About RISE ................................................................. 1
Blog Posts, April 2009-February 2013 .............................. 3
A Visit with Lloyd Nyemba (AMSEN) ............................... 3
Mozambican Student Leads His Country Toward Modern Water Management (SSAWRN) ........................................... 3
And Then There’s the Language Problem (SSAWRN) .............. 4
Research in the Service of Local Needs (WIO-RISE) ................. 5
From Refugee to RISE Participant (AMSEN) .......................... 6
Why is Namibia so Excited About Science? (AMSEN) ............... 7
If Only I Had a Microscope (SSAWRN) ................................. 9
A Better Cuppa Tea for Malawi (SABINA) ............................. 10
After Two Decades, a Chance at a PhD (AMSEN) .................... 11
The Making of a Natural Products Researcher (SABINA) ............. 12
In Zimbabwe, ‘education for children is what parents live for’ ........ 13
Growing Pains (AMSEN) ............................................... 15
Traditional Cure Inspires Biochemistry Student (SABINA) ........... 16
The Ambitions of AFNNET: Natural Products and Beyond ......... 17
Can a New Tea Stave Off Malaria? (AFNNET) .......................... 19
A Resource for Uganda, ‘Where the Poor Are So Many’ (AFNNET) 20
‘What Magic is That?’ (AFNNET) ......................................... 21
The Dream of Preventing Disease and Reducing Suffering (SSAWRN) 22
Man Versus Amoeba (SSAWRN) ........................................ 24
A Long-Term Goal to Help Other Women (SSAWRN) ............ 25
The Dangerous Side of NP Research (AFNNET) ........................ 26
‘Safe, Efficacious, and Affordable’ (AFNNET) ......................... 27
Building Partnerships with Traditional Healers (AFNNET) .......... 28
Seeking an Herbal Cure for Arthritis (AFNNET) ...................... 29
Sweet Buildings (AMSEN) .............................................. 31
Can Kenya Build a Real Steel Industry? (AMSEN) ................. 32
New Uses for Hot African Sun (AMSEN) ............................... 34
The Seaweeds of Zanzibar (WIO-RISE) ............................... 35
Perilous Times for the Squids of Kenya (WIO-RISE) .................. 37
RISE Students Are Among the First Postgraduates at Okavango Research Institute (SSAWRN) .............................. 39
Enduring Shocks of a Stressful Environment (SSAWRN) ............ 40
The Puzzle of the Precocious Southern Fishes (SSAWRN) .......... 41
Searching for the Source of the Okavango’s Nutrients (SSAWRN) 43
Annual Floods as a Key to Fertility (SSAWRN) ........................ 44
‘RISE Was Like a Dream Come True’ (SSAWRN) .................... 46
Grace Mutia’s Work on Seaweeds: An Update (WIO-RISE) ........ 47
Siajali Pamba: Learning to Model River Flow (WIO-RISE) ........... 49
Mushrooms by the Numbers: A SABINA Master's in Bioinformatics 51
Hot Peppers for Better Chicken (AFNNET) ............................. 52
Bringing More Rigor to the Herbal Community (AFNNET) ............ 54
A Chemist’s Research on Newcastle Disease Leads to Patents (AFNNET)........ 56
Commiphora vs. Newcastle Disease (AFNNET).................................................. 58
From Student to Advisor, via RISE (AFNNET)..................................................... 60
A Sound Grounding in Natural Products (AFNNET)............................................. 61
A Lesson from Chimpanzees? (AFNNET)............................................................... 63
'This Is What My Education Is Meant For' (AFNNET)........................................... 64
Alleviating Joint Pain in Rural Kenya (AFNNET)................................................ 65
‘What Was In That Plant? Nobody Knew’ (AFNNET)........................................... 67
‘They Call it the Wonder Drug’ (AFNNET)........................................................... 68
‘The Whole World is Interested’ (AMSEN)......................................................... 69
A Proposal to Make Bioplastics from Seaweed (AMSEN)............................... 71
Vision of Stronger – and ‘Greener’ – Concrete Buildings (AMSEN).................. 74
Steady Progress on Superalloys (AMSEN)........................................................... 77
The Next Frontier of Memory Devices (AMSEN)................................................ 79
Life as a Scientist in Mauritius (WIO-RISE)........................................................ 81
Investigating the Okavango Delta: Carbon Dynamics and Climate Change
(SSAWRN)............................................................................................................. 83
Challenges of Modeling the Congo (SSAWRN)..................................................... 84
An Urgency to Understand the Okavango Delta (SSAWRN)............................. 87
Using Insects to Measure Water Quality (SSAWRN)......................................... 90
Developing Guidelines for Roundup in South Africa (SSAWRN)...................... 93
Why are Hippos Dying of Anthrax? (SSAWRN)................................................ 96
Ancient Remedies for Modern Diseases (SABINA)............................................ 98
Exploring the Genotype of the Tea Plant (SABINA)........................................... 102

About Carnegie Corporation of New York......................................................... 104
About the Institute for Advanced Study.............................................................. 104
About the Science Initiative Group.................................................................. 105
About the Bloggers............................................................................................ 105
Index.................................................................................................................. 106
Regional Initiative in Science and Education (RISE)

The Carnegie-IAS Regional Initiative in Science and Education (RISE) aims to strengthen higher education in sub-Saharan Africa by increasing the population of qualified faculty teaching in Africa’s universities. RISE prepares PhD- and MSc-level scientists and engineers through university-based research and training networks in selected disciplines. Its primary emphases are on preparing new faculty to teach in African universities and on upgrading the qualifications of current faculty.

RISE networks provide comprehensive graduate training programs, where students and faculty seeking advanced degrees can take advantage of the complementary instruction and research opportunities available at each institution within the network. Networks also enable researchers from multiple universities to use specialized scientific instrumentation that may be available at only one of the sites, or to pool resources to obtain new equipment.

The network structure benefits the universities as well, as each gains capacity through affiliation with the others. In the words of one of the successful applicants, “The principle to be employed is to exploit the respective strengths of individual partner institutions for the collective benefit to build capacity.”

RISE is supported by grants totaling over $10.4 million from Carnegie Corporation of New York to the Science Initiative Group (SIG) at the Institute for Advanced Study in Princeton, NJ, USA. The following five networks were selected in 2008 from among 48 proposals:

**African Materials Science and Engineering Network (AMSEN)**
*Academic Director:* Lesley A. Cornish, Director, DST/NRF Centre of Excellence in Strong Materials, University of the Witwatersrand, Johannesburg, South Africa
*Other participating institutions:* University of Nairobi, Kenya; University of Namibia; Federal University of Technology, Akure, Nigeria; University of Botswana
*Description:* AMSEN focuses on developing the skills in materials science and engineering needed to develop and add value to the extensive mineral deposits in southern Africa.

**African Natural Products Network (RISE-AFNNET)**
*Academic Director:* John David Kabasa, University Professor, Natural Products Research Laboratory, Department of Physiological Sciences, Makerere University, Kampala, Uganda
*Other participating institutions:* University of Nairobi, Kenya; Sokoine University, Tanzania
*Description:* RISE-AFNNET seeks to develop Africa’s rich biodiversity into a natural products industry of social and economic significance through coursework and research in engineering, biochemistry, environmental science, pharmacology, economic development, and nutrition.

**Southern African Biochemistry and Informatics for Natural Products (SABINA)**
*Academic Director:* John D. Saka, Professor of Chemistry, Chancellor College, University of Malawi
*Other participating institutions:* University of Namibia; University of Dar es Salaam, Tanzania; University of Pretoria, South Africa; University of the Witwatersrand, South Africa; Council for Scientific and Industrial Research (CSIR), South Africa; Tea Research Foundation of Central Africa, Malawi
Description: SABINA works with natural products that have the potential to increase food security, public health, and value-added exports. Its research emphasis is on biochemistry and chemistry of natural products.

Sub-Saharan Africa Water Resources Network (SSAWRN)
Academic Director: Denis Hughes, Director, Institute for Water Research, Rhodes University, South Africa
Other participating institutions: Eduardo Mondlane University, Mozambique; University of Botswana; Makerere University, Uganda
Description: SSAWRN focuses on the most pressing water issues of sub-Saharan Africa, including rising use, declining quality, insufficient research and teaching capacity, inadequate weather stations, and the likelihood of increased variability of water supplies associated with future climates.

Western Indian Ocean Regional Initiative (WIO-RISE)
Academic Director: Margareth S. Kyewalyanga, Director, Institute of Marine Sciences, University of Dar es Salaam, Zanzibar, Tanzania
Other participating institutions: Eduardo Mondlane University, Mozambique; University of Cape Town, South Africa
Description: WIO-RISE provides research and training in skills associated with the utilization of coastal and marine resources and protection of the coastal and marine environment.
A Visit with Lloyd Nyemba (AMSEN)
By Alan Anderson, 21 April 2009

Lloyd Nyemba is one of four enthusiastic AMSEN grad students who have recently joined the Centre of Excellence in Strong Materials at the University of Witwatersrand in Johannesburg, South Africa. I was struck by his dedication and initiative in finding his way to this advanced center where he has a fine opportunity to move ahead. As a native of Zimbabwe, he had majored in mechanical engineering but had no opportunity for advancing in his career. Instead he followed his brother and sister to Namibia, where they had found jobs unrelated to research, and presented himself to the engineering faculty. There he met Prof. Frank Kavishe, an AMSEN participant, who asked if he might be interested in working on carbon nanotubes in South Africa, where a skilled mentor was waiting. Lloyd, who had barely heard of this lively new field, immediately said yes and began to familiarize himself with it. He is now busy learning to make nanotubes and has proposed to test them for use in the biometric application of fingertip identification. Nanotubes have advantages over conventional silicon in transistors, in that they may be either conductors, semi-conductors, or insulators. He will try to compare the two technologies to see if carbon nanotubes are superior. Already Lloyd has met with two South African companies which are interested in the results. He will be supported by RISE in his work here for two more years, while simultaneously working toward advanced degrees.

Mozambican Student Leads His Country Toward Modern Water Management (SSAWRN)
By Alan Anderson, 22 April 2009

Agostinho Vilanculos, a native of a remote village 250 km north of the capital of Maputo, counts himself lucky to have escaped the fate of so many victims of Mozambique’s civil war and subsequent turmoil. “It was really hard,” he remembers. “It is still hard.” His mother was a “farmer,” and his father had to seek work in the gold mines of South Africa, seeing his son once or twice a year. Two grandparents were murdered during the fighting. But Agostinho is well on his way toward a rewarding career in research and teaching.
Despite little support at home, he was lucky enough to finish high school in his village and pass the difficult college entrance exam. This won him a free pass to the single national university, renamed after revolutionary hero Eduardo Mondlane. There, remembering the floods that plagued the giant rivers of his home area, he chose to study water management in hopes he could learn something that might help.

After graduating, he won a scholarship to work on an MSc at the University of Zimbabwe, where he met Prof. Pieter van der Zaag of UNESCO’s Institute of Water in Delft. He began to learn resource modeling, and Van der Zaag told him about a new stream flow model developed by the US Geological Survey after the disastrous flooding of the Limpopo, Zambezi, and other African rivers in 2001. The model uses satellite cloud data to predict near-term rainfall, and Agostinho was able to correlate cloud data with flooding of the Limpopo, completing a thesis on the subject for his MSc.

Then last year van der Zaag urged him to apply for a RISE scholarship, which he did, proposing to use the technique on the Zambezi River, Africa’s third largest. This proposal was approved by Prof. Denis Hughes of Rhodes University in South Africa, a leader of the SSAWRN network, who also agreed to be his PhD supervisor. Agostinho has begun learning the complex mathematics he will need to model the river system.

At present, water managers of Kariba Dam in Zimbabwe respond to floods at the last moment, releasing huge amounts of water as their dam is threatened. This forces managers of Cahora Bassa Dam downstream in Mozambique to do the same. In some years this has flooded countless unsuspecting villages in the flood plain between Cahora Bassa and the coast. The dam managers do not believe that satellite data can help them, but Agostinho is determined to show them it can once his model is ready. He also hopes to correlate dam discharge with near-shore fish harvests along the rich Sofala Bank.

He admits that he faces a difficult challenge. He works in an ill-equipped, crowded room in a run-down government building. He has no peers in Mozambique who can help him learn the complex modeling he needs, and gets little support from state hydrologists, who give scant thought to floods until they actually arrive. But through the RISE water network, he now has both partnership and guidance from Prof. Hughes, as well as Prof. van der Zaag, and is determined to demonstrate the power of his newly discovered techniques.

And Then There’s the Language Problem... (SSAWRN)
By Alan Anderson, 23 April 2009
Some young scientists in Africa, especially residents of former British colonies, benefit from their legacy of English, the de facto language of science. There is no such benefit here in Mozambique, where would-be scientists struggle to learn not only their discipline but a new tongue that few people outside the tourist industry ever hear in this poor country. Even though I speak some Portuguese, communicating with graduate students Govate Egideo and Agostinho Vilanculos was a strain on us all, and they each described the frustrations of using their scant English to write proposals and reports and to communicate with English-speaking advisers. Govate has sought out a tutor at a foreign consulate in Maputo, but he is not even sure whether the consulate (or the tutor) is British or American.

Agostinho worries that the language barrier will limit his career, despite his determination and encouragement from mentors.

Research in the Service of Local Needs (WIO-RISE)
By Alan Anderson, 23 April 2009

Prof. Antonio Hoguane, coordinator of the Mozambique node for the marine sciences network, is a short, energetic, forceful man who is proud of his heritage and eager to get on with the task of modernization after years of ruinous civil war. He is especially eager to use and strengthen networks of institutions and people in his work modeling ocean dynamics. His own department of marine sciences is an outlier of Eduardo Mondlane University, located farther north in the coastal town of Quelimane, where it now has 13 faculty members. His English is exceptionally good, thanks to his years in Wales, where he earned his PhD at Bangor University under Professor Dave Bowers.

“Long before RISE we belonged to several networks and regional organizations,” he told me yesterday in Maputo. “So the people in the marine sciences know each other and share many things. We’ve been part of UNESCO’s Intergovernmental Oceanographic Commission since 1982. We work with partners in Mauritius, Madagascar, Tanzania, Seychelles, South Africa, and other communities around the Western Indian Ocean. We have worked with Professor [Alfonse] Dubi of Tanzania, the lead RISE coordinator [in Zanzibar], for many years, and there is a traditional partnership of cooperation between our two countries. One of our RISE graduate students, Avelino Langa, will study geoinformatics under Prof. Dubi, with a focus on fluid dynamics of coastal structures. We expect that he will develop the skills to advise not only our government but those of our partners on coastal erosion and other issues.

“Our other graduate student, Fialho Nehama, is more advanced; he will be doing his PhD work supervised by Professor Chris Reason of the University of Cape Town. He will study the
dynamics of the Zambezi River plume over the continental shelf and its effects on prawn production, one of our major export industries.

“There are many advantages to partners and networks. We can share resources, especially instrumentation. We can share people -- none of us can afford to have all the people we need in one country. We avoid duplication and ensure complementarity. We can build common understandings that allow us to speak with a single voice when negotiating with donors or other organizations.

“This is critical for us, because other countries, including some in Europe and South Africa, don’t always understand African issues. For example, their idea of building capacity is to teach us their knowledge. But our problem is not so much a lack of knowledge as a lack of resources, including human resources. We know what we want to do and what we need. What we need are the resources to do it.

“Or a donor may think that what we need is modern technology to solve our problems. We don’t want technology to lead us. We need to articulate what we need and then order the technology that will help us do that. We have moved away from the old curricula created by the Portuguese, because it didn’t have much to do with our needs or lives. We need research that relates to local problems. This is a policy requirement throughout our universities now, and we incorporate that naturally in the projects supported by RISE.”

From Refugee to RISE Participant (AMSEN)
By Alan Anderson, 24 April 2009

Odilon Ilunga, a large but soft-spoken man from the war-torn Democratic Republic of Congo, fretted about his clothes when I asked him to pose for a snapshot yesterday at the University of Namibia in Windhoek. He wore a shiny new suit, but to his eye, his T-shirt was askew and did not line up well under his shirt. His smile and optimism more than compensated.

His presence in the office of the Dean of Engineering there was wildly improbable, after the virtual loss of his home country. He had moved eagerly through school and university in his native city of Lubumbashi, the country’s second largest. He had, after a period of uncertainty, found great excitement in following his brother into an engineering major, choosing his own specialty of metallurgy because of its relevance to the mining industry of the DRC. He planned a career in professional engineering, and after graduation was easily able to find a job concentrating copper ore.

His dream dissolved, however, when war overtook his country in 2001 and he was forced to flee. He choose to appeal for refuge in nearby Namibia because he suspected a need for metallurgists
in its growing mining industry. He was right—but his dream was again postponed when he was
told he would have to stay in a camp for refugees. Undaunted, he gathered materials to study,
and began to teach science to other refugees. He even started a small metallurgical lab to practice
and demonstrate refining technique.

When he was finally allowed to leave after several years, he was quickly offered a job in the
copper mining town of Tsumeb, 400 km from the capital of Windhoek. There he moved rapidly
up the ranks to become co-manager of metallurgy. But he missed the academic and teaching
environment he had loved, so in 2008 he journeyed to the University of Namibia in Windhoek
after seeing ads for a metallurgy teacher. He wanted, he said, “to find out what was happening.”
What was happening was that Prof. Frank Kavishe of Tanzania had been invited to set up the
country’s first faculty of engineering and he needed talented engineers. Odilon was not only
qualified for the graduate program, but was the only metallurgist in Namibia.

When the RISE competition was announced shortly after that and the University of Namibia was
accepted as part of the materials science network (AMSEN), Prof. Kavishe saw a natural fit.
Odilon would extend the network’s reach with his interest in developing a purification process
for Namibian copper, and Odilon would benefit by using the advanced equipment at the
University of Witwatersrand, an AMSEN partner. Although most copper rich countries have
developed refinement techniques, every ore body has its own distinct qualities. A distinct process
must be painstakingly developed for each to remove impurities, “solve problems all along the
way,” and produce ore of 99.9% purity for copper wire and other uses.

Odilon is now pushing to flesh out his proposal for RISE. He must not only demonstrate the
technical parts of his plan, but describe probable costs, specific goals, and “how it is important to
myself, the university, and the country.” Given the expected approval, he will then go down to
Wits and later return for the challenges he has worked so hard to meet.

Why is Namibia so Excited About Science? (AMSEN)
By Alan Anderson, 27 April 2009

Last week we were relieved to hear that yet another free election had been held in South Africa,
whose name was so recently synonymous with apartheid. Many other African nations have
suffered their versions of apartheid and are also struggling through the early stages of self-
governance.

For Namibia, one feature of foreign domination (the region was occupied by Germany for many
years) was an almost complete lack of scientific activity. At the University of Namibia (UNAM),
students could study the humanities, but science and its cousin fields of engineering, economics,
and medicine were banned. It was thought that if Namibians studied science they would become empowered economically and threaten the colonial order.

During my visit to Namibia on Friday and Saturday, I witnessed a consequence of this long privation. The growth of science has begun with lightning speed. The faculties of science and health sciences are the most popular on campus. Last year UNAM inaugurated its first Faculty of Engineering, led by RISE member Frank Kavishe. Next year it will open a Faculty of Medicine.

Friday was graduation day at UNAM, and it was a day of national celebration. The president, ministers, members of parliament, and corps of ambassadors gathered at the Safari Hotel to praise the nation’s students, teachers, and institutions of learning. Proud parents began lining up at dawn, wearing their splendid best and brandishing huge bouquets of flowers. The five-hour ceremony rang with almost continuous cheers, claps, and ululations as the students and families laughed and cheered and applauded each other.

The reverence for education was proclaimed in a rollicking blend of traditions. The students took their places to the strains of “Gaudeamus igitur” by the UNAM Choir and brass band while graduates were embraced by large women wearing colorful native costumes and brandishing horses’ tails, symbols of good luck. The traditional shouts and cries of the women punctuated every announcement.

The keynote speaker was no less than the nation’s President Hifikepunye Pohamba, who took the lead in his praise of scholarship. “Our government has always celebrated education as the catalyst of nation-building,” he said, “of institutions that can move Namibia into the 21st century.”

Vice-chancellor Lazarus Hangula was more explicit, calling the graduates “heroes and heroines on the battlefront against ignorance.” He charged the students to begin their work immediately after graduation. “May your lives serve as an inspiration to the young people in the communities where you will work.”

The highlight of the day was the active presence of Sam Nujoma, a calm, bearded lion of a man who sat next to the current president. He is revered as a revolutionary hero, and since independence has served multiple terms as president of the republic and chancellor of the university.

Now 79, he began his address by greeting his “dear fellow graduates,” drawing loud laughter. It was well known that he, too, was about to graduate with a masters in geology. The dean of science interrupted to announced that he had “done the research,” and that the former president was the only head of state in history to have “gone back to school after retirement to earn a degree in science.”

Not to be outdone in dramatic gestures, Nujoma removed the chancellor’s gown he had worn for decades and placed it over the shoulders of vice-chancellor Hangula, promoting him on the spot. Then Nujoma donned the same plain black garb as his fellow graduates and urged them to be models for the nation. “Go and shine,” he said in farewell. “The world is waiting for your abilities.”

With that, the UNAM choir sang and danced four joyous songs – in Afrikaans, Damora, Oshivambo, and Zulu. A pure celebration of joy and the promise of the future for this newly independent nation.
Dr. Ofurum Francis Arimoro developed his interest in stream biology in his home country of Nigeria, in the rich aquatic habitat of the Niger Delta. His primary interest was to use aquatic insects as indicators of water quality, but he also enjoyed teaching the growing numbers of students interested in water issues and advising the public as well – for example, how to use certain mites to rid waterways of invasive water hyacinths. However, the institution where he earned his PhD and spent years teaching, Delta State University in Abraka, had not a single bifocal microscope, an indispensable tool for biologists who study macro-invertebrates.

Although Francis had published papers on aquatic insects, without a microscope he could seldom identify them below the family level, which limited his research progress.

Thanks to the work he had managed to do, however, he was invited last fall to give a talk on the biomonitoring of rivers in Grahamstown, South Africa, by the SA National Research Foundation. He spoke at the South African Aquatic Biodiversity Institute, located near Rhodes University. As a result of the talk, an expert from Rhodes invited him to work at the university for a month, using the lab’s modern instruments and immersing himself in insect taxonomy.

While at Rhodes, Francis heard about RISE and was accepted as a postdoc. He is now happily developing a stream bioassessment protocol for Nigeria based on an existing local system called the SA Scoring System. This is based on the varying resistance to pollutants, which means that they are reasonably sensitive indicators of stream health. For example, the presence of insects from the families of Ephemeroptera, Plecoptera, and Tricoptera (the so-called EPT group) usually indicate clean water. (Ephemeroptera are so named because their adult life phase usually lasts less than a day.)

The presence of Chironomids, by contrast, indicates water with some degree of pollution; the greater the proportion of Chironomids, the more polluted the environment. However, he still needs optical equipment that lets him identify the insects to the generic level, for many reasons. For example, some genera of Chironomids have different tolerances for pesticides and other pollutants.

Francis has other goals that can benefit his home country. He is developing a taxonomic key to help students learn identification of important indicator groups. “We have a lot of scientists coming up in this area, and I want to be able to help them,” he said. Another goal is to review biomonitoring techniques from around the world and adapt some to Africa by adjusting for climate, environmental features, micro-habitat, and other differences. Finally, because he is
handicapped by the lack of comparable biomonitoring studies anywhere in Africa, a longer-term goal is to do additional studies in East Africa and/or other locations to compare with his own. “For now,” he said, “I would like to learn more, go back home, and pass that along to others.”

A Better Cuppa Tea for Malawi (SABINA)
By Alan Anderson, 6 May 2009

Nicholas Mphangwe, known to his friends as Nick, works as a plant breeder for the Tea Research Foundation of Central Africa, in Malawi. Tea is critical to the Malawian economy, accounting for about 30 percent of the country’s foreign exchange and about 5 percent of the world’s tea crop. (India, Sri Lanka, and Kenya share equally about 70 percent of the world market, with the rest scattered among Uganda, Malawi, South Africa, and a few other producers.)

Producing tea, like other agricultural activities, has become a high-tech enterprise, requiring advanced skills. Nick has honed his skills with a BS from the University of Malawi and a master’s from the University of East Anglia, earned in 1996; he has worked at the Tea Foundation ever since. But his mentor, chief plant breeder Dr. Hastings Nyirenda, is preparing for retirement and has urged Nick to move one more step up the education ladder to take his PhD, which Nick has been eager to do.

Unfortunately, the expense of such an undertaking held him back for years. Even with the relatively low tuitions in African graduate programs, Nick was facing about $2,000 a year in tuition costs, another $4,000 in living expenses, and about $4,000 in bench fees (biochemistry is expensive!). Although the Tea Foundation has been generous in funding research, its income has declined in the past few years. A major contributor, Zimbabwe, has virtually disappeared as a tea producer, its 200 or so farms abandoned, its untended tea plants growing wild in the fields. Tea production generally has sagged worldwide during the current recession.

Luckily for Nick, a long-time collaborator, Prof. Zeno Apostolides of the University of Pretoria in South Africa, recently became a faculty advisor in RISE’s network on biochemistry and bioinformatics, SABINA. He called Nick, who applied to the program and was accepted. Because a main thrust of the RISE program is to help build advanced scientific skills, especially for people who are already experienced and committed to a field of their choosing, Nick was an ideal candidate.

One area of skills needed by Nick – and by the Tea Foundation – is the ability to identify genetic markers that will allow for more accurate and rapid selection of desirable tea strains. The scientists at the Foundation have been raising and studying some 300 tea cultivars, seeking to improve quality by traditional methods of hand selection. Nick hopes to help refine this process
through the use of genetic markers for such desirable qualities as taste, resistance to insects and
diseases, tolerance of low temperature and drought, and reduced caffeine.

While the University of Malawi supports extensive studies of many plant crops, Pretoria offers a
particular focus on tea, supported by well-equipped labs. One challenge is to analyze some 30
different components of tea; Prof. Apostolides is especially proud of a new high-performance
liquid chromatography (HPLC) machine that allows a new level of accuracy in separating,
identifying, and quantifying plant compounds. Nick will also be able to work in the
Bioinformatics and Computational Biology Unit, where he can explore the activity of key
metabolites of tea. SABINA budgets sufficient funds to allow Nick to take full advantage of the
tools and people at Pretoria without drawing down his own savings, making available a range of
advanced biochemical and genetic skills.

Meanwhile, there are signs that during his absence of several years the fortunes of the Tea
Foundation may improve. In Zimbabwe, small numbers of entrepreneurs have begun to return to
the abandoned tea plantations, pruning and tending the once-abandoned plants and laying the
groundwork for a renewed industry. If this trend persists, the country may once again be able to
harvest and sell this important crop, resuming its contributions to the Tea Foundation and to
modern programs that enhance the pleasure of tea-sippers worldwide.

After Two Decades, a Chance at a PhD (AMSEN)
By Alan Anderson, 19 May 2009

For a fortunate few students, RISE has brought opportunity to advance their careers after many
years of routine and yet stressful teaching. This was the case for Bernard Odera, who has toiled
for two decades as an underpaid lecturer at the University of Nairobi, teaching in overcrowded
classrooms with little time or support for research. Since earning his masters in mechanical
engineering at the University of Lagos, Nigeria, in 1987, he had never had the opportunity – or
the funding – to complete his PhD and pursue his academic dreams.

His opportunity came last year when he learned from a colleague about the new AMSEN
program. He was collaborating with colleagues at the University of Namibia, with whom his
department had joint funding for some work in materials science. He quickly pursued this
opportunity, with the assistance of his advisor, Prof. G. O. Rading at the University of Nairobi,
and was accepted into the program.

Bernard’s special interest – design and production engineering in the field of metallurgy – turned
out to be fortuitous. The founding head of the new engineering school in Namibia, Prof. Frank
Kavishe, was already collaborating with renowned metallurgist Prof. Lesley Cornish, director of
the Centre of Excellence in Strong Materials at the University of the Witwatersrand, Johannesburg. Her own expertise in superalloys coincided neatly with his own special interest in metallurgy, and he was admitted into her research group in Johannesburg.

He now finds himself immersed in a cutting-edge field of great complexity and importance to the world of engineering. Superalloys are advanced materials used in high-stress, safety-critical environments, such as nuclear reactors, aircraft turbines, and rocket engines. Engineers have worked for half a century to design alloys that can hold their strength and resist corrosion at ever-higher temperatures – in applications where failure can be catastrophic. Working with Prof. Cornish and her colleagues, Bernard will attempt to design a new formulation for platinum-aluminum-based alloys. Early, two-element formulations using these metals proved too brittle, but the addition of a third element has shown promise. Bernard and his group will attempt to add fourth and fifth elements – niobium and vanadium – to improve both durability and toughness.

His placement at Wits is ideal for him. The Centre has the advanced instrumentation his home institution lacks. A close working relationship between the Centre and Mintek, a leading South African company specializing in mineral and metallurgical products, will bring access to the small but pure samples of platinum, aluminum, and other metals he will need for his work. While RISE will cover the modest tuition of the program, the Centre will cover the surcharge for international students. And for the first time in two decades, Bernard will have the luxury to work as hard as he can in the field he loves. (See update on page 77.)

The Making of a Natural Products Researcher (SABINA)
By Arlen Hastings, 22 October 2009

Like most Malawians, Kumbukani (K.K.) Nyirenda was born in a rural village, in a small house with no electricity or running water. K.K. did not grow up dreaming of being a chemist. He didn’t spend his childhood marveling at the natural world, and he had no special passion for science or any other academic subject. He attended the village’s primary and secondary schools, where he was driven to work hard not by any innate motivation or passion for learning, but by the promise that when he graduated he would be able to go to Blantyre, the country’s financial center some 900 kilometers to the south. K.K. seldom ventured far from his village on Lake Malawi, on the Tanzanian border, and Blantyre became magical in his imagination.

It was enticement enough. K.K. graduated from secondary school and was accepted by Chancellor College (Chanco), the main arts and sciences campus of the University of Malawi. At the age of twenty, K.K. finally made it to Blantyre – a disappointment after so much anticipation, but it had worked its magic – and on to the university, 70 kilometers away in Zomba.
As an undergraduate, K.K. studied a range of subjects, and it wasn’t until his third year that he discovered his affinity for chemistry, which became his major. When he graduated with a BSc (Hons) in 1998, he went to work for Malawi Industrial Research, a firm that conducts R&D on natural products, and there he found his true passion.

A year later, K.K. was awarded a prestigious McNamara Fellowship from the World Bank to conduct a year-long research project on “Medicinal and Aromatic Plants of Malawi,” to culminate in a presentation in the United States. As a McNamara Fellow, K.K. was required to have a local academic supervisor. He left his job and enrolled again at Chanco, this time as a masters student. He was pleased with his research and worked hard on his presentation, but he never had the opportunity to deliver it; scheduled to take place in November 2001, his trip to the U.S. was canceled in the wake of 9/11.

Increasingly intrigued by the chemical properties of natural products, K.K. stayed on at Chanco to complete his MSc, funded in his second year by the International Program in Chemical Sciences (IPICS).

Since 2004, K.K. has been a lecturer at the University of Malawi’s College of Medicine, where he spends most of his time teaching second and third year pharmacy students. His appointment allows him to devote up to 30% of his time to research – provided he raises his own funding, which he is not always able to do. While he is interested in the whole natural products process, from plant material to product design, known as “pharmacognosy,” his particular focus is on phytochemistry – analysis of the chemical composition of plants – and on the efficacy of plant components against HIV, opportunistic infections associated with HIV, and other diseases endemic to the region.

K.K. was recently selected by SABINA to be part of its second cohort of PhD students. In January 2010, on three-year leave from the College of Medicine, he will return once again to Chanco, this time to study under the supervision of Professor John Saka. He will spend a portion of his SABINA term at the University of Pretoria and CSIR in South Africa, where his two co-supervisors are based and where sophisticated analytical equipment is available.

Three years from January, the University of Malawi will be able to boast one more PhD on its faculty.

**In Zimbabwe, ‘education for children is what parents live for’**

By Arlen Hastings, 23 October 2009
Among an impressive cohort of talented RISE students, those from Zimbabwe are notable for their strong academic preparation. Although economic and political conditions have prevented Zimbabwean universities from joining any RISE network, three of them – AMSEN, SABINA, and SSAWRN – offered bursaries to Zimbabwean students in the hope that one day they will return to their country, degrees in hand, to help rebuild Zimbabwe’s once thriving universities and research institutes. With the contacts they make among network faculty and students, the Zimbabwean students will be well placed to help their home universities when conditions improve.

Christopher Chetsanga, a biochemist who is president of the Zimbabwean Academy of Sciences, suggests this is a wise strategy. At the recent annual meeting of TWAS, the Academy of Sciences for the Developing World, in Durban, South Africa, Dr. Chetsanga reflected nostalgically about the heyday of Zimbabwean higher education, tracing its decline to the disastrous policies of President John Mugabe over the past decade. Even so, he voiced cautious optimism that conditions will improve soon.

Chetsanga, himself a product of North American higher education – he has degrees from Pepperdine and Toronto and was a post-doc at Harvard and a professor at the University of Michigan – returned to Zimbabwe in 1983, three years after independence. Hopeful about the country’s future, he accepted an appointment as professor of biochemistry, then dean of science, and finally acting vice-chancellor of the University of Zimbabwe. In 1993 he was asked to set up a new Scientific and Industrial Research and Development Center. He led the center for ten years, during which time it produced more than 100 PhD’s.

All of them have since left the country, unable to work in an environment where research funding has vanished and inflation has rendered salaries all but worthless. Chetsanga’s department, which once had more than 20 lecturers and three full professors, now has five lecturers. Chetsanga himself, no longer affiliated except as a student advisor, is the sole remaining scientist with the rank of professor.

In Zimbabwe, says Chetsanga, “education for children is what parents live for,” and the literacy rate of more than 90% is still among the highest in Africa. Despite the depleted faculty, universities continue to educate a full complement of undergraduates, and while they almost invariably leave the country after receiving their degrees, they tend to remain in the region.

