TWAS 12th General Conference and **23rd General Meeting**

Tianjin, China, 18-21 September 2012

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MINISTERIAL SESSION

SCIENCE, TECHNOLOGY AND INNOVATION FOR ECONOMIC TRANSFORMATION

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The Transformation Agenda of President Goodluck Ebele Jonathan, which covers the period 2011-2015, is inspired by the Nigeria Vision 20:2020 (NV 20:2020), targeted at making Nigeria one of the top 20 economies by 2020. The assumption of an 11.7% per annum GDP growth rate as a baseline will translate to a real and nominal GDP of about N428.6 billion and N73.2 trillion respectively, at the end of 2015. This is also in line with the NV20:2020 target.

The projected GDP growth for the period will be largely driven by oil and gas, solid minerals, agriculture, ICT equipment and software, telecommunications, wholesale and retail trade, tourism and entertainment, manufacturing, and the building and construction sectors. This is unachievable without being rooted in the foundations of science, technology and innovation.

The new Science, Technology and Innovation policy was approved by the Federal Executive Council in December 2011. The thrust of the policy is on building synergy through the seamless collaboration of all stakeholders in education and research, both in the public and private sectors. The funding of novel research to unleash the innovative potentials in Nigerians and to drive the key sectors of the economy will be led by the proposed National Research and Innovation Fund (NRIF). The sourcing and initial funding of NRIF will be provided for in the 2013 budget.

Nigeria has made great technological strides in food security, space research, solar technology and building technology. The Federal Ministry of Science and technology is currently developing a platform for the transformation of technology and innovation into job creation using the cluster concept. The international community is invited to become partners in the Science and Technology Park project, in an effort to make Nigeria a destination for Science, technology and innovation.

CAPACITY BUILDING IN STI, THE KEY FOR ECONOMIC GROWTH AND POVERTY REDUCTION IN RWANDA

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Following the recent history of Rwanda, which culminated in the genocide against Tutsis that took place in 1994 and claimed the lives of more than one million Rwandans, the Government of Rwanda has placed a strong belief in the power of Science, Technology and Innovation, in support of socio-economic growth and poverty reduction in Rwanda. The commitment of the Government is demonstrated in: the Vision 2020 for Rwanda; the Science Technology and Innovation Policy; the Economic Development for Poverty Reduction Strategy (EDPRS); and the National Information and Communication Infrastructure (NICI) plans which are designed to transform Rwanda's currently agriculture-based economy to a knowledge-based economy by year 2020.

An essential component of building Science, Technology and Innovation capacity in Rwanda is education, ranging from a fundamental level through to advanced skills that will enable Rwandans to take the lead in high level research aimed at Rwanda's development.

In the area of ICT, the many initiatives include the development of a national fibre optic backbone, which will link all districts of Rwanda, and the high-speed international submarine cables landing on the East Coast of Africa, to provide high-speed global connectivity. Other initiatives include a high capacity National Data Centre and an electronic ID card system for all citizens of Rwanda.

Many other initiatives aim at developing advanced skills in STI: one example is the partnership between the Government of Rwanda, Carnegie Mellon University (US) and the African Development Bank, in creating a Carnegie Mellon University Rwanda Campus that will provide the same standards of education as CMU in the US. This campus will offer graduate programmes in IT and Electrical Engineering with emphasis on business and entrepreneurship. Other initiatives in Rwanda to promote STI include: a climate observatory station in partnership with MIT, which will cover the COMESA region; scholarships for female students to study STI subjects under the Equal Opportunity Programme in partnership with the AfDB; a distribution of 70% to ST and 30% to non-science fields scholarship scheme from Government funded and cooperation scholarships; STI competitions at all levels of education in partnership with JICA, KOICA and UNECA; the K-Lab initiative for young IT Entrepreneurs in collaboration with JICA; the extraction of methane gas in Lake Kivu; and a centre of excellence in biodiversity.

Capacity building in Science and Technology is enabling Rwanda to create innovative solutions to solve the many challenges facing Rwanda and the region in support of economic growth and improving the lives of all Rwandan citizens.

SOME CHALLENGES IN SCIENCE, TECHNOLOGY AND INNOVATION (STI) DEVELOPMENT

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This presentation builds upon the following two observations: (a) In the context of developing nations, the challenges to STI development, from limited financial, human and institutional capacities, have often been noted. In fact, efforts to address these issues are ongoing through TWAS, our countries, our institutions and other organisations. Beyond these there are other challenges that are the primary focus of this presentation. (b) I strongly believe that STI will ultimately become the primary development agenda for everyone – ranging from people as individuals, to institutions and to countries.

With this background in mind we have the following challenges to address. There is the need to account for and evaluate the contributions STI makes to everyone's life on a regular basis. Who should do that? Perhaps on the individual level, we can suggest that each individual makes a personal evaluation of what STI has meant to his/her life annually. Perhaps for companies and institutions, we can also urge that they give an assessment of the STI contribution in their annual reports; and, perhaps, at the national level we need the STI sector to do the same in close collaboration with the planning sector. For all these subjects the challenge is to focus on this goal in a way that builds genuine recognition that through STI the pace of development is accelerated.

The delivery chain in commercialising research findings has challenges: some research institutions are unable to drive the process, they lack competent partners in the commercial sector or they view it as a digression from their core thrust of scientific research.

If STI is to ultimately become top of the development agenda for everyone, then there is the need to bring proposals of STI solutions to all conflict zones/situations to the forefront. We have a challenge about how to do this and who should do it? Issues like conflicts in the Democratic Republic of Congo, Sudan, the Arab World, Greece and others, essentially call for a vibrant STI solution. What is it?

More explicitly, there is the need to determine which modalities strengthen the capacity to innovate. Comparisons among most countries and most institutions clearly show that it is not just about available funds or well-equipped institutions.

SCIENCE, TECHNOLOGY AND INNOVATION FOR ECONOMIC GROWTH & POVERTY: THE ARGENTINE EXPERIENCE

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Science, technology and innovation should create jobs, reduce poverty, promote social inclusion and strengthen democratic governance in our societies. It is expected that they have a key role in the creation of economic development, as well as in the improvement of the quality of life for all citizens when implemented within a framework of protection of the environment, sustainable growth, and strengthening democracy. They should generate employment and well being through innovation and the commercialization of new products and services; they help reduce poverty; and they improve education, health, and trade.

Argentina is making strong efforts in this direction. Since 2003 with the political decision that science and technology (S&T) play a relevant role in improving quality of life and economic development, the Ministry of Science, Technology and Productive Innovation (MINCyT) has consistently increased national capacity in the field: national investment in S&T has grown by 470%, and today public investment in S&T is comparable to that of developed countries (»0.5 % of the Gross National Product). This decision has led to an unprecedented increase in human resources involved in our S&T system that has grown by a factor of 3-4, being today the highest in Latin America (in terms of the number of scientists/economically active population), new infrastructures for research and development, and different tools that foster private-public joint projects, in particular in the field of new technologies such as information technologies, biotechnology and nanotechnology. Innovation is obviously at the core of the system with 4000 companies and small companies that have used specific MINCyT programs. Also the Ministry is supporting projects with a high social impact such as those in basic health and sanitation, projects to promote clean energy and the creation of an infrastructure for small and isolated communities, among many others. Collaborative efforts including national councils of science and technology as well as international multilateral funding agencies have been actively promoted. Finally, the drain of scientists in our country has been reversed, with about 1000 scientists returning to Argentina in the last years.

The challenges we are facing for the 2012-2015 period are: (a) to increase participation of the private sector in S&T, which remains historically low (»20%, 95% of researchers are in the public sector), (b) to foster entrepreneurship since the national capacity of expertise and analytical ability is now ready to transform new ideas into applications, (c) to reach a better distribution of the scientific and technological staff covering all the regions of our country. This will be fostered by using specific tools to foster young scientists to move to regions with vacancies in close cooperation with local universities and authorities. We hope that a long-term effort in all these directions will have a strong impact on society, reducing poverty and strengthening democracy in our country.

INNOVATION AS AN INPUT TO SOCIAL DEVELOPMENT: SOME PERSPECTIVES FROM SOUTH AFRICA

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It is widely acknowledged that science, technology and innovation (STI) have key roles to play in achieving the Millennium Development Goals and addressing economic growth and sustainable development objectives. New, forward-looking models are needed that consider how people use technology in their daily lives, and how novel innovations are disseminated and adopted over time. Over the coming decades we need to create space for policy experimentation and learning in developing countries, to develop innovative, sustainable, resilient, and equitable solutions to humanity's greatest challenges.

Meeting the interlinked global challenges of poverty reduction, social justice and environmental sustainability is the great moral and political imperative of our age. And science, technology and innovation are necessary – although not sufficient – conditions for success. We believe that this imperative can only be fulfilled if there is a radical shift in how we think about and perform STI. The global south needs to address real questions of choice: Which science? What technology? And, especially, whose innovation?

Another key question that requires interrogation is: To what extent and under what conditions can new models of STI be applied to improve the lives of poor and vulnerable populations in the developing world?

Developing countries must be intellectually bold to break with traditional approaches and explore the role of STI in their development strategies. The aim is not only to foster debate, but also to catalyse action in the global south. This will inevitably take contrasting forms in diverse places. To be effective, this conversation must be concrete and begin with specific problems in specific settings that need solving. While solutions may be context-specific, the processes used to get to answers can be shared and scaled across geographies.

Although the developmental application of STI should be informed by countries of the global south, international cooperation must play a key role in building the required STI capacity. International cooperation within the global south – especially by emerging economies – should focus on strengthening globally competitive science and technology programme and institutions.

INVITED LECTURES

SCIENCE FOR DEVELOPMENT

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Curiosity is a characteristic constant of human behaviour. In the 21st century, we enjoy unprecedented advancements in the fields of communication, computer science, transportation, health care, and others, which have dramatic effects on the quality of life. What we often forget is that the foundation of these achievements was laid down some time ago by scientists who were driven by intellectual curiosity, and not by economic concerns.

This leads to the main theme of my presentation: fundamental physics experiments on the ground and in space, and their relationship with modern developments, technology and society.

SYNAPTIC PLASTICITY AND NEURODEGENERATIVE DISEASES

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Brain cells communicate with each other at specialized sites known as synapses. Synaptic transmission is therefore fundamental for all our brain functions, such as learning and memory. Importantly, the efficacy of synaptic transmission changes upon experience, which forms the cellular mechanisms of synaptic plasticity. Abnormalities in synapse formation and plasticity can have devastating consequences and have been associated with various psychiatric disorders and neurodegenerative diseases.

For example, loss of synapses and impaired synaptic plasticity has been observed at early stages of Alzheimer's disease preceding neuronal death. It is therefore important to elucidate the molecular mechanisms that regulate synapse formation and plasticity, not only because it is fundamental to our understanding of brain functions, but also because it is pivotal for the identification of new molecular targets and drug development s well.

My laboratory is interested in understanding the signalling pathways that regulate synaptic functions in normal and diseased conditions. One major mechanism by which synaptic transmission is regulated involves controlling the formation and morphology of dendritic spines, where most excitatory neurotransmission takes place and their remodelling is tightly regulated during synaptic plasticity. In this talk, I will describe how cyclin-dependent kinase 5 (Cdk5), a serine/threonine kinase, is involved in regulating dendritic spine morphogenesis. By identifying a plethora of novel Cdk5 substrates, we have elucidated how Cdk5 differentially regulates spine growth and elimination through phosphorylation of distinct proteins. Given the association of synaptic dysfunctions and aberrant Cdk5 activity in the brain of Alzheimer's disease patients, our findings raise the intriguing possibility that the molecules identified in the specific Cdk5-dependent signalling pathways are promising targets for developing novel treatments to alleviate the cognitive deficits of afflicted patients. Work is in progress: we are screening for active compounds from Chinese medicine, to develop effective therapeutic options for the treatment of neurodegenerative diseases.

SCIENCE, TECHNOLOGY AND INNOVATION FOR SUSTAINABLE SOCIO-ECONOMIC DEVELOPMENT

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To achieve sustainable development in Science, Technology and Innovation (STI), it is imperative that developing countries clearly define their national short and long-term goals with the help of evidence-based research and regular foresight exercises. The three major players in the development of a knowledge economy are: science and technology institutions (including universities); industry; and government. The development of a knowledge economy requires a thorough understanding of the dynamic interplay between research, invention, innovation, and economic growth.

The role of universities and science and technology institutions is undergoing a dynamic change since they are now moving into an era where promotion of innovation and entrepreneurship has become one of the main challenges. This requires them to set up Offices of Technology Transfer, Science and Technology Parks and provide facilities to new start-up companies including provisions of legal and management services, advice on business plan development, financial services and laboratory technical assistance. Access to modern technologies including digital libraries, video conferencing facilities and collaborations/partnerships with industry serve to establish new horizons for the science institutions of tomorrow. Developing countries must traverse this path of change in order to develop strong knowledge economies and thereby rid themselves of poverty, hunger and deprivation.

