreign Affairs
FET	Further Education and Training
FIT	Federal Institute of Technology
FORS	Foundation for Social Sciences Research
FP7	Seventh Framework Programme
FSHR	Follicle-stimulating hormone receptor
FHNW	Swiss University of Applied Science and Arts Northwestern Switzerland
GCII	Global Cleantech Innovation Index
GCIP	Global Cleantech Innovation Programme
GCP	Good clinical practice
Gd	Gadolinium
GDP	Gross Domestic Product
GEO	Group on Earth Observation
GERD	Gross Expenditure on Research and Development
GET	General Education and Training
GIIS	Graduate Institute Geneva
GINI	Measure of inequality in a population
GLP	Good laboratory practice
HAART	Highly active antiretroviral therapy
HCD	Human capacity development
HDI	Historically disadvantaged individuals
HDL	High density lipoproteins
HE	Higher education
HEdA	Higher education act
HEIs	Higher education institutions
HEQF	Higher Education Qualification Framework
HET	Higher education and training
HIRAX	Hydrogen intensity and Real-time experiment
HIV-1	Human Immunodeficiency Virus type 1
HPLC	High performance liquid chromatography
HSRC	Human Sciences Research Council
HySA	Hydrogen South Africa
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICR	International Cooperation and Resources
ICRI	International Conferences on Research Infrastructures
ICSU	International Council for Science
ICT	Information and communication technology
IDC	Industrial Development Corporation of South Africa
IDSIA	Swiss Institute for Artificial Intelligence
IFAC	International Federation of Automatic Control
IFN	Interferon
IFN-1	Type 1 interferon
ILUPSA	Integrated Land Use Plan for South Africa
IP	Intellectual property
IPR-PFRD	Intellectual Property Rights for Publicly Funded Research and Development Act of South Africa
ISA3	Plant gene Isomylase 3
ISI	Information Science Institute
ISSC	International Social Science Council
iSTEM	Innovation in Science, Technology, Engineering and Mathematics
ISUH	International Society for Urban Health
ITEC	Intergovernmental Committee on Trade and Economic Cooperation
JCST	Joint Committee on Science and Technology
JRPs	Joint Research Projects
KFH	Conference of Swiss Universities of Applied Science
LDL	Low-density lipoproteins
LHR	Luteinising hormone receptor
LSST	Large synoptic survey telescope
MAS	Master of Advanced Studies
MDR-TB	Multidrug-resistant tuberculosis
MeerKAT	Karoo Array Telescope
MELISSA	Measuring E-Learning Impact in primary schools in South project African disadvantaged areas
METAS	Swiss National Metrology Institute
MEX	Plant gene maltose excess 1
MMV	Medicines for Malaria Venture
MOOCs	Massive open online courses
MoU	Memorandum of Understanding
MRC	Medical Research Council
MRI	Magnetic resonance imaging
MS/MS	Tandem mass spectrometry
MTB	Mycobacterium tuberculosis
MTEF	Medium Term Expenditure Framework
NACI	National Advisory Council on Innovation
NAM	Chair of the Non-Aligned Movement
NCCRs	National Centres of Competence in Research
NCDs	Non-communicable diseases
NCEs	New chemical entities
NDP	National Development Plan
NECSA	South African Nuclear Energy Corporation
NEP	National Equipment Programme
NFSD	National Framework for Sustainable Development
NGOs	Non-governmental organisations
NHLS	National Health Laboratory Service
NICD	National Institute for Communicable Diseases
NIPMO	National Intelectual Property Management Office of South Africa
NIR	Near infrared region
NMMU	Nelson Mandela Metropolitan University
NMR	Nuclear magnetic resonance