Secondary schools have been slower to feel the effects of the economic disaster, but in recent years more and more teachers have fled to find employment in neighboring countries. The current RISE post-graduate students are among the last to benefit from Zimbabwe’s outstanding education system. The neighboring countries of Botswana, Namibia and South Africa have become the new beneficiaries, having welcomed some of the best school teachers in Africa.

While Chetsanga laments that “the environment for science in Zimbabwe has been destroyed,” he sees reason for hope – primarily in the advanced age of the current president, who is 85. Even amid the political and economic chaos, universities remain open and infrastructure in place. The few scientists still in Zimbabwe maintain their contacts abroad, especially through the science academies, but research funds are desperately needed to bring their colleagues home. One effective policy of the Mugabe administration has been a 3% AIDS levy imposed on salaries for AIDS prevention and treatment. Chetsanga would like to see a similar levy used to provide
desperately needed research funds. He has an ally in Heneri Dzinyiweyi, the Minister for Science and Technology Development.

Chetsanga is far from alone in his impatience to welcome the scientists back to Zimbabwe. Having built up its research strength once, he is ready to help do it again – along with many former colleagues still in the region. These will almost certainly be joined by the handful of RISE graduates who are preparing themselves for leadership positions among Zimbabwe’s new generation of academics.

**Growing Pains (AMSEN)**
By Arlen Hastings, 26 October 2009

A brand new Faculty of Engineering at the University of Namibia (UNAM) will provide a professional home for at least three students pursuing MSc degrees through AMSEN. After he receives his degree, Odilon Ilunga, who is doing his research in the analysis and refinement of Namibian copper ore, plans to divide his time between employment in the copper industry and teaching at UNAM.

Lloyd Nyemba, a Zimbabwean national, also has an academic job waiting for him at UNAM – although if conditions improve in his home country and he chooses to return to Zimbabwe, “it would not be a loss to the project,” according to his co-supervisor, Frank Kavishe. Professor Kavishe, who heads the UNAM-based AMSEN secretariat, explains that the network aims to build capacity throughout the SADC region.

A native of Namibia, William Nashidengo will begin his studies in January at University of the Witwatersrand in Johannesburg, where he will learn the fundamentals that underpin his project in corrosion control along the Namibian coast. At Wits, he also will have access to sophisticated equipment unavailable to him in Namibia. He will undertake his second year of study at UNAM, and when he finishes he too will have a job there.

Although employment awaits these students at the completion of their MSc’s, all three hope to continue their studies through AMSEN and earn their PhD’s before taking up their academic posts. Prof. Kavishe is eager to give them the opportunity, should funding continue to be available through RISE.

Professor Kavishe is a busy man. In addition to teaching and supervising students and running the AMSEN secretariat, he is spearheading the establishment of his university’s new Faculty of Engineering. To complicate the task, UNAM’s main campus, home of the former engineering department, is in Windhoek, while the new faculty is located in Ongwediva, 720 kilometers to the north. Prof. Kavishe divides his time between the two campuses, flying back and forth
weekly. He works with engineering students and oversees development of the new faculty in Ongwediva, and teaches pre-engineering students and tends to administrative matters in Windhoek.

In many ways, Ongwediva seems to be an ideal site for UNAM’s expansion. The town council, hoping to turn Ongwediva into a “university city of the future,” has offered generous incentives, including free land, to educational institutions to open campuses there, and many are doing so. UNAM’s Faculty of Engineering will be one of six components of a Center for the Built Environment, with architecture, town planning, and other related faculties to be phased in over the next decade. The Government of India is funding buildings and equipment for two departments – computer engineering and information technology, and mining engineering – and will provide visiting faculty. Located 25 kilometers from an airport, Ongwediva is not difficult to reach.

But there’s a problem, a rather serious one for an institution meant to serve as a regional research facility and as the coordinating hub of a regional network. The 60 computer users – staff and students – in the Faculty of Engineering in Ongwediva are linked to the outside world via a single 256K connection to UNAM’s Windhoek campus. As a consequence, simple text emails sometimes take several days to reach their destinations, if they arrive at all, and it is impossible to transmit attachments. The internet is almost inaccessible. Bandwidth is available, but the cost is prohibitive; UNAM pays 3,000 Namibian dollars (US$380) per month for 256K. There are plans to increase the bandwidth to 1MB in December or January and 2MB in the coming year, but this will clearly be inadequate even for basic communication, much less for accessing on-line research resources.

Prof. Kavishe hopes the Indian government’s support for an IT department will include funding for bandwidth or for satellite equipment, which after an initial large investment would make internet access more affordable. Until then, he tends to his responsibilities as a network coordinator when he is in Windhoek – or he uses the telephone.

**Traditional Cure Inspires Biochemistry Student (SABINA)**
**By Arlen Hastings, 26 October 2009**

A childhood encounter with traditional medicine is at the root of Secilia Kaenda Ilonga’s foray into natural products chemistry.

Secilia, an amiable young MSc candidate in the SABINA network, is enrolled in courses at the University of Namibia (UNAM) and is beginning to collect plant materials for the thesis research she will undertake in 2010. Her project, tentatively entitled “Screening for anticancer and
antioxidant compounds from selected indigenous Namibian plants,” will be carried out under the
coopervision of Martha Kandawa-Schulz and Hesham Lotfy El-Sayed of UNAM and Sylvester
Lyantagaye at the University of Dar es Salaam (UDSM) in Tanzania.

As a child in the village of Oshaatotwa, 700 kilometers north of Windhoek, Secilia contracted a
disease known as Ondhiya in her mother tongue, Oshiwambo. Characterized by pus-filled
wounds, usually on the scalp, the disease has no known cure in modern medicine, according to
Secilia. When she fell victim to the disease at the age of ten, she was taken to an older woman
who was known to be expert in the use of traditional medicine. A dried plant, made into a lotion
and applied directly to Secilia’s wounds, proved to be an effective cure.

When Secilia enrolled in UNAM for her BSc, she thought she wanted to study nursing, but soon
was captivated by molecular biology and biochemistry, particularly as they apply to the analysis
of medicinal plants. She was excited by the opportunity to continue her studies through SABINA,
and she is looking forward to her first trip outside Namibia next year to work at UDSM with Prof.
Lyantagaye. She hopes to go on to earn her PhD.

The Ambitions of AFNNET: Natural Products and Beyond
By Alan Anderson, 13 November 2009

Sub-Saharan African countries desperately need to develop products that can meet local needs,
preserve the environment, provide jobs, and drive the economy. John David Kabasa of Makerere
University in Uganda thinks that he and his colleagues in AFNNET have found an answer to this
need in the hot new field of natural products.

Natural products, or NP, is a new term for a centuries-old custom – the use of natural plant
materials to provide food, medicines, cosmetics, stimulants, energy sources, and other
marketable products. What is new for NP is the strategy of linking it with modern science,
management, and entrepreneurship in ways that add value to such products. Stephen Kiama of
the University of Nairobi sees these materials as sources of “alternative wealth” that are
accessible to people of few means, ecologically adapted to local conditions, and sustainable.

Scientifically, the field of natural products has both depth and breadth, requiring many
overlapping skills to discover useful products, analyze them, and apply the quality controls
required by the modern marketplace. For this reason, NP is well suited to a networking approach,
and the RISE network for NP – AFNNET – is one of the most diverse and collaborative. For
example, the participants from Makerere, Nairobi, and Sokoine University of Agriculture in
Tanzania have jointly developed a common curriculum that will allow students to move freely
among partner institutions. Plans call for participants from not only analytical, environmental,
and bio-prospecting fields, but also from the areas of economics, business, patenting, ethics, and “value chain management.”

The development of an NP industry, however, is hindered by a shortage of trained personnel, especially at high levels of academic and professional expertise. This arises primarily, according to Prof. Kiama, from limited funding to train graduate students and high-level technicians. He and his team have found AFNNET funding to be a significant help. “Carnegie support has enabled us to move quite fast,” said Prof. Samuel Okello of Makerere. “In most of our activities we interact as much as we can. Everything we do is interdisciplinary. A single project may include chemistry, pharmacology, and botany.

“At the PhD level we have recruited all 10 of our candidates – five at Makerere, three at Nairobi, and two at Sokoine. We have a good gender balance. We have co-opted many of our colleagues to be mentors, so students have three or four, in different fields. They all enjoy mentoring, because it involves them in research, brings new contacts, and gives them co-author credit on papers.

“Some of our students get short, specialized courses on subjects they need. One is studying statistics. Another went to Addis Ababa, which has one of the best analytical labs. A third went to France for practical analytical training. All of them get training in communication, writing.” Makerere has also developed the first master’s program in the region in NP, which was planned as a joint program among the three nodes giving students the ability to transfer credits from one to another. The graduate school accepted the program in August, and it is now awaiting Senate approval, with an estimated February launch. A “great innovation” of this program, said Dr. Okello, is that students may join at any time instead of awaiting the next semester.

Included in the plan is the private sector. According to Prof. Okello, “At the moment, a lot of NP are exploited for claimed pharma value, nutritional value, etc. We want to learn from the herbalists and others and help them at the same time to improve their investment. The traditional people don’t really know what’s in their products. We plan short courses for these people to help them purify, standardize, package, and market their products, which is what they want. We’ve worked hard to win their trust, and I think it is working. They want to add value, and improve their business. We envision an association with them that brings this about.”

Prof. Kabasa has even more ambitious plans. “We want to transform Makerere from just an academic institution to a societal institution,” he said. “The RISE announcement came just as we were developing this. We have engaged the government for four years about delivering changes to society. The government is very interested in helping us. We want to blend intellectual skills with vocational, managerial, and entrepreneurial skills to form an interdisciplinary, holistic institute. You have to help me find a name for it.”

Links to the private sector are being built through the Makerere University Private Sector Foundation, whose director is head of the Bank of Uganda; the Uganda Investment Authority, whose director, Maggie Kigozi, is a member of the Private Sector Forum; and other investors and associations, such as the Uganda Veterinarian Association.

Some of the activities envisioned for this institute are “value addition along value chains of natural products,” improving the productivity of NP through biotechnology, enhancing biosecurity by studies of disease and public health, and entrepreneurship for young people as
well as small enterprises. They also want to link the institute’s activities to curricula in primary and secondary schools, working closely with the Ministry of Education.

“This program,” concluded Prof. Kabasa, “can be so important to this region. The Masai are bringing natural products into Kampala and selling them. We want to help organize this group, boost the quality, standardize the product, help with packaging and marketing. When the people need to analyze something they can come to our labs which can be a reference lab and a resource center where people can learn through e-learning and training – a one-stop shopping center.

“We’re already sensitive to the needs of the private sector,” he concluded. “This is not the traditional model. The institute will be an NGO without bureaucracy or disciplinary walls. We want it to be a showcase, where people from the region can demonstrate what they have and what they are doing. We want to train the trainers in new ways, and at the same time return to a cultural model of collaboration that is very old. What we are doing is repackaging knowledge to address new needs in society. In veterinary medicine, you get a degree when you solve a problem, not when you sit for passive instruction the old way. We will have a lot of non-degree training, a lot of youth and community support. The President supports us, the university supports us, the private sector supports us.”

Can a New Tea Stave Off Malaria? (AFNNET)
By Alan Anderson, 16 November 2009

Patrick Engeu grew up in the small town of Soroti, in eastern Uganda, where malaria was (and still is) endemic. He, like most of the townspeople, was accustomed to malaria attacks, and to the skills of the local people in treating it at home.

“When one of us had malaria,” he said, “people would go pick some leaves and roots. They’d dry the plants, pound them, boil them, cool them, dry them again. They’d mix up the powder with water in the bathtub and then filter it. They used many plants for malaria – not just artemesia. You’d drink this mix three times a day, and after two days the malaria would be gone. About 60% of Ugandans use these plants for many ailments.”

Patrick’s interest in plants stayed with him through secondary school and then he won a government scholarship to attend Makerere. He found a job at the Ministry of Health, where he was able to study natural products. He was not surprised when his office received a call for advice about a particular malaria remedy. The callers were concerned about any side effects, and whether the amount they were taking would really help. That much was not surprising; the lab had heard such requests before. But Patrick was surprised by the details.
“This was a group of about 1,000 workers at a flower farm in Entebbe,” he recalled. “There was a lot of malaria around. The workers had heard about artemesia and decided to try it. The difference was, they didn’t just take it when they got sick, which is how everyone uses it. They made it into a tea and drank it every day to prevent malaria, not to cure it. We’d never heard of anyone using artemesia as a preventative.”

Patrick and his colleagues got started by dividing the workers into two study groups – 120 tea drinkers, and 120 controls who abstained. He documented cases of malaria in each group, and found encouraging results. According to preliminary findings, those drinking the tea gained a 35-60% protective effect over those not drinking it. The protective effect was higher when the malaria incidence was most severe, after heavy rains.

With the help of AFNNET, Patrick and co-workers will follow the flower workers for a year, trying to answer some of the many questions raised by this discovery: how long will the drug be stable; how long does protection last; can an additive such as avocado improve the bitter taste without altering its efficacy?

Most important, says Patrick, is to isolate the components chiefly responsible for the protective effect. An interesting aspect of the mystery is the artemesia itself. The familiar therapeutic fraction is called artemesinin, which is most active in the bloodstream for only about an hour, and remains in decreasing amounts for only about 6 hours. It is highly unlikely that artemesinin is responsible for prophylaxis. So much chemical detective work remains to be done. “We’ll keep looking for the flavonoids responsible for this,” he said. “We need to know that to bring quality control and to improve the activity.”

A Resource for Uganda, ‘Where the Poor Are So Many’ (AFNNET)
By Alan Anderson, 16 November 2009

When Esther Ebifa Othieno yearned for a career in biology as a girl, she faced formidable career hurdles. Few parents believed in a supporting a girl’s education for fear she would become pregnant or marry, leave home, and take their investment with her. Nor was the academic culture prepared to welcome women into its ranks.

Esther was unusually fortunate on several counts. Her mother was a teacher in Jinja, near the roaring source of the Nile, and her father a farmer who encouraged her interest in plants of all kinds. They believed in her dreams enough to send her to Gayaza School, a boarding school in another town where she studied biology, geography, chemistry, and mathematics. She did well enough to win a government scholarship to Makerere University, which by then was beginning to open its doors to more women.
After graduating with a major in environmental sciences in 1992, she took a diploma in education, which allowed her to secure a teaching position at the new Kyamgogo University, which had been stitched together from three smaller institutions as part of a general buildup of higher education. That turned out to be a strategic move, because she was able to win a leave with pay when she was ready to take her master’s in environment and natural resources. The only condition was that she return to Kyambogo to teach – which she is still doing.

She then faced the same barrier as most MS students – to find funding to work toward a PhD, and for many years she was unsuccessful. She was still searching when RISE was launched, and she was fortunate again in being selected to study under Prof. John Kabasa. “It’s a great privilege to be able to study at this level,” she said recently. “In academia now women are being accepted as equals. There is no discrimination in salary, so we have quite an important role to play, and more opportunities. Funding is hard to come by, but that is true for men as well.”

Perhaps it was her own struggle that guided her decision to study another underdog – the lowly tamarind tree, one of the “neglected natural products” that has not yet received serious attention. “Even though it is indigenous,” said Esther, “its potential economic significance is not known. I have been able to do a literature search for its uses in other places, and I can already see a very high potential for it here.”

She has found, for example, that tamarind is a significant contributor of antioxidants, vitamin C, and minerals. When fruit comes, it is easy to store without refrigeration. The wood has high caloric content and makes excellent firewood. The trees grow well in harsh conditions, polluted soils, and rocky wastelands. The wiry leaves form effective wind blocks and the deep roots help hold the soil against erosion. Elsewhere people eat the leaves and use the bark for medicinal purposes. Some fruits are sour, like lime, and a few are sweet, and she wants to experiment with improving the flavor. The seeds can be processed as high-protein flour, and the bark makes good fiber.

“These things are all known from the Philippines, India, and elsewhere. But in Uganda, only the old people remember when the tamarind was so useful. The areas I want to study, toward the Kenyan border, are dominated by poor people living on dry land. It could bring great benefits for them, and I am so happy to be able to investigate its potential in Uganda, where the poor are so many.”

‘What Magic is That?’ (AFNNET)
By Alan Anderson, 16 November 2009
John Odda recalls growing up as a “village boy” in the Tororo District of Uganda, where his father was a road overseer working for the Department of Public Works and his mother a housewife who was “really deep in folk medicine.”

“Sometimes I would get sick, or my brothers would get sick. We would have all the symptoms of malaria: chills, fever, vomiting, sweats, joint pain. My dad would walk over to some bush and come back with some roots and leaves and then he would cook them all up. He would give me something to drink and I would get well. I remember thinking ‘What magic is that?’ I wanted to know what was in those plants, and I still want to know.”

Now that he has won an AFNNET scholarship, he will have his chance to find out. He notes that malaria is still the number one killer of people in Africa, and many folk remedies are used to fight it, some of them with excellent effect. But little is known about the pharmacology of these treatments. John will focus on a number of plants, especially Combretum collinum, a member of the bushwillow group, many of which are used to make traditional medicines in the tropics.

“How can I contribute here?” he asks. “Tororo has a high transmission rate of malaria. It gives me a chance to use herbs like my dad used to do, but to try to find out what’s in them and standardize the process. They also vary in strength with the season. I’ll spend a lot of time determining the differences, using chromatographic fingerprinting of these plants.”

John is well prepared for this stage of his career. He has focused on science since his years at Manjasi High School in Tororo, especially on agriculture – “because it was practical.” He was accepted at Makerere and supported during his BS years by the Staff Development Fund. Then his advisors saw his considerable promise and recommended him for a scholarship to the University of Alabama, in Tuscaloosa, where he continued his collaboration with Prof. Kabasa at long distance. “That was important to me,” he recalls, “because I feared I might lose my focus on natural products so far away from home.”

When John was selected for the AFNNET program, he was well prepared, except for one surprise: the unpredictability of local customs. When he returned to Tororo to start his work, he followed good current practice in offering people sleeping nets dosed with mosquito repellant. The recipients, however, had other ideas about the nets. Instead of hanging them around their beds, many of the people used them to make wedding gowns for the village brides.

**The Dream of Preventing Disease and Reducing Suffering (SSAWRN)**

By Alan Anderson, 16 November 2009
Joseph Erume is unusual in several ways. Most prominently, he is the first postdoc to work at Makerere University. This is primarily because postdoc funding is extremely difficult to secure in sub-Saharan Africa. Second, he may be the only water researcher at Makerere (or perhaps anywhere else) to drink from the same spring he is studying for pollution.

“When I came back to Makerere as a postdoc,” he said, “we moved into a house that happened to be near one of Kampala’s big valleys, where the water from the hills seeps down. People build springs near the bottom of the slopes, and then they build their houses closer and closer to these springs so they don’t have so far to carry the water. Of course they dig their latrines right below their house, so that that their sewage goes right with the water seeping down to the spring. Sometimes they pile their garbage nearby, and that gets into the water as well. In my house, part of the day our water comes from the city, but it stops flowing all the time, and then we have to get water from the spring. Of course we boil it.”

Joseph has been selecting springs to study, and cultivating relations with the nearby residents so as not to antagonize them by his presence. In the first picture, he and his colleague Irene Naigaga dodge a gutter of trash as they descend to one of these springs; in the second picture they chat with the community “chairman” who is sympathetic to their mission. “We have not yet begun our water collection, so as not to move too quickly into the communities. But we have a lot of people dying of cholera, and amoebic and bacterial water-borne diseases rob people’s energy, and it’s very likely there is a correlation between illness and sites like this.”

Joseph was born in the Amuria District of eastern Uganda, about 300 km from Kampala. His parents were not educated themselves, but made sure he and his siblings went to high school, even though he had to travel to the neighboring district. At that point he didn’t know what career he would pursue – until one of his family’s cows went into a difficult labor. There was no veterinarian in town, and finally the cow died when the calf could not be released. A second cow caught a tick-borne disease called East Coast fever and died as well. “These were our cattle, and their deaths showed me this is the life I had to pursue.”

On his own initiative, he won a scholarship to the Faculty of Veterinary Medicine at Makerere, where he earned his BSc. After that he took an MSc in veterinary microbiology at the Royal Veterinary College of the University of London. He returned to a job he had already secured at Makerere as a lecturer until he had an opportunity to travel to the University of Nebraska for his PhD in integrative biomedical sciences, with a major focus on E. coli. Finally he has the support to embark on his own research – moving across the thin line that divides people from other animals. To Joseph, the larger task is to prevent disease and reduce suffering among all living beings.
Man Versus Amoeba (SSAWRN)
By Alan Anderson, 17 November 2009

Justine (pronounced Justin) Ekou is a friendly but determined young man who grew up with few advantages in a small village in eastern Uganda. His parents were poor farmers who scraped a living from the dry soil, growing and selling cassava, sweet potatoes, millet, and sorghum. He was sent to school in the district capital of Soroti until grade 7, when his parents could no longer support his education. Luckily a paternal uncle stepped in to sustain his momentum through high school. The instruction level was basic; “we had no textbooks at school,” he said. But he applied himself and brought home excellent grades.

When his sister fell ill with the intestinal parasite Entamoeba histolitica, whose incidence is second only to malaria among severe illnesses in Uganda, he resolved to keep studying in order to join the battle against this debilitating disease.

The next step came easily when he qualified for a government scholarship to Makerere. He had his heart set on medicine, but this route was too competitive for someone with only a basic education. He decided to enter veterinary medicine instead, with the hope of helping humans as well as livestock.

After graduating in 2007, he took a year to gain practice by working for several firms that offered large-animal vet services (there is little small-animal veterinary work because few people in Uganda keep small animals as pets). He returned to Kampala to meet with the department head, who encouraged him to go on to an MSc even though he could not afford the fees. Justine was determined to learn about molecular biology, because he was convinced that the answers to disease lie hidden at that level.

He persisted and finally found a scholarship, where he immersed himself in molecular studies. But when it came time to move toward a PhD, Justine was stumped. He repeated the strategy that had brought him luck before, making the rounds of the many departments in the Faculty of Veterinary Medicine. Finally, he found Prof. Michael Ocaido in the Department of Wildlife and Animal Resources Management and heard some good news.

“I told Prof. Ocaido that I urgently wanted to study water-borne diseases,” he said, “because my village has such big problems – typhoid, dysentery, and cholera in addition to amoeba.” Even though Prof. Ocaido has spent his career in the veterinary medicine department, he was sympathetic to Justine’s obvious desire to improve human health, so he told him about the new RISE program. The department wanted to make use of Justine’s strong background in molecular biology and asked him to develop a proposal. He came up with a plan to sample amoebae at four sites in Uganda, where he would apply type analysis to the genome. This would allow him to test
at each location whether the genetic type present in the water supply is the same as the type in infected patients.

As Justine prepares for his field work, he will need all the modern tools he can bring to the task, since the amoeba turns out to be as enigmatic as it is debilitating. “Humans carry many strains of amoeba, but only about one in 10 cause disease. Why? Very little is known about this in Uganda. We are more or less starting from scratch.

“Also, people are discovering that there is a strain of this organism that invades the liver and lungs. This is a separate species called E. dispar, which is very hard to diagnose. It can’t be differentiated from E. histolitica by regular microscopy.” A consequence of this is that conventional assumptions – and public health data – may be off. Justine will have an advantage in using his genetic tools, which should bring him new information about this tricky pathogen.

“Many people thought to have histolitica may in fact have dispar,” he said, “which may be even more prevalent but doesn’t cause gastrointestinal disease. So we have a lot of work to do.”

A Long-Term Goal to Help Other Women (SSAWRN)
By Alan Anderson, 17 November 2009

Irene Naigaga’s mother was a midwife and her father director of a medical center, so it was often assumed by her family and neighbors that she would seek a career in medicine. “In fact I hated medicine,” she remembers. “At home a little girl with mental problems used to burn herself, and the only person she would let clean her wound was me. But I didn’t like doing it.”

Instead she was strongly drawn to a veterinary field center where her neighbor worked amid numerous needy animals. As early as the second grade she would hurry through her homework so she could rush to the center to sort slides and do other chores. “One day I saw someone counting lots of money, and I thought to myself that this must be a good place to work!”

She remembers the excitement of a campaign to eradicate trypanosomiasis in cattle. She was eager to help, and one day a veterinarian showed her the squiggle shape of the organism under a microscope, and she was hooked. “The sight of the money was nice,” she said, “but the sight of that little creature is really what set my mind. My teachers tried to talk me out of it and to go into medicine instead, but I had had enough medicine.”

Following her dream, she graduated on a government scholarship from Makerere’s Faculty of Veterinary Medicine. Then a postgraduate diploma allowed her to do research on pollution in a lake in western Uganda, where she also became interested in wildlife. Eventually she was hired
by the Department of Wildlife at Makerere, which allowed her to complete her master’s at Rhodes University in South Africa under supervisors Denis Hughes and colleagues.

When it came time to search for a PhD project, she found one that was both challenging and useful: the need to develop an inexpensive but accurate technique to monitor water quality in Lake Victoria and its wetlands. “Uganda has no regular water monitoring of this important lake because it is too expensive,” she said. She knew she could not expect to produce a highly sophisticated technique while keeping expenses low, so she turned to her veterinary background. She chose an animal high in the food chain that might be expected to accumulate pollutants over its lifespan: the Nile perch, or tilapia. “I wanted to be able to identify the water quality ‘hot spots,’ at least qualitatively. And I found I could do that with the fish. It turned out that when the water quality goes down, we can see lesions in the tilapia tissue.” This is a new technique for Uganda. It was an excellent match for Irene, because recognizing the histopathology of tilapia required a background in veterinary medicine.

“The RISE grant came to me at a time when I had finished sampling the fish, but I was really stuck. The technique was inexpensive, but I still needed to pay for several thousand dollars in lab charges. I also needed tuition to finish my degree in South Africa, where I will go in a few weeks. We don’t have a good enough library for the work I am doing, and the collection at Rhodes allows me to do better work; their literature is very accessible. I have really, really appreciated RISE. It was like God answering my prayers.”

What will be next? “After I get my PhD, I would like to do more data collection. Then I’d also like to encourage women. Women are vulnerable to pollution. They actually know the environment is polluted, but they go anyway to wash their clothes or draw water because they have no choice. I’d like to link my science of environmental health with the communities of people. I also want to be a teacher. Students need direction, and I think I can give that. Some of them are really lost; they don’t even know why there are coming to class.”

The Dangerous Side of NP Research (AFNNET)

By Alan Anderson, 1 December 2009

Bridging the gap between academic science and traditional healing is a ticklish but critical task. Many of the remedies used by herbalists and the people themselves are widely used and apparently useful, but the active ingredients are largely unknown.

“Our people have survived for centuries without modern medicine,” said Prof. Stephen Kiama, associate dean of the Faculty of Veterinary Medicine at the University of Nairobi and director of the AFNNET node there. “We need to come back to their roots, and these are their traditional
remedies. It’s a matter of urgency that brought us into this research. We cannot go on doing studies that are disconnected from what the people are doing and what they need.”

One of the biggest challenges for academic scientists is to win the trust of the traditional healers, many of whom are suspicious that these big-city scientists will make off with their secrets and reap big profits. All of the AFNNET members have worked patiently to counter these suspicions, and to make the case that a partnership can benefit both camps. In fact, many of the herbalists do want to know what is in their products and welcome opportunities to package and market them to a wider clientele.

In addition to the task of diplomacy faced by the scientists is the equally daunting challenge of finding and reaching the herbalists, most of whom live in remote areas that have poor roads and limited security. Several months ago Prof. Kiama and two colleagues were driving an SUV toward a major meeting with herbalists in the remote town of Maralal, some 450 miles north of Nairobi, when they nearly lost their lives in an ambush. Their lone vehicle was speeding along an unpaved road when it was suddenly riddled by automatic rifle fire and overturned. Bandits, who had fired the shots, began to close in on the vehicle, with every apparent intention of killing and robbing its occupants. Luckily, another vehicle came along, sending the bandits back into the bush.

The scientists were not hit by bullets, but Prof. Kiama’s arm was severely broken during the crash. He was airlifted by helicopter back to Nairobi, while his colleagues, who were unhurt, managed to complete their journey and attend the meeting without him. Fortunately for all, the meeting was successful and laid the groundwork for more detailed collaboration.

As for Prof. Kiama, the details of his adventure quickly became known around Nairobi and soon he was telling his story on TV – looking somewhat the worse for wear.

‘Safe, Efficacious, and Affordable’ (AFNNET)
By Alan Anderson, 22 December 2009

Joseph Mwanzia Nguta is clear about his objective in the field of natural products: “I would like to build a career of research to find safe, efficacious, and affordable cures for malaria.”

He is well aware that this is easier said than done, but he insists on those criteria, which he repeated several times during our talk. He has already assembled 40 plants used by traditional healers from the district of Msembweni, near Mombasa on Kenya’s south coast, where malaria is especially severe. He made this survey to support his first objective: to determine which plants the healers are using. His second objective is to check the aqueous and organic extracts of these plants for bioactivity. He has already submitted a paper on his results to the Journal of Ethno-
Pharmacology, and is proud to be listed as first author, along with his advisor Professor Stephen Kiama of the Faculty of Veterinary Medicine at the University of Nairobi; Dr. James Mbaria of the Department of Public Health, Pharmacology, and Toxicology; and two others.

He is firm in his belief in the overall value of these remedies, despite the continuing deaths caused by the disease (Joseph gives a figure of 42,000 malaria-caused deaths each year in Kenya, most of them among children). He recalled that his parents, who were subsistence farmers in the Machakas district, regularly prepared remedies for him when he had a stomach ailment or other problem. Now he wants to do more for those suffering from the scourge of malaria.

“I’ve seen so many people suffering, so many hospitalized when I was growing up,” he said. “As I got older I kept asking myself how I could help solve this problem. So after I finished my BS, I enrolled in the department of pharmacology and toxicology and wrote a proposal in 2007. But there was no support. I was very fortunate that RISE came along just at the right time.”

He has already spent considerable time interviewing both herbalists and patients in his home area, finding wide varieties of techniques and beliefs. Some malaria remedies are prepared as powder, some as decoctions. About 80 percent of the people go to herbalists when they are sick and 20% make their own medicines based on traditional knowledge. A very small number go to “western” medical practitioners, all of whom use artemesinin, a natural remedy that is widely effective, though not inexpensive. “Almost no one can afford to see a doctor,” he said.

He has now begun work on his second publication – on patient attitudes and behaviors with regard to traditional medicine, based on his own survey. A longer term goal is to ensure that these remedies are safe.

“People have been using these plants since antiquity,” he said. “But, especially for the aqueous solutions, no one knows the effects of long-term use.” Hence his mantra: “safe, efficacious, and affordable.”

**Building Partnerships with Traditional Healers (AFNNET)**

By Alan Anderson, 5 January 2010

Irene Kamanja of the University of Nairobi joins several other RISE students in pursuing a strong interest in traditional remedies – both for the good they can do and also the need to reduce the toxicity that many remedies bring. One Kenyan remedy is made from Clerodendrum myricoides, a common blue-flowered verbena used by traditional healers to treat venereal diseases, especially gonorrhea. But with its acknowledged effectiveness as a medicine comes its equally well-known toxicity; overdoses have been known to be fatal.
Irene first learned of the issue as a student when she read a general survey of herbal remedies used in the Maralel region north of Nairobi. This survey, done by another Nairobi student in 2008, called attention to the toxicity issue without speculating about its cause or a possible solution. Irene consulted with her advisors in the Faculty of Veterinary Medicine, who helped her outline a multi-step plan of research: (1) verify the bioactivity of Clerodendrum through tests against the microbial spectrum of E. coli, Pseudomonas, Streptococcus, and Candida, as well as Neisseria (gonorrhea); (2) do the phytochemistry needed to identify the plant’s active ingredients; (3) conduct the toxicological steps to determine a dosage that is safe as well as effective. The project was deemed important enough to win inclusion in the AFNNET program.

The herbalists viewed this project not with jealousy but with great enthusiasm. Because Clerodendrum is such a key component in their treatment arsenal, they are loath to give it up. And while they are familiar with the plant’s toxicity, they cannot agree on a solution. The issue became a central topic at the meeting of herbalists and academics organized by the Faculty of Veterinary Medicine in Maralel in 2009. At that meeting, about 70% of the herbalists said that they dealt with Clerodendrum’s toxicity by reducing the dosage, while 30% reduced the toxicity by mixing the plant with three or four other agents. This, of course, complicates the effort to measure its toxicity and brings the additional task of analyzing the additives. In general, observed Irene, the herbalists have always determined dosages and treatment through trial and error, but now say they would welcome a more modern means of standardizing the treatment.

“This studying these plants is quite important,” she said. “Herbalism is part of the people’s culture. There’s no restriction against using modern medicine, but they prefer herbal remedies, because that is what they know.”

This is especially true in the regions – or manyetta – that were not settled by white colonists, such as the coastal area around Mombasa. There the Samburu people are nomadic, and for much of the year they are out of reach of western-style medical clinics, schools, and other institutions. She estimated that 20 to 30% of the 35 million people who live in Kenya are nomadic, relying on folk practices of many kinds, including medicine.

Seeking an Herbal Cure for Arthritis (AFNNET)
By Alan Anderson, 2 February 2010

Stanley Wambugu grew up in the Laikipia District of central Kenya, in the arid town of Ol-jorok. His parents were smallholding farmers who raised maize, beans, goats, sheep, and cattle. He went to the rather limited primary school in his home town, but had the good fortune to travel to the larger town of Nanyuki for high school. This town, some 125 miles north of Nairobi, is near
Mt. Kenya. Because of this, it is more closely linked to the outside world, with hotels that cater to climbers, backpackers, and other tourists who like to have their picture taken at the point where the Equator passes through town. From there, Wambugu could see more possibilities in life than the backbreaking word of subsistence farming.

Knowing that, he worked hard in high school and won a government scholarship to the University of Nairobi. There he consciously chose a major that would allow him to do “something of practical value,” he said. Because he came from a region where people depend on livestock, he easily saw the value of a degree in veterinary medicine.

After graduating, he followed the common practice of working as a veterinarian for a year, and then returned to the university for further studies. He was developing a strong interest in neuroscience, which he found to be crucial to his goal of reducing suffering; he moved to the Department of Veterinary Anatomy and Physiology to learn more about it. “That was when I found that this was my true field,” he said. “The main complaint of humans with disease is pain. And I wanted to know more about the nerves and the mechanisms that cause pain – in humans as well as in animals.” He decided to dedicate his MSc studies to this mechanism.