In the last decade, Pakistan has experienced tremendous progress in the higher education sector. This is illustrated by an increase in university enrolment from 276,000 to 803,000 (from 2002 to 2011); an increase in universities/degree awarding institution from 71 to 137 (from 2003 to 2011); an increase in PhD output from 3,281 (during the period 1947-2002), to 3,658 (during the period 2003-2010), and an increase in the number of international research publications from only about 600 per year, in 2000, to 6,200 per year, by 2011.

This was accompanied by a massive foreign scholarship program for PhD level training, placement of an educational satellite in space and a ten-fold increase in faculty salaries on a new contractual system of tenure-track appointments, and a digital library that provides every student in every public sector university with 25,000 international journals and 60,000 text books. The research publications output in internationally abstracted journals from Pakistan is now about the same as India on a per million population basis, illustrating the spectacular progress that has been made during the last decade. This has been termed as a model for other developing countries to follow by the Royal Society (London) in a book entitled "A New Golden Age?" Some of these developments will be presented.

MY VISION ABOUT THE STS FORUM

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STS deals with the lights and shadows of science and technology. We must strengthen the lights and control the shadows of science and technology for the future of humanity from the long-term perspective. Participants including not only professional scientists, but also many kinds of leaders such as policymakers, business executives, and media, should gather to exchange views on how to deal with science and technology issues from the viewpoint of the long-term future of humankind.

ENDOPHYTES: ONE MORE DEFENCE FOR PLANTS

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Brachiaria is predominantly an African genus comprising about 100 species. The centre of diversity of *Brachiaria* is in eastern and central Africa. *Brachiaria* grasses are common and valuable constituents of the natural vegetation in East Africa. Several species of *Brachiaria*, such as B. brizantha, are apomictic and reproduce asexually through seeds. Apomictic reproduction has key advantages for research on endophyte-host interactions and utilization.

Several species of *Brachiaria* have become the most widespread and economically important forage grasses in tropical America. An estimated 55 million hectares are planted with *Brachiaria*, with Brazil growing the most on an estimated 45 million hectares, and requiring at least 40,000 tons of seeds per year for pasture renovation. *Brachiaria* species have greatly transformed several million hectares of infertile, highly acidic Brazilian soils by increasing the productivity of grazing lands even during the critical dry season periods, and representing a technology that dramatically transforms the vast, previously undeveloped savannahs.

The commercial *Brachiaria* species have many desirable agronomic traits. For example, they are persistent and can grow in a variety of habitats ranging from waterlogged to semi-desert areas. Having evolved in the African savannahs, they are highly tolerant to grazing by large herbivores, unlike native American grasses.

Endophytic microorganisms form complex, non-pathogenic, and intercellular associations with their host plants. Endophytic fungi are among the most widely used biological plant protection agents for forage and turf grasses in temperate zones. The list of endophytic fungi and bacteria in tropical plants including Amazon trees, citrus, medicinal plants and grasses is growing.

One well-documented example is the fungus *Acremonium implicatum* that forms endophytic associations with *Brachiaria* species. *A. implicatum* is a seed-transmitted endophytic fungus that forms beneficial symbiotic association with species of *Brachiaria*. The endophyte plays a role in protecting *Brachiaria* species from fungal pathogens, such as *Drechslera* spp., which causes leaf spot disease. Endophyte-infected grasses have also been reported to possess a number of properties of applied values such as improved survival, growth stimulation and drought tolerance. We have also isolated and characterized endophytic plant growth promoting bacteria that tested positive for nitrogenase reductase gene (*nifH*) sequences that are possibly involved in associated nitrogen fixation in species of *Brachiaria*. Under conditions of nutrient deficiency, *Brachiaria* plants inoculated with these bacterial strains had significantly higher biomass production, chlorophyll, and total nitrogen contents in leaves than did control plants, and were darker green. DNA sequence analysis demonstrated that the *nifH* gene sequences were highly similar to other N2-fixing organisms.

The practical implication of seed transmission of endophytes in *Brachiaria* is significant: once associated with the plant, the fungus can perpetuate itself through seeds, especially in apomictic genotypes of *Brachiaria*, for as long as seed storage conditions do not diminish the survival of the fungus. Our work in these endophytic microbes provides a first report.

PUSH-PULL TECHNOLOGY: A PRO-POOR INNOVATION FOR ENHANCING FOOD SECURITY AND ENVIRONMENTAL SUSTAINABILITY IN AFRICA

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The Push-Pull technology (www.push-pull.net) is based on a novel cropping system developed by the International Centre of Insect Physiology and Ecology (ICIPE), Rothamsted Research (UK) and national partners for integrated pest, weed and soil management in cereal–livestock farming systems. This approach involves the use of behaviour-modifying stimuli, to manipulate the distribution and abundance of a pest and/or beneficial insects for management of the pest.

The Push-Pull system makes use of two kinds of companion plants: a trap crop that serves as an attractant (stimulant) for stem borers, to pull them away from cereal field, and a second crop intercropped within the rows of cereal crop to repel the pests. The most effective trap crop deployed thus far is Napier grass (*Pennisetum purpureum*), which is planted as a border around the main crop. Napier grass is preferred to maize plants by stemborer moths for egg laying. However, most of the resultant larvae do not survive on Napier grass.

The fodder legumes in the genus *Desmodium* act as an effective repellent for stemborers with the added benefit of fixing nitrogen in the soils as well as serving as a cover crop to prevent soil erosion. Studies of the mechanisms of striga suppression by *Desmodium* spp. proved that, in addition to the benefits coming from the increased availability of nitrogen and soil shading, there was a strong allelopathic effect of the root exudates of the legume. The root exudates of *Desmodium* spp. contain novel flavonoid and isoflavonoid compounds that interfere with striga parasitisation of cereals. Some of these compounds stimulate striga seed germination, while others prevent attachment of the parasite's roots to the maize roots. This combination thus provides a novel means of *in situ* reduction of the striga seed bank in the soil through efficient suicidal germination.

Both Napier grass and *Desmodium* spp. plants provide high value animal fodder, facilitating milk production and diversifying farmers' income sources. The technology is appropriate to smallholder farmers practicing mixed cropping systems in Africa. It effectively addresses major production constraints, and increases cereal (maize, sorghum, millet and upland rice) yields (*e.g.*, maize yields from below 1 to 3.5t/ha). The technology is economical based as it is on locally available plants and not on expensive external inputs. Adopted to date by over 47,000 farmers in East Africa, key factors in its further up-scaling include effective technology dissemination, adaptability of companion plants for climate resilience, capacity building, multi-stakeholder collaboration, integration with livestock husbandry, improvement in desmodium seed accessibility and the creation of a supportive policy framework.

THE MEDIAL OLIVOCOCHLEAR SYSTEM AND PROTECTION FROM ACOUSTIC TRAUMA

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Sound-induced acoustic injury is one of the most common causes of hearing loss and tinnitus. Finding approaches to increase resistance to damage is a research field of great interest. The medial olivocochlear (MOC) pathway provides inhibitory feedback, through the release of acetylcholine (ACh) onto outer hair cells (OHCs) of the cochlea, thus reducing cochlear sensitivity.

We have explored the MOC pathway's function by generating genetically modified mice carrying a mutation in the nicotinic acetylcholine receptor (nAChR) subunit expressed by OHCs. Mutant cells exhibited greater sensitivity to exogenous ACh and prolonged synaptic currents, indicating that the mutation enhanced nAChR function.

To determine the consequences of this enhanced receptor function for cochlear responses, we measured auditory brainstem responses and distortion product otoacoustic emissions. The suppression of OHC-mediated amplification produced by stimulating the MOC pathway was enhanced and dramatically prolonged in mutant mice. Moreover, mutant mice had a greater resistance to permanent acoustic injury, indicating that activation of the MOC feedback can protect the inner ear from noise-induced damage. Thus, the efferent pathway provides a promising target for pharmacological prevention of inner ear pathologies derived from acoustic injury, such as hearing loss and tinnitus.

MECHANISTIC AND FUNCTIONAL INSIGHTS INTO VARIOUS CELLULAR DNA TRANSACTIONS

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Our research efforts are focused on DNA transaction processes essential for cell survival. DNA topology modulation, regulation of gene expression and R-M systems are the major areas of research in my laboratory, which aims to understand the molecular events and their importance in cellular function. Some of our salient findings on transcription activation and termination, topoisomerases and topology modulation will be highlighted in the presentation.

Transcription initiation is the major rate-limiting step to the expression of all genes, and the main regulatory control is exerted at this stage. In most promoters, RNA polymerase (RNAP) – the enzyme, which carries out RNA synthesis – needs the assistance of activator/s for the productive start of the process. We have elucidated a previously unknown two-step activation mechanism, which directs the expression of a toxic gene. First, the activator unwinds the promoter region to facilitate RNAP binding. Next, the activator transiently interacts with one of the subunits of RNAP to enhance promoter clearance of RNAP and proceed into the elongation phase of transcription. How such an 'irreversible genetic switch' controls a toxic gene expression will be discussed.

Transcription termination is a well-conserved, essential step, but it is a less understood problem in molecular biology. Our genome wide *in silico* analysis with the algorithm GeSTer, that we developed, and experimental verification reveal several new facets in the conserved mechanism. In

addition to the classical *E. coli* (or text book) type terminators, several new kinds of terminators are shown to function as effective terminators, opening up avenues for predicting the organization of genes, operons and for the development of expression systems.

The torsional strain in DNA resulting from various protein-DNA interactions is relieved by the action of a dedicated group of enzymes, known as topoisomerases. Understanding how these molecular machines function in mycobacteria has been a major topic of our study. The reactions carried out by these essential housekeeping enzymes involve DNA cleavage, strand passage and a rejoining step to maintain the topological state of the genome. Development of a new class of inhibitors against mycobacterial enzymes and their novel mechanism action will be dealt with. The role of topology modulator proteins in the protection of topoisomerases for cell survival and evolution of such mechanisms will be presented.

chemistry

FROM MOLTEN SALTS TO IONIC LIQUIDS: A NANO JOURNEY

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Aside from being a special class of classic molten salts, what are the characteristics that make modern non-aqueous ionic liquids (ILs) so special? If molten salts have been known for centuries and have found limited uses, why do modern non-aqueous ILs deserve such increased interest and curiosity? What are the practical characteristics that differentiate classical molten salts from modern non-aqueous IL? To answer these questions, a journey into a nano-structured universe is proposed.

One of the main differences between room temperature ILs, especially those based on imidazolium cations, and simple molten salts, is the molecular asymmetry built into at least one of the ions. This asymmetry in modern, non-aqueous ILs opposes the strong charge ordering due to ionic interactions that normally would cause the system to crystallize. In addition, the presence of a cooperative network of hydrogen bonds between the cations and anions induces structural directionality ("entropic effect"). Therefore, modern ILs form pre-organized structures, mainly through hydrogen bonding, that induce structural directionality (weak interactions ordering structures). In contrast, classical salts form aggregates only through ionic bonds (charge-ordering structure).

ILs cannot be regarded as merely homogeneous solvents. In fact, ILs form extended hydrogen-bond networks with polar and non-polar nano domains, and therefore are – by definition – "supramolecular" fluids. Thus, ILs are better described as hydrogen-bonded polymeric supramolecules of the type $[(DAI)_m(X)_{m\_n})]^{n+}[(DAI)_{m\_n}(X)_x)]^{n-}$.

This structural pattern is a general trend for both the solid and the liquid phase, and is apparently maintained to a large extent even in the gas phase. This structural organization of ILs can be used as "entropic drivers" (the so-called "IL effect") for the preparation of well-defined nanoscale structures with extended order, either in the bulk phase or at the gas/vacuum interface.

BIO-INSPIRED, SMART, MULTISCALE INTERFACIAL MATERIALS

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Learning from nature, we revealed that a super-hydrophobic surface needs the cooperation of micro- and nanostructures. Considering the arrangement of the micro- and nanostructures, the surface structures of the water-strider's legs were studied in detail. Accordingly, a series of super-hydrophobic surfaces have been fabricated. Under certain circumstances, a surface wettability can switch between superhydrophilicity and superhydrophobicity.

Most recently, we developed a superoleophobic and controllable adhesive water/solid interface, which opens up a new strategy to control self-cleaning properties in water. To expand the "switching" concept of the smart 2D surface, we also did a lot of interesting work in 1D system. For example, we discovered the water collection ability to capture silk of the cribellate spider *Uloborus walckenaerius* and then prepared artificial spider silk, which will have great applications in water collection.

In addition, we developed novel biomimetic ion channel systems with a variety of intelligent properties, which were controlled by our designed biomolecules or smart polymers responding to the single external stimulus, providing an artificial counterpart of switchable protein-made nanochannels. These intelligent nanochannels could be used in energy-conversion systems, such as a photoelectric conversion system inspired by rhodopsin from retina or bR, and concentration-gradient-driven nanofluidic power source that mimic the function of the electric eels.