NNEP	National Nanotechnology Equipment Programme
NPEP	Nanotechnology Public Engagement Programme
NQF	National Qualifications Framework of South Africa
NRDS	National Research and Development Framework of South Africa
NRF	National Research Foundation
NRPs	National research programmes
NSI	National System of Innovation
NSTF	National Science and Technology Forum of South Africa
NTNs	National thematic networks
NWU	North-West University
ODA	Official development assistance
OECD	Organisation for Economic Cooperation and Development
OPET	Federal Office for Professional Education and Training
OPVs	Open-pollinated varieties
PBMC	Peripheral blood mononuclear cells
PCT	Patent Cooperation Treaty
PET	Positron emission tomography
PET	Professional Education and Technology
PGM	Platinum Group metals
PhD	Philosophae Doctor
PoC	Programme of Cooperation
PPP	Public-private partnership
PSI	The Paul Scherrer Institute
PWD	Plant gene phosphoglucan water dikinase
R&D	Research and development
RISA	Research and Innovation Support and Advancement
RISP	Research Infrastructure Support Programme
RNA	Ribonucleic acid
RI	Radio Interferometry
S-SAM	Swiss sub-Saharan African Migrations
S&T	Science and Technology
S2M	Science to Market
SA	South Africa
SAASTA	The South African Agency for Science and Technology Advancement
SABIF	South African Biodiversity Information Facility
SABS	South African Bureau of Standards
SADC	Southern African Development Community
SAHS	Swiss Academy of Humanities and Social Sciences
SAIAMC	South African Institute for Advanced Materials Chemistry
SALT	Southern African Large Telescope
SAMRC	South African Medical Research Council
SAMS	Swiss Academy of Medical Sciences
SAQA	South African Qualifications Authority
SARChI	South African Research Chairs Initiative
SARECO	Swiss-African Research Cooperation
SASR	South African Sugarcane Research Institute
SATuRN	The Southern African Treatment Resistance Network
SATW	Swiss Academy of Engineering Sciences
SAVUCA	South African Value-added Cassava
SCNAT	Swiss Academy of Sciences
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SEDA	Small Enterprise Development Agency of South Africa
SER	Swiss Secretariat for Education and Research
SERI	Science, Education, Research and Innovation
SET	Science Engineering Technology
SFIVET	Swiss Federal Institute for VET
SIAF	Swiss Institute for Allergy and Asthma Research
SIB	Swiss Institute of Bioinformatics
SKA	Square Kilometre Array
SMEs	Small to medium enterprises
SNSF	Swiss National Science Foundation
SPECT	Single photon emission computed tomography
SPII	Support Programme for Industrial Innovation of South Africa
SSABDP	Swiss-South Africa Business Development Programme
SSAJRP	Swiss-South Africa Joint Research Programme
STI	Swiss Tropical Institute
STI	Science, Technology and Innovation
STPHI	Swiss Tropical and Public Health Institute
SU	Stellenbosch University
SUC	Swiss University Conference
SUPSI	University of Applied Sciences for Southern Switzerland
T-cell	Infection-fighting lymphocyte
Tb	Terbium
TB	Tuberculosis
TDR	Training and Research in Tropical Diseases Programme
THRIP	Technology and Human Resources for Industry Programme of SA
TIA	Technology Innovation Agency
TNF	Tumour necrosis factor
TPH	Swiss Tropical and Public Health Institute
TRIM	Tripartite motif
TUT	Tshwane University of Technology
TVET	Technical and Vocational Education and Training
TYIP	Ten year Innovation Plan of South Africa
TRREE	Training and Resources in Research Ethics Evaluation
U-TT	Urban Think Tank
UAS	Universities of Applied Sciences
UCT	University of Cape Town
UFS	University of the Free State
UKZN	University of KwaZulu-Natal
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNIBAS	University of Basel
UP	University of Pretoria
UPLC	Ultra-performance liquid chromatography
USAf	Universities of South Africa
UTE	Universities of Teacher Education
UWC	University of Western Cape
UWD	Urbach-Wiethe disease
UZH	University of Zurich
VET	Vocational Education and Training
VIGS	Virus-induced gene splicing
VPET	Vocational Professional Education Training
WHO	World Health Organisation
WITS	University of Witwatersrand
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research
WGS	Whole genome sequencing
WRHI	Wits Repoductive Health and HIV Institute
WSSF	World Social Science Forum
XDR	Extensively drug-resistant
ZHAW	Zurich University of Applied Sciences

GLOSSARY OF TERMS: CHAPTER 7

HIRAX: The Hydrogen Intensity and Real-time Analysis eXperiment (HIRAX) is a new 400–800 MHz radio interferometer developed for deployment in South Africa. HIRAX will comprise 1024 six-metre parabolic dishes on a compact grid and will map most of the southern sky over the course of four years.

BINGO: The Baryon acoustic oscillations In Neutral Gas Observations experiment is a project to build a special purpose radio telescope to map redshifted neutral hydrogen emission between z = 0.13 and 0.48.

MeerKAT: The South African MeerKAT radio telescope is a precursor to the Square Kilometre Array (SKA) telescope and will be integrated into the mid-frequency component of SKA Phase 1.

LSST: The goal of the Large Synoptic Survey Telescope project is to conduct a 10-year survey of the sky that will deliver a 200 petabyte set of images and data products that will address some of the most pressing questions about the structure and evolution of the universe

DES: The Dark Energy Survey is an international collaborative effort to map hundreds of millions of galaxies, detect thousands of supernovae, and find patterns of cosmic structure that will reveal the nature of the mysterious dark energy that is accelerating the expansion of our Universe.

PRIZM: Probing Radio Intensity at high-Z from the Marion.

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