Here again his choices were influenced by personal experience, especially his memories of family members who had been victims of arthritis. A close relative on his mother’s side, in particular, was afflicted by chronic pain caused by rheumatoid arthritis. He knew that his relatives, like most rural Kenyans, had sought relief from traditional healers, and he yearned to know more about the remedies they prescribed, especially about the mechanisms that often brought relief. He had heard from rural people that the herbalists’ remedies often worked well enough not only to provide temporary relief from arthritis, but sometimes to bring about lasting change that resolved the symptoms altogether. What was in those remedies? How could they work so well? He was eager to answer not only those basic questions, but also to learn how the effectiveness of these plant products could be improved. To do that, however, he would need the financial support to investigate these plants, and the university was unable to help.

When he heard about RISE, he easily saw an opportunity to approach the subject in more depth. He met with the faculty who had supported his MSc studies, quickly designed a PhD project around his topic, and was accepted into the AFNNET program at Nairobi, under the supervision of Prof. Stephen Kiama.

The phenomenon he wanted to study is anti-nocioception, which is a reduction in sensitivity to pain. This can be accomplished naturally by the body, when it releases endorphins or similar opioids, or by synthetic or herbal drugs that mimic this activity. Stanley’s challenge was to find out which herbs were most effective at mimicking the body’s natural pain-fighting responses and whether these responses could be strengthened.

In response to the RISE-AFNNET call for proposals in 2008, he proposed the evaluation of anti-inflammatory and rheumatoid properties of selected medicinal plants used around the town of Machakos, a hilly, arid region some 40 miles southeast of Nairobi. Like his own native region, Machakos has a population mostly of subsistence farmers, raising sorghum, millet, a fast-maturing maize, indigenous sheep and goats, and zebu cattle. They also rely primarily on herbalists to treat illness.

His first challenge was to win the trust of the herbalists so as to learn what they were doing. He was met by considerable enthusiasm, because the herbalists themselves were interested in
knowing more about their products and improving them. Wambugu agreed that in return for the knowledge he needed for his study, he would return to meet with them again and explain what he had learned during his studies.

As he approached the botanical phase of his study, he hoped for simplicity: Had the healers all used the same single plant to combat the kind of pain he was interested in, his task might have been straightforward: identify the bio-active agent responsible for pain relief and learn how to improve it. Instead, as he followed his teachers around the region, he was introduced to no fewer than 53 different plants. He was able to focus on six species as the most important, but each healer used at least three of those six, and most of them used their own particular mixtures. The task of isolating the most active agents would not be easy. (See update on page 65.)

Sweet Buildings (AMSEN)
By Alan Anderson, 2 February 2010

Even in some of the more traditional academic areas, such as civil engineering, RISE students are finding innovative approaches to ongoing needs. For example, John Mwero, a PhD student at the University of Nairobi, faced the familiar challenge of building new, high quality buildings at lower cost and with reduced environmental impact.

When John was considering a PhD in engineering, he looked at a problem of significant dimension. Virtually all new buildings in Nairobi are built of concrete, which accounts for 15-20 percent of the structure’s cost. Concrete is relatively expensive, and requires large amounts of energy to produce. He started thinking about ways to reduce these costs, and found numerous suggestions that various raw materials, including agricultural wastes, might be used to replace some portion of the concrete in buildings.

Where John grew up, in Kilifi, near Mombasa, sugar cane was a central feature of life. His mother kept a garden of stalks near the front door of their house so she could cut a bit of cane to chew on when she went out. A sugar cane mill was located not far from the house, and sugar cane dominated the landscape. Huge piles of stalks and leaves – bagasse – surrounded every mill.

Disposal of this bagasse has become a substantial environmental problem. Some of it is useful as mulch for farmers, and some is bagged as fuel for boilers – indeed, the price of sugar is now so low that the sale of bagasse can be more profitable than the sale of sugar. And recently sugar plants have been burning the bagasse to reduce its volume, using a controlled spray technique to reduce the smoke. But burning still leaves large piles of ash.
John began a literature search and found suggestions that such organic residues might find a new application as a substitute for concrete. But how much could be used? He began some early tests, making small cubes of concrete and sugar cane ash. His early results were encouraging. Although large amounts of ash would weaken the concrete, small amounts – about 6-8 percent – would actually bring a slight improvement in strength. He found similar results with rice husks.

“I’m very much encouraged,” he said. “Bagasse is very available, and would reduce the demand for cement, which is very energy intensive to produce. This might also mean extra revenue for the farmer eventually, and solve the problem of disposal of bagasse. And we may be able to find ways to reverse the loss of strength at higher proportions.”

John has the support of his four supervisors in this project, and he sees better linkages between academic engineers and private firms as essential to innovation. “People in companies have a very low opinion of people in academia,” he said. “I’ve had people tell me, ‘You know, an engineer with a masters is not necessarily the best engineer.’ When someone comes from a university and goes into a firm, it’s like starting out fresh. Academics lose track of the cutting edge of industry. We have to reduce that gap by having more people in industry who are also teaching. If students are taught by someone actually doing work on the ground, they will be much better engineers.”

In John’s case, one of his supervisors is a consulting engineer for a large firm in Nairobi, where he also worked for a year before starting his MS work in 2003. “I would also like to be a consulting engineer, because then I can make a good link between the theory and the practice,” John told me.

At the same time, he enjoys teaching, which he began last year, and would like a permanent position on the faculty. He acknowledges a problem in classes that are too large (60-90 students) to allow discussion or attention to individual students. In the Kenyan system, engineering majors in a particular field all attend the same classes together for the five years of the program. Civil engineering attracts few women, he says; in his class of 60 graduating students, only three were women. He attributes this in part to tradition and in part to the large class sizes, where aggressive students have an advantage. (See update on page 74.)
steel billets and local scrap to feed its small local industry, which produces mostly nails, wire, rebar, and pipes, and most of its industry is owned by Indian or other foreign interests. Virtually all the high-quality steel is imported from India and elsewhere, including the EU for specialty steels and South Africa for stainless steel. Kenneth feels that Kenya must move into steel with more aggressiveness if it is to succeed economically.

“Why work with steel?” he asks. “It’s the principal structural material in machines. Africa is shifting: we’re moving into materials science as a matter of necessity. Special alloys of steel is a place where we can add value to commodities. The new challenges in this materials field are to teach computer design and analysis skills. This is the future of materials. The old way was to design by hand, build a prototype, and test it. Now we design the prototype by AutoCAD and simulate all the testing, which is much cheaper and good for us. With this technique you expect the prototype to run for some time. We are learning the skills to design, test, import, and manufacture.”

Kenneth acknowledges some special problems facing Kenya and other African countries in building high-tech industries. One is the difficulty of importing new technologies and equipment, which can be controlled by political whim. Another is land ownership, which is controlled by the traditional tribes. He noted that a large Canadian company had been trying to develop a significant titanium deposit in Chiomi, near Mombasa, since the 1990s, but had been unable to close the deal on the land. Just last year, a Chinese conglomerate moved in to try its luck.

“It’s almost impossible to buy land,” he said. “You offer the tribe one thousand, they ask for two thousand. The haggling can go on for a lifetime. For mining you need space, tax relief, guarantees. It can happen; it happened for the sugar cane industry, which has had to buy land for processing. But you have to be careful. If you are from the wrong tribe, it’s impossible. I would have trouble buying the titanium land because I am Kikuyu, the tribe of the President, and other tribes are jealous of Kikuyu power.”

In Kenneth’s view, a good beginning strategy for Kenya is to take advantage of the many opportunities in outsourced design work for firms that build automobiles, aircraft, and other equipment. This is an activity that depends on knowledge of structures, materials, and computer design techniques rather than the availability of large tracts of land or mineral wealth.

“Kenya is a land that just got the submarine Internet cable,” he said. “The costs of IT are going to come down. Once we have sufficient expertise and a critical mass of people, we can think about building up our manufacturing capacity. We do have some computer numerical controlled [CNC] machines, and a fairly modern casting plant. We have copper, labor, and coal, and transportation costs are not high. Power is still expensive, and we don’t know how big our iron deposits are. But a number of industries have one piece of what we need, and we’ll find out if we are cost-competitive. The East African Community would be our beginning market, and we are the only member country in a position to build a steel industry.”

For his PhD research under AMSEN, Kenneth will do his bit to push the Kenyan industry ahead by learning more about techniques for analyzing steel materials. “We have always relied on information generated by experiments,” he said. “It’s much better to understand phenomena at the micro-structure level. This takes a lot of computational power and time. Others have already done a lot of work on this. Now we need to know more about the links between the behavior of steel at the micro level and the behavior at the macro level. That’s what I’m going to do.”
New Uses for Hot African Sun (AMSEN)
By Alan Anderson, 2 February 2010

Charles Ayieko’s excitement is palpable as he describes his cutting-edge work on solar cells at the University of Nairobi. Huge expanses of terrain in Kenya and other sub-Saharan countries still lack electrical power, even the modest amounts that could allow rural people to read or work at night, hear outside news on the radio, and charge their cell phones. Solar electricity generators, powered by solar cells, have the potential to fill many such needs – once costs are lower and efficiency is higher. Charles is working in the midst of this competitive field, using a new technique to raise solar conversion efficiency.

His particular approach begins with extremely thin absorber, or ETA, solar cells. Thin-film solar cells, also called thin-film photovoltaic (PV) cells, are solar cells made by depositing one or more thin layers of photovoltaic material on a substrate. The ETA solar cell is a relatively new PV configuration, by which a porous or structured material some 2 to 10 micrometers (millionths of a meter) in thickness is coated with a layer of light-absorbing inorganic semiconductor. A large number of semiconductor materials appear to be suitable for use in ETA cell configurations, but most of them are yet to be tested in ETA cells.

There are many advantages to Charles’ choice of ETA cells. First, they are nontoxic and cheap to produce. Like other thin-film designs, they are flexible and light-weight, making them practical for rooftop arrays on small houses. Specifically, thin-film photovoltaic cells can use less than 1 percent of the expensive substrate (silicon or other light absorbers) required by wafer-based solar cells, leading to a significant cost savings. ETA cells can be engineered into flexible sheets and are mechanically robust, requiring no protection from minor events like hail or tree strikes. Finally, they do not suffer from the purity problems of silicon-based cells.

Charles’ own contribution, which he began working on in early 2009 under his grant from AMSEN, is to study the use of titanium dioxide as a coating for ETA solar cells. TiO2 is a widely available material used as a pigment in everything from paints and sunscreens to food coloring and coffee creamers; this availability helps bring down costs for users. Specifically, Charles is researching the effects of “doping” the TiO2 layer with tiny amounts of nitrogen. The reason for doping with nitrogen is that it has been found to raise the cell’s conversion efficiency, which is a key issue for ETA cells. “This doping changes everything,” he says excitedly, meaning that without it, his ETA cells would not be competitive with more traditional rigid silicon cells.
While the benefit of the nitrogen doping is clear, his task is to determine whether the doping can change any of the desirable qualities of the cell. Charles’ project requires patience and painstaking work. “We need to check many things,” he says: “the position of the nitrogen, the porosity of the TiO2, which has to remain very high, and most importantly, whether the introduction of the nitrogen has changed the structure of the cell itself.”

His work requires several sophisticated instruments that are not available in Kenya or in most countries of sub-Saharan Africa. He needs a scanning electron microscope (SEM) or transmission electron microscope (TEM) to study the morphology and roughness of the material; this will tell him whether the elemental structure has changed. He also needs x-ray diffraction to check all three mineral forms of TiO2, the anatase, brookite, and rutile. These vary with temperature, and their proportions should not be changed by the introduction of nitrogen. Luckily, Charles’ participation in AMSEN is providing the opportunity to use machines for these advanced techniques at other nodes of the network where they are available.

The Seaweeds of Zanzibar (WIO-RISE)
By Alan Anderson, 3 February 2010

As a faculty member at the University of Nairobi several years ago, Grace Mutia had achieved unusual success in the realm of academic science in Kenya; among women she was even more of a rarity. She had earned a master’s in hydrobiology, aquatic resources, and management. She was eager to move higher to the PhD level and complete her dream – to teach and do research on the path toward becoming a full professor.

Unfortunately, she stalled at the same point where so many promising African students languish – at the threshold of PhD field work where personal or family resources run dry and no public or foundation funding is available. She resigned herself to an indefinite future at the School of Biological Sciences, applying for every scholarship she could find. “I was being turned down every time,” she said. “I got only ‘regrets’.”

When her professors heard about the Western Indian Ocean (WIO)-RISE program and urged her to apply, she had no more reason for optimism than she had had in the past. Nevertheless, she sent in the required documents – and did her best to brace for another “regret.” She did learn that the program would be based at the Institute for Marine Sciences (IMS) in Zanzibar, part of the University of Dar es Salaam in neighboring Tanzania. This was promising, since the IMS research agenda closely matched her own interests in aquatic biology. So she applied and agreed to provide a description of her study objectives if accepted.
Among the available topics, she chose natural products from the marine environment, partly because she knew she would find expert mentoring among the IMS faculty, and also because she felt she might find new ways to help the struggling families of the marine coast. She knew that Tanzanian scientists had already taught many coastal women to earn a living by harvesting seaweeds, but that much remained to be learned about the biochemistry, taxonomy, and uses of local species.

The pioneering work to develop seaweed into a commercial crop was initiated by a puckish but dedicated biologist named Keto Mshigeni, who has long championed the nutritional and medical uses of seaweeds, mushrooms, and other natural products throughout Africa. Despite being born in a highland village near Mt. Kilimanjaro, Prof. Mshigeni was able to understand the plight of coastal women, who for generations had used sticks to plant maize and cassava in the rocky coral soil and buckets to carry water to their plots. He helped them learn a new way to farm by tying seaweed plants to twine that is strung between sticks at low tide on the Zanzibar flats, then harvesting, drying, and baling them for sale. The two most widely grown species are Kappaphycus alvarezii (locally known as cottonii) and Eucheuma denticulatum, both red algae that are rich in carrageenans – in high demand worldwide as a commercial gelling, thickening and stabilizing agent for toothpaste, food products, pharmaceuticals, cosmetics, and many other products.

Time passed slowly for Grace as she waited to hear from WIO-RISE. She could see that the large number of applicants listed on the website would reduce her chances. She heard nothing for two months, then three. After four months, when she had all but given up hope, she received an email from the program director: She had been chosen after all, and would have the support she needed to do her PhD field work.

Soon after arriving at the IMS she could see that seaweed farming had already improved life on Zanzibar. A significant industry had evolved, visible almost daily in the port of Stone Town, where men stagger under huge bales of dry seaweed, dumping them aboard coastal freighters that informally beach themselves near the tourist hotels. She visited the women at their seaweed plots and learned that they now had some cash to spend; many owned 20 or 30 outfits of Kenyan clothing and were able to send their children to school.

But she also saw many challenges. K. cottoni is vulnerable to monsoon currents that wash away the strings and sticks, predation by sea urchins, and die-offs when the beach is not flushed by enough water. The women’s work is hard, drying is slow in the rainy season, and die-offs can set back seaweed growth by months. The low prices received by the women are dictated by a single company that controls the market; they receive about 200 Tanzanian shillings (15 US cents) per kg of dried, baled product.

However, Grace quickly learned of some local customs that can be exploited to improve livelihoods. For example, local fishermen crush certain seaweeds and place them in hand-woven traps as bait for parrotfish, a common local food. But they sail all the way to Bagamoyo to collect this seaweed, a 50-mile roundtrip by dhow. She believes that if she can isolate and produce the fish-attracting chemical, she can improve the lot of the fishermen and reduce the heavy demand on seaweed. She also hopes to teach women to grow this seaweed for sale to the local fishermen.
“We have many opportunities,” she said. “What are the nutritional properties of the seaweed? Why do the fish choose them?” She is also studying a new floating line system developed to grow K. cottoni in water about 10 feet deep. Although this depth seems to prevent the die-offs, it is difficult for the women, who are not good swimmers.

“If the men can work there too,” concluded Grace, “they could all benefit. They can help with the seaweed and also catch more fish in their basket traps – without having to maintain a boat or work all night. It would push the fishermen farther out from the beach, which is good because there they won’t take so many juvenile fish. So we have many benefits to work for.” (See update on page 47.)

Perilous Times for the Squids of Kenya (WIO-RISE)
By Alan Anderson, 12 February 2010

Francis Murage Mwonjoria’s academic career as a biologist began auspiciously and rapidly. He earned a BSc in botany and zoology from the University of Nairobi, followed by an MSc in hydrobiology. For his master’s degree, he joined a research project that was both interesting and valuable: measuring the results of efforts to restore mangrove ecosystems to good health. He and his team chose the mangrove region of Gazi Bay, near Mombasa, which has suffered from deforestation and water pollution for many years. The loss of trees had become a considerable threat to the local population, which both harvested the wood and depended on the health of the forests at the same time. The deforestation had other negative effects, including decreased availability of wood, fish, and prawns; lower revenues paid to the government in royalties and tourist fees; an increase in coastal erosion; and the eventual reduction of sea grasses and coral reefs.

Efforts to replant the mangrove forests by hand had begun in the 1990s, but little was known about how effective these efforts were. To answer this question, Francis’ team set out to evaluate and compare three types of environments: (1) undisturbed forests, (2) forests that had been degraded, and (3) forests that had been degraded and replanted over a period of 10 years.

“My question was,” he said, “now that we’ve replanted them, is the ecosystem recovering? What we found was good recovery when reforested. It was not complete, but very exciting. When you look at the animals from all of these environments, one, two, and three, you can see everything coming back: nematodes, copepods, then the fish.”

It was not so easy, however, to measure the fish populations. The biologists did use the traditional fish traps, or malema, which are wooden structures that allow fish to enter and then prevent them from leaving. But it was very hard with this technique to catch statistically useful
samples. So Francis and the others used an ad hoc system of “stick nets,” which was not traditional.

“We would bury a net in a trench,” he said, “and then six of us would station ourselves all around the net, each holding a stick. When enough fish came over the net someone would yell ‘One, two, three’ and we would all pull up on our sticks and bring the net up under the fish. This was very hard, and we had to do a lot of it by swimming. Then we still couldn’t count the fish, so we had to leave the net up on the sticks until the tide went out.”

After this interesting project, his career all but came to a halt. He faced the same quandary as most of his RISE colleagues: finding the support to continue working toward a PhD. He did keep busy, including his duties as one of the chief fisheries officers of Kenya, and persisted in his efforts to land some kind of scholarship.

“It’s very hard,” he recalled, shaking his head. “We had no support in Nairobi. I spent ten years applying for scholarships everywhere: DAAD, SIDA, JICA. Every year the chances became less, because the foundations give preference to recent graduates. I heard about RISE in Nairobi, and everyone was surprised when I got the scholarship. Even my seniors at the Ministry of Fisheries can’t find support for research. You struggle, you just struggle to get research money. So this was like a dream. I feel very good.”

For his RISE work he will change gears to investigate the steady decline in the near-shore squid fishery in Kenya. This will be done at the Institute for Marine Sciences in Zanzibar, where faculty members have ample expertise to supervise his work. “My question is simple,” he said: “Why is it going down? This is important because squid meat is very popular locally and for export. In fact, it costs more than fin fish.” Part of the reason for its popularity in Kenya, he said, is its unfortunate reputation as an aphrodisiac; it is also said to help nursing mothers produce more milk.

While overfishing is clearly a threat, this common species, the bigfin reef squid (Sepioteuthis lessoniana), has been reported in the literature to decline with rising sea temperatures. Francis has begun his investigation here, using surface data from the US National Oceanographic and Atmospheric Administration (NOAA). He will also collect data from fishermen in the jig fishery, who search for squid at night using lights, and from the Ministry of Fisheries. Finally, he will survey the records of companies that use ships to troll for prawns, lobster, and squid, including East African Seafoods, Basta and Sons, and Trans-African Fisheries. He already has the title of his study, if not the results: “A Survey of the Squid Fishery of Kenyan Coastal Waters, With Emphasis on the Biology and Ecology of the Bigfin Reef Squid (Sepioteuthis lessoniana).”

“I think it is mostly global warming,” he hypothesized. “But we have many questions. The squid is susceptible to degradation of the environment, especially deforestation. El Nino has caused a lot of rain, soil runoff, and coral reef die-off. I must also look at the southeast monsoon, which can bring lots of changes in the sea from spring to September. When current velocities are very strong, they can affect the reproduction of the squid. So there may be more than one cause.”
Five RISE students have been part of an exciting transition at the Okavango Research Institute (ORI), in Maun, Botswana. As of October 1, 2010, the ORI (formerly the Okavango Research Center) attained the standing of a full Institute of the University of Botswana, and it is scheduled to become the University’s second campus by 2015. The RISE students are part of the first 15-member group of graduate students to work at ORI, after a multi-year effort by research leaders to bring them. “As a researcher,” said Professor Wellington Masamba, coordinator of the RISE program there, “I felt like a fish out of water.”

All the RISE students are working on related aspects of the hydrology, biology, and sociology of the Okavango Delta, the swamp that absorbs the annual flooding of the Okavango River, Africa’s fourth longest. This river is fed by the annual rainfall of the Angolan highlands, creating one of the world’s largest endorheic basins: It is a river that never reaches the sea.

For many years, local lore had it that the water simply disappeared into the sands of the Kalahari Desert. Since hydrology studies began at ORI several decades ago, it is now known that 60 percent of it is consumed by evapotranspiration of plants and 36 percent by evaporation; just 2 percent percolates into the aquifers above volcanic basement rock, and another 2 percent reaches Lake Ngami far to the south, where it supports abundant bird life.

In the Okavango, the annual pulses of flooding support huge numbers of wild animals that in turn attract tourists from all over the world. They also support some 120,000 people in Maun and around the Delta, most of them belonging to one of five ethnic groups and speaking their own local language.

The ORI is still only about 15 years old, and the RISE graduate students and their colleagues have brought fresh energy to the countless questions about the delta. The following five profiles give some indication of the scope of their work, and of the many, often conflicting demands placed on the water and life forms of this remarkable place.
Moseki Motsholapheko entered the RISE program by an unusual route – from the field of political science, and “from the inside.” He had been working as a social scientist at the Okavango Research Institute since 2000 as a research assistant, studying human adaptation to flooding.

The human population of the Okavango region has grown rapidly in recent decades, slowed only by the onslaught of HIV/AIDS, and Moseki has worked with Prof. Donald Kgathi, an economist, to understand the response of villagers and rural farmers to the many “shocks” inherent in a region where relentless drought is punctuated by occasional floods. In a land as flat as a table, as is the Okavango, a flood that raises the water level by even a meter can destroy houses and fields across a vast area. The shock of dessication can deny water to livestock, curtail fishing, and prevent planting of crops. “I’ve been doing research on livelihoods, on the adaptation of people to drought, diseases, and other large shocks,” said Moseki. “The shock I’m working on now is dessication.”

He heard about RISE in 2008, when he had nearly completed a study of water and livelihoods in the area around the Boteti River, near Maun. He was about to complete an MS in environmental science, having decided to shift toward the natural sciences. During his work with Prof. Kgathi, he had participated in a large, three-nation SADC project on water management and policy issues around ephemeral river basins, such as the Boteti. An ephemeral river is one that flows briefly in response to rainfall, then returns to a dry state. In southern Africa, the Okavango River is an anomaly, pulsing in response to the Angolan rainy season, but continuing to flow during other months of the year.

One of the findings of the study, said Moseki, was that dispersed management authority over water issues had been both top-down and inefficient, creating policy conflicts and inconveniences for users. Challenges ranged from outright lack of water for some users to policies that created barriers to people seeking water. For example, he said, people in rural communities who needed to apply for a borehole permit to obtain water for a kitchen garden might have to travel 200 km and pay a 10-pula fee (about $2, a substantial amount for a peasant farmer) to fill out an application.

“I co-authored a paper about this,” he said, “and a lot of the issues we raised have been included in the review of the national Water Master Plan, which was completed in 2009. Some of the results have been good. For example, the water authorities that used to be in charge of regulation, policy, and supply services are dividing those responsibilities into three different offices, as they should.”
At the heart of much of Moseki’s work has been the hydrological cycle of the Okavango. The subsistence farmers around the Okavango depend on two different kinds of farming. Conventional farming depends on ordinary rainfall, which is scant and unpredictable. Flood recession farming, or molapo farming, uses the same technique that farmers have followed along the Nile for millennia. When the annual floods recede, the farmers plant quickly in the rich soil of the flood plain, hoping their crops will flourish in the moisture left behind. The yields from this technique can be very high; a good molapo year can produce more than 16 times the yield in sorghum as dryland farming. But such yields are never certain; during some years, the flood water may never leave the fields, or it may return to inundate fields that have already been planted, or it may not arrive at all. During drought years, molapo farmers are forced to depend on the same ordinary rainfall as the other farmers, which is scant and undependable, and may occasionally bring its own floods. Only a few crops are amenable to molapo farming: primarily maize, sorghum, and millet, with smaller amounts of beans, melons, pumpkins, and groundnuts. Many people also earn income by processing sorghum into a kind of beer.

“Our findings confirm that the people in this region generally have a low capacity to adapt to shocks,” said Moseki. “They lack almost every kind of capital they need – human capital, financial capital, and physical capital when they are far from the main settlements. There has also been a general decline in social capital, the close human networks that people count on during times of shock. We believe that policies and strategies should promote high access to natural capital” – essential resources such as water, grazing land, fisheries, and forests for firewood. “This is a way to increase the resilience of households when a shock comes.”

The Puzzle of the Precocious Southern Fishes (SSAWRN)

By Alan Anderson, 22 November 2010

When Kondja Amutenya was growing up in northern Namibia, he was instructed early and often how important it would be to get a good education. His father, who worked in a diamond mine in the south, was virtually never home with his family. Kondja learned first-hand about another kind of life he did not care for – livestock herding. During every vacation from school, his mother dispatched him from his village of Uukuuvu-Onemanya to help his cousins look after the cattle, goats, donkeys, and other livestock at the family’s remote cattle post. Just to get to the post was a 70-kilometer walk, he recalls. “I would get up early in the morning and just walk without stopping until I got there.”

Against these experiences was the consistent and supportive voice of his mother, a teacher, who told Kondja and his three sisters that this was the kind of life they could expect if they did not study hard in school. She never bullied them, he recalls, but simply encouraged them, bringing home books for them to read whenever she could. He listened carefully, studying hard enough to
get into high school in the regional capital of Oshakati, near the Angolan border, where the northern campus of the University of Namibia (UNAM) is now being developed. And his sisters listened as well: Today, one is a geologist, another an environmental scientist and the third a medical student in Pretoria, South Africa.

Kondja, after earning a BS in natural resources at UNAM, found a job at the National Marine Institute Research Center, in Swakopmund. This beach resort, founded in 1892 as the main harbor of then-German South-West Africa, is adjacent to the Namib Desert, one of the oldest and driest in the world. Tourists come to see the nearby sand dunes, some of which are nearly 1,000 feet tall. Kondja came to learn about fisheries.

When a friend studying in Stellenbosch, South Africa, told him about RISE, he contacted Denis Hughes, leader of the SSAWRN network. On the basis of his university performance and experience with fisheries, he was accepted as an MPhil student at the Okavango Research Institute (ORI) of the University of Botswana. At the ORI, near the northern city of Maun, he was set to work with fellow student Siziba Nqobizitha on a puzzling size difference between tilapia of the same ages from the northern and southern parts of the Okavango Delta. “This phenomenon had been observed earlier,” he said, “but they didn’t know how prevalent it was. When we started, we could see that a little fish down here that was six or seven inches long would have the same gonad development as a fish of about 13 inches up north. We needed to know if the northern fish was older, or what was going on.”

Since he couldn’t tell the ages of these fish by length, Kondja set to work learning a more accurate technique of aging that uses the tiny otoliths, or “earstones,” which are hard calcium carbonate structures located directly behind the brain. Otoliths have been found to exhibit growth rings similar to those of trees as the fish grows. A fish grows more slowly in the winter, forming a darker, denser ring; in the summer, when the fish grows faster, a clearer ring is formed. Kondja’s results showed that the small fish in the south are indeed the same age as their much larger cousins in the north, and just as mature sexually. The current hypothesis to explain this discrepancy is that the southern fish, which depend on the temporary seasonal flood water to grow and mature, must do so rapidly, whereas the northern fish, which live in permanent flood channels, have more time to mature.

Kondja works with his faculty advisors, Wellington Masamba and Keto Mosephele, on other features of the fishery as well, such as the impact of water quality on growth, including dissolved oxygen, pH, and temperature. Fisheries issues are highly important – and often contentious in the Delta. Some of these fishes, especially the three-spot and red-breasted tilapias, are important sources of livelihood for 40 to 50 commercial gill-netters. Also, some 3000 women and young girls fish for small fish with baskets, traps, and simple rods and lines. Finally, the recreational fishermen who stay at the tourist lodges pursue the larger game fish, mostly tiger fish and large-mouth tilapia.

Because the commercial fishermen have been accused of overfishing the Delta and causing fish stocks to decline, the ORI has attempted to investigate this claim. A recent study concluded that the more significant catch fluctuations are caused not by overfishing but by drought, spraying for tsetse flies, and burning of riverine vegetation for cattle grazing. It found that the current total catch of about 1000 tons of fish a year could be at least doubled with no detrimental effect. Another important conclusion is that compared to other African wetland systems, the density of
fish in the Okavango is low because of the clean, low-nutrient water that feeds the Delta from the undeveloped highlands of Angola.

Meanwhile, Kondja, perhaps remembering his father’s hard work in the diamond mines of Namibia, is eager to continue his hydrology studies on another front as well. He wants to apply what he has learned to test the effects of diamond mining on groundwater quality back in his native Namibia. Since most of the people of Botswana and Namibia depend on bore holes sunk into the sand, the quality of this stored water is crucial to livelihoods – but easily jeopardized by surface activities.

Searching for the Source of the Okavango’s Nutrients (SSAWRN)
By Alan Anderson, 22 November 2010

Kelebogile “Kele” Cole entered the RISE program last year with powerful momentum – and from an unlikely background. Her family originated in Sierra Leone, but her grandfather, curious about the outside world, moved to the United States in search of a different life. After his curiosity was satisfied, he returned to Africa, settling in what is now Lesotho. One of his sons, Kele’s father, moved to Botswana, where he met Kele’s mother and settled down to raise his own family. Kele’s nickname is a remnant of that long-ago family foray to the States.

The family stayed in the capital and only major city, Gaborone, which is less than 10 miles from the South African border. (Gaborone, named after a famous Tswana chief, is pronounced ha-ba-ROHN-eh. Locals usually settle for Gabs.) Kele was a bright student, and when it came time for college, the University of Botswana in Gabs was the logical choice. She had already developed a curiosity about how different forms of life could survive in the harsh, dry climate of Southern Africa, and decided to major in ecological studies.

During her studies she took advantage of a workshop on research methods offered by what was then called the Okavango Research Center in Maun, more than 300 miles to the north. She sufficiently impressed her professor, Dr. Caspar Bonyongo, so that he asked her to keep in touch. After graduation, following her own adventurous impulse to see the outside world, she went to Russia on an internship sponsored by the International Association for Exchange Students for Technical Experience. She landed a position at the Russian Academy of Sciences’ Institute of Biochemical Physics, helping to make biodegradable plastics.

She did keep in touch with Dr. Bonyongo and learned from him that the RISE program had been announced and that positions might be available to study at Okavango. In September 2009, she was accepted there, first in the capacity of a research assistant, helping with administrative tasks for the new graduate student program – purchasing supplies, processing allowances and student reports. Then in March 2010, Prof. Wellington Masamba invited her to apply to the new RISE
program and begin work on a master’s degree. She quickly agreed, finding that she could continue her existing job and use her salary to pay for student expenses. Like the other RISE students at what is now (as of October 1) the Okavango Research Institute (ORI), she was assigned to work on an aspect of wetlands research. The Okavango Delta is one of the world’s largest interior wetlands, whose annual flooding from heavy rainfall in the Angolan highlands allows it to support huge numbers of fishes, plants and animals, including the elephants, hippos, leopards, and other large mammals that attract well-heeled tourists.

Only in recent years have scientists, many of them located at or working in partnership with the ORI, begun to study the Delta’s essential basic functions, and Kele was asked to join this effort. She works under the guidance of Drs. Bonyongo and Masamba on the effects of the flooding on nutrient budgets of the soil. The question she is investigating is the following: How can the Delta, swollen each year by flood waters that are poor in essential nutrients, continue to be so productive?

Kele’s field investigations have built on work by other researchers that bears on this question. For example, scientists have found that one source of some nutrients is the wind-blown dust that arrives from the Chobe district to the northeast. However, this dust does not provide nearly enough carbon, nitrogen, phosphorus, and other minerals to support the vast natural wealth of the region. Based again on early work, she is investigating the contributions of two significant components of this ecosystem: (1) decomposed sedges and other vegetation, and (2) mineralized animal dung. “We have a lot of elephants up there,” she said helpfully. “And all of these sources add up.”

She has also investigated the sediment load from the upper “panhandle,” the long, narrow neck of the delta that confines the Angolan flood waters before they begin to spread into the characteristic fan shape of the delta. This water is rich in minerals, especially carbonates, which appear during dry times as the whitish patches or “pans” throughout the region. These and other dissolved minerals make much of the groundwater in Botswana too salty-tasting to drink – even when the floods bring enough water to fill near-surface aquifers. The mineral content also restricts the kinds of plants growing in the delta to the most salt-tolerant species.

After Kele writes up the results of her field work, she will confront the next challenge for young scientists in Africa: finding support for the PhD studies she will need for a career in academia.

**Annual Floods as a Key to Fertility (SSAWRN)**
By Alan Anderson, 22 November 2010
Gaolathe Tsheboeng, congenial and easygoing, had a smoother and more direct path into the RISE program than those who spent years searching for financial support while surviving on less stimulating work. Gaolathe, a native of Gaborone, the capital of Botswana, heard about RISE just as he was finishing his BS degree at the University of Botswana and was quickly able to take advantage of it. He also differs from most of his peers in having earned a degree in education, rather than in science, though he did take a science emphasis. He has had experience teaching “integrated science” in public school, but the RISE scholarship has given him a chance to move into an experience of hands-on research – in an area of high importance to Botswana.