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CLIMATE IMPACTS OF ELEVATED ABSORBING AEROSOL LAYERS

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The crucial role of aerosols on regional and global climates is well recognised by the scientific community. Due to its diverse geographical features, high population density, rapid urbanization and industrialization, the Indian region is characterised by a wide variety of aerosols. Though natural aerosols (such as sea salt and desert dust) dominate the global aerosol composition, the anthropogenic species (such as sulphates, nitrates, black carbon and organics) dominate locally in industrialized areas and regions of extensive biomass burning.

Recent years witnessed a substantial increase in interest for the climate impact of black carbon (BC) aerosols, due to its high absorption characteristics. Long term observational data on aerosols from several climate observatories spread across the Indian subcontinent indicates an increasing trend in composite aerosol loading. While the build-up of aerosols over the Asian monsoon regime with strong circulation systems is a disturbing fact, interestingly BC aerosols have shown a decreasing trend during recent years.

Using data from various field campaigns on the vertical distribution of composite aerosols (microphysical and optical properties) and aerosol black carbon measured using a suite of instruments mounted in a research aircraft, we found the prevalence of elevated absorbing aerosol layers over the Indian mainland (around 2-4 km) during the summer and pre-monsoon seasons and a strong northward gradient in its position and its absorption characteristics.

These findings have far-reaching climate significance on the regional scale and are expected to have strong influence on the Indian monsoon system. Near-simultaneous radio sonde ascents made over the northern Bay of Bengal showed the presence of convectively unstable regions separated by a stable region in between, which can act as conduits for the advection of aerosols and favour the transport of continental aerosols in the higher levels (> 2 km) into the oceans without entering the marine boundary layer below.

In situ measurements of BC mass concentrations carried out using a high altitude balloon have indicated the presence of substantial amounts of BC even at free tropospheric altitudes. Radiative transfer simulations using these data indicate that large BC-induced absorption and subsequent atmospheric warming due to BC create a stable atmospheric layer, thus creating "own home" up in the atmosphere. This raises several issues on the lifetime of elevated BC layers, climate effects and probable impacts on cirrus clouds and even the ozone layer. The climate implications of elevated absorbing aerosol layers are discussed in this presentation.

IN SITU SR-ND-HF ISOTOPIC ANALYSES AND THEIR APPLICATIONS IN GEOLOGY

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Sr, Nd and Hf isotopic compositions of geological materials are a kind of important geochemical tracer, widely used in geology to identify various sources of rocks and processes that have shaped our Earth. Traditionally, these isotopes were determined on whole-rock samples through dissolution, chemical separation using time-consuming liquid chromatographic exchange and measurement by thermal ionization mass spectrometry (TIMS). This kind of bulk analysis cannot provide spatial information with high resolution, which, however, is extremely important for geological studies, since most geological materials are heterogeneous in both occurrence and composition.

The advent of inductively coupled plasma mass spectrometry (ICP–MS), however, makes it possible to measure these isotopic compositions rapidly on the scale of sub-grains, if a laser ablation technique is employed.

During the past decade, our laboratory has installed a quadruple Agilent 7500a and Neptune multi-collector (MC) ICP–MS instruments with a 193nm laser ablation system, in order to provide in situ Sr-Nd-Hf isotopic data with high resolution. One of our important technical developments is the simultaneous determination of U–Pb age, Sr (or Nd or Hf) isotopic compositions and trace element contents of minerals. Using this simultaneous technique, we have conducted a comprehensive work on zircon, baddeleyite, monazite, xenotime, zirconolite, calzirtite, apatite, titanite, perovskite, loparite, eudialyte, etc, from various igneous, sedimentary and metamorphic rocks. It is indicated that these data can be effective to decipher the geological processes that operated on our Earth.

engineering sciences

MOBILE TELECOMMUNICATION AND ITS APPLICATIONS

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Since 1980, mobile telecommunications networks have been rapidly developed. During the 1990s, modelling techniques were developed for network planning of large-scale mobile telecommunications services. In this talk, we introduce important issues of mobile telecommunications including mobility management, heterogeneous networks, mobile number portability, prepaid services and so on, and show how to evaluate these services through modelling techniques.

Then we describe how broadband services affect mobile telecommunications. We first introduce the mobile broadband reinforcement cycle. Based on this reinforcement cycle concept, we describe how fast developments in mobile broadband technologies have occurred. Several applications such as location-based services are investigated.

We further show how remote broadband sensing can be achieved, and how mobile telecom can be integrated with cloud computing to solve complicated issues such as human movement behaviour. Specifically, we show that mobile telecommunications networks can be used to investigate issues such as the prediction of vehicle traffic and the spread of contagious diseases.

LIE ALGEBRAS, LIE SUPERALGEBRAS, AND SUPER DUALITY

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We shall explain the novel and conceptual viewpoint of super duality, which makes a direct connection between certain representation categories of classical Lie algebras and Lie superalgebras, or in other words, between classical symmetry and supersymmetry. We shall explain how this concept can be applied to give a solution to the irreducible character problem of classical Lie superalgebras.

CONTRIBUTIONS TO NON-LINEAR FRACTIONAL ELLIPTIC EQUATIONS

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In this talk we review some recent results on the analysis of various problems on non-linear equations involving fractional elliptic operators. We will first discuss the *long jump random walk interpretation* of the fractional laplacian (and non-linear versions) and then we present various typical mathematical questions for equations involving these nonlinear diffusion operators.

We start with the study of some limiting theorems for the *heat equation* with a nonlinear fractional operator, when the order of the operator approaches zero. These results are proved in the context of viscosity solutions, with an appropriate use of the comparison principle and barrier functions for bounded domains. With a related approach we then present some results for the existence of *boundary blow-up solutions* for these non-linear fractional elliptic equations in bounded domains, making use of the same basic approach with super- and sub-solutions and barrier functions.

For a different class of local non-linearities, we analyse related problems for the existence of positive solutions in a bounded domain with a Dirichlet boundary condition. Here, the existence tool is the classical Leray-Schauder degree in connection with the duality between a-priori estimates for positive solutions in bounded domains and non-existence of positive solutions in the whole space. This duality is provided by the blow-up approach and the Liouville type non-existence theorems. Again, the comparison principle is the key tool, but a good understanding of the fundamental solutions of the fractional operator involved in the equations is required. These Liouville type theorems should be known for the whole space and also for the half space. This last situation gives the motivation for extension of these non-existence results for cones, which can be applied in domains with less regularity.

We conclude this talk discussing another class of problems, by assuming that the fractional operator has a variational formulation, providing a much richer structure to the nonlinear equations. We present applications to the non-linear Schrödinger Equation with the fractional laplacian and also some regional operators, including concentration phenomena occurring in this setting.

REGULATION OF ALTERNATIVE SPLICING: HOW EACH GENE MAKES MANY PROTEINS

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When a gene is expressed, its DNA sequence is transcribed (copied) into a different nucleic acid known as RNA. This RNA molecule is made in the cell nucleus by a specific enzyme called RNA polymerase, and represents the precursor form (pre-mRNA) of a shorter RNA known as messenger RNA (mRNA). In fact, before leaving the nucleus internal segments are excised from each pre mRNA molecule and the remaining ones are joined to form the shorter mRNA. This process is known as pre-mRNA splicing. Once in the cytoplasm, each mRNA is translated into the corresponding protein.

Alternative splicing is a variation of splicing in which each pre-mRNA molecule can give rise to different mature mRNAs, depending on which segments are joined and which are excised. Alternative splicing is a major contributor to protein diversity because it explains how every individual gene generates multiple proteins.

Recent findings justify a renewed interest in alternative splicing. Estimated to affect nearly 90 per cent of human genes, alternative splicing is more the rule than the exception, and mutations that affect this mechanism are a widespread source of human disease, including many genetic disorders and cancers.

Our work focuses on the regulation of alternative pre-mRNA splicing, with particular emphasis on the mechanisms that couple the processes of splicing and transcription. We study how changes in the rate of transcription by RNA polymerase inside the genes (known as transcriptional elongation) affect alternative splicing decisions and contribute to the generation of multiple protein variants from a single gene.

On the other hand, DNA is not naked in the nucleus but associated to histone proteins to form chromatin. The chromatin context also affects RNA polymerase elongation rates and, in turn, alternative splicing. We discovered the mechanism by which changes in nerve cell activity and neuron differentiation, that either loosen or compact the chromatin structure, promote changes in transcriptional elongation affecting alternative splicing of genes that are key for neuronal function. Furthermore, we have found experimental methods and specific molecular tools to modify the chromatin structure in a controlled and gene-specific way as to regulate alternative splicing.

In another line of investigation of the same subject, we have found the cellular mechanism by which DNA damage caused by ultraviolet light (UV) irradiation affects alternative splicing. This mechanism is the key to understand how skin cells respond to UV light contained in sunlight. DNA is the only biopolymer that is neither disposable nor recyclable, and therefore must be repaired when damaged. It has been estimated that through natural processes more than 20,000 DNA lesions are produced per cell in a single day. We found that after DNA is damaged by UV irradiation, the cell responds by adding new phosphate groups to the RNA polymerase enzyme, which makes it slower and therefore affects alternative splicing decisions of many genes, which in turn promotes the death of the cells carrying the damaged DNA, preventing the proliferation of mutated cells that could eventually become cancer cells.

INFERRING THE QUANTUM STRUCTURE OF SPACE-TIME FROM CLASSICAL GRAVITY

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Recent research suggests that gravity is likely to be an emergent, long wavelength phenomenon with the field equations of gravity having the same conceptual status as the equations of, say, elasticity or fluid dynamics. The evidence for this new perspective, which has far reaching implications, comes from several results obtained in the last decade or so.

To begin with, it turns out that the field equations of gravity reduce to the thermodynamic identity $TdS = dE + PdV$ when evaluated on a horizon in any space-time in a wide class of theories of gravity, including – but not limited to – Einstein's theory and its generalizations like Lovelock models of gravity.

If gravity has a thermodynamical interpretation, as suggested by the above result, then the action functional describing gravity must encode this information. There is indeed a "holographic" relationship between the surface and bulk terms of the action not only in the case of Einstein's theory but in a much wider class of gravitational theories. Taking this idea further, one can interpret the action functional in a wide class of gravitational theories as the free energy of the space-time.

These results show that the connection between thermodynamics and gravity goes far beyond Einstein's theory of gravity and suggests that gravity is the thermodynamic limit of the statistical mechanics of "atoms of space-time". In the usual statistical mechanics, Boltzmann's equipartition law, $E=(1/2)NkT$ is a direct link between the microscopic degrees of freedom and macroscopic physics. The E and T in this relation can be defined in the continuum limit of thermodynamics, but N has no direct meaning in the continuum limit. Remarkably enough, one can prove an identical relation in the case of a general class of gravitational theories and read off N – which is like determining the Avogadro number of space-time!

Given this backdrop, it is obvious that one should be able to derive the field equations for a wide class of gravitational theories from purely thermodynamic arguments. One can do this by introducing an expression for the entropy density of space-time in terms of the horizons perceived by locally accelerated observers and maximising it. The expression for this entropy density immediately links macroscopic physics to the underlying microscopic degrees of freedom in a very simple and transparent manner.

In this lecture, I will describe several of these aspects which lead us to an emergent perspective of gravity, and show how many peculiar features of classical gravity find a natural explanation in this new perspective.

ABDUS SALAM MEDAL LECTURE

TWAS AND THE FUTURE OF SCIENCE IN THE DEVELOPING WORLD

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In this talk I will first reflect on the different stages of the evolution of TWAS and its activities over the past 30 years. I will then highlight a number of important challenges and opportunities that developing countries face in seeking to build local capacities in science, technology and innovation (STI) and apply these capacities to solve local and global problems. Finally, I will present a number of key issues that developing countries and their global partners should address to promote S&T-based development. The important role of TWAS in addressing some of these issues will also be discussed.

TWAS 2012 MEDAL LECTURES

INTRA-AFRICAN COOPERATION IN CHEMICAL SCIENCES: HIGHLIGHTS OF ACHIEVEMENTS IN THE CHEMISTRY OF NATURAL PRODUCTS

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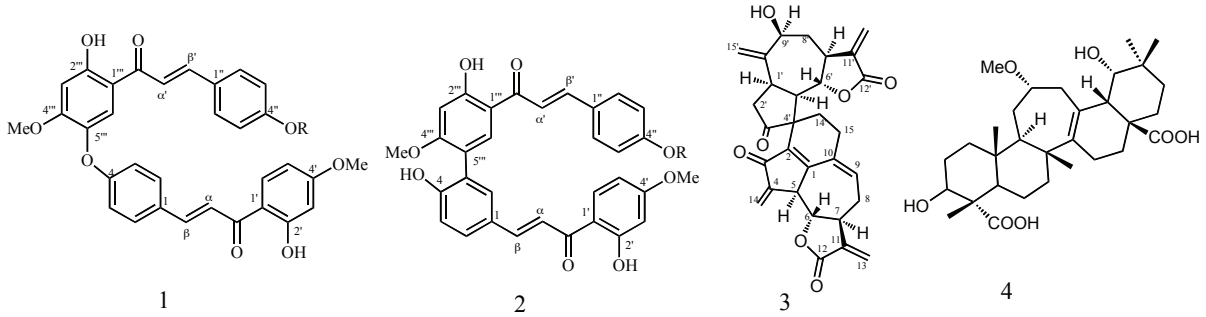
This presentation is based on results obtained through the Network for Analytical and Bioassay Services in Africa (NABSA), based at the University of Botswana and supported by the International Science Programs of Uppsala University and the TWAS Associateship program. The Network delivered analytical services in the form of NMR and MS data to postgraduate students belonging to various research groups in Africa. It also allowed annual visits of three to five scientists (senior professors as well as their students) from the Universities of Yaoundé, Dschang, Ile Ife, Zimbabwe, Tanzania, Kenya and Addis Ababa.

The presentation will highlight the joint efforts of phytochemists, biochemists and synthetic organic chemists from institutions in Africa to do exciting, and development-oriented research in natural products. We will present results revealing novel natural products from three medicinal plants, namely *Rhus pyrodies* (Anacardiaceae) and *Dicoma anomala* (Compositae) and *Duboscia macrocarpa* (Tiliaceae).

The isolation, characterization, biological properties and total synthesis of a number of novel bichalcones (*e.g.* Fig. 1 and Fig. 2) from *R. pyroide* [1], and sesquiterpenes (*e.g.* Fig. 3) from *D. anomala* (unpublished results) and *dubane* [2] (Fig. 4) will be presented. The novelty of the bichalcones structures lies in the manner in which the two molecular halves are joined. One group contains an oxygen bridge while the other group has the two chalcone moieties linked directly. These bichalcones possess interesting antiprotozoal and antiproliferative properties. We have developed successful



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methodologies that exploit the Ullmann coupling for the ethers and application of the Suzuki coupling of appropriately substituted chalcones for the C-C coupled bichalcones.

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MESO-SCALE SCIENCE: CHEMICAL ENGINEERING PERSPECTIVES

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This presentation will review a three-decade research work on meso-scale phenomena in chemical engineering that has been carried out at the Institute of Process Engineering of the Chinese Academy of Sciences. It will also address perspectives on meso-scale science.

We started to be engaged in this topic when studying the phenomenon of particle clustering in gas-solid systems. The energy-minimization multi-scale (EMMS) model was formulated to bridge the particle-fluid interaction at micro-scale of a single particle and the global parameters at macro-scale of a reactor by integrating conservation equations and stability conditions.

Later on, the model was verified, extended, generalized and applied to other systems, resulting in the formulation of a multiple objective variational problem and the EMMS paradigm for supercomputing. Gradually, we recognized that all meso-scale phenomena might follow a common principle with respect to their stability criteria, that is, the possibility of forming meso-scale science, and that the EMMS paradigm may define a promising computation paradigm with respect to modelling, software and hardware to raise the efficiency and capability of supercomputing. The EMMS paradigm features the logic of 'first global, then regional and finally specific' and the structural consistency between problem, model, software and hardware, which has been implemented by the development of a supercomputer of 1.0 petaflops, envisaging the future possibility of virtual process engineering. This system has been widely used both in academia, for the understanding of fundamental issues, and in industries, to solve engineering problems.

From the three-decade practice of meso-scale modelling in chemical engineering, we believe that multi-scale research should shift attention to "meso-scales" due to the recognition of difficulties at these special, intermediate scales in between at different levels. There is a clue that all meso-scale structures come from the compromise between dominant mechanisms, which defines the correlation between scales and the stability criteria of complex systems, indicating the possibility of establishing a common discipline: meso-scale science. To generalize it into a common methodology, however, is far beyond our current capacity in chemical engineering, calling for interdisciplinary contributions from mathematics and physics, for example. We hope that this presentation can stimulate more interest from different fields and promote further the exploration of this very important topic.

We live in a multi-scale world and have to deal with various multi-scale issues, everyday and everywhere. The understanding of multi-scale spatial-temporal dynamic structures in nature, life, society and engineering, is one of the common challenges for scientists and engineers around the world while meso-scales hold the key to solutions.

TB OR NOT TB

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I am working with my postdoctoral research associate, Dr. Kangning Ren, and a faculty member from the Stanford School of Medicine, Dr. Niaz Banaei, to develop a new cell sorting method, which we believe, might be a promising strategy for the rapid diagnosis of infectious diseases in settings where technical expertise, laboratory infrastructure, and financial resources are lacking.

Current diagnosis methods can be divided into two major groups: (1) culture-based methods, which detect the presence of target microorganisms after their multiplication in a selective media. These methods are limited by the slow proliferation rate of the microbes and the strict requirement of specific culture conditions for fastidious pathogens; and (2) culture-free methods, which recognize the characteristic molecules (*i.e.*, nucleic acids or antigens) in target microorganisms. These methods are often quicker than culture-based methods, but usually require expensive instrumentation and disposables.

In contrast, we believe that our method overcomes most of the problems mentioned above. It uses a synthetic polymer to selectively capture and concentrate the target microorganism with no need for sample processing or incubation. Further, the reagents are inexpensive and have a long shelf life, thus making possible low-cost infectious diseases diagnostics for resource-poor settings.

We have chosen tuberculosis (TB) as our first target. TB is one of the top ten causes of death worldwide, as it kills about two million individuals in developing countries each year. Quick and accurate diagnosis of TB is important for rapid treatment and prevention of transmission to new individuals. However, the 'gold standard' for TB diagnoses, based on cell culture, is extremely slow: it could take months, assuming that culturing facilities are available. Although there are quicker methods based on nucleic acid amplification tests, these technologies are expensive and generally unaffordable in low-income countries. Most laboratories in developing countries perform microscopy to screen sputum samples for tubercle bacilli. Although microscopy is low-cost, it is not very sensitive. The standard microscopy could only detect TB when the sputum sample contains a high concentration of bacilli – it has a false negative rate of 50% and the performance is even poorer in developing countries, where preconcentration of sputum is not performed. Therefore, a low-cost method that selectively concentrates the TB bacilli from the patient samples would significantly improve the sensitivity of microscopy. This lecture will present the progress to date for achieving this goal.

BUILDING UP STRENGTH ON BIOTECHNOLOGICAL MANUFACTURING: FROM CONCEPT TO STRATEGIC EMERGING INDUSTRY

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Over the past century, the rapid development of human society has put huge pressure on climate, environment and natural resources. This is especially true in China, where a large population shares relatively limited water, land, mineral and oil resources, but an increasing concentration of CO_2 and waste discharge. In order to achieve sustainable development, it is urgent to change the pattern of economic growth.

Biotechnological manufacturing (BioManu) refers to the exploitation and utilization of "biological functionality" for the production and the processing of substances. Recent scientific and technological breakthroughs in life sciences have accelerated the development of BioManu technology. BioManu has been used to produce a variety of fuels, fine chemicals, bulk chemicals, and materials in an advanced, efficient, and environmental-friendly way, through the integration of biotechnology into manufacturing technology. BioManu aims to establish a new mode for economic growth by gradually changing the raw materials and processing modes of industrial production, which are strategically important for the sustainable development of society.

In the last seven years, the concept of BioManu in China was proposed, developed, and established through the efforts of the Chinese Academy of Sciences (CAS).

The development of the Tianjin Institute of Industrial Biotechnology (TIB, CAS), originally the Tianjin Industrial Biotechnology R&D Center (TIBC, CAS), through a joint effort of CAS and the Tianjin municipal government, highlights the efforts that CAS has made to pioneer the development of BioManu in China. TIB has established a National Engineering Laboratory on Industrial Enzymes and a CAS Key Laboratory on Systems Microbial Biotechnology, which are playing key roles in the relevant sectors.

CAS also established a CAS Bioindustry Innovation Alliance and initiated the Biotechnology Innovation and Bioindustry Promotion programme, which effectively promotes the development of bioindustry in China. All these efforts have led to the recognition of BioManu as one of the key sectors in bioindustry, and one of the seven strategic emerging industries in China.

This lecture will review the development of the concept of BioManu, followed by illustrating the development of related policies, and achievements made in this field. Finally, a roadmap for the future development of the BioManu industry will be described, with the aim of showing how BioManu can contribute to the development of a biotechnology-based, sustainable economy system.

THE SYNTHESIS OF CONJUGATED POLYMERS: A CONTRIBUTION FROM ETHIOPIA

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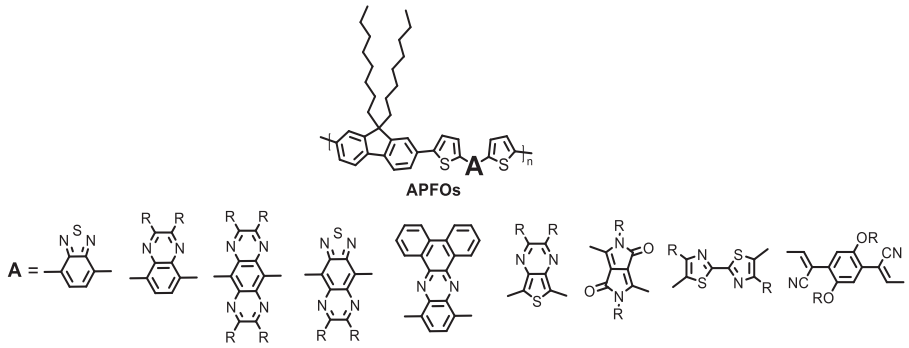
Towards the mid 1990s, we took a bold and ambitious step to launch a research program on the synthesis and device performance of conjugated polymers through a generous grant from the International Science Programmes (ISP) at Uppsala University in Sweden. Since then, sustained support from ISP has allowed us to build a strong research capacity and to train scores of MSc and PhD candidates in the arts of polymer synthesis and device characterization at the Departments of Chemistry and Physics of the Addis Ababa University. Together with our Swedish research collaborators, we have made concerted efforts to prepare a wide variety of polythiophenes and polyfluorene copolymers and study their performances in opto-electronic devices.

This presentation will highlight some of our achievements. The structural variations we created in polythiophenes allowed us to study the structural effects that are responsible for tuning the color of the emission from polythiophenes for use in polymer light-emitting diodes and light emitting electrochemical cells. We have also studied the solar cell applications of polythiophenes prepared electrochemically from their monomers on nanocrystalline titanium dioxide (*nc*-TiO_2)-coated ITO-glass. An array of oligo (ethylene oxide)-substituted polythiophenes were prepared and investigated for their application in the roll-to-roll production of polymer-based electrochromic displays on flexible substrates. The solvatochromic and thermochromic behaviors of phenyl-substituted polythiophenes were also studied.

In our quest for efficient polymer solar cells, we have prepared a wide variety of low band gap alternating polyfluorene copolymers (APFOs) and studied their optical, electrochemical, and photovoltaic characteristics. In the design of the APFOs, 9,9-disubstituted fluorene units were incorporated onto low band gap donor-acceptor-donor (DAD) segments. The donors were typically thiophene units, and the acceptors varied from benzothiadiazole to quinoxaline, thienopyrazine and other units. Thus polymers were prepared that had optical absorptions covering the visible and the near IR region of the electromagnetic spectrum in order to harvest more photons as the intensity of sunlight is high in these parts of the solar emission. The band gaps could also be engineered to shift both the HOMO and LUMO energy levels for better match with the energy levels of acceptor materials. Bulk heterojunction solar cell devices were fabricated and studied by combining the APFOs with fullerene derivatives, typically the phenyl C_{61} butyric acid methyl ester (PCBM). The best performing solar cell device had a power conversion efficiency of 3.7%.



We have also prepared, and in some cases studied the properties of a variety of polymers including paraphenylenes, oxadiazoles, carbazoles, isoindigos, and diketopyrrolopyrroles.

PRESENTATIONS BY TWAS YOUNG AFFILIATES

medicine

NOVEL 4-(1*H*)-QUINOLONES AND TETRA-HYDROACRIDONES PREVENT THE TRANSMISSION OF THE HUMAN MALARIA PARASITE *PLASMODIUM FALCIPARUM* TO THE MOSQUITO VECTOR

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Malaria is a disease that kills 1.2 million people a year, mainly in sub-Saharan Africa. It is caused by the protozoan parasite *Plasmodium* and transmitted by the female mosquito *Anopheles*. The two most prevalent species of *Plasmodium* that cause malaria in humans are P. *falciparum* and *P. vivax*. Severe disease and resistance to antimalarial drugs have been documented for both species, and efforts to control malaria have become more challenging in recent years due to widespread drug resistance. Essential steps in the life cycle of the parasite are the infection of the human liver, the intraerythrocytic cycle and the development of transmission stages in the vector.

Inside the *Anopheles* female, gametocytes, the sexual forms of the parasite fuse and become ookinetes that transform into oocysts in the mosquito midgut. In the oocyst, sporozoites form and then travel to the salivary glands to be transmitted to a new host. Preventing transmission of malaria through the mosquito is necessary for the control of the disease; nevertheless, the vast majority of drugs in use are effective only against the blood stages and to the best of our knowledge none of the current antimalarial drugs have been shown to be effective against transmission stages.