Like most of his peers at the Okavango Research Institute (ORI), his research is part of a broad effort to understand the relationships between the annual flooding, the vegetation, and the animals of the Okavango Delta. Gaolathe came to the ORI at a fortuitous time to study these relationships. A two-decade-long drought had just been swept away by the second-largest flood since record-keeping began in 1923, offering a dramatic contrast of conditions. When he was asked to study the relationship between flooding and vegetation distribution, he was able to drawn on the results of two studies done during the drought, in 1996 and 2004, and compare them with the current flood of 2010. Last March he began visiting the same areas studied earlier, comparing the levels of nutrients and kinds of plants found there during drought with those found during heavy flood times.

The primary plant in his study was the abundant sedge Cyperus esculuntus, of the same genus as the papyrus cultivated by early Egyptians to make writing material. One of the results he found was predictable: The Cyperus, accustomed to growing in wet areas, had now invaded areas that had been dry for many years but were now wet. At the same time, the plants that had been growing in these newly wet areas had disappeared.

But another result was a surprise – one that may have important policy implications for the Delta. While the ORI scientists expected the large flood of 2010 to reduce the concentration of nutrients in the water by a process of dilution, in fact the nutrient levels were found to be higher than they were during years of low flood. The hypothesis of Gaolathe and his colleagues is that the nutrients accumulated from years of the build-up of dead plants and animal dung were released by the fresh flow of water and gave rise to sudden increases in plankton, fish, and bird populations. “We think that when more area is covered by the flood, more nutrients are pulled from those areas. We also assume that there was burning of plants upstream, and the big flood brought down the nutrient-rich ashes to our flood plain.”

A logical consequence of this nutrient cycling is that the flooding is necessary to preserve the natural richness of the Okavango Delta and its biota. Gaolathe and others hypothesize that any major hydrologic changes that reduce or harness the flooding – such as construction of dams upstream, which has long been contemplated by Angola – would reduce the rich plant and animal biodiversity of the ecosystem. This, in turn, would threaten the native cattle herders, fishermen, and flood recession farmers, as well as the large tourist industry on which the nation depends. (See update on page 87.)
Siziba Nqobizitha, a young man who grew up in a family of “peasant farmers,” as he puts it, was fascinated by the natural world around him in Zimbabwe. As soon as he was introduced to biology in high school, he knew he had found his life’s interest. “I always liked to study plants and animals,” he said, “and during my vacations I looked for opportunities to tutor other high school students. This was a way to help people who were interested in solving many problems. And add to that, when I went into towns from our rural area, I saw that pollution and water resources are big challenges for Africa.”

He seized the opportunity to go on to college, at Midlands State University in Gweru, a city in central Zimbabwe, where he specialized in the study of aquatic ecology. From there he moved to the National University of Science and Technology, in Bulawayo, where he got his masters.

After that his progress seemed to stall. “I looked for two years for some way to start on my PhD work,” he said. “No luck. Then I got an email about RISE from a guy who headed the African Wildlife Foundation in Zimbabwe, and I applied. RISE was like a dream come true for me.”

Fortunately, he had not wasted his time while looking for a PhD program. He had found temporary employment as a research assistant at Lake Kariba Research Station, a program of the national university. Lake Kariba, located on the Zambezi River, is the largest artificial lake and reservoir in the world, covering more than 2000 square miles and supporting rich aquatic life. Aside from finding a stimulating work environment, he also met the director, Prof. Moses Chimbari, who would soon be leaving for the Okavango Research Institute and would invite Siziba to join him. Prof. Chimbari and the director of ORI, Prof. Lars Ramberg (now retired), helped him fine-tune his application (“I wanted to work on everything – climate change, water resources, the increasing demand for water”), and he was accepted.

In fact, the final title of his research program – “The Importance of Seasonal Flooding on the Food Chain Link of Zooplankton and Juvenile Fishes in the Okavango Delta” – did touch on his central interests, including water and life. As Siziba described the situation, “The ecological integrity of the Delta is threatened by climate change and by increasing water demand, and these are likely to affect the integrity of the ecosystem. We are studying all of this.”

His work has focused on three types of flood plain: (1) the primary flooded areas that are permanently wet and receive new flood water every year, (2) the secondary flood plain which may be flooded twice every decade by robust floods, and (3) the rarely flooded savannah, which may receive water only once in 20 years during exceptionally high pulses. Previous nutrient research had focused on the primary flood areas, and less was known about the more rarely flooded areas. Thanks to the ongoing study, on which RISE student Kele Cole is also working,
the ORI now knows that the flood waters in these areas have more nutrients, released from the plants that have died since the last flood and from animal dung. Therefore they have more zooplankton than the permanently flooded areas, and attract more fish that feed on the zooplankton.

The significant policy implications of this result have not escaped Siziba and his faculty advisors. Among them are that any changes that interrupt this flooding pattern – such as upstream dams that would regulate the flow of the Okavango River and stop or reduce the flooding – would have the effect of lowering the populations of zooplankton in the Delta. As Siziba points out, “Damage to the fish would come next.”

Such ecological links between the water and life of the Delta are just now coming under study, thanks to the much-enhanced research capabilities of the ORI. These capabilities include the 15 graduate students, among them five RISE-supported students, who only began working there in 2009. The advent of the grad students is the result of long lobbying by the leadership of ORI, who argued with the University in Gaborone that faculty can be fully productive only when graduate students are part of the study environment – and that graduate programs are essential for training the next generation of researchers. The productivity of the current group of students is helping to vindicate this argument.

Grace Mutia’s Work on Seaweeds: An Update (WIO-RISE)
By Alan Anderson, 16 May 2011

This is an update on an earlier profile; see page 35.

When Grace Mutia of Kenya became a member of the first round of students in the WIO-RISE network, she was already an experienced biologist. She had a master’s degree in hydrobiology, aquatic resources, and management, and taught on the faculty at the University of Nairobi. But she had been trying without success for several years to find the funding she needed to complete her PhD studies. When she was accepted in the RISE program, she found the opportunity she had dreamed of. She elected to begin by studying the seaweeds of the Zanzibar coast and the seaweed industry that has raised the standard of living for thousands of women and their families (see The Seaweeds of Zanzibar, February 3, 2010).

One thing she learned early in her investigations was that the coastal fishermen, many of them the husbands of the women who raised seaweed along the beaches, had also discovered the value of seaweeds – not as a crop to be sold for commercial uses, but as bait to catch fish. On Zanzibar, these men had learned that the crushed leaves of certain seaweed species were appealing to the
common parrotfish, and they had developed techniques of using these extracts in hand-woven fish traps.

She also found, however, that the fishermen had to sail at least as far as Bagamoyo, on the mainland, to collect the kinds of seaweed favored by fish; this was a round trip of more than 50 miles. Having already learned much about the Zanzibar seaweed industry, she decided to shift her investigations to the mainland to see how she might help improve the livelihoods of the island and coastal fishermen. She was also curious to expand her investigation of fishermen to the coast of her native Kenya, where the tradition of using seaweed baits is also strong.

“My interest was in finding which species the fishermen use, why they use them, and how they can be cultured,” she said recently.

She quickly found that the fishermen were not using the two common commercial species harvested on Zanzibar, Kappophycus cottonii and Eucheuma denticulatum. These are both important sources of carrageenans, a family of gel-forming polysaccharides with many commercial uses. But neither grows well along the Kenyan coast. Instead, she found that the fishermen were using several species of the genus Ulva, the common sea lettuce found worldwide. Ulva is familiar in almost every kind of environment, growing in bright green sheets that have wavy or ruffled margins. The leaves resemble a fragile kind of lettuce, growing up to 40 cm long but only two cell layers thick.

Sea lettuce is eaten as a nutritious additive to soups and stews, but it can also be considered a nuisance plant and even a danger when it “blooms” in over-enriched waters, outcompetes other species of algae, and dies off in huge thick banks along the shore. Because it gives off dangerous amounts of hydrogen sulfide as it decomposes, it has caused illness and even fatalities among people unaware of the danger.

According to the website of AlgaeBase, about 100 species of Ulva are currently recognized, along with hundreds of additional variants and subspecies. The type species alone, Ulva lactuca, named by Linnaeus in 1753, has about 50 variants. So identification of the Kenyan species is a painstaking process. Grace noted that many species of sea lettuce thrive along the Kenyan coast, but some of them are poorly known by scientists. She said she had been the first investigator to take an interest in sea lettuce species used by Kenyan fisherman and has already begun to bring back new knowledge about them. “I’ve been able to identify eight species,” she said, “and some are found only in Kenya. I knew from the literature that fishermen were using many of them, but I have to visit the herbariums to identify most of the species.”

As she comes to know the species better, her next goals are to do more chemical analyses of the sea lettuce, identifying the proteins, amino acids, minerals, and other nutritional qualities that may bring new applications. She hopes that in addition to being gathered for fishing, they can also be raised through techniques of aquaculture and mariculture to provide larger and more reliable harvests. At present, the high nutritional value of this genus is largely wasted when most of the leaves rot on the beaches. If harvested in ponds and elsewhere, she hopes, they can be used both as food for humans and as meal to feed pond fish.

“Last year the Kenyan government came up with money for 1,000 aquaculture ponds along the coast,” she said, “and finding enough nourishing fish feed is a big issue. So my hope is that the seaweeds can be a big part of this as we work out the chemistry and culture techniques.”
As for her own progress through the RISE program, she plans to devote the months through September 2011 on data collection and then to turn more fully to literature review and writing, which she has already begun. She hopes to have the writing completed by January 2012, and will then begin the process of defending, revising, and editing her thesis.

Siajali Pamba: Learning to Model River Flow (WIO-RISE)
By Alan Anderson, 16 May 2011

When we posted our first blog entries for the Institute of Marine Sciences in Zanzibar, Siajali Pamba had just begun his PhD work there, under IMS director Prof. Alfonse Dubi. By now Pamba (he is called by his last name) is well along in his field research, and with Dr. Dubi’s departure, the advisory duties have moved to Dr. Yohana Shaghude and Prof. Alfred Muzuka. His topic, as he carefully explains, is to “investigate the transport and dispersion of suspended particulate matter.”

This new topic represents a considerable expansion of the research he did as a master’s student at the University of Dar es Salaam between 2004 and 2008. There he worked on the same general subject – suspended particulate matter – but his target was specifically marine pollution. In particular, he was interested in the ability of mangrove trees to filter and clean wastewater before it was returned to the ocean. His focus was the large tourist hotels near the shore, which emit a steady discharge of sewage water into the ocean. Pamba decided to propose a more environmentally friendly method by running the wastewater first into a pond where suspended particulate matter could both settle to the bottom and be taken up by the mangrove trees in a self-sustaining system of water purification.

He found that the system was indeed helpful, with the mangrove trees absorbing a good deal of the suspended nutrients, but that the trees needed more time to do a thorough job. He calculated that the wastewater was spending an average of about three days in the settling pond before moving through to the ocean, and that it needed to stay there at least six days for the system to be effective. Also, the trees were unable to remove bacteria from the water, so that an additional treatment step would be needed involving chlorination or a bactericide.

After he completed his own investigation, another student took up the project while Pamba wrote up his results for his master’s thesis. He also published a research paper on his work, and then faced the challenge of getting the word of his findings out to the community. He tried to arrange a meeting with the hotels themselves, he said, but “the political system did not support this.” He then wrote an article for the Dar es Salaam newspaper, the Daily News, which was printed, and he also took a video of his results to the local television station. He is still uncertain about whether his suggestions will be adopted, but he hopes to continue publicizing the results.
When he was accepted into the RISE program to begin work in 2009, he broadened his work to include one of the major water systems of Tanzania, the Pangani River and its estuary. His goals include the monitoring and measuring of sediments suspended in the water, as well as measuring the river flow, tides, waves, and salinity.

There are many reasons for doing this work, he said, especially in a country with little rainfall and heavy dependence on agriculture. In Tanzania, more than 70 percent of the flow of the five major rivers is pumped out for irrigation before it reaches the ocean. As the economy matures, more water will be needed for industry and power generation.

“A lot of water is extracted without considering the impact on the estuary,” he said. “If the river flow is too low when it reaches the coast, it does not supply the necessary nutrients and sediment that makes the estuary productive. This affects many kinds of fisheries, especially the prawn fishery, and navigation.”

Already at Pangani, he said, so much water is extracted upstream that salt water is intruding higher into the river. At 20 kilometers upriver from the coast the salinity now rises to 17 parts per thousand.

Much of his work involves the placement of monitoring devices. He has installed a current meter to monitor river flow, and 13 sediment traps across the river mouth and along the estuary. He has retrieved core samples from four places in order to obtain records of past sediment deposition to compare with the present. Prof. Muzuka has been helping him to prepare and analyze the sediment.

The work has not been easy. In choosing to study the Pangani River, Pamba must travel from Zanzibar to Dar, and then northward to the small town of Pangani where there are few resources and many physical challenges. The estuary is often buffeted by high waves and winds, so the research equipment has to be well secured. In rough waters, safety concerns mandate that two divers must be used to retrieve and replace sediment traps. In addition, a security guard must be employed to watch over the current meter.

His next challenge is to learn new computer skills to accompany the field work. He is scheduled to travel with Dr. Shaghude to the University of Cape Town, South Africa, to learn MIKE-21, an advanced software program created by the Danish Hydraulic Institute (DHI). He will then be able to enter his own data and satellite data into this software, allowing him to model many conditions of the river and estuary, including water flows, waves, sediments, and ecological features.

At a practical level, MIKE-21 can be used for many tasks, such as to optimize port layout and coastal protection measures, estimate availability of cooling water for industry and power generation, analyze desalination and recirculation activities, and gauge the environmental impacts of marine infrastructures. It will also allow him to model and forecast coastal flooding, storm surge warnings, and inland flooding. “The dispersion of sediments depends on the river flow,” he said, “so when we know what the hydrodynamic behavior is at Pangani, it will be easy to use the software to compute what happens when the river flow changes.”
“The vision of our country is to place a priority on agriculture,” he concluded. “That will mean more demand for water. So I think the outcome of these studies will help the government plan strategically how to manage our estuaries.” Pamba’s plan is to continue his work until 2013, when he hopes to complete his PhD and then return to teaching at UDSM, transmitting his newly acquired skills to future students.

Mushrooms by the Numbers: A SABINA Master's in Bioinformatics
By Lori Mulcare, 21 October 2011

“Nature alone is antique, and the oldest art a mushroom. –Thomas Carlyle

Highly valued as a tasty, low-calorie, and nutrient-rich food staple, mushrooms have been consumed for millennia by people around the world. The varieties of mushrooms eaten today are grown on farms or collected in the wild. In addition to their value as food, mushrooms have been used for medicinal purposes for centuries, especially in China, and since the 1960s, scientists in other nations have become increasingly interested in studying extracts from mushrooms to assess their antibacterial, antifungal, and potentially even anticancer compounds.

Liberata Mwita, a RISE-SABINA student working toward her master’s degree at the University of Dar es Salaam, is using the modern techniques of biotechnology and bioinformatics to identify bioactive compounds for mushrooms and enhance traditional uses. Liberata is working on *Coprinus*, a genus of wild mushroom that has been domesticated for its food value and is also known to have bioactive compounds. While it is widely used as food, it hasn’t been used for medicinal purposes, despite its potential applications. Not surprisingly, the genome of the Tanzanian strain of *Coprinus* has not yet been sequenced, so Liberata’s research will be an immediately useful addition to current biomedical knowledge.

Tall and well-spoken, with a brilliant smile, Liberata Mwita comes only recently to her place in bioinformatics. As a little girl, the eldest of four children born to Tanzanian medical doctors in Lindi, Tanzania, she urgently wanted to be a pilot. Liberata credits her parents with inspiring and gradually guiding her toward her standout academic work in science. She also speaks highly of her advisors, Dr. Sylvester Lyantagaye at the University of Dar es Salaam and Professor Oleg Reva at the University of Pretoria, for taking her under their wings and giving generously of their time.

At the beginning of her master’s studies, Liberata was given the opportunity to go to South Africa from February to November 2010. She began with a seven-week crash course in bioinformatics at the Center for Computing at Cape Biotech, in Cape Town, and then moved on to the University of Pretoria to work with the state-of-the-art instrumentation and software
available there. (She used the same kinds of instruments used by pharmaceutical companies, which are extremely expensive and unavailable to researchers at her home university in Dar es Salaam.)

Conventional drug discovery and development can be a ten-year process, from selecting materials to study through producing and clinically testing an end product, but recent developments in biotechnology and computer science -- like those Liberata is learning -- enable modern scientists to significantly reduce that timeline. When we visited Liberata at UDSM in June 2011, she had wrapped up her work from South Africa and begun cultivating *Coprinus cinereus* to verify her computational work. The amount of bioinformatics research taking place in Tanzania is small and concentrated, so the addition of Liberata’s expertise guarantees a meaningful impact on her field.

After Liberata has earned her master’s degree in biotechnology (she hopes to finish by January 2012), she will apply to join the university staff. This will require a formal application process, including the approval of the government of Tanzania, which has a say in university appointments. With her excellent training and her unique set of skills, Liberata Mwita has every hope of becoming an asset to the higher education community in Tanzania.

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**Hot Peppers for Better Chicken (AFNNET)**

By Alan Anderson, 1 December 2011

Peregrine Sebulime, a PhD student at Makerere University, has been working on a project since 2009 that differs substantially from those chosen by his AFNNET peers. He is looking not primarily at questions of health care or environmental sustainability, but at the effects of a plant on meat production – specifically, the effects of *Capsicum*, a diverse genus of tropical pepper plants, on chicken meat.

He came across this idea at the beginning of his RISE scholarship when he was looking through the scientific literature in search of a research topic. He found abundant evidence that *Capsicum* goes well with chicken, as a glance at numerous Chinese and Indian cooking websites makes clear. But these home recipes are interested only with using *Capsicum* (most often ordinary bell peppers) to improve the flavor of the food, like any other kind of chili pepper. What Peregrine came across in his scientific reading, however, was the possibility of feeding dried and powdered capsicum to live chickens to improve the quality of the meat.

Could it really be true that ingested *Capsicum* could improve food value? He found that people near Kampala, who raised large numbers of chickens, already fed their animals a variety of plant products to improve meat quality. He also found that consumers preferred local birds because
they thought its meat quality was superior to imported chicken. But there had been no scientific
demonstration of whether either assertion was true.

As he dug deeper into the literature, he found that *Capsicum* has been used for many centuries
for physical disorders ranging from indigestion to ulcers to migraine. It was also said to lower
blood cholesterol, boost circulation, and serve a general antibiotic function to fight infection. It is
used topically to reduce muscle pain, arthritis, or other ailments in which “heat” is desired. Some
species are so spicy as to be inedible; one is the active agent in the pepper spray used for riot
control and personal defense.

Most intriguing of all to Peregrine were claims that *Capsicum* is a powerful anti-oxidizing agent.
One of the liabilities of chicken is that the meat has high concentrations of unsaturated lipids, or
fats. These lipids are chemically unstable, tending to oxidize quickly during and after slaughter,
which degrades the quality of the meat. If *Capsicum* could reduce the lipid content of the chicken
meat, both slowing the oxidation process and reducing the dietary fat content, it could be a boon
to chicken producers and consumers alike.

While these beneficial effects seemed likely, they had not been demonstrated, which Peregrine
set out to do. He focused his testing on the species *Capsicum frutescens*, both because it had
been described in the literature as a meat quality enhancer and because it was locally abundant
and inexpensive. It had also been tested as an antibiotic, with good results, and had been found to
reduce lipid content in another food -- rice.

For his testing, Peregrine made use of the Makerere University Agricultural Research Institute in
Kabanyolo, which has extensive chicken raising facilities. He began with 500 chicks of a strain
of “exotic chickens,” one of the world’s common broiler varieties called Ross 308. This variety
is bred to sit still, eat voraciously, and gain weight rapidly, reaching a market weight of four or
five pounds in as many weeks. He fed the Ross 308 chicks a common starter diet and later, at the
age of four weeks, *Capsicum* was included as a dietary supplement. During the supplementation
phase, he divided the birds into different groups, each receiving a different amount of the pepper
for varying amounts of time. During supplementation, the live weight of the chicken was
measured at seven-day intervals.

At slaughter, Peregrine measured the weights of the carcass and other organs including the heart,
gizzard, liver, and intestine of each chicken. He found that the supplementation with *Capsicum*
had an effect on the carcass and intestine weights as well as on the lipid content of the chickens.
The chickens that received the supplementation for longer durations weighed less than those
receiving it for shorter durations and the control group. In addition, shorter duration
supplementation appeared to improve feed conversion; chickens on the short duration
supplementation had higher carcass weights and lower intestine weights, despite no major
differences in live weights and the feed intake for both categories of chickens. Just as he had
hoped, *Capsicum* was reducing the amount of lipids in the meat.

Peregrine then tested the effects of *Capsicum* on local chickens, choosing for this batch 1,000
birds. The local birds are slow-growing and can take four times longer to reach market size than
the exotic birds. Dietary supplementation was done between the ages of seven and eight months.
In one batch of local birds, the dietary supplement was given with a high fat source whereas a
low fat source was used in the other. In each batch, different groups of chicken received varying
amounts of *Capsicum*. After slaughter, Peregrine conducted organoleptic tests, which are
standardized ways to measure taste and quality. Analysis of the results for the local chicken is yet to be fully completed.

Peregrine is most enthused by one result in particular: Reducing lipids reduces the amount of calories in the meat, which raises the possibility that *Capsicum*-fed animals will appeal to dieters wishing to reduce the risks of obesity and cardiovascular disorders. Peregrine is already thinking about the larger importance of his work. “If we can show the value of this supplement,” he said, “we can create demand for local producers of the chili peppers. When chicken producers in developed economies appreciate the fact that they can use chili to grow more healthful chickens containing less saturated fat, Ugandan farmers can potentially be mobilized to produce *Capsicum* for companies involved in global trade. This is one way to generate new income, replacing aid with sustainable trade opportunities and shortening the path for our people out of the ‘bottom billion.’ We can be a supplier to other countries and build sustainable trade.”

**Bringing More Rigor to the Herbal Community (AFNNET)**
By Alan Anderson, 6 December 2011

When we first spoke with John Odda two years ago, he was preparing to begin work as a RISE-supported PhD student at Makerere University in Kampala, Uganda. His work in natural products is now well underway, under the mentorship of Prof. John David Kabasa, his principal adviser, and Prof. Celestino Obua, deputy principal of the College of Health Sciences. During a brief review of his field work to date, he reaffirmed his determination to help relieve the scourge of malaria in the Tororo District of eastern Uganda where he grew up and where the disease is still part of everyday life.

When John was a child in a village some 100 miles from Kampala, virtually everyone suffered from malaria, and his father, an employee of the highway department, was one of those who used herbal remedies to combat the symptoms. His father was not unusual, John said, in having no special training in herbal medicine, and he had no way of knowing exactly what was in the remedies he concocted. But they did work, according to John, who found himself wanting to know more about exactly what was in these concoctions, and how they worked.

The preparations themselves, he recalls, were quite crude. The healer would simply dry the plant, pound it into a powder, and mix it with water. Nonetheless, the knowledge of the plant’s identity and the preparation techniques was closely guarded by family members and communicated only to those family members judged to be discreet enough to keep the secrets.

“For me it began with my late grandmother,” said John. “Whenever someone was sick, she would go behind the house and find some plants that only she knew about. When she was old
and ready to die, she said to my father, ‘You are my first-born son, and I am going to tell you a secret. You remember how you had malaria when you were a boy, and I gave you some medicine? Now this is what I did.’ And she told him all about the plants behind the house, and how to prepare them.”

When his father died, the knowledge was passed to John. Normally, the honored recipient would have been the first-born, but John, the third-born, was chosen instead. He suspects that his father considered the older brothers too talkative, or perhaps he recognized and valued John’s early interest in plant remedies. “So he chose me, and showed me the plants, and how to use a calabash – a gourd with a handle – to measure them out. He said that when I married and had children, and they got malaria, I should get the shoots of such and such a plant, crush them, and mix them with drinking water, and then give them to the sick person three times a day.”

Even as a young student, however, John was disturbed by the apparent lack of rigor in many aspects of herbal medicine as practiced in the community. He was reasonably sure, for example, that neither his grandmother nor his father could tell whether their patients in fact had malaria. “The way they diagnosed malaria was just from the fever,” he said. But the fever and other symptoms were similar to those of other diseases, such as typhoid, brucellosis, and babesiosis, a malaria-like parasitic disease transmitted by ticks.

He was also disturbed by the knowledge that there was no way to calculate or standardize the proper dosage of plant extracts for malaria. Did the plants in one person’s back yard have the same efficacy as those in another? Traditionally, he said, healers would harvest and process the plants only when a patient fell ill, rather than when the plant’s efficacy or other features were at their peak. This is a significant issue, said John, because the efficacy of such plants is thought to vary considerably by time of year, weather conditions, local environment, soil type, plant age, and other factors.

He has been studying just such questions, using the World Health Organization (WHO) guidelines for various plant groups. For example, herbalists have assumed that if one is going to use the shoots of a plant, the best time to harvest the shoots is when the plant is beginning to flower. But this has never been verified, so John is conducting a baseline study of herbalist customs – tracking down the details of local customs, such as how the plants are cultivated, when they are harvested, and how they are used.

One of the lessons John himself has learned in the course of his project is that the scale of the research needs to match the time available. His original ambitions were outsized, as shown by the title of his proposal, “Standardization of selected anti-malarial herbs in Tororo District, Eastern Uganda.” He quickly realized that developing full standardization procedures, based on the WHO minimum standards for efficacy, would require many sequential steps, including raising plants under controlled conditions and comparative analysis of those plants. Such a project, he realized, would require many years. For plant A, for example, he would have to harvest some samples at the flowering stage, others at the fruiting stage, and so on, requiring extensive travel, horticulture, and maturation time. “And there would have been hundreds of plants worth looking at,” he admitted. His proposal now more modestly aims at the best ways to evaluate and standardize “selected anti-malarial herbs in Tororo District.”

He has focused on the two plants used by his father to make his concoctions – a species of Acacia tree and a shrub from the genus *Phyllanthus*. Both have strong pedigrees as botanicals in
many regions of the world. The sap and leaves of Acacia species, which typically bear large amounts of tannins, have been used as pharmaceuticals and preservatives since the time of ancient Greece. The second plant, a common member of the spurge family, is also used medicinally in many countries, especially to promote liver health; it is also reported to be active against hepatitis B virus and several kinds of cancers.

To understand local herbalist customs, John has used a general questionnaire as well as “inside information” from certain key informants, including district agricultural officers and district community development officers, who are charged with “cultural practices” that include the use of herbal remedies. “The healers themselves are very secretive,” said John. “They are reluctant to share what they know with outsiders. So often we have to depend on informants – if we can find them.” During his baseline studies of the plants he has learned much about how the healers harvest, prepare, package, and administer their extracts. “Once we have discovered which plants truly have activity,” he said, “we can grow them in the district where the herbalists can use them and test them for themselves.”

He is also moving to more analytical steps, such as a stability study he is doing with Medipharm Industries. After preparing batches of medicine according to WHO guidelines and to herbalist practices, he is testing to see how much active ingredient is present at time 0, at three months, six months, and so on. He has been able to identify active fractions of the extracts using flash chromatography in Addis Ababa, which is essential in screening for activity. Additional steps will include the use of liquid chromatography to identify the structure of the active agent, and nuclear magnetic resonance (NMR) imaging to measure purity. With the shortage of advanced instrumentation at Makerere, these steps are proving to be a challenge. But he does have access to some equipment in the local Department of Chemistry and is hoping to use an NMR at the University of Nairobi or perhaps another RISE partner institution.

Based on these early studies, John has submitted one paper to a local journal club for comments and corrections. Ultimately, as he gathers more data about the extracts, his hope is to share what he learns with the herbalists in Tororo so they can improve their own practice and provide even better relief from malaria.

A Chemist’s Research on Newcastle Disease Leads to Patents (AFNNET)
By Alan Anderson, 7 December 2011

For Tanzania, whose economy is dominated by small farmers, new remedies for agricultural diseases are urgently needed – especially remedies that are affordable for a society gripped by poverty. Some of the worst agricultural diseases afflict poultry; a farmer's flock can be virtually annihilated in a matter of days by a scourge as contagious as Newcastle disease.
As an AFNNET student at Sokoine University of Agriculture, in Morogoro, Faith Mabiki has dedicated her PhD research to finding an herbal remedy for destructive poultry diseases. She is a chemist, and her strength is in doing the analytical research needed to isolate and identify the specific chemical compounds with strong but safe activity against these diseases. She works closely with her RISE colleague Gaymary Bakari, who complements Faith’s analytical work with clinical veterinary studies.

To find the most likely candidates for a cure, Faith began by consulting herbalists near where she grew up, near the Iringa and Njokme region, some 500 km south of Sokoine. Her familiarity with the area gave her a good chance of finding allies among herbalists who use plants to combat diseases in domestic birds.

“That part is often not so easy for scientists,” said Faith. “The herbalists need to trust you before they will tell you anything about their plants, like the dosage. Herbalists are very shy; in fact, not just the herbalists, but many of the other people who use plants medicinally. And their cooperation was essential to my project.”

She began her work with meetings with groups of herbalists and other members of the community, along with interviews of each individual. After many conversations and many reviews, she winnowed down the list of candidates to the most promising: a southern African plant originally known as *Synadenium glaucescens*. This plant has recently been reclassified, using DNA sequence data, into the genus *Euphorbia*, which is one of the largest plant genera in the world. The genus contains more than 2,000 species. As a group, they are appropriately known as spurge, a name derived from the Middle English word for purge, which refers to the laxative powers of the plants’ milky sap. Nearly half of Euphorbia species are succulents, some with and some without spines; others look like cacti; perhaps the best known species is the common Poinsettia. *S. glaucescens* is not conspicuous for its looks, however, but for its powerful effect on many diseases. (Other researchers have described anti-tumor activity in humans, which may eventually prove valuable as well.)

Faith knew that her choice is active against not only one destructive poultry disease but three: Newcastle disease, fowlpox virus disease, and infectious bursal disease, all of which have spread worldwide. Her task was to focus on the most active fraction of the plant’s juices, and identify the specific chemical generating the activity. She decided to begin with the herbalists in their village, learning to use the basic techniques they had developed over many decades, then try to improve upon them. Of the three diseases, she made Newcastle the primary target because of its ongoing heavy toll among chickens in Tanzania.

Newcastle disease was named for Newcastle-upon-Tyne, in the United Kingdom, where it was first identified in chickens in 1926. The Newcastle virus can be carried without causing illness by many bird species, such as Amazonian parrots; it causes mild or no symptoms among humans. But it is violently destructive to poultry, capable of spreading through and eliminating whole flocks within days of infection. Several vaccines are effective as prophylaxis, but they are too expensive for most farmers in Tanzania. An inexpensive, durable, reliable natural product to combat Newcastle would bring enormous relief to the poultry industry.

Once her investigations with the herbalists were complete, Faith returned to Sokoine to begin her analytical work on Newcastle under her advisor, Prof. Robinson Mdegela. She prepared several
extracts from various plant parts, testing their strength against seven different strains of Newcastle virus, as well as three fungi and other viruses. Then she began to compare the efficacy of the extract against the virus in eggs (in ovo) and then in live birds (in vivo). She found it to be effective in reducing the disease virus at both stages. Her work was advanced by a scholarship from the UK’s Royal Society of Chemistry that allowed her to work at the University of York for two months, from January to March 2010. The Society also supported a week’s working visit to Ethiopia, where she attended the first Pan African Green Chemistry Congress and took part in a workshop with other chemists from several countries.

She was able to fractionate the extract with the highest activity by using the column chromatography available at Sokoine. Sokoine University of Agriculture has been granted two patents for her work. For further identification of the key chemical constituents, however, she has had to submit her samples to colleagues in France who have a nuclear magnetic resonance (NMR) scanner. Sokoine does not have one of these costly instruments, and Faith has been waiting for more than five months now for her NMR data.

She is also busy with many parallel activities. She helps younger students in their studies by including them in her own work. “I give pieces to students,” she said, “and mentor them.” One parallel project with its own exciting potential has been to test the extract against tuberculosis. She has found that the root extract has strong activity against this disease, and a nearby community is currently using the plant on an experimental basis to treat TB patients. Meanwhile she waits – not altogether patiently – for her NMR results, and presumably the possibility of applying for additional patents once she can report the structure of the active chemicals.

Commiphora vs. Newcastle Disease (AFNNET)
By Alan Anderson, 7 December 2011

PhD student Gaymary Bakari works closely with Faith Mabiki at the Sokoine University of Agriculture (SUA), both of them searching for herbal cures for major poultry diseases. While Faith is a chemist in the Department of Science who is working to isolate and identify the most efficacious chemical compounds of the natural products, Gaymary is a physiologist in the Department of Veterinary Medicine who tests the effectiveness and safety of various dosages, including clinical tests on living birds.

From Gaymary’s point of view, a major achievement during the past year has been the donation by the university of an old but basically sound building on the “old farm campus” of SUA, where generations of agriculture students had done their research on animals of agricultural importance. While Faith, Gaymary, and their advisor, Prof. Robinson Mdegela, are trying hard to raise funds to renovate, modernize, and outfit the old building with laboratory equipment, they at least have a facility to house live animals in a secure environment.
While Faith is analyzing the chemistry of one promising herbal remedy, *S. glaucescens*, Gaymary is experimenting with another plant that is also used by herbalists to prevent Newcastle disease, *Commiphora sp.* Known as myrrh in the Bible, *Commiphora* has already demonstrated considerable power against several parasitic organisms. For full clinical testing, she zeroed in on Coccidiosis, a severe intestinal disease of chickens; and Newcastle disease, a lethal plague caused by Newcastle disease virus (NDV).

For both disease organisms, Gaymary began her protocol by “challenging” the disease organisms with plant extract in vitro, where it showed good activity, and then in chicken eggs (in ovo), where it was also effective. Finally, she turned to experiments with live chickens, which were given oral doses of the organisms. At the same time, chickens in a control group were given the disease organisms without any protection from *Commiphora*.