The study described herein focuses on the activities of novel compounds derived from the potent anti-erythrocytic stage agent endochin. In particular, three 4(1*H*) quinolones (4-Q), one 7-(2-phenoxy-ethoxy)-4(1*H*) quinolone (PEQ) and one 1,2,3,4-tetrahydroacridin-9(10*H*)-one (THA) were assessed for their transmission blocking activity against the mosquito stages of the human malaria parasite *Plasmodium falciparum*. Results showed that the experimental compounds reduced or prevented the exflagellation of male gametocytes, prevented parasite transmission to the mosquito vector and reduced the number of sporozoites that reached the *Anopheles* salivary glands. These findings suggest that analogues of endochin which have activity against the blood stages can also prevent the transmission of *Plasmodium* to the mosquito. They are hence ideal candidates for advancement as novel antimalarial compounds.

CANCER RESEARCH IN THE DEVELOPING WORLD: OPPORTUNITIES, CHALLENGES AND CAN WE MAKE A DIFFERENCE?

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Cancer occurs in more than 12 million of the world's population and leads to more than 7.6 million deaths annually, making it the number one killer in economically developed countries, and the second leading cause of death in developing countries. Despite the universal occurrence of cancer, cancer survival rates differ dramatically between developed and developing nations, where cancer associated deaths are at least twice those in developed nations. This significant variation in survival rate is due to several factors related to differences in prevention, detection and treatment.

A key to reducing cancer lies in prevention, and a substantial proportion of the worldwide burden of cancer could be prevented through our knowledge of risk factors, by implementing programs for tobacco control and lifestyle changes, and vaccination. Whilst some programmes such as tobacco control have been effective in reducing the burden of certain cancers in developed countries, these programmes are not widespread in developing nations. Furthermore, cancer survival tends to be worse in developing countries because of a combination of late diagnosis and limited access to timely and appropriate treatment. For example, whilst the application of targeted therapies improves cancer management in the developed nations, there remains a poor understanding of the cancers that are more common in the developing world.

In my presentation, I will talk about our efforts to improve the management of oral cancer, a type of cancer that occurs predominantly in south and Southeast Asia, through research programmes to prevent, diagnose and treat the disease. In particular, I will present our work aimed at improving cancer awareness for early detection, and our multi-disciplinary efforts in building infrastructure and expertise to combat oral cancer by understanding the genetic drivers of the disease.

As for oral cancer, there are many other cancers including stomach, liver, oesophagus and head and neck that occur predominantly in developing countries, with an urgent need to improve survival outcomes. Recent data has already named cancer as the disease that has the most devastating economic impact in the world compared to any other cause of death. With more than half of the cancer cases and deaths occurring in developing countries, the questions should really be, "Can we afford to not make a difference?"

EVALUATION OF THE EFFICIENCY OF WASTEWATER TREATMENT PROCESS FOR THE REMOVAL OF MICROBIAL PATHOGEN: *VIBRIO* PATHOGENS AS A CASE STUDY

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Vibrio infections pose a serious threat to public health. *Vibrio* disease outbreaks have created a painful awareness of the personal, economic, societal, and public health costs associated with the impact of contaminated water in the aquatic milieu. Therefore, this study was designed to assess:

(1) The prevalence of *Vibrio* pathogens in the final effluents of wastewater treatment plants (WWTPs) in the Eastern Cape Province of South Africa;

(2) Their ability to survive the treatment processes of the activated sludge system, either as free cells or as plankton-associated entities, in relation to the physicochemical qualities of the effluents;

(3) The antibiotic resistance genes the vibrio pathogens may possess.

Unacceptably high levels of COD (<10–1180 mg/l), nitrate (0.08–13.14 mg NO_3^- as N/l), nitrite (0.06–6.78 mg NO_2^- as N/l), orthophosphate (0.07–4.81 mg PO_4^{3-} as P/l), DO (1.24–11.22 mg/l) and turbidity (2.04 - 159.06 NTU) were observed. Temperature, COD and nitrite varied significantly with season ($P < 0.05$), while pH, EC, salinity, TDS, COD, and nitrate all varied significantly with sampling site ($P < 0.05$). Free-living *Vibrio* densities varied from 0 to the order of 103 cfu ml-1, while the plankton-associated *Vibrio* densities vary with plankton sizes as follows: 180 µm (0–4.50×10^3 cfu ml^{-1}); 60 µm (0–4.86×10^3 cfu ml^{-1}); 20 µm (0–1.9×10^5 cfu ml^{-1}).

Four species of *Vibrio* were identified in the treated effluents which in order of prevalence included *V. fluvialis* > *V. vulnificus* > *V. parahaemolyticus* > *V. Metschnikovii*. The *Vibrio* strains were resistant to 11 test antibiotics and the antibiotic resistance genes detected include: *dfr18* and *dfrA1* for trimethoprim; *tetA*, *strB*, *floR*, *sul2 blaP1*, for tetracycline, streptomycin, chloramphenicol, sulfamethoxazole and β-lactams respectively. The efficiencies of WWTPs in the Eastern Cape of South Africa remains a matter of concern, and their effluents could be potential reservoirs of vibrio pathogens and antibiotic resistant genes in the aquatic environment.

CLAY MINERAL FROM TUNISIAN ENVIRONMENT PROTECTS AGAINST ZEARALENONE CONTAMINATED FEED

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The safety of the food and feed supply is paramount to the health of every person in the world. Zearalenone (ZEN) is an estrogenic mycotoxin causing diverse toxic effects in experimental cells, livestock and humans. Removing ZEN from contaminated food and foodstuffs remains a major problem, and there is a great demand for effective decontamination technology.

One strategy is to use clay minerals to bind ZEN in the animal's digestive tract and thus reduce toxin bioavailability. We used a natural chemisorbent product from the Tunisian environment in order to evaluate its ability to prevent, or at least diminish, the adverse effects of ZEN on body weight gain, food consumption, serum clinical chemistry, organ weight, immunology parameters and organ histopathology as well as its teratogen and estrogenic effects.

The results showed that the used clay – Montmorillonite – counteracts the ZEN's toxic effects. It has the ability to strongly bind ZEN *in vitro* and in the gastrointestinal tract of many animal models and the ZEN/clay complex is excreted in the faeces. Consequently, it decreases its bioavailability and this prevents its toxic, carcinogenic and immunosuppressive effects. The basis of interest in the biological effects of montmorillonite concerns one or more of their physical and chemical properties, such as ion exchange capacity, adsorption and related molecular sieve properties.

IMMUNOTOXICITY AND GENOTOXICITY INDUCED BY ZEARALENONE: POSSIBLE PROTECTIVE EFFECTS BY ISOTHIOCYANATES EXTRACTED FROM TUNISIAN *RAPHANUS SATIVUS*

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Zearalenone (ZEN), is a naturally occurring contaminant of animal feed that has been implicated in several mycotoxicoses in farm livestock. Recent investigations seem to indicate that ZEN causes cancer or at least increases its prevalence, although the mechanism of action is unknown. Many papers mentioned that exposure to ZEN results in oxidative stress, genotoxicity and DNA damage.

Therefore, we investigated the chemopreventive role of 4-(Methylthio)-3-butenyl isothiocyanate (MTBITC) extracted from Tunisian *Raphanus sativus* (radish) on the cytogenetic and immunologic effect of ZEN in Balb/c mice and in vitro cultures of mouse lymphocytes. We determined chromosome aberrations and micronuclei formation, as well as the mitotic index and DNA fragmentation following ZEN treatment alone or in combination with MTBITC.

This report is the first to provide evidence of a statistically significant decrease of structural chromosome aberrations and micronuclei formation associated with an augmentation of the mitotic index and inhibition of DNA fragmentation in all ZEN-MTBITC treated mice or mouse lymphocyte cultures. In the same way, MTBITC proved to counteract the immune toxicity causes by ZEN in all the immune parameters we studied. In conclusion, MTBITC alone was safe and succeeded in inhibiting the availability of ZEN by counteracting the oxidative stress and protecting against the genotoxicity and immunotoxicity resulting from ZEN.

MONITORING WATER POLLUTION FROM OPEN SOLID WASTE DUMP SITES IN SRI LANKA

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Landfill leachate is a well-reported source of contamination of soil, surface and ground water. This is due to the fact that the predominant waste disposal method still in use in Sri Lanka is open dumping, which generates significant amounts of leachate mostly nearby water sources. Gohagoda open dumpsite is one such site, located at the world heritage city of Kandy in Sri Lanka. Due to the absence of a proper lining system or any treatment mechanism before disposal, the leachate directly flows into the Mahaweli River, which is the main water source for the entire province.

Hence, this study was focused on the characterization of leachate generated from the Gohagoda dumpsite: we assessed its spatial and temporal variations, identified subsurface canals and perched water bodies in the wetland system affected by the leachate flow.

Leachate samples were collected monthly for one year from different points of the leachate drainage channel and tested for quality parameters as pH, temperature, EC, TDS, TS, VS, TSS, VSS, TOC, DOC [including Humic acid (HA), fulvic acid (FA) and hydrophilic fraction (Hyd)], BOD5, COD, alkalinity, hardness, nitrates, phosphates, ammonium nitrogen, chloride and heavy metals (Fe,

Mn, Zn, Cu, Pb, Ni and Cr). Leachate characteristics indicated that the leachate is in the methanogenic phase. Long-term monitoring results suggest that the leachate from Gohagoda open dump site may act as a pollution source for the drinking water supply, which is in close proximity. These findings can be effectively used to obtain a better understanding of the pollution from open landfills and to awake policy developers in order to focus their attention on environmental pollution from open dumpsites.

chemistry
earth sciences

METAL-ORGANIC FRAMEWORKS (MOFS): INTERPLAY OF STRUCTURAL TUNABILITY AND FUNCTIONALITY

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The chemistry of metal-organic frameworks (MOFs) or porous coordination polymers (PCPs) is running in its vernal era and efforts are continuing to uncover their fascinating properties at various levels like gas storage (like H_2, CH_4), catalysis, separation, sensing, and drug delivery. Multifunctional materials, *i.e.* materials that combine a set of well-defined properties (*e.g.* porosity and magnetism, porosity and optical, magnetism and ion exchange, magnetism and conductivity) for specific applications are gaining more and more importance.

Such synergism, where two different functionalities are combined, would open up the possibility and prospect of finding novel physical phenomena for designing smart materials. Magnetism has generic dependence on distance while the porosity is enhanced with long linkers and hence combination of these two is not always straightforward. For example, a Mg(II)-MOF composed of excited state intramolecular proton transfer (ESIPT) responsive linker (2,5-dihydroxyterephthalic acid) shows tunable emission in different solvent systems depending upon the polarity and also exhibits highly selective carbon dioxide uptake at 195 K. This talk will explore some of these MOFs systems with coexistence of multiple functionalities.

DYE-SENSITIZED SOLAR CELLS

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The ever-increasing global demand for low-carbon economy is compelling our scientists and engineers to seek favorable alternatives to traditional energy strategies. Amongst several renewable energy sources, solar energy is the most abundant one, and as such it is able to meet our future energy supply. The present challenge rests in finding a viable means by which humankind can exploit solar energy at an affordable cost. Conventional solar cells made from crystalline silicon have attained a

power conversion efficiency of ~25%, but their price per kilowatt-hour with respect to that of the routine electricity grid has restricted their widespread application.

In the family of various cutting-edge photovoltaic technologies, the dye-sensitized solar cell (DSC) has attracted considerable attention owing to its perceivable merits of low cost, low weight, coloring, and easy processing. Elaborate engineering of some ruthenium polypyridine and zinc porphyrin complexes as well as metal-free organic dyes has greatly impelled the efficiency progress of this cutting-edge photovoltaic technology.

In this talk, I will first present the recent progress we have made on new materials for high-performance DSCs and then focus on the complicated energetic and kinetic interplays at the titanium/dye/electrolyte interface, shedding light on the chances of future device improvement.

ELECTRONIC AND STRUCTURAL PROPERTIES OF COVALENT INORGANIC COMPOUNDS STUDIED BY EXPERIMENTAL AND THEORETICAL METHODS

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Structure and bonding lie at the heart of modern chemistry. It is not too much to say that the renaissance of inorganic chemistry was concurrent with the development of a myriad of spectroscopic methods for structure determination. Innovative spectroscopic techniques allow a deeper understanding of chemical processes. However, the conviction by Vladimir Prelog (Nobel Lecture 1975) that "chemistry takes a unique position among the natural sciences, for it deals not only with materials from natural sources but creates the major parts of its objects by synthesis" is very suitable, especially at present times when the need for interdisciplinary research appears to be increasing.

Following these principles, our work concerns the synthesis of small inorganic covalent molecules, many of them being novel species for which no preparation methods are reported in the literature. The main objective is the study of the structural, conformational and electronic properties, focusing the analysis on the synthesized molecules, which are tailored in such a way that systematization of the results is attainable, for instance, through the preparation of similar related species inside a given class of compounds.

Our interest is mainly devoted to molecular species of medium-size, belonging to the Chalcogen (Group XVI) main group elements. Fundamental properties in the ground electronic state, including the molecular structure and conformation, are studied by using a combined experimental and theoretical approach. Also, the electronic structure of both valence and inner-shell electrons are investigated. In fact, the distribution of the outermost electrons in a molecule is a key property for chemists, since chemical reactivity (bond breaking and formation) depends upon the valence electrons. Moreover, detailed studies on simple neutral and charged species are necessary to clearly understand the behavior of more complex systems. For instance, sulfenylcarbonyl compounds are an interesting family of molecules related to important biological systems such as coenzyme A (CoA).

A complete set of results including the synthesis and the molecular and electronic structure of selected species will be presented.

TREATMENT OF STABILIZED LANDFILL LEACHATE USING AN INTEGRATED H_2O_2 OXIDATION AND GRANULAR ACTIVATED CARBON (GAC) ADSORPTION

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This study investigated the treatment performances of H_2O_2 oxidation alone, and its combination with granular activated carbon (GAC) adsorption for raw leachate from the NENT landfill (Hong Kong) with a BOD_5/COD ratio of 0.08. The COD removal of refractory compounds (as indicated by COD) by the integrated H_2O_2 and GAC treatment was evaluated and compared to that obtained by H_2O_2 treatment alone with respect to dose, contact time, pH, and biodegradability ratio.

At an initial COD concentration of 8,000 mg/L and NH_3-N of 2,595 mg/L, the integrated treatment achieved a higher removal (COD: 82%; NH_3-N: 59%) than the H_2O_2 oxidation alone (COD: 33%; NH_3-N: 4.9%) and GAC adsorption alone (COD: 58%) at optimized experimental conditions. The addition of 1.8 g of Fe(II)/L improved the removal of refractory compounds by the integrated treatment from 82% to 89%. Although the treatment could treat leachate of varying strengths, treated effluents were unable to meet the local COD limit of less than 200 mg/L and the NH_3-N of lower than 5 mg/L. This suggests the need for subsequent biological treatments for complementing the degradation of target compounds in the leachate prior to their discharge.

THE COMBINED EFFECTS OF STEREOISOMERIC AND STERIC FACTORS ON ELECTRONIC AND PHOTOPHYSICAL PROPERTIES OF BIS-CYCLOMETALATED IR(III) COMPLEXES CONTAINING 2,5-DIARYL-1,3,4-OXADIAZOLE DERIVATIVES

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This work was conducted on a series of cyclometalated iridium(III) complexes with 2,5-diaryl-1,3,4-oxadiazole (oxd^n) derivatives to shed light on the effects of the stereoisomeric and steric factors on the photophysical properties. On the basis of the results reported herein, we attempt to explain the experimental observations according to which, complexes *N,N-trans* [$Ir(oxd^0)_2(acac)$] (1a) and *N,N-trans* [$Ir(oxd^1)_2(acac)$] (2a) [with oxd^0 = 2,5-diphenyl-1,3,4-oxadiazole, oxd^1 = 2,5-bis(4-fluorophenyl)-1,3,4-oxadiazole and acac = acetylacetonate] show high quantum phosphorescence efficiencies (Φ_{PL}) of 35 and 44%, while an extremely low Φ_{PL} (<1%) was observed for a number of oxd^n based complexes including *N,N-cis* [$Ir(oxd^3)_2(acac)$] (4b) [with oxd^3 = 2-(4-fluorophenyl)-5-(2,4,6-triisopropylphenyl)-1,3,4-oxadiazole]. While new insights were gained on structural and electronic properties, the unusual photophysical properties recently reported for 4b were found to be not inherent to spin–orbit coupling (SOC) effects, but determined by both the S_1–T_1 splitting energy ($\Delta E_{S_1-T_1}$) and the transition dipole moment (μ_{S1}) upon the $S_0 \rightarrow S_1$ transition.

Drastically large $\Delta E_{S_1-T_1}$ and small μ_{S1} for 4b (0.70 eV and 0.23 D, respectively) comparative to those for 2a (0.38 eV and 2.76 D, respectively) and 1a (0.58 eV and 2.44 D, respectively) were found

to be tightly linked to the twisting degree of the oxdn ligand and to the trans–cis structural isomerism. On the basis of these parameters, the unusual physical properties of 4b were interpreted with respect to 1a and 2a, and the higher Φ_{PL} of 2a with respect to that for 1a was explained.

The second part was conducted on a series of similar complexes obtained by substituting the acetylacetonate (acac) ligand with the picolinace (pic) ligand, in order to gain more insights into the influence of the ancillary. The results supported the conclusion derived from the preliminary results, confirming that the conformation and twisting factors play an important role in the photophysical properties. Having identified the influence of the two parameters, the next step is the design of potential complexes with improved photophysical properties. The present work is likely to guide experimentalists in the synthesis of good OLED materials.

GEOHERITAGES AND GEOTOURISM IN ETHIOPIA: IMPLICATIONS FOR SUSTAINABLE DEVELOPMENT

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Ethiopia is one of the most significant environmental and cultural reserves on Earth, strewn with unique and significant natural geological and archaeological monuments. The underlying geological feature often determines natural scenery and landforms. All over the world, a place's geology is usually a strong tourist attraction. Ethiopia is no exception: the active Ethiopian Rift with its chain of rift lakes and the world-famous archaeological and anthropological sites; the unique Afar rift with its active volcanoes like Erta'ale and its expanding extension centre leading to the formation of new oceanic crust; the Simien and Bale massifs; the Tis-Isat fall along the mighty Blue Nile river; and the Sof-Omar caves are just a few examples.

Ethiopia is also one of the few places in the world where its cultural history, religious manifestations and civilization are imprinted in rocks: the rock-hewn churches of Lalibela and Central and Eastern Tigrai, and the stelae of Axum are all there because of the unique geological materials available. Furthermore, geomorphological and geological features, notably the isolation of the northwestern highlands from the external world by the harsh Danakil plains close to the sea, somewhat determined the route of Ethiopian history and its destiny. However, no systematic geoheritage evaluation and conservation strategies have been adopted at any level, although tourism has been identified and prioritized as one of the major sustainable development sectors in the country.

We started addressing this issue by identifying the major geological heritage sites in the country and designed a project to make a basic inventory and description of these geosites. We published the results of our first phase of research in a book entitled "Geotourism in Ethiopia", in 2009. We are currently working on the next phases. In addition to popularizing the subject to the scientific community, policy makers and the general public, we have partnered with the Geological Survey of Ethiopia, which initiated a discussion on the identification of potential sites which can be designated as Geoparks. We are planning to designate the first Geopark in Ethiopia in the near future.

DISCOVERY OF POTENT ANTIDIABETIC AGENTS FROM THE MAURITIAN FLORA

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Diabetes with its associated complications is turning out to be a major pandemic throughout the world, and the intensity of this crisis is set to increase in future decades. Tackling diabetes and its related consequences is rapidly becoming a priority for scientists and health authorities as well as policy makers globally. Mauritius ranks third in the world as far as the prevalence of diabetes: one out of two Mauritians is either diabetic or has already reached the pre-diabetic stage.

Interestingly, diabetes is perhaps the pathology against which medicinal plants are most extensively being used locally. Many indigenous/exotic herbs and food plant species of Mauritius and other Mascarene Islands have been used in folkloric medicine to treat and manage diabetes. Indeed, it is becoming more obvious that studying traditional medicines might offer a natural key to unlocking the diabetologist's pharmacy.

Nonetheless, few medicinal herbs and food plants from Mauritius have been scientifically evaluated for their possible medicinal application. To this effect, during the last few years, we have been evaluating the antidiabetic potential of locally available medicinal herbs and food plants of Mauritius, which are traditionally and routinely used as dietary adjuncts for the management of diabetes. They were evaluated for their blood glucose lowering potential using a plethora of *in vitro* and *in vivo* bioassays like antiglycation properties, preventing and restoring integrity and function of β-cells, insulin-releasing activity, improving glucose uptake and utilisation by phytochemicals and inhibition of digestive enzymes that might offer exciting opportunities to develop into future novel nutritional therapeutics. This presentation will therefore highlight recent findings in relation to the potential of Mauritian flora with potent antidiabetic properties.

CALCIUM AND ROS JOINTLY CONTRIBUTE TO THE SYNAPTIC PLASTICITY DEFECTS INDUCED BY AMYLOID-βPEPTIDE OLIGOMERS, THE DISTINCTIVE MARKERS OF ALZHEIMER'S DISEASE

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Aging is the main risk factor of Alzheimer's disease (AD), a neurodegenerative disorder that, due to the increasing life expectancy of the population, represents a major health problem worldwide. Increasing evidence indicates that memory loss, the main symptom of AD, results from the extensive synaptic dysfunction promoted by accumulation of soluble amyloid-β peptide oligomers (AβOs) in the brains of affected individuals. After binding to neurons, AβOs disrupt normal Ca^{2+} signaling and activate Ca^{2+}-dependent deleterious pathways.

We have studied different signaling pathways in primary hippocampal neurons treated with sub-lethal concentrations of AβOs. We reported that AβOs increase the concentration of excitatory amino acids in the extracellular milieu, induce Ca^{2+}-dependent generation of oxygen reactive spe-

cies (ROS) and promote lipid peroxidation. In addition to increasing ROS generation, we described that the increased Ca^{2+} entry through N-methyl-D-aspartate receptors (NMDAR) produced by AβOs elicits abnormally long-lasting Ca2+ signals, arising from the joint activation by Ca^{2+} and ROS of Ca^{2+} release mediated by ryanodine receptor (RyR) channels, which act as Ca^{2+}-sensitive cellular redox sensors. The aberrant Ca^{2+} signals produced by AβOs trigger significant mitochondrial network fragmentation, decrease RyR2 and RyR3 mRNA expression, and transiently decrease RyR2 protein content without affecting RyR3 protein levels.

Treatment with AβOs also impairs the increased RyR expression and dendritic spine remodeling produced by brain-derived neurotrophic factor or the RyR agonist caffeine. Interestingly, inhibition of RyR or NMDAR activity abolishes the decrease of RyR2 expression and prevents the mitochondrial fragmentation induced by AβOs. These results suggest that AβOs, by sequentially stimulating NMDAR-mediated Ca^{2+}-influx and RyR-mediated Ca^{2+}-release, cause defects in neuronal mitochondrial dynamics and spine remodeling that contribute to impairing synaptic plasticity, a hallmark of AD. No clinically accepted treatment to interrupt the progression of AD exists to date. Consequently, we have also explored neuroprotective strategies to counteract the neuronal damage caused by AβOs. We found that activation of inhibitory GABAA receptors to hyperpolarize neurons and prevent Ca^{2+}-influx protects neuronal death caused by lethal levels of Aβ aggregates, whereas the use of antioxidants to prevent oxidative stress and the ensuing emergence of aberrant Ca^{2+}-signals mediated by RyR prevents the mitochondrial fragmentation induced by AβOs. The use of combined therapeutic strategies might counteract the harmful effects of AβOs on hippocampal synaptic plasticity.

Supported by FONDECYT (11110322, 1100052), CONICYT (79090021), FONDECYT-FONDAP (1501006), MILLENNIUM BNI (P-09-015F).

THE ROLE OF HOST GENETIC FACTORS ON THE INTERPLAY BETWEEN HIV AND HBV CO-INFECTIONS

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In response to the HIV/AIDS pandemic, many African countries have rolled out the administration of antiretroviral (ARV) drugs, improving disease prognosis. While ARVs are in use, variation in genes associated with drug metabolism, excretion and transport (ADME) and in virus-restriction genes is largely uncharacterised in African populations. Thus, the risk of drug toxicity or therapeutic failure remains a potential clinical dilemma. In addition, hepatitis B virus (HBV) is endemic in sub-Saharan Africa (5-20%), HIV/HBV co-infected individuals are at a higher risk of developing hepatocellular carcinoma (HCC) and this may be associated with the emergence of specific HBV strains.

There are several cellular factors, which interact with HIV throughout its life cycle in order to restrict its propagation. These factors include IL10 (a modulator of inflammatory response) produced by T-helper 2 (Th2) cells, an apolipoprotein B mRNA-editing enzyme-catalytic, polypeptide-like 3G (APOBEC3G), stromal cell-derived factor-1 (SDF-1) and tetherin (BST2), a protein able to trap enveloped virions on the cell membrane and restrict dissemination. Polymorphisms in these genes may contribute to variation in the disease susceptibility and progression.

The aim of our research is to determine the role of genetic variants in genes coding for drug metabolising enzymes and virus restriction genes and then correlate the distribution of these variants with the presence or absence of HIV/HBV co-infection. Participants were recruited from

various countries in Southern Africa and variations determined by genotyping using PCR-RFLP, sequencing and SNaPshot. Participants will be screened for HBV by genotyping for the surface gene PCR as well as using HBV antigen kits.

Preliminary analysis shows a pattern in the distribution of some of the genetic variants that mirrors the pattern of HIV infection prevalence in Africa. In this work, we report the association between HIV/HBV co-infection with certain combinations of virus restriction gene genotypes. These findings are in addition to our observations of genotypes in ADME genes that are associated with differential response to ARVs.