In both cases, the *Commiphora* was successful. The testing with Newcastle is especially significant, because the disease has been such a devastating scourge for poultry farmers for nearly a century. In the Newcastle testing, the experimental group was divided into two sub-groups. One sub-group was given doses of *Commiphora* as prophylaxis and the second sub-group was treated with the extract therapeutically after already being infected with NDV. Of the control group, 14 of 16 birds died within days. In the experimental groups, however, nearly two-thirds of the sub-group treated prophylactically survived, and in the sub-group treated after they already had the virus, nearly half survived. This success is likely to be improved through further identification and isolation of the most active fraction of *Commiphora* extract.

Although three vaccines against Newcastle disease have been developed elsewhere, all are too expensive for use by most smallholder farmers. In addition, the refrigeration and extensive services required for preservation and distribution of vaccines are seldom available in rural settings. The excitement around Gaymary’s work is based on the combination of effectiveness, wide availability, and low cost.

*Commiphora* builds on a long tradition of using plant extracts for prophylaxis against Newcastle; farmers have used extracts of aloe vera, red pepper, and papaya caciea, for example. But they have done so simply by grinding up these plants and mixing them with the chicken feed in more or less random quantities. One of Gaymary’s concerns is that there is no dosage control, even for plants of high potential toxicity. She has found that overdoses of *Commiphora*, for example, can damage the chickens’ livers and even cause death. It must be administered properly in order to be the life-saver she hopes for. She has already submitted a patent request for her process.

Gaymary has also found that *Commiphora* has therapeutic power against other types of disease agents. These include gram positive bacteria in fungi, especially *Candida albicans*, which is an important cause of mortality and morbidity in immuno-compromised patients, such as AIDS patients and those undergoing chemotherapy. In addition, the extract has the ability to lower cholesterol levels in humans. This was discovered by herbalists of the Masai tribe, whose traditional diet as herders consists primarily of red meat and milk. *Commiphora* extract may have the potential to help other people who suffer from high cholesterol, regardless of tribe or nationality.
From Student to Advisor, via RISE (AFNNET)
By Alan Anderson, 12 December 2011

Since Joseph Mwanzia Nguta first offered us a tour of the University of Nairobi’s Upper Kabete Campus two years ago, he has made substantial progress. He is no longer a student but a fully employed assistant lecturer earning a regular (if modest) salary. He has received his PhD and become a valued mentor to current graduate students. He has become one of RISE-AFNNET's first postdoctoral fellows.

With his new status have come new responsibilities. He finds that the one he enjoys in particular – despite no formal preparation for it – is working as an advisor of younger graduate students in RISE and other programs. And his conclusion so far is that these students, far from being timid about their ambitions, are surprisingly bold in their plans for research. He has found himself spending a great deal of time not urging them on, but reining them in – trying to pare down their proposals to a scale better aligned with the time they have available. This is usually two years to complete an MSc degree and three years to complete a PhD.

Joseph now has six graduate students (five MSc students and one PhD student) – two at the Upper Kabete Campus (Pharmacology and Toxicology; Natural Products and Bioprospecting); two at the Chiromo Campus in the School of Biological Sciences, and one at the Institute of Nuclear Sciences, all from the University of Nairobi. The PhD student is developing his proposal under Joseph's mentorship and is to register in the Pharmacology and Toxicology section. Joseph has been coaching the students on the essential steps of graduate research: conceiving the idea for a research project, adding shape and perspective to the proposal through a literature search, and converting the idea into concrete written form. “They need a lot of coaching on what is expected of them,” he said. “We teach them about research methodologies so they can conduct their own work with a sound strategy. We train them to think on their own, to understand what has already been done in the field, and to be ready when something new presents itself.”

Virtually all of the students, he said, were overly ambitious: They all wanted to find out everything about every plant. “They come here thinking too big,” he said. “We’ve been working with them on their proposals since June [four months earlier] or before, introducing them to the broad thinking of natural products. They had no idea how long it takes to collect enough plants, evaluate a question, test an idea. We have quite strict limits of time for this stage of their education, and limits of cost. They all came thinking too big; none of them came with too small a question.”

One student, he said, was hoping to survey all the species of Aloe in all eight districts of the country. He planned to analyze the extract of each one that is used for medical purposes, such as the healing of wounds and skin diseases; determine which fraction of the extract was the most...
active; and perform a comparative evaluation of each for its commercial potential. This, suggested Joseph, would be a project for a lifetime – “at least.” Over the course of several months, he was able to help the student refine his project into something manageable – a simple comparison of two species, one harvested from a farm, the other from the wild. The goal would be to calibrate and compare the efficacy of each variety.

As for Joseph’s own research, he has already published four papers in peer-reviewed journals on his RISE topic, “The Ethno-pharmacology and Toxicology of Selected Anti-Malaria Plants from Msambweni district, Kenya.” He noted that in the rural areas of Kenya, as in most countries, the best place to start a research program in natural products was in the villages. “The village people tell you more than you can find out elsewhere,” he said – “including information about the efficacy and the side effects.”

With early momentum from his herbalist partners, Joseph was able to identify plants that had good efficacy against *Plasmodium* (the protozoan parasite that causes malaria) and were quite safe for use by humans. During his postdoc appointment, he will investigate how to use the World Health Organization standards to formulate a variety of plant products that may have commercial potential, including detailed toxicology studies on extracts of various strength.

He also suggested the entire field of natural products had been held back for many decades by what he viewed as a grievous mistake: the Witchcraft Act of 1925. This measure was enacted by the British to suppress a range of practices deemed disruptive or dangerous to society, but which included many beneficial practices as well. “They wanted to get rid of the witchcraft,” said Joseph, “and they got rid of the well-intentioned herbalists at the same time.”

He then amended that statement to say that the herbalists had not disappeared, but had taken their practices underground. However, the law made it more difficult for them to test and advance their knowledge. Even today, as numerous RISE students have discovered, many herbalists are reluctant to talk about their work or accept outsiders into their confidence. Gradually, however, with the help of their advisors, the students are learning to cautiously introduce themselves to the herbal communities and to make clear their willingness to bring back the knowledge they develop. Once the herbalists’ trust is engaged, they in turn are eager to learn from the students.

A Sound Grounding in Natural Products (AFNNET)
By Alan Anderson, 15 December 2011

After a solid first year of coursework, Zachary Muthli Rukenya is now beginning to prepare himself for the research phase of his RISE scholarship. Already he has received an impressive grounding of natural products from his academic experience.
He began in the College of Biological & Physical Sciences at the University of Nairobi’s Chiromo campus, where he was introduced to the fundamentals of natural products science: chemistry, biology, ethnobiology, interaction with the environment, and the estimated effects of climate change.

He then moved to a second set of courses at the College of Agricultural and Veterinary Sciences at the university’s Kabete campus. There he studied bioprospecting and value chains, natural products and biological systems, analytical techniques, entrepreneurship and economics, safety and efficacy, policy and ethics, biostatistics and scientific communications – a rich portfolio of topics.

“The order of the courses made sense,” he said. “We started by taking the plant from the farm and getting the crude extract. Does the extract have biological activity against some kind of disease organism? If it does, then we’re interested.

“The next challenge is the systems biology, starting with the cell. Where does the extract interact with the cell, tissue, organ, a system, the whole body, interactions with other bodies. If the product is still interesting, we may want to do the qualitative and quantitative phytochemistry of the product, followed by molecular elucidation of the active principles. But of course we have to be concerned with efficacy, quality, and safety of the product before taking it to the market…this forms an important component of the value chain. To study these things you need analytical skills, which overlap with chemistry and methodologies that allow us to isolate and identify chemicals.

“Once you have an efficacious, safe, and high-quality product, you think about packaging it in a certain way and getting it to market. And while you are doing these things as a scientist, you need the skills for writing proposals, communicating about your work, and finding grants to support what you do. So we are trained in those skills as well.”

For his MSc project Zachary chose to work on a plant that was widely used but little studied, *Aloe turkanensis*, named after Kenya’s Turkana community. Indigenous healers have long used the plant to combat malaria, heal wounds, and for many other purposes. For his thesis work he will compare two “ecotypes” of this aloe species – that is, two populations of the same species growing in different environments. One population is growing wild in Lodwar, in Turkana County. The second population is propagated in a domestic setting by a woman in Embu County. Many questions naturally occur, such as does the efficacy of the two populations differ? Is this difference caused by a difference in soil, or climate? What dosages are efficacious in the two populations? His research project, which will take place in the university’s Department of Public Health, Pharmacology, and Toxicology, will address the phytochemistry, antibacterial and antifungal activity and toxicity effects of *Aloe turkanensis*.

Zachary hopes to continue working with the plant for his PhD project. There a new set of studies awaits him: quantitatively evaluating the phytochemicals in the plant and investigating its anticancer and antiviral activity.
James Kuria began his MSc studies in November 2010, along with his colleagues Zachary Rukenya and Ronald Okindo Onzago, all at the University of Nairobi’s Kabete campus. Like them, he grew up in a rural village, but much closer to the big city of Nairobi -- in Kiambu county, part of the Central Province just north of the capital. The village was far enough from the big city to lack modern medical facilities, however, and he, like the others, had been exposed since childhood to a variety of herbal practices.

“We all had to use herbal remedies,” he said. “You just naturally get acquainted with them. In childhood, in adolescence, it was common. I had allergies, and I would take some plant medicine, and people said it would work, so that made me want to know more. I took one remedy especially, it was supposed to work for 40 diseases, and everyone called it the wonder drug. ‘Take this,’ someone would say, ‘you will not suffer so much.’ It was bitter, I remember. I don’t think it helped me much, but it made me so curious. I had a passion for pharmacology and for veterinary surgery.”

James’ ‘wonder drug’ is known to science as *Azadivachta indica*, a tree of the mahogany family native to India, where it is called *neem* and many similar names. In Swahili it is known as *muarubaini*, which means “tree of the 40.”

James has finished his coursework, and for the time being he has chosen to study not the wonder drug, but a modest member of the daisy family – partly because of its greater availability. He has arrived at a proposal, which he titled: “A Study of the Phytochemistry, Antimicrobial Activity, Effects in Wound Healing, and Topical Adverse Effects of *Aspilia pluriseta.*”

While *Aspilia* may be smaller and perhaps less wondrous than *Azadivachta*, it does have an intriguing place in the scientific literature. Several scientists working on a study site with Jane Goodall near Lake Tanganyika in the 1980s observed the leaves of the plant being eaten by chimpanzees. Unlike the rest of the foods in the chimps’ diet, which were eagerly chewed, the leaves of this plant were eaten only whole. And the chimps ate them only first thing in the morning, slowly, as though savoring them or enjoying some effect. While other scientists have speculated on the purpose of this ritual (a mood-enhancing effect? birth control?), the effect of *Aspilia* remains mysterious.

Many medicinal effects have been described by humans, however, and James will begin by following up the studies of herbalists in the scientific literature. He will look for any adverse effects on animals, and try to develop “some deeper knowledge of how it’s used.” In the past, both the roots and leaves of the plant have been harvested for medicine, but he will follow the
environmental guidelines adopted by AFNNET. “For conservation, we’ll use just the leaves and stem,” he said, “so it can grow back.”

'This Is What My Education Is Meant For' (AFNNET)
By Alan Anderson, 10 January 2012

Johnson Nasimolo is one of the few RISE students who grew up in a big city – in his case Nairobi. His mother told her children that “education is the only thing I can give you.” She made sure that they all went to school and studied hard, encouraging them at every step. With so much momentum, he achieved the family goal of higher education, earning a bachelor’s at the University of Nairobi.

He enrolled as a master’s student in the University of Nairobi’s Department of Veterinary Anatomy in 2009, devoting the first year to natural products coursework. In 2010 he received a RISE scholarship and embarked on research. He had always wanted to work on nervous system ailments, especially sleeping sickness, which afflicts many people in his home region. It its most severe stages, trypanosomiasis moves into the central nervous system, where it does its debilitating work beyond the reach of any known cure. Because it is a tropical disease, large pharmaceutical companies have little incentive to invest in new cures, and few local remedies have been examined with the benefit of modern scientific techniques.

Johnson moved to his master’s thesis research toward the end of 2010. Surveying the scientific literature for a plant with curative potential, he came across a promising candidate in *Erythrina abyssinica*, a common tree of the legume family. *E. abyssinica* is sometimes called the flame tree for its spectacular orange-red flowers; the Latin name derives from the words for “red” and “Abyssinia,” now Ethiopia. Its furry brown pods, up to six inches long, contain seeds rich in protein. Humans have found many uses for the plant over the years, including feed for livestock, forage for bees, lumber that resists termites, and dyes from the bark and roots.

More relevant for Johnson was its high reputation among traditional healers. It has been used in Kenya to treat not only sleeping sickness, but also for pain management and to treat malaria, venereal diseases, inflammation of the eyes, burns and skin ailments, abdominal worms and stomach pains, anthrax, and skin diseases in cattle. Its otherwise toxic seeds have served as an anesthetic. It has also been studied by chemists, but not by the physiologists who must develop systematic knowledge of its efficacy and toxicity.

Now he is well into his investigations, which began with preparation of powder from dried and ground root bark. For testing, he dissolved the brown powder both in water and in methanol to obtain different fractions of the plant. He is now injecting these fractions into mice to determine
the maximum tolerable dose. Once that is established, he will begin to measure its efficacy against various diseases, beginning with trypanosomiasis and the parasitic protozoan that carries it inside the tsetse fly. It is the bite of the tsetse fly that infects humans with sleeping sickness.

Alternative treatments to sleeping sickness are urgently needed for several reasons: western medical treatments are seldom available in rural areas; relapse is common; and some protocols, used in cases of resistant disease, cause encephalopathy. Trypanosomiasis still threatens some 60 million inhabitants of southern and eastern Africa; it killed 48,000 people during an outbreak in 2008. And it poses a difficult medical challenge because the trypanosome organism is surrounded by a protective glycoprotein coat that shields it from the body’s natural immune defenses. Furthermore, it is capable of genetically “switching” from one antigenic variant to another to further evade the immune response.

“I feel that I was called to work on the nervous system,” says Johnson. “This sickness is a major challenge when it enters the brain. I hope to finish my work on toxicity in mice for my MSc, and then to go on to a PhD. This is what my education is meant for.”

Alleviating Joint Pain in Rural Kenya (AFNNET)
By Alan Anderson, 26 January 2012

This is an update on an earlier profile; see page 29.

When we first spoke with Stanley Wambugu, he was still in the planning stages of his PhD project – to explore the herbal remedies being used to combat joint pain in his home region of Kenya. Since then, with the cooperation of a group of experienced herbalists, he has moved rapidly through the field studies required for his thesis. As early as the first months of 2011, he and his advisors submitted a paper describing his work to the *Journal of Ethnopharmacology*, published by Elsevier, and the paper was carried in the September 2011 edition. This study offered not only important context for the herbal treatment of joint pain in Kenya, but also a more general and revealing picture of the challenges of herbalism as a practice.

Stanley persuaded 30 traditional herbal medical practitioners to join his study and tell him the details of their practice (he also gave them credit in the acknowledgements section of his paper, along with Carnegie Corporation of New York and RISE). The practitioners, nine of whom were women, gathered for an intensive workshop and, while Stanley was visiting, helped the research team and a botanist gather specimens.

The study was done in Machakos and Makueni counties, where almost no conventional medical care is available and acceptance for herbal remedies is very high, particularly for chronic
diseases. “It is therefore important that such important information on traditionally used medicinal plants is documented and appropriately preserved to avoid erosion of our cultural heritage, as well as to form a basis for scientific validation of their claimed efficacy and safety,” wrote Stanley. “Furthermore, conservation measures need to be addressed [because] the region is facing vast environmental degradation which threatens to wipe out its rich fauna and flora.”

Together, Stanley and his team found a total of 37 plants that were locally considered to be “important” remedies for joint pain. While many of the plants were well known to the field of natural products and in common use, eight of them were new to the field and scientifically identified for the first time.

Given the low level of knowledge in Kenya about the causes of joint pain – of some 5,000 doctors in Kenya, only 200 work in any branch of internal medicine and almost none specialize in joint pain – Stanley was not surprised to find a lack of specificity in joint pain treatment. Of the 30 herbalists, fewer than half had any formal schooling; only 37 percent got as far as primary school. Only a few were able to distinguish between osteoarthritis and rheumatoid arthritis, but all used the same treatment for both. The preferred treatments were, in order of choice, leaves; root and stem bark; leaves and roots; leaves with stem bark; and stems. Each practitioner used a preferred concoction, usually a complex combination of different plants and plant parts, prepared by various methods including boiling, infusion, powder, or simple chewing.

Given all this variation in herbal practice, one of Stanley’s chief findings was that the “major challenge to the use of traditional phyto remedies is the lack of standardization, safety measures, and quality control, and adulteration with conventional medicines”; in other words, various added ingredients from pharmacies or other sources.

Given the limited time available to him for his studies, Stanley has only begun to scratch the surface of this complexity. Of the plants recommended to him, he has identified the three with greatest activity against joint pain and is busy trying to isolate and identify the compounds that are active against arthritis. Using a basic column chromatography fractionator, he has been able to extract and remove active compounds from the plants, but he is slowed by the absence of more advanced instrumentation in his own department. One of the most useful pieces of equipment has been a Soxhlet extractor, invented in 1879 by Franz von Soxhlet for the continuous extraction of various compounds from mixtures. Stanley has every hope that a good working relationship with the local chemistry department and with other RISE universities will allow him to make further progress during the time that remains on his current scholarship.

A complicating factor in Stanley's work is that of the two major causes of joint pain, osteoarthritis and rheumatoid arthritis, the former is a degenerative disease and the latter is an auto-immune disease. Another confounding factor is that plants are most often collected by herbalists when a patient is ill, rather than when their efficacy is known to be optimal.

Already, Stanley Wambugu's experience is equipping him to answer questions such as when to harvest plants for greatest efficacy, further contributing to the alleviation of joint pain in rural Kenya. He is poised to complete his research this month, and after that he will begin to write up his formal thesis.
Ronald Okindo Onzago, an MSc student at the University of Nairobi, started his graduate studies at the same time as his friend Zachary Rukenya, in November 2010. He reminded us that he, like all the other RISE MSc students, is formally known as Dr. Onzago, which is earned in Kenya with the completion of a bachelor’s degree in veterinary medicine. And he, like Dr. Rukenya, has now finished his coursework and is preparing to enter the research phase of his program.

Like so many RISE students, his upbringing had much to do with his choice of academic field and his research topic. Ronald grew up in a town named Kitalea, with only about 200 other people, in Trans-Nzoia County of the Rift Valley Province.

“In that local area,” he said, “we did not have conventional drugs. So the people go to herbalists. For example, I had dental problems – toothaches – and my mother would tell me, ‘This is a good leaf.’ And it would be good – I would take several bites and it was already working.

“What was in that plant? Nobody knew. I wanted to know, and it has been my dream since I was young. I wanted to work in this field so I could find out.”

The first giant step toward his dream was to complete his bachelor’s degree in veterinary medicine at the University of Nairobi. After that, he gained experience by working as a veterinarian in his home county for a year before beginning graduate work. When he finished his proposal and gained approval for his research project, he returned home to harvest enough plant samples for his needs. He also drew up a list of questions he wanted to answer: “I want to know how it works, what is the right dosage to give, when is it useful, when is it toxic.” The title of the thesis he proposed was “The Toxicity, Antimicrobial, and Analgesic Activity of Vernonia hymenolepis, A Medicinal Plant Used in Kenya for Oral Health Care.”

Many of the questions he needed to answer grew directly out of the coursework he had done: how to extract and concentrate plant chemicals; how to harvest plants sustainably; what policies would be most appropriate in regulating the use of a medicine derived from the plant. He is also prepared, when the time comes, to explore ideas about bio-prospecting, value chains, and the marketing of plant-derived products.

For the moment, however, he is focused on the most fundamental questions of natural product science: Will the plant extract be efficacious, and will it be safe. “When I was growing up,” he said, “the herbalists sometimes didn’t know how big a dose to use, and sometimes they used too much. I can remember seeing some people dying because of this lack of knowledge. That hurts.”
Another factor restraining knowledge about herbal remedies has been the Witchcraft Act of 1925 [see blog entry for Joseph Nguta, page 28], and the government’s reluctance to involve itself in cultural issues that are poorly understood. Fortunately, said Ronald, there is now a traditional medicine act before the Kenyan parliament that proposes more realistic regulations for testing herbal remedies and establishing safe dosages. “This will help the herbalists, who really want to know. Back in the villages we have many cases of people who seem drunk from these medicines because they get too much. The herbalists are searching for answers: Am I giving too much? Two cups or one? The Ministry of Health and Sanitation is supporting the new act, and it would help to advance this whole field if it can become law.”

‘They Call it the Wonder Drug’ (AFNNET)
By Alan Anderson, 10 February 2012

After a slow start in life, Karambu Muriithi is today a RISE student in a hurry. She grew up in a poor region of the equatorial Meru district, near the slopes of Mt. Kenya, where she had the misfortune of belonging to the wrong one of Kenya’s two major clans – the one that did not control the presidency. As a result, the government wasted little funding on Meru, which to this day suffers from famine and poverty.

Nonetheless, Karambu did well in school and became interested in the use of medicinal plants, which she observed all around the countryside of her semi-arid but plant-rich home. She was enthusiastic about her studies, succeeded in graduating from college, and became one of the fortunate few to be accepted in the RISE MSc program in natural products. Since her acceptance, in 2009, she has sped through not only her coursework but her thesis program; she proudly informs a visitor that she is the first chemistry student to finish her thesis and earn a full master’s degree in just two years. With confidence and momentum, she now she plans to continue her studies of healing plants at the PhD level.

The plant she has chosen as her primary subject is a sedge that grows to a height of about six feet. It is common around the world, flourishing in damp, marshy, and flooded areas, but it is also abundant in the drier Meru region, as well as neighboring Theraka. Its tubers are well known to healers, who use them for many herbal remedies.

“I got the idea of using this plant from my grandmother,” she said, “who brought me up. She used the extract on us to treat fevers; she would put it right on our faces. Herbalists all around us also used it to treat almost every kind of ailment and disease, including common cold, fever, malaria, flu, wounds, stomach aches. They call it the wonder drug, and they even use it as perfume.” The plant finds uses wherever the sedge grows, including new applications as a
sedative, pain reliever, and, in some cultures, an inducer of dreams. The customary preparation technique is to grind or juice the rhizome and mix the extract with a little water.

To begin her research, Karambu collected some of the essential oil used by herbalists and tested it for activity against common diseases in her University of Nairobi laboratory. She tried it against *Staphylococcus aureus* (“staph” infection), *Streptococcus pneumoniae* (pneumonia), and *Salmonella* (a common cause of intestinal disease); the sedge extract was active against all of them.

One of the experiments she performed was exquisitely simple, if a bit daunting. She enlisted the help of a cage full of hungry mosquitoes. First she put a clean hand into the cage for them to feast on. In five minutes, she recorded 39 landings and 30 bites. After an hour, she put the same hand back in and recorded 63 landings and 55 bites. Then she pulled that hand out and washed, shampooed, and wiped it with ethyl alcohol. Once it was completely clean, she dabbed on about five grams of the plant extract and put it back into the cage. For five minutes, no mosquitoes landed. After an hour, she put the treated hand in again for five minutes; only one mosquito landed, but did not bite. “And even that one I think was a mistake,” she said, “because I had pushed it into a corner.” She has experimented with using the extract as an air freshener, a perfume, and a spray for mosquito netting, all successfully.

She has begun some analytical work using column chromatography to find out what the active fractions of the extract are. She has isolated six compounds, but they are impure. Further purification will depend on additional plant collection, which she says is expensive, and on access to some sophisticated instrumentation, including gas chromatography and a mass spectrometer, that will enable her to identify individual chemical compounds. She has made some progress, but the literature informs her that the extract contains some 59 different terpenes, and she wants to determine which of them – or which combination of them – provides the deterrent effect she has observed. This work lies ahead, and she is eager to devote her PhD years to it. After that, she hopes to return to the slopes of Mt. Kenya with a well-understood and far more useful extract of the plant she’s studying for the herbalists to use with greater precision and confidence.

‘The Whole World is Interested’ (AMSEN)
By Alan Anderson, 11 April 2012

If names are any guide, Isiaka Oluwole Oladele would seem to have been born under an auspicious star. His middle name, Oluwole, means roughly “God has come home” in the Yoruba tongue of his native Nigeria. Indeed, by personality he is positive and confident, a young PhD candidate in the AMSEN network ready to make the most of his opportunities. During his
childhood, however, there were few signs of good fortune or even hope, and his ability to move this far into academic engineering today seems all but miraculous.

Isiaka was born in Owo, in the southwestern corner of the country, and when the time for schooling approached, his father gave him no support. “He was speaking from the Nigerian perspective,” said Isiaka. “He discouraged me from going to school. He said that when you’re a student, you don’t earn anything to take home to your wife and family.”

He left home to live with his mother, hoping for a better chance. But she was taking care of his older brother, and said she could not be expected to take on the additional burden of young Wole. “I decided right then,” he said, “that I was going to depend just on myself and my friends.” He went to work for farmers, saving his earnings and biding his time. He had an additional insight when he was sent to stay with his uncle for a time. His uncle was a technologist at the University of Ibadan, and with a regular salary, he was able to maintain a comfortable household. “I saw how he treated his children,” recalled Isiaka. “They would go and buy things in stores, plan their meals, and had a nice home. I told myself I was going to have that.”

He learned an additional lesson from his uncle, who complained that because he lacked a university education, he could never be a lecturer; he was stuck at the level of a technologist. Isiaka went to high school in Owo, graduating in 1990, but after that he seemed stuck, finding only a basic job in a textile factory. “I was illiterate,” he said. “I didn’t know anything.”

But one day he followed a friend home and heard his mother giving guidance to her son. He decided to listen to whatever advice she gave his friend – and to follow it himself. When the mother advised a career in science, he decided that science was for him as well. His friend, however, had family support, and so he could aim for medical school. Isaika knew he could not afford that route, but he also knew he was bright enough to study some branch of science, along with other junior level friends who were choosing the same path.

In 1994 his opportunity came when he was admitted to the Federal University of Technology in Akure (FUTA). His uncle, who knew how much the boy loved football, told him firmly that it was now time to “face the books” – to change his priorities. He did just that, consulting with his friends and taking every science course available. He began to turn toward engineering, because of its perceived importance at FUTA. “I didn’t go into physics,” he said, “because that was not recognized as engineering. When you are an engineer, you are somebody.” Further, he began to specialize in materials engineering. He decided that materials engineers were going to “rule the world. If you talk about any important advancement, you are talking about materials.”

When he graduated, he had no luck find a job lecturing or consulting in his chosen field. His friends urged him to go on for a master’s degree, but he was reluctant to prolong schooling. He limped along with low-pay teaching posts in private schools until he finally agreed that he needed advanced degrees. “I was reluctant,” he said. “I did it just to quiet my friends. I had to borrow money, but they kept pushing me.”

He was able to sign on for the master’s program at FUTA, in the Department of Metallurgical and Materials Engineering, and found an interesting project developing automobile engine gaskets from new hybrid materials. He mixed traditional bonding material with natural products that would reduce costs and be sustainable, including bamboo, coconut husk, sawdust, and plant...
sponge, or loofah. He tested the strength and efficacy of each in a simulated engine environment, finding that coconut fibers and sponge were the best.

In 2009, even before he finished his MSc, FUTA offered him a teaching appointment with full staff benefits. The university also required him to continue his studies at the PhD level, but by this time “he was hooked on materials research and teaching, and no friends were needed.” At around the same time he heard about AMSEN, and was accepted into the program. He was eager for the chance to advance his studies of mixed materials. He launched a study of sisal fiber, using it to reinforce polypropylene as a strong, lightweight, waterproof composite for structural applications, such as ceiling tiles.

Sisal appealed to him for several reasons. The first was that it is renewable and inexpensive – unlike petroleum products. Also, it was availability locally. Sisal is extracted from the leaves of agave plants, especially *Agave sisalana*, which thrives in East Africa and is particularly abundant on vast estates around Morogoro, Tanzania. And while its usefulness for ropes and twine has been known since the end of the 18th century, it has recently been found suited to a wide range of applications, including low-cost and specialty papers, buffing cloth, geotextiles, filters, carpets, wall coverings, macramé, and even dartboards. It is utilized as a strengthening agent to replace asbestos and fiber glass, and is increasingly favored by the automobile industry, where its strength, "naturalness," and environmentally friendly characteristics are valued.

For his research, he has investigated several new ways to make the use of sisal more economical and environmentally friendly. It is traditionally extracted by an energy intensive process called decortication, in which leaves are crushed and beaten by a rotating wheel inset with knives. Instead, Isiaka uses soil retting – leaving the harvested leaves in soil to allow micro-organisms and moisture to soften and separate the sisal fibers. He also experimented with simple chemical treatments to strengthen the fiber-polypropylene bonding, and evaluated the mechanical properties and water resistance of the final product. He has concluded that soil retting allows easier extraction of the fiber, and that potassium hydroxide treatment best enhances the properties of the extracted fiber. The resulting sisal-polypropylene composite is found to perform better than polypropylene alone, at lower cost.

Isiaka remains hooked on materials engineering, and looks forward to continuing his work on additional materials. His goal is to be able to take his investigations to the nanoscale level. “If I have my way,” he said with great energy, “and get my own lab, I will keep doing this work in polymers. The whole world is interested.”

*A Proposal to Make Bioplastics from Seaweed (AMSEN)*
By Alan Anderson, 12 April 2012
Like the other AMSEN students attending the network’s annual meeting in March 2012, Naomi Shifeta of the University of Namibia (UNAM) was asked to give a brief PowerPoint presentation about her research topic. She was expected to defend her choice of topic, its value to society, and her proposed research methodology.

At dinner the night before her talk, she was so nervous she could speak only in whispers and barely touched her food. As one of the newest and youngest AMSEN students, and only the second woman to be accepted into the program, she had little experience speaking in public; nor did she know any of the senior faculty members from four countries who had assembled for the meeting. Two of her own advisors and traveling companions, Erold Naomab and Diina Shuuluka, were also new to the program. They kept her company at dinner, and tried to ease her anxiety. They knew she had heard tough questions tossed by faculty members at some of the more advanced students, and they tried to play that down.

“You’re going to be fine,” said the soft-spoken Dr. Naomab. “They know this is just a proposal, and they know you have just begun to sort things out. They won’t grill you about the kinds of details expected from the students who are well into their research.” Naomi nodded and attempted a smile.

By the next day, Naomi’s jitters had given way to renewed confidence and an obvious passion for her topic – making bioplastics from the red seaweed that washes onto the beaches of southwestern Africa. She spoke with a firm voice, a bright smile, and great enthusiasm; only a few pauses hinted at the terrors of the evening before.

Like many other young RISE students, she conveyed a zealous commitment to the values of her generation: sustainability, care for the environment, outcomes with the potential to help the poor and the needy. As she described her proposal, each of these elements became clear, as did her obvious love of research.

Most plastics manufactured today, she told the faculty, students, and others AMSEN participants who assembled in Nairobi, are carbon-based polymers derived primarily from the world’s steadily dwindling stocks of non-renewable petroleum. These plastics have the advantage of durability, but their dark flipside is the tendency to resist degradation in the soil or water for many years. They constitute a major cause of pollution, degrading the quality of the environment and threatening countless wildlife that accidentally ingest plastics. Worldwide, about 1 million tons of petroleum-based plastics are produced and used annually, including an estimated trillion plastic bags handed out by grocery and other stores.

Biomass-based plastics, or bioplastics, by contrast, are derived from renewable bio-resources, many of which can be broken down into simple compounds by the action of naturally occurring micro-organisms such as bacteria, fungi, and algae. “My research,” said Naomi, “aims to explore the potential for large-scale production of bioplastics.”

She was born in the tiny town of Oshakati, near the Angolan border far to the north of Windhoek, where the main university campus is located. Nonetheless, she was able to go to high school in Windhoek after her father moved there, and found her first mentor. “I had a great biology teacher in high school,” she said. “She fired up my interest, and because of that, I was always first in biology.” She went on to UNAM, where she majored in both biology and chemistry.
graduation, she was working as a lab technician and tutoring undergraduates when Dr. Naomab, then her advisor, urged her to apply to AMSEN. Frank Kavishe, the Namibian node director for AMSEN, asked Dr. Shuuluka to co-supervise her, and she began her studies in February 2012.

She has learned the fundamentals of her new field quickly. She told her audience that many kinds of bioplastics are already in use, made from such raw materials as vegetable oils, corn starch, sugar cane, pea starch, cellulose, and bacterial sludge. They find applications in blister wraps and foils for fruit and vegetables, organic waste bags, packaging “peanuts,” cutlery, pots, jars, drinking straws, bottles, ball-point pens, diapers, tire components, and drug capsules for pharmaceuticals.

Even though biopolymers have been adapted to some applications for half a century, especially those based on cellulose, there remain challenges to scaling up their use. For example, some people caution that they are likely to compete for resources with biofuels; this might raise prices, undermining one strong advantage of bioplastics. Others fear that millions of acres of forest and savannah might be sacrificed for planting bio-crops. Still others warn of the risk of excess planting of corn or other bio-crops that require heavy use of fossil fuels, pesticides and fertilizers. Finally, some bioplastics do not degrade quickly without the use of industrial-scale composters.

However, Naomi pointed out that the seaweed she studies, a common red algae named *Gracilaria gracilis*, avoids many of these disadvantages. *Gracilaria* grows abundantly along the western Namibian and South African coast (as it does in many other locations around the world). There it is nourished by the nutrient-rich upwelling of the Benguela current, bypassing any need for agricultural inputs such as fertilizer. She will harvest her samples from Luderitz Bay, a highly productive environment near the southern end of the Namib Desert. The alga’s natural polysaccharides, or long-chained sugars, which can be used to make bioplastics, degrade readily after use. These polysaccharides are already used to make agar, a biopolymer with broad uses as a Jello-like food and highly valued qualities as a biological substrate for growing and testing drugs. The potential markets for *Gracilaria* bioplastics are many, including food technology, biotechnology, microbiology, and the general plastics industry.