MECHANISMS OF GLOMERULAR INJURY IN DIABETES: ROLE OF AMPK, MTOR AND TUBERIN

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Glomerular podocyte apoptosis represents a critical mechanism for excessive loss of urinary albumin that eventuates in kidney fibrosis. Pharmacological doses of the mTOR inhibitor rapamycin reduce albuminura in diabetes by unknown mechanisms. We explored the hypothesis that mTOR mediates podocyte injury in diabetes.

High glucose (HG) induces apoptosis of cultured podocytes and increases the levels of Nox4 and NADPH oxidase activity. HG also inhibits the phosphorylation of AMPK on the activating site Thr^{172}, increases the phosphorylation of tuberin on its inactivating sites Thr^{1462} and decreases it on the activation site. HG also activates mTOR and enhances the phosphorylation of its substrate S6 kinase. Inhibition of mTOR by low doses of rapamycin prevents HG–induced expression of Nox4, NADPH oxidase activity and podocyte apoptosis. Inhibition of mTOR had no effect on AMPK or tuberin phosphorylation indicating that mTOR is located downstream of these two signaling molecules. In isolated glomeruli of OVE26 type 1 diabetic mice, there is similar decrease in the phosphorylation/activation of AMPK, enhanced phosphorylation of tuberin on the inactivating site Thr^{1462} and activation of mTOR and S6 kinase together with increase in Nox4 and NADPH oxidase activity.

Our data provide evidence for understanding a novel function of mTOR in Nox4-derived ROS generation and podocyte apoptosis that contribute to urinary albumin excretion in type 1 diabetes. Thus mTOR inhibition may represent a therapeutic modality of diabetic kidney disease.

BLACK HOLES IN AN ACCELERATING UNIVERSE

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Several astrophysical observations show that the observable Universe is expanding with acceleration, supposedly driven by so-called 'Dark Energy'. Cosmology (the study of the history and evolution of the Universe), has been trying to find a consistent and coherent way to explain this phenomenon for more than a decade, so far with no success. In scientific literature, one can find numerous candidates including cosmological constant, quintessence and phantom energy (to name a few).

On the other hand, 'Black Holes' (the ultimate relic of fully gravitationally collapsed stars from which even light cannot escape) are the most mysterious objects in the Universe: despite the fact that they have been studied for nearly a century, we still need to investigate many of their features. In this talk, we explore the interaction of dark energy with a black hole. We are interested to know how the mass of a black hole evolves while accreting dark energy. As the Universe also contains matter and radiation, we incorporate the effects of radiation, matter and dark energy on the mass of a static black hole.

The results reported here have been published: "Effect of Vacuum Energy on Evolution of Primordial Black Holes in Einstein Gravity", Bibekananda Nayak and Mubasher Jamil, *Physics Letters B*, Vol. 709, 118 – 122 (2012).

NATURE-INSPIRED OPTIMIZATION ALGORITHMS AND THEIR APPLICATION IN SOLVING ENGINEERING PROBLEMS

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Humans, by nature, always try to optimize living conditions, and in countless areas of human life we attempt to exploit the limited amount of available resources to maximize output or profit. In the same way, we deal with the task of allocating limited resources where the main motivation is to comply with basic standards, and also to achieve good economic results. Turning problems of this basic nature into mathematical functions with corresponding conditions and constraints helps to realize this aim clearly. Optimization offers a technique for solving issues of this type by providing a theoretical foundation, as well as methods to solve problems.

Every process has the potential to be optimized. Optimization occurs through the minimization of time, cost and risk or the maximization of profit, quality and efficiency. Contrary to the fact that many applications in science, industry, engineering, economics and business can be formulated as optimization problems, a large number of such real-life optimization problems are complex and difficult to solve. Therefore, due to being time-consuming, they cannot be solved in an exact manner. Instead, approximate algorithms are developed as the main alternative to solve this class of problems.

Many of the classical optimization methods require substantial gradient information, and final results depend on the initially selected points. The number of computational operations increases as the design variables of a problem become greater. Instead, nature-inspired metaheuristic algorithms are more general approximate algorithms applicable to a large variety of optimization problems. Therefore, nature-inspired metaheuristics are becoming an important class of efficient tools for developing intelligent systems and providing solutions to complicated engineering problems.

Due to their capability of exploring and finding promising regions in the search space in an affordable time, nature-inspired metaheuristics methods are quite suitable for global searches and furthermore alleviate the need for continuous cost functions and variables used for mathematical optimization methods. This paper strives to review the latest development of metaheuristics and their applications in engineering. Topics include review of optimization algorithms, swarm intelligence, particle swarm optimization, artificial bee colony, genetic algorithms, ant colony optimization, big bang-big crunch algorithm and charged system search with diverse applications in engineering.

DYNAMICS OF FLOWS WITH SINGULARITIES

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In this talk, we present some ideas and results in the theory of flows arising from Ordinary Differential Equations with singularities, mainly in dimension three and towards higher dimensions. Since the advent of calculus, differential equations were used to model phenomena from nature and to give a theoretical background to problems of physics and other sciences. Hence, a major problem in mathematics is to know which properties and mechanisms belong to the solutions. As an example, we cite Lorenz equations, used to model some meteorological phenomena.

These equations present chaotic behaviour coupled to the presence of singularities. This presence forbids the use of classical hyperbolic theory. However, some important properties of the flow are robust. This inspires the theory of sectional hyperbolic flows, which is the key idea that will be exploited here.

A NEW FAMILY OF RANDOM GEOMETRIC GRAPHS: THEORY AND APPLICATIONS

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In this talk, a novel random geometric graph family called proximity catch digraphs (PCDs) will be discussed. PCDs, introduced in 2003, are based on the relative allocation of points from two or more classes. PCDs resulted when a problem with no analytic solution was modified by making use of appealing properties of a better known (and well behaving) concept.

Three main PCD types will be defined. Various aspects of PCDs including extension to higher dimensions, geometry invariance property for uniform data and how it can be obtained, distribution of the domination number, and relative arc density, and their applications to testing multivariate spatial point patterns of segregation and association will be investigated. Several prospective research directions on PCDs will also be pointed out.

SYMPOSIUM 1: LECTURES ON SCIENCE AND TECHNOLOGY DEVELOPMENT IN CHINA

ADVANCES IN CHINA'S LUNAR EXPLORATION

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China's lunar exploration is divided into two stages: unmanned lunar exploration and manned lunar landing exploration. Currently, China has deployed unmanned lunar exploration, which includes lunar orbital exploration, soft-landing and rover exploration, as well as lunar sample collection and sample return to Earth.

Lunar orbiter Chang'E 1 was launched in 2007, and conducted global and integrated explorations of the Moon; lunar orbiter Chang'E 2 was launched in 2010 to test key technologies of landing on an extra-terrestrial body, and to undertake further lunar orbital scientific explorations; lunar soft lander is scheduled to launch in 2013, to conduct an integrated in-situ exploration of the lunar surface and lunar rover exploration, and to accomplish detailed regional explorations.

In 2017, China will accomplish an unmanned lunar sample return, conduct detailed regional explorations of the landing area, and collect and return lunar samples to Earth for systematic, integrated, and in-depth analysis in laboratories on Earth, and deepen our scientific understanding of the Moon.

After 495 days of orbital operation, CE-1 orbiter was designed to impact onto *Mare Fecunditatis*. CE-1 successfully accomplished all scientific exploration goals, including obtaining 3-D stereo images of the lunar surface, analysing the elemental composition and distribution of materials on the lunar surface, exploring the characteristics of lunar regolith and depth and the He-3 reservoir, and exploring the near-Moon space environment. CE-1 obtained 4 TB of scientific data in total, which are published and available for researchers all over the world to use.

The main tasks of CE-2 are to test and prove part of the key technologies and new equipment related to soft landing on the lunar surface, and to test new Earth-Moon trajectories in order to lower the risks associated with soft landing on the Moon; to conduct detailed surveys of the whole lunar surface and landing area and delineate their topography and morphology in detail. CE-2 obtained a 7-m resolution image map of the whole lunar surface, which surpassed comparable international lunar digital map products in spatial resolution, image quality, data consistency and completeness, and mosaic precision. CE-2 also compiled images of *Sinus Iridum* with resolutions better than 1 m/pix, in addition to mosaic image data and Digital Elevation Model (DEM) data of typical morphological units of the five candidate landing areas. On August 25, 2011, CE-2 was controlled to successfully enter the L2 point orbit 1.50 million km away from Earth, to start exploring characteristics of charged particles in Earth's distant magnetotail and to observe potential solar X-ray storms and cosmic gamma-ray storms.

On April 25, 2012, after 235 days of orbital operation in the L2 point orbit, CE-2 accumulated large amounts of exploration data, and was controlled to travel further into the deep space in the solar system 10 million km away, awaiting opportunities to conduct asteroid fly-by and rendezvous tests, in order to gain experience for future small body explorations.

Through three-staged explorations – "orbit, land, return" – China will master the engineering technologies of unmanned lunar exploration, obtain new lunar exploration, technological and sci-

entific results, build a space engineering system for lunar explorations, and lay a solid foundation for conducting follow-up deep space explorations and manned lunar landing exploration.

LUMINESCENT METAL-BASED MOLECULAR MATERIALS: FROM DESIGN TO ASSEMBLY AND FUNCTIONS

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Functional materials research is one of the top priority strategic areas of development in science and technology in the 21st century. Organic and metal-organic molecules can serve as versatile building blocks for molecular-based functional materials; they can be rationally engineered and prepared, and their physical, mechanical and electronic properties are tunable with a proper understanding of structure-property relationships. Development of molecular-based materials is deemed to provide impetus, and offers enormous potential for materials science research and development in the forthcoming decades.

Recent work in our laboratory has shown that novel luminescent metal-based molecular materials could be assembled through the use of various metal-ligand chromophoric building blocks. In this presentation, various design and synthetic strategies, together with the successful isolation of new classes of complexes of selected metals will be described. A number of these complexes have been structurally characterized and shown to display rich luminescence behaviour. The luminescence properties have been studied and their emissive origins elucidated. Correlations between the luminescence behaviour and the electronic and structural effects of the metal complexes have also been made. Some of these complexes have also been shown to exhibit interesting functional properties. Different approaches and assembly motifs have been employed to tune the absorption and emission characteristics of these materials based on the understanding of their spectroscopic origins.

Through rational design and various strategies, these molecular materials may find potential applications and functions as efficient triplet light-emitting materials, and in chemosensing and luminescence signalling.

OBSERVATION OF ELECTRON-ANTINEUTRINO DISAPPEARANCE AT DAYA BAY

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Three out of twelve elementary particles, which are building blocks of our matter world, are neutrinos. The abundant amount of neutrinos, like photons, implies that they are extremely important for astrophysics and cosmology. With their mass, tiny as it is, neutrinos may significantly influence the evolution of the universe. Indeed, they have peculiar properties. Having a mass, a neutrino can turn from one type – electron or muon or tau – to another, during the flight. This phenomenon is called neutrino oscillation. Having three kinds of neutrinos, we can observe three pairs of transformations.

Since 1998, we know that neutrinos can oscillate, and two out of three types of transformations, denoted as theta_12 and theta_23, have been determined. The third one, theta_13, is un-

known. The Daya Bay neutrino experiment, located in the south of China, 60km from Hong Kong, was proposed in 2003 by a group of physicists at IHEP. The experimental setting, next to 6 reactor cores of the Daya Bay nuclear power plant, consists of an underground tunnel 3100m long, three underground experimental halls, each with a water pool, plus a RPC cover for muon veto, and eight 110t neutrino detector modules.

The construction started in 2007, and all the detectors in three halls started the operations on 24 December 2011. After 55 days recordings, the experiment observed electron anti-neutrino disappearance from reactors with a statistical significance of 5.2 standard deviation, corresponding to oscillation amplitude of 9.2%, with an error of 1.7%.

Daya Bay is an international collaboration, consisting of about 250 members from 38 institutions in 6 countries and regions.

EVOLUTION, GENOMICS AND CANCER

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Large populations are expected to be genetically diverse; however, this diversity may often be a simple outcome of random mutations and genetic drift. Rigorous theories have been advanced in previous decades to infer the effect of selection in natural populations. These theories can also be extended to infer whether natural selection drives intra-tumour genetic diversity and how the identified driver mutations might govern cell proliferation.

In this study, we combine methods of evolutionary population genetics with an explicit design of extensive sampling from 12 cases of hepatocellular carcinoma (HCC). Each case of HCC was found to consist of multiple genetically distinct cell lineages. Descendant lineages usually have a higher estimated fitness than parental ones. Because the data suggest that every sequenced tumour section in this study represents an independently selected lineage, the rate of selective diversification appears far higher than that suggested by previous studies.

The observed diversification often follows a spatial pattern where cell migration precedes clonal expansion. Mutations in extracellular matrix components are common, hinting that selectively favoured mutations that confer cell motility further enhance lineage diversification. The degree of selectively driven diversification observed here suggests that tumours may continue to diversify at an accelerated rate as tumours grow.

SCALABLE QUANTUM INFORMATION PROCESSING

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Combining quantum manipulation with information technology results in quantum information science and technology. Quantum information enables information security (quantum communication), improving computation speed (quantum computing), revealing laws of complex physical systems (quantum simulation), and improving measurement precision (quantum metrology) etc., to beat classical limits.

This talk will give an overview about current progress in quantum communication, quantum computing, quantum simulation and quantum metrology. In the meantime, we will provide a perspective view about promising development trends for scalable quantum information processing.

Based on the state-of-the-art in fiber technology and rich fiber resources, the prevailing quantum communication technology allows practical communication in the metropolitan area. There have already been some quantum communication networks constructed around the world, associated with preliminary applications. Moreover, based on linear optics, some progress has been made in quantum computing, quantum simulation and quantum metrology. However, scalable quantum information processing is still facing big challenges.

On the one hand, the distance of fiber-based quantum communication is very limited, due to intrinsic fiber loss and the decreasing entanglement quality caused by the coupling of fiber and environment. On the other hand, a probabilistic single photon source and entanglement source would cause an exponential increasing overhead for scalable quantum information processing. To solve these issues, future wide-area quantum communication needs quantum repeaters and the transmission of optical quantum bits in free space. In addition, promising and scalable quantum computing, quantum simulation and quantum metrology all draw support from quantum repeaters to achieve multipartite entanglement. Furthermore, through quantum control of cold atoms and combining optical lattice and Feshbach resonances technology, one is allowed to maintain quantum simulation in cold atoms systems, which is a very promising direction of future development.

STUDY OF MOLECULAR INTERACTIONS AND DYNAMICS IN LIVING CELLS: ONE AT A TIME

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In recent years, basic sciences have witnessed a revolution, which exploits new single molecule detection and manipulation techniques to monitor and analyse molecular dynamics at the molecular level. The burgeoning use of single-molecule methods in living cells, the basic units of life, has enabled what was once the scientist's dream – "watching individual molecules at work" – to become real.

As the structure of and the interaction between biomolecules change dynamically and asynchronously in cells, averaging from the ensemble measurements could cover important molecular features and dynamic properties. Single molecule approaches offer great potential to enhance our understanding of cellular processes and the molecular mechanisms of cell function.

My group is interested in the development and application of both single-molecule fluorescence imaging and single-molecule force spectroscopy methods to investigate biomolecular interaction and dynamics in living cells. In this talk, some of our recent work on single-molecule study of protein dynamics for cell signal transduction study will be presented:

(1) Investigation of the dimerization of growth factor receptors by taking advantage of single-molecule sensitivity;

(2) Monitoring the transient docking of the intracellular protein on cell membrane to study the downstream protein activation;

(3) Study of the heterodimerization of growth factor receptors upon activation and the signalling inhibition mechanism of clinically used anti-cancer drugs.

SYMPOSIUM 11: STEM CELLS AND GENOMICS

STEM CELLS AND REGENERATIVE MEDICINE

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Stem Cells, with their unlimited proliferation ability and their full developmental potential, have become an important resource in regenerative medicine research. Since most research focuses on embryonic stem cells, the ethical issue has been an obstacle to their application. Induced Pluripotent Stem Cells (iPSC) have been the hotspot of stem cells research since they were obtained, in 2006.

Up to now, ESC (Embryonic Stem Cells) and iPSC have been successfully derived from mice, humans, monkeys, rats and pigs, and they have been differentiated into many tissue-specific cells. During the last years, significant progress in stem cells research has been achieved: for example, the demonstration of pluripotency of iPSC, the generation of iPSC by recombinant proteins and the identification of pluripotent markers of stem cells. Moreover, the success of direct reprogramming of somatic cells into multipotent stem cells has expanded the available resources, and this is important in the field of stem cells applications. These achievements will bring a more promising future to stem cells, both in basic research and in regenerative medicine.

FROM SEQUENCING TO "THE CENTURY OF BIOLOGY"

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The year 2013 will see global celebrations for the 10th anniversary of the official completion of the Human Genome Project (HGP), the first internationally collaborative project carried out by both developed and developing countries in the history of the natural sciences.

The most important impact of the HGP is the spirit of 'owned by all, done by all, shared by all' and the culture of collaboration, as well as the '-omicsization' of life sciences. The HGP has cultivated genome science, which is regarded as the foundation of life sciences, the upstream of biotech, and the fountain of bio-innovation. As the core technology of genomics, sequencing made three major technical breakthroughs in the last decades, and has changed the scope and scale of the whole of the life sciences.

With the strong belief that 'life is of sequence' and 'life is digital', and in collaboration with global partners, BGI-China has developed *de novo* assembly and other bioinformatics tools, and has sequenced and analysed numerous genomes of humans, other animals, plants and microorganisms, releasing approximately 650,000 Gb sequence data, as of the end of 2011.

Sequencing is at a new era of providing 'reference genome sequence' for every species, many individual genomes for 'genome diversity/variations' of a species and those with identified traits for 'phenotypic sequencing', as well as for applied genomics in agriculture and health, with the ambition to sequence "every (living) thing on Earth" and "everybody in the world". A combination of molecular biology techniques, SC/iPC, animal cloning, synthetic biology and genomics, as well as other future emerging techniques, will make "the Century of Biology" a reality in the 21 century.

SUCCESSFUL REPAIR OF THE DAMAGED CORNEA USING LIMBAL STEM CELLS

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The annular ring surrounding the cornea of the eye stores stem cells which not only self-renew but also differentiate to generate a continuous supply of cells that make the corneal epithelium (outermost layer). When the ocular outer surface is damaged by burns (thermal, chemical), limbal stem cell deficiency occurs, leading to scarring and resultant impairment of vision.

We show how it is possible to biopsy a tiny piece of the residual limbus, culture the stem cells from there on a suitable scaffold to produce a transparent and functional corneal epithelium, thus obtaining a stable ocular outer surface and vision restoration.

Long-term (10-year) analysis of the outcome of such cultivated limbal epithelial transplantation (CLET) of 398 eyes of patients reveals an over 72% rate of success. And in an exciting innovation, we have simplified the procedure by allowing the biopsied limbal tissue *in situ*, on the pannus-cleared eye of the patient himself, thus avoiding the need of a laboratory to do *ex vivo* culturing. This simplified limbal epithelial transplantation (SLET) is equally successful as CLET, and makes it possible for any qualified corneal surgeon to practise limbal stem cell therapy.

MOLECULAR AND GENETIC BASIS OF VISION IMPAIRMENT IN PAKISTANI POPULATION

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The prevalence of hereditary vision impairment in Pakistan is significantly higher than the world average. This is attributable to a high degree of consanguinity in the Pakistani population. For more than 5000 years, the north-western parts of the Indian sub-continent, which now form Pakistan, have served as the main gateway to invading armies from central Asia and Europe, including: the Aryans, the Mongols, the Greeks, the Uzbeks and the Khazaks. After conquest and occupation, the foreigners remained culturally isolated. This was further facilitated by the local caste system that villages have often established by a few extended families, and despite their geographic proximity, marriages have been (and continue) to be arranged within extended families.

Vision loss can be divided into three categories. The first one, retinitis pigmentosa (RP), is a retinal disorder causing night vision impairment. It is generally associated with other ocular symptoms, such as nystagmus, myopia and strabismus. The second, cataract, is a disorder that affects transparency of the crystalline lens, resulting in vision impairment. The third one, glaucoma, is a group of neurodegenerative disorders characterized by the deformation of the optic nerve, loss of retinal ganglion cells, and irreversible vision loss due to damage to the optic nerve.

Discovery and characterization of genes responsible for hereditary vision impairment has contributed significantly to our understanding of the multiple molecular mechanisms essential for the biochemical pathways. Given the multiple pathways involved in the perception of visual process and in its impairment, genetic analysis of causative mutations is a powerful tool for understanding eye functions. The willingness of extended families, identified in Southern Punjab, Sindh, Baluchistan,

Khyber Pukhtoon Khaw and tribal areas on the borders of Pakistan, has been an enormous help for our studies on vision impairment.

We have identified 7 new genes for RP, 2 new genes and 9 loci for cataract; one new gene and 4 new mutations that cause glaucoma in Pakistani population [1, 2, 3]. Our recent data from a genome wide scan of DNA from members of consanguineous families and fine mapping showed that a homozygous missense mutation in GNAT1 is associated with autosomal recessive stationary night blindness. DNA Sequence analysis identified nine different mutations in FYCO1 having a causative role in the onset of cataract in 12 highly inbred families. In addition, data have shown that mutations in this gene are the commonest causes of cataract in Pakistani populations.

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SYMPOSIUM III: INTERDISCIPLINARY

INNOVATION IN GLOBAL HEALTH: GRAND CHALLENGES CANADA AND ITS RISING STARS PROGRAM

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In its 2008 federal budget, the Government of Canada announced a major innovative policy initiative: the creation of a Development Innovation Fund. This was sourced from a small proportion of Canada's foreign aid envelope and resulted in the creation of Grand Challenges Canada (GCC), two years ago (2010). The major focus is on funding innovations in global health using the grand challenges approach. More than 80 per cent of the funding has gone to principal investigators in low- and middle-income countries.

Among GCC's funding initiatives is the Rising Stars program, which funds great ideas by young scientists through a simple application process. GCC also focuses on Integrated Innovation, namely innovation not just in science and technology but also in society and business.

I will describe the evolution of the grand challenges approach, the creation of GCC, and describe its global health funding programs, with particular emphasis on the Rising Stars program.

SOLAR PV STATUS AND INCENTIVES IN CHINA

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Solar PV (Photovoltaics) is a clean energy: it doesn't pollute, it doesn't make noise, and it poses no limitations in resources, with respect to both energy supply (from the sun) and the materials

(silicon) used. Today, China is the largest world producer of solar PV manufactured articles: in 2011, 21GW were produced in China, which equalled 66% of the world total PV productions. PV industry in China is heavily dependent on the international market, and 95% of its PV products have been exported to Europe and USA, in the last 5 years.

To enlarge the domestic market of PV, incentive policies such as FIT of PV, 50% capital subsidy to building PV systems, VAT tax credit, and others have been launched by the Chinese government.

Solar PV will play a very important role in the future, for China's power supply: China has a 2015 target for cumulative installation of solar PV which equals 15GW, shared 1% of total power capacity in China by that time, and another target for 2020 (50GW).

This presentation will provide information not only for solar PV but also an analysis of the energy structure and other renewable energy shares in China.

PALAEOBIOLOGICAL INSIGHTS FROM FOSSIL BONE MICROSTRUCTURE

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Fossilized bones and teeth are, in general, all that remains of extinct vertebrates. Thus, reconstructing the biology of extinct animals often relies on indirect assessments from fossil records. However, since the microscopic structure of fossil bone remains intact even after millions of years of fossilization, it is increasingly recognized as a valuable tool for directly assessing various aspects of the biology of extinct vertebrates.

A host of experimental studies on modern bone suggests that bone is a plastic tissue, highly responsive to its environment. From such studies it is evident that the microscopic structure of bone is affected by a variety of factors, such as its actual formation rate, the biomechanical functioning of the particular element within the skeleton, the ontogenetic age of the individual, disease, etc. Comparisons among the preserved bone microstructure of various extinct animals and that of modern bones have provided invaluable insight into various aspects of the biology and life history of several extinct taxa.

During ontogenesis, several dinosaur taxa have undergone well documented morphological and allometric changes: for example, a decrease in relative orbital size, an increase in tooth counts, increase or decrease in robusticity of limb elements, and the development of secondary sexual characteristics such as horns and frills. Since the rate of osteogenesis also changes during ontogeny, with distinctive patterns of bone tissue forming at different stages of growth, the microscopic structure of fossil bone provides reliable information on the ontogenetic age, as well as insights about the processes that affected growth.

This talk will briefly outline some of the histological studies that have been conducted on fossil bones in order to unravel aspects of the biology of extinct animals. For example, studies of non-avian and avian dinosaurs have provided an understanding of the evolution of growth patterns among the Dinosauria. In addition, research on different ontogenetic stages of *Pterodaustro*, an unusual filter feeding pterosaur, have permitted an assessment of their growth trajectory. Recent studies comparing dinosaur taxa at high and lower latitudes have provided fresh insights into the adaptations of dinosaurs living well within the Arctic Circle.

It has become increasingly recognized that – to better understand the nature of bone tissues preserved in fossil vertebrates – it is imperative to conduct more research on modern taxa, to better understand the factors that affect bone growth and development.

UNVEILING THE FUNDAMENTAL LAWS OF NATURE

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Particle physics studies the elementary constituents of matter and their fundamental forces. Very short distances are explored using particle collisions at very high energies, creating conditions similar to those governing the Universe just after the Big Bang. Laws of Nature become then easier and can be described in terms of simple mathematical theories.

The current theory, called the Standard Model, provides an accurate description of all known physical phenomena in the micro-cosmos but had until recently a missing component needed to explain the short range of the Weak Force and the origin of mass of elementary particles. This was the main reason for constructing the Large Hadron Collider (LHC) at CERN, the most powerful machine of colliding protons around Geneva in Switzerland, which has recently made this important discovery, entering into new unexplored territories of physics beyond our current understanding of Nature.