The aim of Naomi’s research is to create from this alga a specific biodegradable bioplastic that will have comparable tensile strength and chemical resistance to the petroleum-based plastics in use today. This work will include harvesting *Gracilaria* from the field, extracting its agar, manufacturing the bioplastic, and testing its biodegradability, tensile strength, and general chemical resistance.

She will be closely assisted by Diina Shuuluka, who is based at UNAM’s Sam Nujoma Marine and Coastal Resources Research Centre (SANUMARC) at Henties Bay. As an expert in marine botany and algae biochemistry, Dr. Shuuluka was trained by renowned seaweed scientist Prof. John Bolton.

Like Naomi, Dr. Shuuluka glows with enthusiasm for her work, and honors the mentors who guided her. “I came into the study of algae from my background in chemistry because of Prof. Keto Mshigeni. I think he has something contagious, and I caught it. I definitely share his love for the field, and I love to do research.” Prof. Mshigeni, who helped design the University of Namibia and served as its academic pro vice-chancellor from 1995 to 2000, has returned to his native Tanzania, where he is director of the Tanzanian Academy of Sciences and vice-chancellor of the Hubert Kairuki Memorial University, a private medical school.
Because of his influence, UNAM also has a program on mushroom research, which is his second great passion. “We now have seven priority areas at SANUMARC,” said Dr. Shuuluka. “And I hope to bring more young students into these fields. Especially more young women, like Naomi.”

By the time of the AMSEN party and dance on the final evening, Naomi had fully recovered her confidence. After snake dancing around the buffet with faculty and fellow students, she broke away to join the band, seizing the microphone and singing the Namibian national anthem to loud applause.

Vision of Stronger – and ‘Greener’ – Concrete Buildings (AMSEN)
By Alan Anderson, 18 April 2012

This is an update on an earlier profile; see page 31.

In 2009, when John Mwero entered the AMSEN program as a young engineer, he described his dream of solving two problems with a single solution. He wanted to find a cost-effective way to make concrete structures cheaper and “greener” without reducing their structural integrity, and he wanted to find a productive use for the giant mounds of sugarcane waste, or bagasse, that dot the tropical landscape around his native Kenya. He remembers his mother keeping a “garden” of cane in the backyard where she would cut a piece to chew on when she went out.

Most sugarcane plants leave bagasse to rot, while others burn the bagasse to produce electricity and use some of the ash as fertilizer. But John discovered that when the bagasse is burned to ash, it takes on potential value as an industrial material. He dug into the scientific literature, finding evidence that sugarcane waste fiber ash, or SWFA, might be useful in making concrete.

One of the reasons for John’s enthusiasm is that concrete is virtually the only material locally available for large construction projects in East Africa and many other parts of the world – but it is expensive. Also, the manufacture of cement consumes huge amounts of energy and is one of the largest producers of global greenhouse gas emissions. Any measure that would decrease the proportion of cement in concrete could help address both these challenges.

On the hopeful side, he found that the waste ash itself was regarded by the sugar companies as useless, and therefore it would be available at virtually no cost. At the same time, the potential for producing ash is large. John estimated that Kenya’s sugar plants could generate up to 120 metric tons of SWFA daily by burning their bagasse, using a special spraying technique to minimize smoke emissions.
His advisors in AMSEN gave their blessing to his idea, and John plunged into three years of experimental testing to verify the utility of SWFA as a concrete additive. He knew from previous research that other kinds of ash are useful for this purpose, such as volcanic ash, fly ash from coal plants, and other concrete “extenders.” And he knew about Kenya’s great need for low-cost, high-quality housing and commercial structures. For example, the government is committed to building new housing stock in Kibera, the largest slum in Nairobi and second-largest in Africa, and it will need to do so economically. At the end of those three years, his own work has provided evidence that SWFA can bring substantial advances for Kenya in the field of concrete engineering.

The history of concrete is as complex as its chemistry. Most simply, concrete is a composite that consists of some kind of filler, such as gravel or sand, and a paste-like binder of cement mixed with water. The cement binder, manufactured when limestone and clay or similar minerals are burned at very high temperatures, combines chemically with water and “glues” the filler into a conglomerate.

Crude concretes have been known since Macedonian times, but the technology was refined by Roman and Egyptian engineers who used it as a construction material in expanding their empires through the use of enormous aqueducts, buildings, and harbors. A key to their success was the discovery of so-called pozzolan additives, which were similar in many ways to sugarcane ash. These additives, named for the volcanic ash around the city of Pozzuoli, near Naples, were a product of the high temperature of volcanoes, which produced their own cement-like powders. Such pozzolans are called concrete extenders because they add cement-like strength when reacting with water. Pozzolan mixtures have been used to build such strong and enormous structures as the cupola of the Pantheon and the dome of St. Paul’s Cathedral in London.

The next revolutionary step in improving concrete was finding a way to speed up the hardening process. In the 19th century, English engineers needed a kind of concrete sturdy enough to build bridges and harbor structures – and to harden during the 12 hours between one high tide and the next. These engineers discovered that adding up to 5 percent gypsum to the concrete would cause the initial hardening to happen within a few hours – well within their intra-tidal needs. It would then continue at a much slower pace for as long as decades. This new mixture was called Portland cement because the engineers were seeking to mimic the beauty of stone quarried from the Isle of Portland, just off the Dorset coast. This whitish-gray Portland stone, easy to work yet long-lasting, beautifies structures throughout the English-speaking world, from Buckingham Palace in London to the United Nations headquarters in New York city.

John Mwero, “standing on the shoulders” of these giants of engineering, set about to apply historic advances to local conditions. He had to ensure that sugarcane ash could be hardy and durable, both reducing the amount of expensive cement while maintaining the toughness of the final product. Here John quickly found grounds for optimism. The chemical composition of SWFA contained a high silicon dioxide content, which is indicative of a good pozzolan. That is, sufficiently siliceous materials tend to react with calcium hydroxide to prolong strength development in the concrete. As he had hoped, it can thus decrease the amount of Portland cement used in the concrete – an environmentally friendly outcome. In addition, he found that the addition of SWFA, in amounts between 4 and 10 percent by weight, resulted in improved mechanical strength, reduced pore sizes, better durability, and early strength gain. Amounts up to 20 percent could also be used with little loss in strength.
Another issue he had to address is the heat that is generated by curing concrete. Heat can increase the formation of cracks and voids that may later weaken the concrete. Heat of hydration is a special concern in construction where masses are large, such as large buildings and dams, where this heat may be trapped and cause expansion and cracking.

To test this, John created a series of mixtures, adding successively more SWFA to Portland cement, from 0 to 20 percent. As he had hoped, he found that the addition of SWFA to cement pastes in amounts between 10 and 20 percent reduced the heat of hydration. He attributed this to the “interference” of the SWFA particles with the hydration process, thus reducing the chemical reactions and the heat itself. This, concluded John, “can be useful in construction of large-mass concrete structures, where heat of hydration is usually a challenge.”

Finally, he compared the chemical shrinkage of his new concrete mixtures with those of concrete without SWFA. This shrinkage, which reduces the size of a structure early in curing, is caused by the reduction of the volume of the cement paste itself, and by the collapse of voids between particles. He found that reducing the amount of Portland cement reduced the chemical shrinkage, and that introducing new particles (of SWFA) filled some of the voids. All samples of SWFA between 10 and 20 percent reduced the amount of chemical shrinkage.

With these results, John considered the experimental phase of his work to be persuasive, and will now look for the most appropriate applications. The first step, he suggests, is to enlist the support of government agencies. “They are invested in reducing costs, and in the environmental aspects. Some agencies, such as the National Housing Corporation and the Kenya Industrial Research and Development Institute, should be receptive to this.”

He also notes that in his native region near Mombasa, most people build houses with coral blocks bound together, but that this material is too weak for structures more than two or three stories high. “Our work can be useful in a rural setting. It is stronger than coral blocks and costs less than concrete.”

He also needs to convince the sugar companies and the cement manufacturers that producing SWFA concrete at a fair price is in the industries’ and the country’s interest – and to develop a system whereby the sugarcane farmers receive part of any profits. He hopes to make his case from several professional vantage points: both as a lecturer at the university and a consultant to government and industry. He is under no illusions that the construction industry will change overnight because of his results. “One PhD will not be enough to convince the world that this is what they should be doing,” he said. But he hopes that his results will be sufficient to nudge his country toward new practices that make environmental as well as economic sense.
Steady Progress on Superalloys (AMSEN)
By Alan Anderson, 19 April 2012

This is an update on an earlier profile; see page 11.

When we last visited with Bernard Odera in 2009, he had recently joined AMSEN and arrived at the University of the Witwatersrand, in Johannesburg, from his home in Kenya. He was thrilled to find an opportunity at last, after many years of teaching at the University of Nairobi, to grapple with cutting-edge research in his chosen field of metallurgical engineering and have the chance to complete his PhD.

He is well on his way. Since then, he has become a mainstay at Wits, doing research on superalloys both at the university’s Faculty of Engineering and at the DST/NRF Centre of Excellence in Strong Materials, also located on the Wits campus. His work ethic has been exemplary, as has his collegial attitude toward collaboration at both institutions. “Bernard is just the rock on our team,” said Prof. Lesley Cornish, Director of the Center of Excellence, Assistant Dean for Research in the Faculty of Engineering, and Academic Director of AMSEN. “Whenever I feel overwhelmed, I know I can count on Bernard to calm things down and remind me that they will turn out right.”

It might be understandable for Bernard to feel overwhelmed as well, given the critical functions of the materials he is studying. Engineers have worked for half a century to design alloys that can hold their strength and resist corrosion at ever-higher temperatures – in applications where failure can be catastrophic. Some of the places superalloys are put to use include valves for internal combustion engines, bomb casings, nuclear reactors, space vehicles, and turbine blades for hot sections of jet engines. With continual demands for increasing power and performance from the airlines in particular, superalloys are expected to perform reliably under ever-greater stresses, including especially longer endurance under higher operating temperatures.

Current alloys are fast approaching the application limit because of the melting temperature of nickel. Most of them are based on nickel, which has been used since the 1940s with great success. Over the decades, the addition of more than a dozen complementary metals have helped to optimize the behavior of nickel-based alloys in terms of hardness, strength, and resistance to corrosion and melting. Today’s nickel alloys allow engines and other mechanisms to function safely at temperatures of around 1100 C. But such temperatures are now in the range of 85 to 90 percent of the melting point of these superalloys.

“Now we’ve just about reached the limit for nickel,” says Bernard. “The only way out is to develop a different alloy.” Following up on the work of others, he is working on a somewhat challenging new combination of platinum (Pt) and aluminum (Al). They are challenging because Pt is somewhat heavier than nickel, at a time when airlines in particular are seeking to lighten
their materials, and it is more expensive. In addition, the same hard work that has gone into improving nickel superalloys must now be replicated for platinum-based alloys in order to increase its hardness, corrosion resistance, and melting point.

“We are trying to increase the operating temperature for platinum-based alloys to 1300 C,” he said. “That would bring a lot of benefits. Airlines can use fuel more efficiently if they can operate at higher temperatures. They can also have greater thrust with less pollution and less noise.”

At the recent annual meeting of AMSEN, Bernard brought his fellow AMSEN scientists up to date on his work, reporting that platinum alloys containing various amounts of aluminum, chromium, and ruthenium have proven to be the most promising so far. He is now adding vanadium, as a possible fifth element to one of the target alloys, which is expected to act as a solid solution strengthener, with high solubility in platinum. Vanadium is both cheaper and lighter than platinum, and his studies have already suggested that enough vanadium can be added to the alloy to more than compensate for the cost and weight disadvantages of platinum. It is also expected to increase the melting temperature of the alloy and reduce both cost and density as it replaces some of the platinum.

At the AMSEN meeting, Bernard reported on many of the details of his studies, including phase diagrams and scanning electron microscope images of the alloys, revealing fine details of structure that are associated with alloy strength and other qualities. He reported on his studies of other alloys as well, including a six-element alloy system of platinum-aluminum-chromium-ruthenium-vanadium-niobium. Much of this work has been published in peer-reviewed journals and at conferences.

Bernard is fortunate to be working with both industrial and international partners, which add to his perspective on superalloys. At the international level, he is a member of a Materials Science International Team (MSIT) based in Ringberg, Germany. On his last trip to Ringberg in February 2012, he attended an International Seminar on Heterogeneous Multi-component Equilibria and also took the opportunity to visit with their research collaborators at the University of Beyreuth. The industrial partner is Mintek, a minerals research and processing firm in South Africa that furnishes the arc-melting furnace he needs to melt the metals, as well as microscopy equipment and some of the precious metals themselves. His contact with industrial engineers also gives Bernard an understanding of the kinds of research outcomes that will interest the private sector and may be commercializable at some point.

He still cannot predict whether his platinum alloys will become useful in industrial applications, given the cost and weight challenges of platinum. One reason for choosing platinum for his work at Wits, he pointed out, is that more than 70 percent of the world’s known platinum deposits are located in South Africa. Platinum is not easy to extract from its ore and the cost of extraction makes it one of the most expensive metals, but should a company decided to commercialize a platinum-aluminum based superalloy, it could at least assume the availability of a reliable supply of platinum should the technology itself – through the work of Bernard and his colleagues – perform as well as expected.
Cosmas Muiva, born in Kenya in 1971, is one of several RISE students who have been waiting for many years—more than a decade, in his case—for the support he needs to advance in his academic career past the bachelor’s level. Thanks to his own perseverance, and the good fortune of an advisor who knew of the RISE program, he is now well on his way toward the PhD he has desired for so long.

His birthplace was 200 miles southeast of Nairobi, in the semi-arid county of Makueni, where his father had worked as an agricultural officer until the end of British occupation. When the British left, those steady jobs were gone. By the time Cosmas was a child, the British had departed, along with their jobs. “I never saw my father work full-time anywhere during my life,” he said. “Just occasional employment in the then-Atushi chain of hotels.”

His thirst for education began to grow when he saw some people in his village taking A-level coursework at the local high school. “I saw how this later let their families move from grass houses to iron houses,” he said. “I saw that it was worth doing.” He began to study harder, and after getting his own A-levels he won a government scholarship to Kenyatta University. Part of the scholarship was a loan, which he didn’t have to pay back until he got a job. He did so by teaching science in his community.

“I knew I had special talents in science. I used to invent some electronic gadgets that would attract people from far and wide to our village to see. At high school and as a high school teacher, our science congress projects were featured occasionally and won prizes at national competitions.”

In December 2004, when the great tsunami struck Indonesia, Cosmas dedicated himself to designing a prototype of an early warning system which was featured in a 2005 science congress competition. The project won many awards at all levels of competition and at the national level was judged second-best in the physics exhibits category. “We were invited to exhibit at the county trade fair,” he said.

However, he knew he needed more schooling to advance in science, the field he loved. “In my teen years and up to my mid–thirties, I was struggling to keep my head up. The country was so run down by politicians that earning a living wage was a challenge even for a graduate. I had to work for over 10 years because I could not raise money to enroll at a local university for an MSc. Life was a daily struggle.

“With the new millennium,” he continued, “we had a new dawn, a new political dispensation. Everybody was more optimistic, and we began looking into the future.” He had a relative in
Gaborone, the capital of Botswana, who told him that if he was admitted to the University of Botswana (UB), he was likely to be given a part-time job, and he could live with the relative to supplement his fees and living expenses. He took this advice, began his work and was admitted to the MSc program in Physics at the University of Botswana in 2006. Even though he soon had to take a leave from the job without pay, he was successful at earning his MSc in physics, specializing in materials science. He did his research on optical materials for solar cells, completing his research in “a record 18 months,” and returned to his country, where his wife was supporting their children on her salary as a teacher. He knew he still had career work to do, and began applying for scholarships.

One day, waiting at home, Cosmas was told that he had received an email at an internet café some miles from where he lived. After rushing to the café he found an application form for AMSEN from Prof. Pushpendra Jain of UB, head of the AMSEN node there. His work experience was a good fit with the AMSEN program, and he was accepted.

He decided to shift from studying materials for solar cells to the field of reversible, non-volatile phase-change memory (PCM). This area involved familiar research challenges, but offered the excitement of developing a new form of electronic memory. He knew that the current memory technology – so-called flash memory – had been tremendously successful in bringing robust storage ability to tiny devices, such as iPods and cell phones. But it is widely understood that flash memory is reaching its limits of performance and reliability, and a faster, safer technology is needed. There is also need to improve on materials used in non-volatile memories such as CDs and DVDs.

The leading candidate for next-generation memory is well known to materials science – but not to the general public. It is a family of chalcogenide “glasses” that includes several “metalloid” elements and non-metals, notably sulfur, selenium, and telluride – members of Group 6 of the periodic table, along with “nearby” elements of arsenic germanium, antimony, indium, and others.

These chalcogenides are already used to record data on CD’s, DVD’s, and other devices. As long ago as 1955, researchers had found that chalcogenide glasses had semiconducting properties, and in the 1960s, researchers began to see the potential for developing them for data storage. A key to their potential is that they are solids with a non-crystalline (i.e., amorphous) structure that behaves much like familiar window glass when heated toward the liquid state. Heat produced by the passage of an electric current can switch this material between the two states, crystalline and amorphous, which can emulate the 1’s and 0’s of digital language. That is, heating or cooling can either (1) allow a current to pass (conducting) when in the crystallized state, or (2) impede a current (non-conducting) when in a non-crystallized, or amorphous, state.

The actual mechanism for doing this is astonishing. Each memory location, or bit, has a tiny heater that can melt the glass and then cool it in one of two ways: either (1) to allow crystals to grow or (2) to prevent crystals from growing. These heaters are so small they can heat or melt the material very rapidly – on the order of nanoseconds – in a given location. This allows for extremely fast data “writes” and prevents disturbance of adjacent data bits. From an optical perspective, these two states have different optical properties such as reflectivity. Localized, high intensity photons in the form of lasers are used to “write” data bits onto these materials.
Over the last decade, certain chalcogenides have been used in this way, primarily in the CD-RW and DVD-RW disks in use since the late 1990s. More recently, several companies have begun to market PCM memory and are trying to bring its costs down.

Because PCM is so new, there is a great deal of basic physics to be accomplished in order to understand the best materials and techniques. This basic work is what Cosmas has been doing — what he describes as sintering (creating objects from powders), melting, quenching, and identifying. He is measuring the physical processes that need to be understood to produce the best products: crystallization rates, cooling rates, thermal stability; optimizing glass forming conditions; measuring fragility indexes; and so on. He uses models to calculate the activation energy for glass crystallization, and examines the crystallization mechanism itself. He studies the chemical bonds formed among elements, and how bond energies affect crystallization and melting.

His own particular specialty is the study of a chalcogenide alloy made of selenium, indium, and antimony (Se-In-Sb), especially its thermal and optical properties when heated. For the time being, he will have to be content with this basic work, rather than trying to produce commercial products for the marketplace. “We don’t have the equipment to do that,” he said. “Only industry has that. But we are trying to characterize the materials that industry will want to use. That will be our contribution, and it can be done at our AMSEN laboratories.”

For his research, AMSEN has allowed him to work not only at several of the UB (physics, geology, and the Electron Microscope Unit), but also at the Centre of Excellence in Strong Materials and the School of Chemistry at the University of the Witwatersrand, in Johannesburg, and the University of Nairobi. His studies with his colleagues and advisors have been published in peer-reviewed journals.

For now, says Cosmas, as much as he enjoys his research, his own next step will be to bring his family together — his three children, along with his wife, who is still teaching in Kenya. “I’ll probably try to find a teaching position at a research-intensive institute or university in the area,” he said. “I can’t support a family going to school.” At least he won’t have to wait any longer to complete his scientific training — he can now begin planning for his next employment opportunity as a full faculty member. “I have set high goals for my career,” he said. “The sky now is the limit. Keep checking Google scholar!”

Life as a Scientist in Mauritius (WIO-RISE)
By Joseph Jean Maurice Ravina, 4 September 2012
Mr. Ravina, a native of Mauritius, earned his MSc from the Institute of Marine Sciences at the University of Dar es Salaam in November 2011 through WIO-RISE.

I am currently working for the Mauritius Research Council (MRC) as a Research Assistant. The MRC was set up in 1992 to promote and coordinate government investment in research. I am based on Rodrigues Island. The Rodrigues Office of the MRC was launched at Port Mathurin, Rodrigues Island, on 31st October 2011.

The objectives of the MRC Rodrigues office are to:

1. Address potential research gaps in Rodrigues
2. Act as a platform for technology transfer between Mauritius and Rodrigues
3. Promote capacity building in research and research-related sectors

Apart from my work for the MRC, I have recently initiated an NGO (Ter-Mer Rodriguez) by gathering several young professionals/graduates in the fields of agriculture, health and safety, environmental science, marine biology, marine sciences, statistics, biology, fisheries sciences, entrepreneurship, coastal engineering and social science. The rationale behind gathering the young Rodriguan professionals was to constitute a strong team that can think about and work toward sustainable development. The objectives of Ter-Mer Rodriguez are to:

1. conduct multidisciplinary research
2. promote education and awareness campaigns around the theme of sustainable development (sustainable Rodrigues Island)
3. foster capacity building
4. conduct projects aimed at promoting a Sustainable Rodrigues Island

Rodrigues Island accounts for about 108 square kilometers of land that is surrounded by coral reefs, making a 200 km lagoon. The main socio-economic and livelihood activities of Rodrigues involve agriculture, fishing, tourism and small and medium enterprises. Rodrigues Island aspires to become a model in sustainable development. In the face of the world economic crisis and climate change, a small island such as Rodrigues needs to adopt a model of socio-economic development and strategies that involve moving towards sustainable development. The mission of Ter-Mer Rodriguez is to work towards promoting a Sustainable Rodrigues Island.

A managing committee has been constituted, and I will be serving as the president of the organization for the next two years. The NGO is new, and we want to work towards becoming a key actor in the development of Rodrigues Island, becoming known and accepted locally and internationally so that we can better serve our island. While the NGO is awaiting legal status, the managing committee has already prioritized some projects that coincide with the theme Sustainable Rodrigues Island.

Also, I have recently been appointed as the Focal Point for Coral Reef Management under the Indian Ocean Commission/ ISLANDS Project of the Rodrigues Regional Government. The work consists of fostering best coral reef management practices. Through this initiative I have recently participated in a study tour in Queensland, Australia.

One of the main goals in my life is to be able to contribute to the development of my island. I intend to pursue my PhD studies without having to leave my island, as certain universities offer
programs that allow students to conduct PhD research work in their home countries. I hope to study the management of marine and coastal resources, thus directly helping my island.

**Investigating the Okavango Delta: Carbon Dynamics and Climate Change (SSAWRN)**
By Kelebogile Cole Mpho, 8 October 2012

*Ms. Mpho, born in Botswana, is earning her MPhil from the University of Botswana's Okavango Research Institute.*

I am currently a Visiting Student Research Collaborator (VSRC) in the Department of Civil and Environmental Engineering, Princeton University. I am in the last stages of my MPhil work – a thesis write-up on *Flooding effect on litter decomposition and nutrient dynamics of a seasonal floodplain in the Okavango Delta*. I am part of Prof. Kelly Caylor’s EcoHydrology group, whose research is focused on determining the way land use and climate change interact to affect the hydrological dynamics and ecological resilience of global dry lands. I have an opportunity to interact closely with a PhD student who is studying how spatially heterogeneous vegetation structure and sporadic rainfall patterns found in savannas influence the carbon dynamics of the ecosystem.

The main aim of my visit was to join the group, study the scope of its research, and find a place to fit my own research interest, while using Princeton University resources to assist in my thesis writing. Prof. Caylor and I are working on a proposal for research on carbon storage and release in Southern Africa, focused on the Okavango Delta and its responses to climate change. According to Gurney & Eckels (2011), Southern Africa has been shown to have interesting carbon dynamics. It has been suggested that Southern Africa has shifted from being a net source of global land-atmospheric (non-fossil-fuel) carbon in the 1980’s to a weaker, near-neutral source in the current decade. I am working on a literature review for this area and will submit a proposal for further research on this topic.

From this visit to Princeton, I have developed a keen interest in how climate change affects nutrient dynamics in ecosystems, particularly in wetlands such as the Okavango Delta. My thesis work has focused on how flooding affects nutrient dynamics, particularly in living swamp macrophytes. I used decomposition experiments to look at litter decay rates and ion exchange resins to understand nutrient mineralization in soil during decomposition of the macrophyte sedge *Cyperus articulatus*, a dominant Okavango plant species. I also examined the role of ungulate fecal matter in litter decomposition and nutrient dynamics. Because seasonal floodplains attract great numbers of these animals, one would expect them to influence ecosystem dynamics.
In a greenhouse we simulated wetland conditions by generating flood pulses and studying their effects. The main findings were:

1. Non-flooded areas had the highest decomposition rates, followed by continuously flooded areas. Areas that had alternating wetting and drying conditions had the lowest decay rates. These results are contrary to the suggestion of many investigators that alternating wetting and drying cycles are optimal for decomposition.
2. Areas with abundant ungulate fecal matter had higher decomposition rates than those without dung. This feature was consistent across all flooding conditions.
3. Nutrient dynamics were such that during decomposition, nitrogen (N) was immobilized and phosphorus (P) was mineralized. There were clear shifts between immobilization and mineralization throughout the experiment period, revealing regions where nutrients are limiting and where they are not.
4. The effects of ungulate fecal matter on nutrient dynamics in decomposing litter were such that there were no significant differences in N content between dung and no dung treatments across all flooding areas. P dynamics were such that dung treatment had higher P content than no dung treatment.

The Okavango Delta is a highly pulsed system, and flooding is greatly affected by climate change. Understanding this system depends on greater integration of climate change models for ecosystem biogeochemistry. I propose a program of research aimed at understanding the Southern African carbon dynamics, focused on the Okavango Delta; how the Delta’s carbon dynamics have changed in the past three decades; why they have changed; and how much of these changes can be attributed to and explained by global climate models (GCMs). This proposal is in line with my interest in PhD work, which I hope to pursue after I complete my MPhil work.

**Challenges of Modeling the Congo (SSAWRN)**

By Alan Anderson, 10 January 2013

Raphael Tshimanga is the first RISE student in the SSAWRN network to have completed his PhD, and he is impatient to put it to good use. He will do so by returning to his home institution, the University of Kinshasa, in the Democratic Republic of Congo (DRC), where he has been appointed Deputy Head of the Department of Natural Resources Management. While the department has few resources to support either his teaching or his research on the hydrology of the Congo River basin, his task is clear to him and his work is already begun. It is nothing less than to quantify the water use of human populations in the Congo and to calculate the amount that can safely be used in the future without jeopardizing the health of the river basin itself.
While the task of formulating sound policies is inherently difficult in a land with few scientific resources, the difficulty is compounded by the country’s political instability and the many demands on a vast but finite water resource. At first glance, the Congo might seem large enough to slake the thirst of all Africa; it is, after all, the world’s deepest river (in places more than 700 feet), and the third largest in volume of flow, behind only the Amazon and the Ganges-Brahmaputra. Its flow is also unusually constant, because the Congo River basin straddles the Equator. The rainy season north of the Equator peaks in August, while the rainy season south of the Equator peaks in March, bringing heavy rains to the basin almost constantly. The region itself, within the Intertropical Convergence zone, is also the wettest part of the continent.

However, the present and especially the future demands on the Congo are enormous. Not only do the DRC’s 10 neighboring countries expect a large share, but so do other drought-plagued regions from Cairo to Johannesburg. Complex inter-basin treaties have developed over the years, as have the DRC’s own needs.

Amid these complex demands, Raphael will attempt to focus on the science. In particular, he will attempt to quantify the future impacts of land use and climate change on the amount of water that may be available for use.

His interest in helping the DRC is deep and life-long. He was born in Kinshasa, and earned his bachelor’s at the University of Kinshasa. He majored in agricultural engineering, specializing in soil and water science, and went on for post-graduate studies in Cairo. There he learned much about hydraulic engineering and river basin development in a country that has managed its own great river for many centuries. He also shares a connection with Egyptian water managers in that both the Nile and the Congo are fed by the same wet highlands that rise along the western edge of Lake Victoria.

After earning a master’s degree in hydrology at the University of Dar es Salaam, in Tanzania (another country bordering Lake Victoria), he worked as a research fellow at the University of Bergen, Norway, in water resources management. There he heard about RISE, through his connections with WaterNet, a southern African network of water researchers and students. After receiving information about SSAWRN from academic director Denis Hughes, he wrote a proposal for the work he had long hoped to do on the Congo. His title – “Hydrological Uncertainty Analysis and Scenario-based Stream-Flow Modeling of the Congo River Basin” – described his ambitious goals of quantifying and predicting the water resources of the basin.

Once accepted to RISE, his first challenge was to assemble enough accurate data from a region with little instrumentation or meteorological expertise. He needed as much data as possible about rainfall, evaporation, stream flow, and other features. Because monitoring instruments were few across the vast countryside, he had to depend heavily on data from satellites and from other institutions, especially the University of East Anglia, the Food and Agriculture Organization of the United Nations, and the Global Runoff Data Centre in Germany. Along with meteorological data, he also learned as much as he could about the physical properties of the basin, including land cover, soil type, geology, and geomorphology.

Because of these data shortcomings, building a model capable of simulating the climate of the entire Congo basin – second in drainage area to only the Amazon – was an enormous challenge. Raphael calls the result a “conceptual hydrological model,” or an “aggregation of processes.”
Nonetheless, after much work in testing and validating his model, he concludes that it is sufficiently useful for the task of calculating future runoff. “We concluded that our model is good,” he said, “by using international standards that have been established to evaluate models such as these. It works well to estimate and predict water resources, and the future impact of various land uses and climate changes.”

The early estimates based on the model have already been useful, for example, in predicting near-term responses to climate. Should climate change proceed as predicted, he said, it would decrease rainfall in the northern Congo, and increase evapotranspiration. The combined result, he calculates, is likely to be a decrease in the mighty Congo’s stream flow of about 10 percent.

But such early results, he said, while encouraging, are not good enough. When assembling the model, he had sufficient ground data only to make rough predictions for the northern part of the basin – the portion above the equator that borders Uganda, Sudan, Central African Republic, the Republic of the Congo, and others. “More local data are needed to validate the satellite data, including at least 30 reliable ground stations,” said Raphael. “There should be more than 30, but that would help.”

And Raphael is even more concerned about having insufficient data for the large portion of the DRC that borders Tanzania, Zambia, Angola, and other countries south of the Equator. This region supports about 150 weather stations, but their maintenance is not efficient or consistent.

And he anticipates many requests for stream flow data in next decade. These are not yet quantified, but he needs to be prepared with responses when they do arrive. “We will need many studies to bring deep understanding of hydrological behavior of the basin and how it will respond to water withdrawals,” he said.

The needs for Congo water will be both internal and external. The DRC itself will use more water for electricity, irrigation, industry and drinking water. The country will also face pressures from other water-poor countries, and Raphael will help devise the most efficient ways to comply. One technique is “virtual water transfer,” such as growing corn in the Congo and sending it to Botswana or elsewhere as food instead of by constructing pipelines, which is very expensive. He will also be asked to explore the feasibility of hydropower network development, such as joint projects of the Congo and Nile basins. The water of the Nile is being used mainly by downstream countries such as Egypt on the basis of long-standing colonial agreements. Upstream countries are eager to find their own water to promote development – water they would like to receive from the Congo.

Political pressure is already coming from the many countries that depend on the dwindling waters of Lake Chad, located along the borders of Chad and Nigeria. About 5,000 years ago, this enormous expanse of water and wetlands was a vast inland sea, thought to have covered about 150,000 square miles. Its size has fluctuated dramatically since then, shrinking to less than 10,000 square miles in 1983 and only 580 square miles in 2000. While it has recovered somewhat since then, it has always been extremely shallow and vulnerable to evaporation. Comparable in area to Lake Tanganyika, its maximum depth is only about 34 feet, compared with a maximum depth of nearly a mile (4820 feet) for Lake Tanganyika.

Lake Chad, dependent on the unreliable inflow of the Chad River, faces heavy demands from farmers and ranchers. The Lake Chad Basin Commission (LCBC), including many countries with legal claims on the lake’s waters, has discussed ways to replenish the lake. In 2008, a
summit meeting of the LCBC announced plans for an interbasin diversion project featuring water from the Congo. Part of Raphael’s challenge will be to calculate the consequences of diverting various quantities of water from the Congo basin without jeopardizing the DRC’s own water security. “There will be a lot of pressure on us,” predicted Raphael. “There will be more competition for development, and when they say development, they mean water.”

He added that he also must educate leaders in his own country about the need for better data before making political decisions. For example, there is almost no data on the present uses of Lake Chad water, which must be known before an agreement can be valid.

“The future of the Congo basin is now unknown,” said Raphael. “People don’t want to wait for the science, they just want to go ahead with the planning. But what is planning without science, without information? How can we do good planning without knowledge?” The DRC government today has a better understanding of water resource issues than it did 10 years ago, he said, but its policy options are limited by shortages of money, skills, and public will.

Meanwhile, he is anxious about having sufficient time and resources for both teaching and research, but is determined to do his best. He has already organized three orientation courses at the university, on soil and water, flora and fauna management, and forestry, and he expects to plan more courses to educate students about water resources. He has published five papers about his work, and submitted three more to journals, but raising funds for continuing research is a challenge. He has early indications of interest from the IDRC of Canada and Laval University in Quebec City, but he will have to work hard to build a program of the quality he envisions.

“I am going back because I have done this work, and it is appreciated, and I would like to try to implement these ideas in the Congo,” he concluded. “I hope to help bridge institutional barriers, and bring researchers together with decision makers. When it comes to political activity, good decision making requires information and skills. If we are able to provide those, we can help good decision making.”

An Urgency to Understand the Okavango Delta (SSAWRN)
By Alan Anderson, 14 January 2013

This is an update on an earlier profile; see page 44.

As a native of Botswana, Gaolathe Tsheboeng is familiar with his research subject – plants in watery places. He was born in the village of Moletemane, near the “great, gray-green, greasy Limpopo River,” as Rudyard Kipling once called it. As a RISE student, he has spent the past two years working on another watery region of Botswana, the Okavango Delta, which covers much
of the northern corner of the country. He has studied the response of the huge expanses of grasses and sedges to varying water levels in the Delta. These plants provide most of the food for both the wildlife of the region and the cattle of native herders, whose ancestors have inhabited the Okavango since the end of the Stone Age several millennia ago.

The annual “pulse” of floodwater, rushing southward out of the highlands of Angola, has gradually created this hot, flat environment (its elevation varies only about six feet over some 100 miles), which today is rich in organic matter and teeming with life. The yearly floods nourish a unique network of productive ecosystems: languid lagoons, reed- and papyrus-filled swamps, spongy grasslands, and tree communities of the riverbanks and elevated woodlands. Although any census of life forms in this vast wetland can only be approximate, the Okavango Research Institute (ORI), near Maun, estimates that the Delta supports some 1,300 species of plants, 70 species of fishes, 30 species of amphibians, 65 species of reptiles, 445 species of birds and 120 species of mammals. Among the mammals are the “Big 5” – lion, elephant, buffalo, leopard, and rhinoceros – which, along with spectacular birdlife, attract tourists world-wide.

The source of the Delta’s fertility is the floods themselves. Each time they come, they release the nutrients of decayed vegetation from the previous year, more than tripling the concentration available to growing plants. A steady, year-round flow of water would not provide this service, confining Delta flow to permanent channels and swamps that are low in dissolved organic carbon and support little biodiversity. "Seasonal flood plains become productive grazing areas only after the rains," says Michael Murray-Hudson, a research scholar at ORI who supervises Gaolathe’s work. "The dissolved nutrients fuel microbial populations and biological productivity at every level, up to the herbivores and predators."

In addition, the floodwaters support many thousands of humans, including hunters, fishers, harvesters, and farmers. The farmers are keenly attuned to the timing of the floods, planting their crops at the very end of the flood season so as to reap the nutrient bounty of the retreating waters. This technique, called molapo (flood recession) farming, has also been practiced for thousands of years along the Nile.

Yet the pulsing of the floodwaters is neither regular nor reliable, and its reach can vary by hundreds of miles. During the wet years, the Thamalakane River may fill to the banks, spill over into the dusty town of Maun, and push far to the southeast where it covers the vast salt pans and attracts huge flocks of flamingoes and other water birds. During dry years, stream flow in the rivers and smaller channels may practically cease, threatening cattle and wildlife alike.

Like most other water systems, the behavior of the Okavango is expected to vary more widely with climate change. For this reason, many scientists at the ORI, including Gaolathe, are learning as much about the hydrology of the region as they can before such changes are obvious. Gaolathe began his studies on grasses and sedges two years ago, and has completed the requirements for his MSc degree at ORI, part of the University of Botswana. He has now begun his PhD studies, shifting his emphasis to woody plants, the other dominant kind of plant community in the Delta. He hopes to learn how the floodplain tree communities and the nutrients that support them change in response to flood variation.

As he did for the grasses and sedges, he will examine the response to recent extreme conditions, as well as setting up his own test plots. For nearly a decade after the turn of the millennium, the floods were weak throughout the Delta and water levels sank. Suddenly, in 2009, the picture
changed abruptly as heavy floods arrived. By looking through the data gathered over the past decade, Gaolathe has found that these abundant pulses encourage the spread of water-loving grasses and sedges, which in turn supports larger numbers of grazing animals. These plant species (and their nutrients) are most abundant near waterways, expanding outward during years of heavy floods. If the flooding is too intense, however, the water-loving papyrus becomes dominant along the waterways, crowding out the smaller grasses and sedges. During dry years, the papyrus and then the grasses and sedges retreat, reducing the available stand of food for grazers. Trees and bushes quickly encroach on the wetlands, reducing the grazing areas and offering fewer nutrients.

On the basis of his early studies, Gaolathe proposes that the Delta is best suited to a flood pattern that alternates between wet and dry. If either is too prolonged or severe, plants and animals do less well. Without full flooding, the edible grasses would not expand, and woody species would move in to take their place. Without some drying, the inedible papyrus would overtop the grasses.

This question has gained urgency in recent years as the countries bordering the Okavango region – namely Botswana, Namibia, Angola, Zambia, and Zimbabwe – jockey for the right to Okavango water. A major source of debate is the Okavango River itself, which flows out of Angola, where it is known as the Cubango. It also crosses a sliver of land known as the Caprivi Strip, which protrudes about 280 miles from Namibia to the Zambezi River. Caprivi was created for the convenience of a land swap in 1890 between England and Germany, in which Germany gave up its claim to Zanzibar for Caprivi. It did this to gain access to the Indian Ocean via the Zambezi River, which turned out to be impossible. Today, Namibia lays claim to the strip (as does Botswana), and its water.

A continual worry for ORI scientists is the potential interruption of the Okavango’s flow through dams or removal, which would likely alter the life-giving pulses of the flood waters and jeopardize the Delta ecosystem. A body known as OKACOM, the Okavango River Basin Water Commission, is trying to provide information and mediate scientific discussions among Botswana, Namibia, and Angola, and the ORI scientists are working hard to spread more understanding of the Okavango system.

For Gaolathe, the next job is to create a vegetation map for the whole Delta and a classification and tracking system for its tree species. He hopes to learn how these and other plants replace themselves after they die, and understand the environmental forces that determine their distribution. He has begun to set out study plots, running from the river outward, for the entire Delta. He has the good fortune to be supported by the Future Okavango Project, a five-year program sponsored by the German government, along with another student from Botswana supervised by Dr Mike Murray-Hudson. He is not quite looking over his shoulder as he works, but he understands well the urgency of a research question that is both complex and politically charged.
Odume Oghenekaro Nelson is a Nigerian student who entered the RISE program at Rhodes University in Grahamstown, South Africa, in 2009. Since then he has become adept in the use of a new approach in testing water quality based on the presence or condition of certain aquatic insects. Unlike traditional chemical methods of detecting water pollutants, the use of an insect-based technique promises a more accurate and complete picture of ecosystem health.

Nelson’s early studies of aquatic insects, which are now complete, earned him an MSc degree in 2011. He has decided to continue this work at the PhD level, expanding the scope of his work to include the water policies formulated by the South African Department of Water Affairs.

His MSc research was accomplished along the Swartkops River that flows through Port Elizabeth and into the Indian Ocean. He chose the Swartkops for its proximity to his university in Grahamstown, and for its hydrological, ecological, and recreational importance to the Eastern Cape region. The entire Swartkops catchment area, in which about 1 million people live, is subjected to both industrial and agricultural pollution, as is the 12-mile estuarine segment where it broadens, slows, and flows through Port Elizabeth. Activities that degrade its water quality along the way include sand and clay mining, sewage treatment, a salt works, a tannery, multiple discharges from a large industrial area along the river just upstream from the tidal reach, and a large storm water canal system.

Nelson found that traditional chemical techniques for testing water quality did not give accurate or meaningful readings, especially for chemicals that were not on the testing list or that were present in very small amounts. More important, chemical testing gave virtually no information about organisms inhabiting the water, changes in animal and plant communities, and other features that determine the ecological health of rivers.

The presence (or absence) of organisms such as insects, on the other hand, can reveal a great deal about the environment. Those he studied first were small, slender flies of the common family Chironomidae, often known as non-biting midges. While the adult midges superficially resemble mosquitoes, the larvae are the familiar reddish bloodworms found in the river muds of many climates. Both the adult and larval phases of chironomids provide important food for countless species of predators world-wide, including fishes, dragonflies, toads, beetles, swallows, bats, newts, and others. Because of their importance to many other organisms, their own health is fundamental to overall environmental function.

Members of the Chironomidae family have long been known to prefer relatively clean to polluted water, so that their presence alone provides a rough indication of water quality. When some of these sensitive species are exposed to even small, sub-lethal doses of certain pollutants,
however, they show deformities of the mentum, or mouthparts. Although these deformities may not be noticeable to the non-expert, Nelson has learned to see them as reliable and sensitive indicators of water quality. During his MSc research he learned to identify even slight changes in the mouthparts of chironomids exposed to pollutants, especially the cadmium, chromium, copper, or zinc used in the mining and automotive industries. In such environments, he found, certain mouthparts would be missing, fused, or duplicated, and he developed particular water-quality indexes based on such changes.

He has also studied other insects that can be used to create water quality indices. One is the EPT index, which includes the insect orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Tricoptera (caddisflies). He has also worked with the SASS index, or South African Scoring System, and the ASPT index, for the Average Score Per Taxon (a taxon is a taxonomic unit, such as a genus, order, or family). Yet another index is the ETOC, which includes the Ephemeroptera and Tricoptera of the EPT index plus the Odonata (dragonflies) and Coleoptera (beetles). In all, he has experimented with about 19 such indices in the Swartkops. Some were sensitive not only to heavy metals, but also to nutrient pollution caused by wastewater and agriculture, or to general pollution that may contain organic compounds, pesticides, nutrients, and other pollutants.

Nelson used a “multi-layered” approach in applying these indicators. In the first layer he compared the baseline (clean-water) insect community with various insect communities that indicate pollution. In the second layer, which he called multi-metric, he tested river water against all 19 metrics. At the third level, he looked for mouthpart deformities. Learning to apply these three stages of evaluation earned Nelson his MSc “With Distinction,” along with a series of publications, three of them in international journals, including the Elsevier journal *Physics and Chemistry of the Earth*.

In moving to the PhD stage of his work, Nelson and his supervisor, Prof. Tally Palmer of Rhodes University, began to study how the new insect tools could be useful in strengthening two pieces of water legislation in South Africa: the National Water Act (NWA) and the Water Services Act (WSA). The NWA created two strategies: (1) Resource Directed Measures, or RDM, which were designed to protect environmental resources; and (2) Source Directed Controls, or SDC, which were designed to regulate use of water resources through licensing, authorizing, and permitting. For example, companies intending to discharge mine wastes into waterways must comply with limits specified by the SDC.

The Water Services Act, or WSA, sets out strategies to provide water services and sanitation to the public, with two programs for doing so. The first is the Blue Drop certification program, which regulates the structure and management of drinking water systems. The second is the Green Drop program, which regulates the infrastructure by which wastewater is treated before discharge into a river.

The Green Drop program had many good features, says Nelson, but because it depends on traditional chemical techniques for evaluating water quality, it did not succeed in raising environmental water quality. When Nelson and Prof. Palmer had studied their new techniques, they decided to present them to the people in positions to use them: the administrators of the Nelson Mandela Bay Municipality, in Port Elizabeth, and the nearby Sundays River Valley Municipality, a key citrus growing area. They presented their findings, and after some initial confusion about the concept, the administrators agreed to help with additional testing.
“What we wanted to do,” said Nelson, “was to get these two pieces of legislation – the National Water Act and the Water Services Act – to relate to each other. We needed metrics that were sensitive enough to make them both work better. The question we posed was, if we treat our wastewater, and find it is compliant at the discharge point, does that protect our resources in the river? At the present moment, wastewater compliance is measured only chemically. If it’s below the chemical limit, everyone says, that’s fine. But that tells us nothing about the health of the ecosystem.”

What Nelson proposed to the municipalities was to test the wastewater by the insect-based techniques after wastewater treatment. When the municipalities agreed, he selected a particular wastewater plant. In July 2012, he laid out a series of nine small test streams (20 feet long and 6 inches wide) that allow the treated effluent to flow through them en route to the river.

The test streams began running in August, and sampling began in November 2012. The effluent from the plant to the first three streams was treated with the customary amount of chlorine to kill bacteria (i.e., 100 percent effluent concentration); the effluent in the second three streams was diluted with dechlorinated tap water to give a 50 percent concentration of the original effluent; and the last three streams received only dechlorinated tap water. The wastewater will be allowed to run through the streams for at least six months, with regular sampling of insects. At the same times, the river itself will also be sampled.

Nelson will also make the sampling more accurate by moving from simple analysis of species to analysis of traits (features) within each species. “What we are after,” he said, “is a trait-based approach for monitoring water pollution in South Africa. We want to measure multiple insect traits: body size, shape, level of hemoglobin, respiration mode, diet, feeding methods, mobility, and rate of dispersal as the larvae emerge as adults. All these tell us something about the health of the species, and the ecosystem. We will make up our own specific index using these traits. This will tell us what traits allow the insects to survive, and how they are affected by pollution.”

He acknowledges that there are limitations to the use of insects. For one, the aquatic immature stages of the insects are often difficult to identify. Also, the chironomid index can be used only when chironomid species live in the water to be sampled. And some individual insects have different responses to pollutants than others, so that multiple species – and indexes – are needed.

“We know we’ll have problems to fix,” he said. “But I am optimistic that we can fix them. The good thing is that these new indexes give us a way to bridge the needs of the National Water Act and the Water Services Act. One is trying to protect the environment, and one is trying to protect the quality of the water for the people who use it. What we are doing protects both at once.”
Paul Kojo Mensah, a SSAWRN student at Rhodes University in South Africa, has tackled and completed a project of great value and considerable complexity: testing the effects of herbicide use on aquatic organisms in the Eastern Cape region, and developing guidelines for herbicide use based on the responses of those organisms.

Paul’s interest in this topic grew out of his discovery that there were no such local guidelines in place, and considerable reason for concern, given the increasing use of herbicides by farmers, private land owners, public agencies, and the flourishing wine industry.

Paul, who was born in Ghana, has always dreamed of using his biological training to help protect the environment. When he was studying biology as an undergraduate at the University of Cape Coast in his home country, he hoped to move on to graduate school so that he could become a marine biologist and a university professor. After graduating with honors in 2001, however, he was unable to find sponsorship for his master’s studies – like most other science graduates in Africa. He had no choice but to enter the job market, and was fortunate to find work teaching in a secondary school in Ghana.

After four relatively unproductive years, he moved to South Africa in 2005 to try his luck in a new environment. Again, he supported himself by teaching in secondary school, enrolling at the same time in the new Walter Sisulu University in the Eastern Cape, recently formed by a merger of three other institutions. He saved as much money as he could from his teaching salary, and by 2006 was able to begin his MSc studies in zoology, working also as a teaching assistant at the university.

By 2008, he had completed his MSc and began trying to find a supervisor and support for PhD studies in ecotoxicology, an interest he had acquired at WSU. While searching the Web, he came across the name of Dr. Nikite Muller at Rhodes University’s Institute for Water Research in Grahamstown. He emailed her, and she suggested that he apply to the RISE program as well as to Rhodes. In November 2008 he received an emailed acceptance from both programs.

Working with Dr. Muller and her colleague Prof. Tally Palmer, both members of the Institute for Water Research (IWR) at Rhodes, he had access to many potential research ideas. He would not be working in marine biology, as he had earlier planned, but he soon learned that he might be able to make a substantial contribution in freshwater biology. He heard about a problem that was receiving virtually no research attention in South Africa – the growing presence of toxic chemicals in waterways and the effects of these chemicals on aquatic organisms. Both of his mentors, who had long experience in the field of ecotoxicology, encouraged his interest and helped guide his research planning.
As he learned about the regional use of herbicides to control weeds and invading aquatic species, he was not surprised to find that the most widely used chemical was glyphosate, most commonly sold under the commercial name Roundup and liberally used throughout the province. He was surprised, however, to find that South Africa had no water quality guidelines for glyphosate that were based on indigenous species, unlike the United States, Australia, Canada, and the European Community – even though it has been found in high concentrations since the 1990s in the Hex River Valley, an intensive grape-farming area in the Western Cape Province.

There were reasons for urgency in creating science-based guidelines. One is that glyphosate is commonly used near and even on rivers and other waterways, draining into them when it rains. As an aquatic biologist, Paul knew that many species of aquatic animals are sensitive to chemical pollutants, and he saw the need to protect populations of economic and ecological value. Also, he learned that weed species in South Africa and elsewhere are quickly developing resistance to glyphosate, prompting some users to increase their application rates.

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The action of glyphosate was discovered in 1970 by John Franz, an American chemist employed by Monsanto, and glyphosate was introduced commercially in 1974. Franz and his team discovered that the glyphosate molecule interferes with an enzyme vital to a critical biochemical pathway in virtually every plant, bringing farmers a powerful new tool in their war with weeds. And unlike its predecessors DDT and 2,4-D, glyphosate seemed to bring little or no risk to humans or other animals, in which this pathway is not present. For many years before Paul began his work, glyphosate was viewed by many agricultural researchers as the “perfect herbicide” – a broad-spectrum, systemic agent that killed virtually every weed and invasive species, broke down in the environment, and posed little risk to users.

Over the next two decades, glyphosate’s popularity grew steadily but slowly. Farmers used it to spray fields before planting, but they could not use it after crops emerged. In 1996, however, this all changed when molecular geneticists succeeded in moving a glyphosate-resistant gene from a soil bacterium into ordinary crops. This meant that every major “world crop,” from corn to rice to wheat, could be shielded from the danger of glyphosate, which could now be applied directly to the crops themselves and the weeds among them. Monsanto developed seeds for these resistant strains and watched the use of glyphosate soar around the world. Within a decade, some 90 percent of all major crops were grown with the Roundup Ready system, which included both the spray and the seeds. From then until now, about half of Monsanto’s revenues have been generated by this system.

Recently, however, the Roundup picture has clouded somewhat. Persistent use of glyphosate has spurred the emergence of resistant weed strains, including some “superweeds” that dominate as the weeds around them succumb. And evidence is accumulating that the Roundup system is not quite as safe as it was thought to be. Numerous studies have found evidence that it does indeed harm some organisms, such as the nitrogen-fixing bacteria in soil and many species of frogs, which are commonly viewed as the aquatic equivalent of “the canary in the coal mine.”

While the glyphosate molecule itself is thought to be safe, it must be mixed with “adjuvant” chemicals, such as surfactants, that enhance its application or activity. It is these glyphosate formulations that appear to threaten some animals, often through changes in reproductive,
endocrine, nerve, or developmental functions. Studies have also suggested that the formulations can alter the natural biota and nutrient availability of soil and damage human DNA, among other effects.

* These assertions are disputed by Monsanto, and the heavy application of glyphosate has continued in regions worldwide, including the Eastern Cape. Paul’s primary objective has been to evaluate its safety and to design evidence-based guidelines for use. In order to gain perspective for his work he began by examining other countries’ guidelines. Then he began testing the sensitivity of local aquatic organisms.

Many of them showed some degree of sensitivity to glyphosate exposure, but he began by looking for a single reliable biomarker, or indicator species, that was both common and sensitive to herbicides. Through the IWR, he worked closely with the Department of Water Affairs at sites along the Swartkops River to plan his research strategy. He found what he needed in *Caridina nilotica*, a common fresh-water shrimp occurring throughout the continent, from the Nile to South Africa. He found that this shrimp is both sensitive to herbicide pollution and exhibits a range of responses that can be readily observed.

One was that Roundup depressed the activity of a vital enzyme, acetylcholine esterase (AChE); the higher the concentration of herbicide, the greater the depression of AChE activity. AChE is essential to the transmission of nerve signals, especially at nerve-muscle junctions and in the brain.

A second behavior of *C. nilotica* caused by glyphosate was lipid peroxidation (LPx), a process which results in the degradation of the fats in cell membranes. Paul tested this behavior by exposing post-hatch shrimps to high concentrations of Roundup for 96 hours to measure acute toxicity; he also exposed them to smaller amounts of herbicide over a much longer 21-day period. Biochemical testing showed that LPx was significantly higher in animals exposed to Roundup than in control animals.

Finally, he assessed the toxicity of Roundup using three different life stages of the shrimp: neonates (less than seven days after hatching), juvenile (more than seven days and fewer than 20 days post-hatching), and adult (more than 40 days post-hatching). All were exposed to varying concentrations of the herbicide in 48- and 96-hour tests. All three life-stages of the shrimps that were exposed to herbicide responded with erratic and slow movements, with neonates showing the most irregular behavior. This indicated that even low levels of Roundup may adversely affect the health and survival of *C. nilotica*.

For his ultimate goal of suggesting guidelines for both short-term and long-term exposure to glyphosate, Paul chose to examine the responses of eight species of organisms belonging to five taxonomic groups: insects, crustaceans, mollusks, fish, and green algae. He measured the effects of both high-level, acute exposure, such as might be caused by spills and surface runoff, and to low-level, chronic exposure, as might be caused by gradual, steady seepage of herbicide from soil into nearby waterways.

He found wide variations in sensitivity among the test species. For example, the water flea, *Daphne pulex*, was about nine times more sensitive to glyphosate than the midge, *Tanytarsus*.
For the algal species, *Chlorella sorokiniana* was found to be 10 times more sensitive in a 48-hour exposure than *C. protothecoides*, and 200 times more sensitive in a 72-hour exposure. Arthropods and fish were the least sensitive of the groups tested. Based on analysis of his data on species sensitivity, he was able to recommend water quality guidelines that can help avoid both severe effects during acute, transient events (such as spills) and long-term exposure. In general, he concluded that the herbicide should be carefully managed to minimize any negative impact on non-target freshwater organisms, and suggested the amount of herbicide that can be used safely. To date, Paul and his co-authors have published four papers on these results. He based his PhD thesis on this work, and it has been successfully completed.

Meanwhile, Paul’s circle of connections in the world of freshwater management has expanded with the departure of Dr. Muller from Rhodes University. She left in 2010 to become an environmental officer with Amatola Water, a water services provider to municipalities in the Eastern Cape. She remains his co-supervisor, along with Prof. Palmer.

He now hopes to continue his study of the herbicide as a postdoctoral fellow if he is able to find support for his work. Much remains to be done, as the use of glyphosate in the Eastern Cape continues to be heavy. The provincial government has been cooperating with Monsanto since 2005, when the company began providing farmers with GM seed and the Roundup regimen. “One result is that the farmers are using too much Roundup,” said Paul. “They believe that ‘If some is good, more is better.’ They are also using more no-till farming, which requires lots of herbicide. Ours is still the only field work being conducted on this issue, and we have the responsibility to communicate what we have found.”

**Why Are Hippos Dying of Anthrax? (SSAWRN)**
By Alan Anderson on 28 January 2013

Celsus Sente is just beginning his work as a RISE student, but he brings to it a wealth of diverse experiences in several fields and a fervent curiosity about nature. As a Ugandan born in the remote western district of Rubirizi, he grew up near the Queen Elizabeth National Park, which is 764 square miles of rich, diverse terrain that spans both Uganda and part of the adjacent Democratic Republic of Congo. When he was studying Veterinary Medicine as an undergraduate at Makerere University, he met Ludwig Siefert, a lecturer and lion researcher at the university who has worked for three decades towards the conservation of lions, leopards, and other large carnivores which have suffered massive and indiscriminate poisoning and poaching. Celsus began to tag along as his mentee, learning much about the park from him.

After earning his bachelor’s in Veterinary Medicine, he immediately enrolled for a master’s degree in Wildlife Health and Management, also at Makerere. While studying he got involved in
small projects here and there, including a study on community attitudes toward rhino conservation in Uganda. Celsus was later involved in mass vaccination and treatment of various diseases in domestic animals at the human-livestock-wildlife interface at the Bogoria Game Reserve in Kenya; he notes that this was one way of involving rural communities in wildlife conservation. In the winter of 2006, he went on a brief sojourn to United Kingdom, where he took a short course in Poultry Health at the Pirbright Institute (formerly the Institute for Animal Health) and participated in a barn owl workshop at Monks Wood Experimental Station in the East Midlands. In 2007 and 2008 he lived and worked in Norway as a wildlife biologist and veterinarian, developing his skills in wildlife handling and restraint.

Returning to Uganda in 2009, he secured a post at Makerere as an assistant lecturer, where he became interested in wildlife diseases, especially anthrax, on which his PhD study is based. Celsus heard about RISE from professors and colleagues at Makerere who had been participating in the program from the outset. “They were looking for someone to conduct water-related research,” he recalled, “and I had already become interested in water and anthrax.”

Anthrax, a highly infectious bacterial disease, is familiar to many people for its virulence and occasional use as a sensation-getting tool of bioterror. In the U.S., for example, much of the country was riveted by the anthrax attacks of 2001, when letters containing anthrax spores were mailed to the offices of several news media offices and two U.S. senators, killing five people and infecting 22 more. During the 1970s, the Soviet Union produced hundreds of tons of weapons-grade anthrax, though it was never deployed.

In its natural environment, anthrax most commonly infects wild or domesticated herbivorous mammals, such as sheep, cattle, and goats. These animals may ingest or inhale the bacterial spores while grazing, and in turn may pass the disease to humans. People most at risk include farm workers, veterinarians, and woolworkers. Disease begins when the bacterial spores “germinate” or sprout, releasing toxic substances that cause internal bleeding, swelling, and tissue death. Once the spores reach the bloodstream, anthrax is usually fatal. Another menacing feature of anthrax is that the spores may remain viable for decades and even centuries. The disease once killed hundreds of thousands of people and animals annually before Louis Pasteur developed the first effective vaccine in 1881.

Anthrax is a perennial problem in the Queen Elizabeth National Park. In 2004 to 2005 and in 2010 a number of hippos were reported dead in the Kyambura River and Kazinga Channel, which supplies water to fishing communities and to wild and domestic animals. Kyambura Gorge harbors a diversity of wild animals that are easily exposed to anthrax outbreaks, making it a possible hub for anthrax spillover into livestock and humans. But little is known of the cycles that allow anthrax to persist in the hippos’ environment.

“We know the hippos die,” said Celsus, “and we know they die of anthrax. We know that the soil is the reservoir for the bacteria, but probably, without water collecting, concentrating and distributing the spores, there would be no anthrax. And that is all we know. The outbreaks in the hippos mostly occur right after the rainy season, so the water plays a crucial part in the anthrax cycle. I want to see how it collects and disperses anthrax spores, and learn to model future outbreaks.” It is important to relate stagnant water and free flowing water with the physico-chemical nature of the landscape, water flow pattern, presence/absence of anthrax spores in the environment, and geospatial distribution of ecological risk determinants.
Another dimension of his project is the place of humans in the anthrax cycle. In this rural region of Africa, hippo meat is revered, and the local people cannot resist an easy meal of fresh dead hippo meat. As a consequence, many people die of anthrax from eating the hippos. The number of deaths is unknown, but Celsus is determined to explore this ongoing mystery. “The people won’t talk about how many people die, because they know that eating hippos is illegal. But they will often talk about it at drinking joints or during any other casual talk session, as long as they trust the people they are talking with.”

Many of the large animals of the park were killed during the Uganda-Tanzania War of 1978-79, which led to the overthrow of Idi Amin. Since then these populations have largely recovered, but anthrax remains a continuing menace.

Celsus’ work through RISE will include collection of soil and water samples in the dry and rainy seasons to capture the seasonal variation in anthrax. In addition, he will review scientific reports and literature and hold Focus Group Discussions (FGDs) to capture the views of communities. The reports and FGDs will give insight into the temporal trend of anthrax in QEPA. Through transect walks, boat rides, and observation facilitated by GPS, the spatial dynamics of anthrax and landscape features will be determined. The laboratory phase will involve analysis of soil and water samples for physico-chemical properties, presence/absence of anthrax bacillus and isolation of DNA. The title of his proposal is “Ecohydrological Risk Determinants for the Prediction of Anthrax Outbreaks in Queen Elizabeth Protected Area.”

Among the chief mysteries is whether animals can catch anthrax directly from water, and Celsus Sente hopes to break new ground on this question. When the rainy season begins, the water accumulates in low-lying spots, valleys, dams, pools, and drainage channels where the hippos congregate and begin to die. Celsus will begin his studies here. His long-time collaboration with Dr. Siefert will be invaluable, both for Dr. Siefert’s long experience and for his access to remote regions. “I will help him in his work,” said Celsus, “and he will help me. He has a vehicle, which I don’t have, and I will depend on our friendship for my RISE project.”

Ancient Remedies for Modern Diseases (SABINA)
By Alan Anderson, 31 January 2013

SABINA graduate Justin Omolo was the first RISE student to earn his PhD, which he completed in December 2011. In doing so he has traveled an original and creative path, exploring surprising links between the knowledge of traditional healers and the techniques of modern bioinformatics and synthetic chemistry. This journey may have brought him to the threshold of a treatment for HIV/AIDS that is both ancient and brand-new.
His scientific education began at the bachelor’s level in the early 2000s, when he enrolled in a triple program of chemistry, biology, and education at the University of Dar es Salaam (UDSM) in Tanzania. After earning his B.S. in 2004, he won a DAAD-NAPRECA Regional Scholarship from Germany in 2005, which allowed him to continue his studies at the chemistry department of University of Botswana in Gaborone, Botswana. His main interest was in phytochemistry — analyzing plant extracts and looking for active compounds in medicines, especially those used by traditional healers. He began by focusing on a small tree called *Ziziphus mucronata*, or buffalo thorn, which commonly grows on termite mounds in Tanzania. Because of its thorns it is often used as a fence; it also bears nutritious, grape-sized fruits, and like other members of the *Ziziphus* genus, is used by traditional healers to reduce fever, kill pain, and treat various other symptoms.

Traditional healers in Tanzania have been identifying, experimenting with, and using natural products to treat patients for millennia. While modern medicine came to regard the use of such crude extracts as unscientific a century or so ago, patients continued to trust their local healers, both because there were few medical doctors available and because they could not afford the cost of a modern clinic.

In fact, the work of healers is based on a large and enduring truth: Virtually all plants have medicinal qualities because they must produce chemical defenses against pathogens. Plants lack legs, fangs, claws, or brains, and must remain rooted for a lifetime to the same spot from which they must face their attackers. Hence, they developed a sophisticated defense against invaders — a defense that early healers learned to "borrow" in order to treat viral, fungal, and bacterial infections of humans, often with great success. Many plant medicines are extracted from the roots, root bark, and stem bark — the zones where invading pathogens first attack and where attack — unlike a disease of the leaves or bark — can be fatal. In these vulnerable regions, a plant may have the ability to begin excreting as many as hundreds of unique chemicals within seconds of an attack. This sophisticated armamentarium now offers curious humans a vast selection of potential medicines we have only begun to analyze.

While Justin was eager to get to the chemical core of *Z. mucronata*, he also had to do a year of coursework for his masters, leaving him only a year for lab research. During that year he succeeded in isolating the plant’s terpenoids, some of which showed moderate activity against HIV, and found them relatively easy to identify. He also demonstrated strong anti-microbial activity in a group of alkaloids, but when he began the complex task of identifying the specific alkaloid compounds responsible for the activity, progress slowed. “These alkaloids are much more complex than the terpenoids,” he said, “and I didn’t have the time to identify them. There were four alkaloids, but if you’re not experienced in that area, you can spend a year guessing which the active fractions are. At other times you may be lucky and get it right away.” Despite this difficulty, his work was judged favorably and he finished his MSc degree in December 2006.

At that point Justin could not find support for further studies, and instead joined the staff of UDSM in June 2007 as an assistant lecturer. After supporting himself there for several years, in 2009 he heard about the RISE program and was able to secure a SABINA scholarship with the help of Quintino Mgani, a UDSM lecturer and RISE advisor.

Together they developed a plan that would enhance Justin’s skills not only in phytochemistry, but also in synthetic chemistry. There were several reasons for pursuing both activities. First, phytochemistry is essential to identify pure compounds that have a desired medical activity. This begins with harvesting the plant itself, isolating the most active crude fractions, and, through
repeated purification steps, isolating the single chemical responsible for the desired activity. This compound is then examined with an NMR instrument to identify the chemical properties of the molecules. Once the chemical structure is identified it can be produced synthetically and, in theory, developed into a drug that is sold commercially.

Purifying a chemical from whole plants, however, is a burdensome process. The number of tons of raw plants required to obtain useful amounts of pure chemical can be so large as to jeopardize entire plant populations in the wild. Through the techniques of synthetic chemistry, however, producing an active compound can be done quickly and efficiently from commercially available raw materials.

Fortunately, one of the SABINA faculty advisors, Prof. Charles de Koning of the University of the Witwatersrand in South Africa, is a synthetic chemist who agreed to help supervise Justin’s work. And Prof. de Koning, in turn, introduced him to a colleague, Dr. Vinesh Maharaj of South Africa’s Council on Scientific and Industrial Research (CSIR), who was already working closely with traditional healers. These healers lived in the region around Tanga, a city in northeastern Tanzania, where the humid coastal environment supports a treasure trove of biological diversity.

An exciting aspect of Dr. Maharaj’s project was that he had found a willingness among both healers and modern doctors to pool their knowledge. This had already given rise to the Tanga AIDS Working Group (TAWG), formed at the height of the Tanzanian AIDS/HIV epidemic around 1990.

The TAWG partnership had grown out of an observation made by a German physician, Dr. Elmar Ulrich of Pangani District Hospital, who had noticed that many of his surgery patients harbored clumps of what he thought were powders provided by healers. It is normal in Africa for patients to simultaneously visit hospitals and traditional healers in their search for help, but in this case, Ulrich decided to try to bring the two groups closer together and perhaps create a mutual referral network. The healers responded enthusiastically and soon began meeting with health professionals from Pangani Hospital on how they could collaborate.

Dr. Ulrich succeeded in hosting a series of meetings where they shared knowledge and discussed how to treat various diseases and ailments. One of the participants was an 84-year-old healer named Waziri Mrisho. When discussing AIDS, Mrisho slowly stood up and said he would like to volunteer to treat HIV/AIDS patients with three traditional extracts -- within the hospital. He said that his own grandfather had taught him the value and use of these plant extracts, and that they could alleviate many of the symptoms characteristic of AIDS. The group agreed, and Mrisho brought the extracts and administered them to various in-patients according to his family’s guidelines.

At the time, the only medicines available for AIDS patients were aspirin, anti-fungals, and antibiotics, and even these basic medications were often unavailable. According to an American researcher and Tanga resident, David Scheinman, however, the use of traditional medicines brought to various patients improved appetites, weight gain, fewer and less severe opportunistic infections, and better health and well-being. Subsequently the plant remedies became the hospital's standard HIV/AIDS treatment for patients who preferred herbal medicine. The success of the program brought support from OXFAM, the World Bank, and USAID.
By the time Justin came into contact with the TAWG, Mrisho had died, a fourth extract had been added, and Scheinman and others had initiated an additional project, the Tanzania National Medical Group (TNMG). This group had the goals of identifying the active compounds in the four herbal remedies and then assessing the feasibility of synthesizing them and scaling up production to a commercial level.

Justin began working with the plant extracts at the Council for Scientific and Industrial Research (CSIR) in Pretoria, with support from the Global Research Alliance, of which CSIR is a member. At first he worked on phytochemistry using dried plant samples purchased from the healers around Tanga. As his work became more specialized, he was able to prepare 17 separate fractions that showed antimicrobial activity. He took the most promising three of these to the University of Basel in Switzerland, where he tested them for activity against HIV/AIDS, and then to an institute in the Netherlands for further antimicrobial testing. He then concentrated on those fractions showing highest activity, and continued to purify them until he had isolated the chemical compounds.

When scientists from the lab in Switzerland came to South Africa, they brought some encouraging news. It was already known that the HIV replication cycle begins with the fusion of the virus to the surface of the host cell, and continues with entry into the cell and multiplication of the viruses. They told Justin that the plant extract operated by inhibiting the HIV virus from fusing with the cell surface, and they promised him support in Basel to do a postdoc after completing his PhD studies.

While Justin was doing the second part of his studies at the University of the Witwatersrand with Prof. de Koning, the Swiss emailed him again – but this time the news was disappointing. His fraction was indeed very active against HIV, they said, but it was also toxic to humans. Justin and his colleagues were puzzled to hear this -- especially since TAWG had treated thousands of AIDS patients with good results since the early 1990’s. Justin and his advisors are determined to finalize their testing to resolve any such questions. Then they plan to take the results to the Gates Foundation and other funders to request support in synthesizing the compounds.

He is also working with National Institute for Medical Research (NIMR) in Tanzania, attempting to isolate about five grams of each of the three compounds for further testing by a U.S. pharmaceutical firm. As of early 2013, the firm had not yet been identified. Justin estimates that the phytochemistry for that project alone will require half a ton of plant materials.

He also continues to work with Mr. Scheinman, now residing in Houston, Texas, on all of the complex activities that make up a researcher’s life: writing proposals, editing papers, raising funds. “The hardest part,” he confesses, “is to wait for funding. We are ready to synthesize the compounds at the School of Chemistry, University of the Witwatersrand, which will allow production at larger scale than we can do by phytochemistry. But it is expensive, and we need more support.”
Exploring the Genotype of the Tea Plant (SABINA)
By Alan Anderson, 11 February 2013

Raising and exporting black tea is an activity of major importance in Africa today; Africa has become the world’s second largest tea exporting region after India. Tea has been grown in China for perhaps a millennium “by hand,” with farmers seeking out and hand-selecting the tea bushes producing the best yield and quality of tea. Since tea growing reached the West in the 19th century, however, tea cultivation has rapidly incorporated techniques of genetics and, most recently, of molecular biology. While tea breeders continue to walk the fields daily to monitor the health of crops and to seek out the most promising bushes, the real action today is in the laboratory, where the breeder’s skill is supplemented by work done at the molecular scale with instruments of enormous complexity and cost.

Pelly Malebe, a doctoral student in the SABINA network, has been swept up in this genetic revolution and is eagerly helping to help push it along. She works under the supervision of Prof. Zeno Apostolides at the University of Pretoria’s Department of Biochemistry, riding the crest of an agro-technological revolution. The instruments of the present can not only analyze and compare the genes of the tea plants, but also allow biochemists to accomplish research feats undreamed of just a decade ago.

Pelly is a member of a research partnership between the University of Pretoria and Malawi, where the Tea Research Foundation of Central Africa (TRFCA) is located. Another of her SABINA colleagues is Nicholas Mphangwe, a Malawian who is actively involved in the TRFCA’s breeding program. Their work carries considerable weight in Malawi, where the tea crop provides about nine percent of the country’s foreign exchange and about five percent of the world's output.

The primary focus of Pelly’s work is to locate and understand the sections of tea DNA that help the plant resist drought. Such a section is known as a marker, a gene or DNA sequence with a known location on a chromosome that can be used to identify the trait of interest in an individual or species. This is critical for tea, which prefers at least 50 inches of rain a year, and begins to drop its leaves when rainfall is not sufficient. Because Pelly is a native of the dry Limpopo province of South Africa, she is no stranger to drought, and her experience with dried-up crops and hungry farmers lends urgency to her work.

As a master’s student at the University of Pretoria in 2009, Prof. Apostolides assigned her the task of searching for a genetic marker in tea plants that are relatively drought-hardy. She proved adept at picking up the complex techniques of tea genetics and was soon able to identify a putative marker for cultivars that show high resistance to drought. A cultivar is a plant selected by growers for certain traits and then vegetatively propagated by stem-cuttings so the next
generation will have an identical genome. Virtually all food crops and ornamental plants sold today are cultivars that have been selected for certain traits; very few wild plants are used for commercial purposes.

Such activities are by no means unique to tea; the analysis of genetic variation is an essential part of most plant genetics and crop improvement programs. Knowledge of DNA sequences has become indispensable for basic biological research and in numerous applied fields such as diagnostics, biotechnology, and forensic biology. The type of analysis depends on understanding the plant’s DNA and determining the precise order of the four bases (adenine, thymine, cytosine, and guanine) that function as the “letters” of the DNA alphabet (arranged in base pairs because of the double helix shape of DNA). The “words” that are formed by various arrangements of the letters determine the output, traits, and reproduction of the genome – for tea and every other organism, from virus to human. Any change in the spelling of these words is critical to DNA analysis as it might signify, for example, greater (or lesser) resistance to drought.

Pelly spends much of her time analyzing the DNA sequences that determine the genetic makeup, or genome, of tea. The huge number of base pairs in the genome makes this analysis extremely complex. The tea genome, for example, is estimated to be about four billion base pairs long – even more than the 3.2 billion base pairs of the human genome. Such a “library” of genetic information is so daunting that it has taken many decades to decipher it. The structure of DNA was established as a double helix by James Watson and Francis Crick in 1953, but not until the early 1970s could scientists reliably interpret the sequence of even a few DNA fragments in the laboratory.

Since the development of automated analysis, however, DNA sequencing has advanced rapidly. When Pelly first began to learn genotyping several years ago, she used a relatively slow technique known as RAPD PCR, or random amplified polymorphic DNA polymerase chain reaction. This technique limited her analyses as it is time consuming and has a low reproducibility rate. In the brief time since starting her PhD research in August 2011, she has moved to a more advanced genotyping technique that is orders of magnitude faster.

“This technology is evolving so rapidly that there seems to be a new instrument every day,” she said.

One reason Pelly and her colleagues depend on current generation technology is that the sequences of DNA that indicate various behaviors in tea involve many genes. She has found, for example, that about 40 percent of tea strains, or cultivars, which she has worked with have sequences of DNA that indicate some degree of drought tolerance. But for best results she needs to know exactly which base-pair combinations are generating the best drought tolerance. She also needs to recognize as many DNA markers as possible. She identified a 1,400-base-pair marker during her MSc work, but current technology will bring her far more information.

Pelly and Nick are also looking for several kinds of selection methods for different traits, including the ability for better yield, disease resistance, and cold hardiness. From the breeding work done using conventional means over many years at the TRFCA, many desirable cultivars are already known.

The trait of drought resistance is a particular concern for Africa, and many growers are concerned by the prospect of climate change. To refine her early work on drought resistance,
Pelly relies on cultivars gathered by Nick and others from the Malawi fields, or from elite mother bushes gathered there in previous years. When a promising cultivar is recognized, it may be propagated at the TRFCA plant nursery. The DNA itself is extracted from a tea leaf with a special kit. Then the DNA is treated with anti-DNAase enzyme to prevent other enzymes from breaking up the DNA, and protease enzymes are added to clear away unneeded protein, producing a pure sample of DNA.

“Then we run it through analysis looking for markers at the most likely DNA sequences,” said Pelly. “This technique is random, because we want to look everywhere. When we find possible sequences, then it’s up to me to identify which are most likely associated with the trait.”

Once a cultivar that is thought to have genes involved in drought resistance has been identified, the next step is to test the plants in the field. Instead of waiting for a drought, however, this can be now done in real time. Thanks to a European Union grant to POL-SABINA (SABINA’s sister organization at the University of Pretoria) a rain shelter has now been erected at the TRFCA in Malawi. The tea is planted beneath the shelter, which can then simulate varying degrees of drought for the plants.

“This will show whether the markers are there just by chance or whether they signal drought tolerance,” she said. “Then if you find the same marker in a second plant that is known to be drought-tolerant, you have a good clue. We got a head start using a small number of drought-tolerant plants identified in a previous experiment which are already available and perfectly valid for our testing. Eventually we hope to expand the numbers. This helps us with the breeding process – having a known trait and being able to use the plants with the trait as parents for the next generation.”

Prof. Apostolides has been working with Kenyan and Chinese colleagues to plan cooperative sequencing research around the world that will be placed in the public domain. By promoting the sharing of knowledge with other countries, SABINA researchers are honoring the traditional scientific practice of openness.

**About Carnegie Corporation of New York**
Carnegie Corporation of New York was created by Andrew Carnegie in 1911 to promote “the advancement and diffusion of knowledge and understanding.” Under Carnegie’s will, grants must benefit the people of the United States, although up to 7.4 percent of the funds may be used for the same purpose in countries that are or have been members of the British Commonwealth, with a current emphasis on Commonwealth Africa. As a grantmaking foundation, the Corporation seeks to carry out Carnegie’s vision of philanthropy, which he said should aim “to do real and permanent good in this world.”

**About the Institute for Advanced Study**
The Institute for Advanced Study is one of the world’s leading centers for theoretical research and intellectual inquiry. The Institute exists to encourage and support fundamental research in the sciences and humanities – the original, often speculative, thinking that produces advances in knowledge that change the way we understand the world. It provides for the mentoring of scholars by Faculty, and it offers all who work there the freedom to undertake research that will
make significant contributions in any of the broad range of fields in the sciences and humanities studied at the Institute.

**About the Science Initiative Group (SIG)**

SIG is an international team of scientific leaders and supporters dedicated to fostering science in developing countries. Formed in 1999 to provide scientific and administrative oversight for the Millennium Science Initiative (MSI), SIG is governed by a six-member board consisting of three scientists from developing countries, two leading US scientists and an entrepreneur. SIG is administered by a small staff based at the Institute for Advanced Study in Princeton, New Jersey.

Since 2008, SIG’s attention has been devoted primarily to development and implementation of the Regional Initiative in Science and Education (RISE).

SIG’s work has been supported by grants from The David and Lucile Packard Foundation, The Andrew W. Mellon Foundation and Carnegie Corporation of New York.

**About the Bloggers**

**Alan H. Anderson, Research and Editorial Consultant, SIG**

Alan Anderson has worked for the Science Initiative Group since its inception. He also works for other organizations, including the National Academy of Sciences, where he has written reports on science policy, science education, science and the law, and other topics.

He has worked in science and medical journalism for over 25 years, serving as a reporter, writer, and foreign correspondent at Time magazine, Saturday Review, Psychology Today, and other publications; edited several newspapers; and written or edited five books on scientific topics. He holds a BA in English from Yale University and an MS in Journalism from Columbia University.

**Arlen K. Hastings, Executive Director, SIG**

As director of the Science Initiative Group (SIG) at the Institute for Advanced Study, Arlen Hastings is involved in the design, implementation and administration of initiatives to build scientific capacity in the developing world. A senior administrator at the Institute since 1992, Ms. Hastings was instrumental in conceptualizing and establishing SIG and its first project, the Millennium Science Initiative, in 1998, and later the African Regional Initiative in Science and Education (RISE) and the Global Science Corps. Ms. Hastings came to the Institute from the International Research & Exchanges Board, where her responsibilities included organizing US-Soviet academic conferences. She holds an A.B. in anthropology and Russian studies from Princeton University.

**Lori Mulcare, Program Associate, SIG**

Lori Mulcare helps administer the RISE program, provides support to the SIG board and Executive Director, and manages the SIG website. She previously held a Princeton Project 55 Fellowship in New York City. Ms. Mulcare is a 2006 Near Eastern Studies graduate of Princeton University.
Addis Ababa University, 18, 56
AFNNET, 1, 17, 18, 19, 20, 21, 22, 26, 27, 28, 29, 30, 52, 54, 56, 57, 58, 60, 61, 63, 64, 65, 67, 68
agriculture, 10, 22, 31, 50, 51, 56, 58, 73, 79, 82, 85, 90, 91, 94
algae, 36, 48, 72, 73, 95
alloys, 12, 33, 77, 78
aloe, 59, 62
aluminum, 12, 77, 78
Amatola Water, 96
Amin, Idi, 98
amoeba, 24, 25
AMSEN, 1, 3, 6, 7, 11, 14, 15, 31, 32, 33, 34, 35, 69, 71, 72, 73, 74, 75, 77, 78, 79, 80, 81
Amutenya, Kondja, 41
Anderson, Alan H., 105
Angola, 39, 40, 42, 43, 44, 45, 72, 86, 88, 89
anthrax, 64, 96, 97, 98
antibiotic, 53, 100
anti-inflammatory, 30
anti-nociocpection, 30
antioxidants, 17, 21, 53
Apostolides, Zeno, 10, 11, 102, 104
aquaculture, 48
aquatic organisms, 93, 95
aquatic resources, 35, 47
Arimoro, Ofurum Francis, 9
artemesia, 19, 20
artemesin, 20, 28
arthritis, 29, 30, 53, 66
Australia, 82, 94
Ayieko, Charles, 34
bacteria, 23, 49, 51, 59, 62, 72, 73, 92, 94, 97, 99
bagasse, 31, 32, 74
Bakari, Gaymary, 57, 58
Bangor University, 5
Bank of Uganda, 18
biochemistry, 1, 2, 10, 14, 17, 36, 73
bioinformatics, 10, 11, 51, 52, 98
biology, 9, 17, 20, 24, 35, 39, 46, 62, 72, 82, 93, 99, 102, 103
biomedical sciences, 23
biomonitoring, 9
bioplastics, 71, 72, 73
biosecurity, 18
biostatistics, 62
biotechnology, 18, 51, 52, 73, 103
Bolton, John, 73
Bonyongo, Caspar, 43
botany, 18, 37, 73
Botswana, 1, 14, 39, 42, 43, 44, 45, 80, 83, 86, 87, 88, 89, 99
Bowers, Dave, 5
bushwillow, 22
cadmium, 91
carrageenans, 36, 48
Caylor, Kelly, 83
cement, 32, 74, 75, 76
Central African Republic, 86
Centre of Excellence in Strong Materials, 1, 3, 12, 77, 81
Chad, 86
Chad River, 86
chalcogenides, 80, 81
chemistry, 2, 13, 16, 18, 20, 48, 59, 62, 66, 68, 72, 73, 75, 98, 99, 100
Chetsanga, Christopher, 14, 15
chickens, 52, 53, 54, 59
Chimbari, Moses, 46
chimpanzees, 63
China, 33, 51, 52, 102, 104
cholera, 23, 24
cholesterol, 53, 59
chromatographic fingerprinting, 22
chromatography, 11, 56, 58, 66, 69
c chromium, 78, 91
civil engineering, 31, 32
Clerodendrum, 28, 29
cclimate change, 46, 62, 82, 83, 84, 85, 86, 88, 103
goal, 33, 75, 94
Cole. See Mpho, Kelebogile Cole
colonialism, 5, 8, 29, 79, 86
Columbia University, 105
cconcrete, 31, 32, 74, 75, 76
Congo River basin, 84, 85
conservation, 64, 66, 96, 97
continental shelf, 6
copper, 6, 7, 15, 33, 91
coral reefs, 37, 38, 82
Cornish, Lesley, 1, 11, 12, 77
corrosion, 12, 15, 77, 78
Council on Scientific and Industrial Research (CSIR), 1, 13, 100, 101
Crick, Francis, 103
curriculum, 6, 17, 19
DAAD, 38, 99
Danish Hydraulic Institute, 50
de Koning, Charles, 100, 101
Delta State University, 9
Democratic Republic of Congo, 6, 84, 85, 86, 87, 96
diamonds, 43
disease, 11, 13, 17, 18, 22, 23, 24, 25, 28, 30, 40, 54, 55, 56, 57, 58, 59, 60, 62, 63, 64, 65, 66, 68, 69, 97, 98, 99, 100, 103
DNA, 57, 95, 98, 102, 103, 104
drinking water, 55, 86, 91
drought, 11, 40, 41, 42, 45, 85, 102, 103, 104
Dubi, Alfonse, 5, 49
dysentery, 24
Dzinotyiweyi, Heneri, 15
E. coli, 23, 29
E. dispar, 25
E. histolitica, 25
East African Community, 33
ecology, 38, 43, 46, 47, 50, 83, 90, 94, 97
ecosystem, 37, 44, 45, 46, 83, 84, 88, 89, 90, 92
ecotoxicology, 93
Eduardo Mondlane University, 2, 4, 5
Egideo, Govate, 5
Egypt, 85, 86
Ekou, Justine, 24
El-Sayed, Hesham Lotfy, 17
Engeu, Patrick, 19
England, 57, 58, 89, 97
entrepreneurship, 11, 17, 18, 62, 82
environment, 1, 2, 9, 17, 21, 26, 31, 38, 40, 42, 49, 50, 52, 55, 62, 64, 66, 71, 72, 73, 75, 76, 82, 88, 89, 90, 91, 92, 93, 94, 96, 97, 100
ephemeral river basins, 40
erosion, 5, 21, 37
Erume, Joseph, 23
ethics, 18, 62
ethnobiology, 62
ethnopharmacology, 28, 61, 65
European Community, 94
European Union, 33, 104
export, 6, 38
farmers, 24, 28, 29, 30, 31, 40, 41, 46, 54, 56, 57, 59, 70, 76, 86, 88, 93, 94, 96, 102
farming, 30, 36, 41, 94, 96
Federal University of Technology-Akure (FUTA), 1, 70, 71
fever, 22, 55, 68, 99
fish, 4, 26, 36, 37, 38, 41, 42, 44, 45, 46, 47, 48, 88, 90, 95, 96
fishermen, 36, 37, 38, 42, 45, 47, 48, 88
fishing, 38, 40, 42, 48, 82, 97
flood, 4, 39, 40, 41, 42, 44, 45, 46, 47, 50, 83, 84, 88, 89
flood recession farming, 41, 45, 88
fluid dynamics, 5
food, 2, 17, 26, 34, 36, 46, 48, 51, 52, 53, 63, 73, 86, 88, 89, 90, 103
fossil fuels, 73, 83
Franz, John, 94
funding, 10, 11, 13, 14, 15, 16, 18, 21, 23, 30, 35, 38, 45, 47, 58, 68, 87, 101, 104
Gates Foundation, 101
genetic markers, 10
genome, 24, 51, 103
geoinformatics, 5
Germany, 7, 78, 85, 89, 99
Ghana, 93
Global Runoff Data Centre (Germany), 85
glyphosate, 94, 95, 96
gonorrhea, 28, 29
guest blogs, 43, 82
Hangula, Lazarus, 8
Harvard University, 14
Hastings, Arlen K., 105
hepatitis, 56
herbal medicine, 54, 55, 100
herbal remedies, 29, 54, 56, 57, 59, 63, 65, 68, 101
herbalists, 18, 26, 27, 28, 29, 30, 55, 56, 57, 59, 61, 63, 65, 66, 67, 68, 69
herbicides, 93, 94, 95, 96
hippos, 44, 96, 97, 98
HIV/AIDS, 13, 14, 40, 59, 98, 99, 100, 101
Hoguane, Antonio, 5
Hubert Kairuki Memorial University, 73
Hughes, Denis, 2, 4, 26, 42, 85
hydrobiology, 35, 37, 47
hydrology, 4, 39, 41, 43, 83, 84, 85, 86, 88, 90, 98
hydropower, 86
IDRC (Canada), 87
Ilonga, Secilia, 16
Ilunga, Odilon, 6, 15
India, 10, 16, 21, 33, 63, 102
Indian Ocean, 2, 5, 35, 82, 89, 90
industry, 1, 5, 6, 7, 11, 12, 13, 15, 18, 19, 32, 33, 36, 45, 47, 48, 50, 57, 71, 73, 74, 76, 78, 81, 82, 86, 90, 91, 93
infections, 13, 53, 57, 69, 99, 100
innovation, 18, 32
insects, 9, 11, 90, 91, 92, 95
Institute for Advanced Study, 1, 104, 105
Institute for Water Research, Rhodes University, 2, 93
Institute of Marine Sciences, 2, 49, 82
International Program in Chemical Sciences (IPICS), 13
invasive species, 9, 94
irrigation, 50, 86
Jain, Pushpendra, 80
JICA, 38
Kabasa, John David, 1, 17, 18, 19, 21, 22, 54
Kalahari Desert, 39
Kamanja, Irene, 28
Kandawa-Schulz, Martha, 17
Kariba Dam, 4
Kavishe, Frank, 3, 7, 8, 11, 15, 16, 73
Kenya, 1, 10, 27, 28, 29, 32, 33, 34, 35, 37, 38, 47, 48, 61, 62, 64, 65, 66, 67, 68, 69, 74, 75, 77, 79, 81, 97, 104
Kenya Industrial Research and Development Institute, 76
Kenyatta University, 79
Kgathi, Donald, 40
Kiama, Stephen, 17, 26, 27, 28, 30
Kigozi, Maggie, 18
Kuria, James, 63
Kyewalyanga, Margareth S., 2
Lake Chad, 86, 87
Lake Kariba, 46
Lake Tanganyika, 63, 86
Lake Victoria, 26, 85
Langa, Avelino, 5
language, 4
Laval University, 87
Lesotho, 43
Limpopo, 4, 87, 102
Luderitz Bay, 73
Lyantagaye, Sylvester, 17, 51
Mabiki, Faith, 57, 58
Madagascar, 5
Maharaj, Vinesh, 100
Makerere University, 1, 2, 17, 18, 19, 20, 22, 23, 24, 25, 26, 52, 53, 54, 56, 96, 97
malaria, 19, 20, 22, 24, 27, 28, 54, 55, 56, 61, 62, 64, 68
Malawi, 1, 10, 11, 12, 13, 102, 104
Malawian Industrial Research, 13
Malebe, Pelly, 102
mangrove, 37, 49
mariculture, 48
marine sciences, 5, 82
Masai, 19, 59
Masamba, Wellington, 39, 42, 43
materials engineering, 70, 71
materials science, 1, 7, 11, 33, 80
mathematics, 4, 20
Mauritius, 5, 81, 82
Mauritius Research Council, 82
Mbaria, James, 28
McNamara Fellowship, 13
Mdegeula, Robinson, 57, 58
meat quality, 52, 53
mechanical engineering, 3, 11
medicinal plants, 13, 17, 30, 66, 67, 68
Medipharm Industries, 56
Mellon Foundation, 105
memory devices, 79
Mensah, Paul Kojo, 93
mentors, 3, 5, 10, 11, 14, 18, 22, 28, 29, 36, 42, 47, 49, 51, 54, 57, 58, 60, 61, 65, 72, 73, 75, 79, 81, 93, 96, 99, 100, 101, 104
metallurgy, 6, 7, 11, 12, 77
metals, 12, 77, 78, 80, 91
Mgani, Quintino, 99
microscope, 9, 25
microscopy, 25, 78
Midlands State University (Zimbabwe), 46
Millennium Science Initiative, 105
minerals, 21, 44, 48, 75, 78
mining, 3, 6, 7, 16, 33, 41, 43, 90, 91
Mintek, 12, 78
molapo farming. See flood recession farming
Monks Wood Experimental Station, 97
Monsanto, 94, 95, 96
mosquitoes, 69, 90
Motsholapheko, Moseki, 40
Mozambique, 2, 3, 4, 5
Mphangwe, Nicholas, 10, 102
Mpho, Kelebogile Cole, 43, 46, 83
Mrisho, Waziri, 100
Mshigeni, Keto, 36, 73
Mugabe, John, 14
Muiva, Cosmas, 79
Mulcare, Lori, 105
Muller, Nikite, 93
Muriithi, Karambu, 68
Murray-Hudson, Michael, 88, 89
mushrooms, 36, 51, 74
Mutia, Grace, 35, 47
Muzuka, Alfred, 49, 50
Mweru, John, 31, 74, 75
Mwita, Liberata, 51, 52
Mwonjoria, Francis Murage, 37, 38
Naigaga, Irene, 23, 25
Namibia, 1, 3, 6, 7, 8, 11, 14, 15, 16, 17, 41, 42, 43, 72, 73, 89
Naomab, Erold, 72, 73
NAPRECA, 99
Nashidengo, William, 15
Nasimolo, Johnson, 64
National Institute for Medical Research (Tanzania), 101
National Oceanographic and Atmospheric Administration (NOAA), 38
National Research Foundation (South Africa), 9
natural products, 1, 2, 13, 16, 17, 18, 19, 21, 22, 27, 36, 54, 57, 58, 60, 61, 62, 64, 66, 67, 68, 70, 99
Nehama, Fialho, 5
nervous system, 64, 65
Netherlands, 101
neuroscience, 30
Newcastle disease, 56, 57, 58, 59
Nguta, Joseph Mwanzia, 27, 60, 68
nickel, 77
Niger Delta, 9
Nigeria, 1, 9, 11, 69, 86
Nile, 20, 41, 85, 86, 88, 95
Nile perch, 26
niobium, 12, 78
nitrogen, 34, 35, 44, 84, 94
Njoroge, Kenneth D., 32
Norway, 85, 97
Nqobizitha, Siziba, 42, 46
nuclear magnetic resonance (NMR), 56, 58, 100
Nujoma, Sam, 8, 73
nutrients, 43, 44, 45, 46, 47, 49, 50, 51, 73, 83, 84, 88, 89, 91, 95
nutrition, 1, 18, 36, 37, 48
Nyemba, Lloyd, 3, 15
Nyirenda, Hastings, 10
Nyirenda, Kumbukani, 12
obesity, 54
Obua, Celestino, 54
Ocaido, Michael, 24
ocean dynamics, 5
Odda, John, 22, 54
Odera, Bernard, 11, 77
Odume, Oghenekaro Nelson, 90
Okavango, 39, 40, 41, 42, 43, 45, 46, 47, 83, 84, 87, 88, 89
Okavango Research Institute, 39, 40, 44, 45, 46, 83, 88
Okavango River Basin Water Commission, 89
Okello, Samuel, 18
Oladele, Isiaka Oluwole, 69
Omolo, Justin, 98
Onzago, Ronald Okindo, 63, 67
organic residues, 32
Othieno, Esther Ebifa, 20
OXFAM, 100
Packard Foundation, 105
pain, 22, 30, 31, 53, 64, 65, 66, 69, 99
Palmer, Tally, 91, 93
Pamba, Siajali, 49
Pangani District Hospital, 100
Pangani River, 50
parasite, 24, 61
Pasteur, Louis, 97
pathogens, 25, 99
Pepperdine University, 14
pesticides, 9, 73, 91
petroleum, 71, 72, 73
pharmacognosy, 13
pharmacology, 1, 18, 22, 28, 60, 62, 63
phase diagrams, 78
Philippines, 21
phosphorus, 44, 84
physics, 70, 79, 80, 81
phytochemistry, 13, 29, 62, 63, 99, 101
Pirbright Institute, 97
plastics, 43, 72, 73
platinum, 12, 77, 78
Pohamba, Hifikepunye, 8
policy, 6, 14, 40, 41, 45, 47, 62, 67, 85, 87, 90, 91, 105
political science, 40
pollution, 9, 21, 23, 25, 26, 37, 46, 49, 72, 78, 90, 91, 92, 94, 95
POL-SABINA, 104
polymers, 71, 72, 73
poultry, 56, 57, 58, 59
pozzolan additives, 75
prawns, 6, 37, 38, 50
Princeton University, 83, 105
private sector, 18, 19, 32, 78
protein, 21, 64, 104
public health, 2, 18, 25
Rading, G. O., 11
rainfall, 4, 39, 40, 41, 44, 50, 83, 85, 86, 102
Ramberg, Lars, 46
Ravina, Joseph Jean Maurice, 81
Reason, Chris, 5
Rhodes University, 2, 4, 9, 26, 90, 91, 93, 96
rice husks, 32
Rodrigues Island, 82
Roundup, 93, 94, 95, 96
Royal Society of Chemistry (UK), 58
Rukunya, Zachary, 61, 63, 67
Russia, 43
ruthenium, 78
SABINA. 1, 2, 10, 11, 12, 13, 14, 16, 17, 51, 98, 99, 100, 102, 104
SADC, 15, 40
Saka, John D., 1, 13
sanitation, 91
scanning electron microscope, 35, 78
Scheimman, David, 100, 101
Science Initiative Group, 1, 105
Scientific and Industrial Research and Development Center (Zimbabwe), 14
scientific equipment, 1, 6, 7, 9, 12, 13, 15, 16, 33, 35, 50, 51, 56, 58, 66, 69, 78, 81, 85, 100, 102, 103
sea lettuce, 48
seaweed, 35, 36, 37, 47, 48, 71, 72, 73
Sebulime, Peregrine, 52
sedges, 44, 45, 68, 69, 83, 88
sediment, 44, 50
Sente, Celsus, 96, 98
sewage, 23, 49, 90
Seychelles, 5
Shaghude, Yohana, 49, 50
Shifeta, Naomi, 72
shrimps, 95
Shuuluka, Diina, 72, 73
SIDA, 38
Siefert, Ludwig, 96
Sierra Leone, 43
silicon, 3, 34, 75
sisal fiber, 71
sleeping sickness, 64, 65
social science, 40, 82
sociology, 39
Sofala Bank, 4
Sokoine University of Agriculture, 17, 57, 58
solar cells, 34, 80
South Africa, 1, 2, 3, 4, 5, 6, 7, 9, 10, 13, 14, 26, 33, 42, 50, 51, 52, 78, 90, 91, 92, 93, 94, 95, 100, 101, 102
South African Aquatic Biodiversity Institute, 9
South African Department of Water Affairs, 90
Soxhlet extractor, 66
squid, 37, 38
Sri Lanka, 10
SSAWRN, 2, 3, 4, 9, 14, 22, 24, 25, 39, 40, 41, 42, 43, 44, 46, 83, 84, 85, 87, 90, 93, 96
steel, 32, 33
stream flow, 4, 85, 86, 88
Sudan, 86
sugarcane, 31, 32, 33, 73, 74, 75, 76
superalloys, 12, 77, 78
sustainable development, 82
Swartkops River, 90, 95
Switzerland, 101
synthetic chemistry, 98, 99, 100
tamarind, 21
Tanga AIDS Working Group, 100
Tanzania, 1, 2, 5, 7, 17, 35, 50, 51, 52, 56, 57, 71, 73, 85, 86, 98, 99, 100, 101
Tanzania National Medical Group, 101
taxonomy, 9, 36
tea, 1, 10, 11, 19, 20, 102, 103, 104
Tea Research Foundation of Central Africa, 1, 10, 11, 102
Ter-Mer Rodriguez, 82
Thamalakane River, 88
tides, 36, 38, 50, 75
tilapia, 26, 42
titanium, 33, 34
toxicology, 28, 60, 61, 62, 93
traditional healers, 27, 28, 62, 64, 98, 99, 100
traditional medicine, 16, 17, 22, 28, 68, 100
traditional remedies, 22, 27, 28
transmission electron microscope, 35
trypanosomiasis, 25, 64, 65
tsetse fly, 42, 65
Tsheboeng, Gaolathe, 45, 87, 89
Tshimanga, Raphael, 84
tuberculosis, 58
TWAS, the Academy of Sciences for the Developing World, 14
typhoid, 24, 55
Uganda, 1, 2, 10, 17, 19, 20, 21, 22, 23, 24, 25, 26, 54, 55, 86, 96, 97, 98
Uganda Investment Authority, 18
Uganda Veterinarian Association, 18
Ulrich, Elmar, 100
UNESCO, 4, 5
United Kingdom. See England
United Nations, 75, 85
United States, 13, 43, 94, 104
University of Alabama, 22
University of Basel, 101
University of Bergen, 85
University of Beyreuth, 78
University of Botswana, 1, 2, 39, 42, 43, 45, 47, 80, 83, 88, 99
University of Cape Coast, 93
University of Cape Town, 2, 5, 50
University of Dar es Salaam, 1, 2, 17, 35, 49, 51, 82, 85, 99
University of East Anglia, 10, 85
University of Ibadan, 70
University of Kinshasa, 84, 85
University of Lagos, 11
University of Lubumbashi, DRC, 6
University of Malawi, 1, 10, 11, 12, 13
University of Michigan, 14
University of Nairobi, 1, 11, 17, 26, 28, 30, 31, 32, 34, 35, 37, 47, 56, 60, 62, 63, 64, 67, 69, 77, 81
University of Namibia, 1, 6, 7, 8, 11, 15, 16, 17, 42, 72, 73, 74
University of Pretoria, 1, 10, 11, 13, 51, 102, 104
University of the Witwatersrand, 1, 7, 12, 15, 77, 78, 81, 100, 101
University of York, 58
University of Zimbabwe, 4, 14
University of Toronto, 14
US Geological Survey, 4
USAID, 100
value addition, 1, 2, 17, 18, 33
value chain, 18, 62, 67
van der Zaag, Pieter, 4
vanadium, 12, 78
verbena, 28
veterinary medicine, 19, 23, 24, 25, 26, 28, 29, 30, 57, 58, 63, 67, 96
Vilanculos, Agostinho, 3, 5
virus, 56, 57, 58, 59, 101, 103
Walter Sisulu University, 93
Wambugu, Stanley, 29, 30, 31, 65, 66
wastewater, 49, 91, 92
water management, 4, 40
water quality, 9, 26, 42, 90, 91, 94, 96
water resources, 46, 85, 86, 87, 91
water-borne diseases, 23, 24
WaterNet, 85
Watson, James, 103
wetlands, 26, 44, 83, 86, 89
WIO-RISE, 2, 5, 35, 36, 37, 47, 49, 81, 82
Witchcraft Act of 1925, 61, 68
women, 8, 20, 21, 26, 32, 35, 36, 37, 42, 47, 65, 72, 74
World Bank, 13, 100
World Health Organization, 55, 56, 61
wounds, 17, 60, 62, 63, 68
x-ray diffraction, 35
Yale University, 105
Zambezi, 4, 16, 46, 89
Zambia, 86, 89
Zanzibar, 2, 5, 35, 36, 38, 47, 48, 49, 50, 89  zinc, 91
Zimbabwe, 3, 4, 10, 11, 13, 14, 15, 46, 89  zoology, 37, 93
Zimbabwean Academy of Sciences, 14