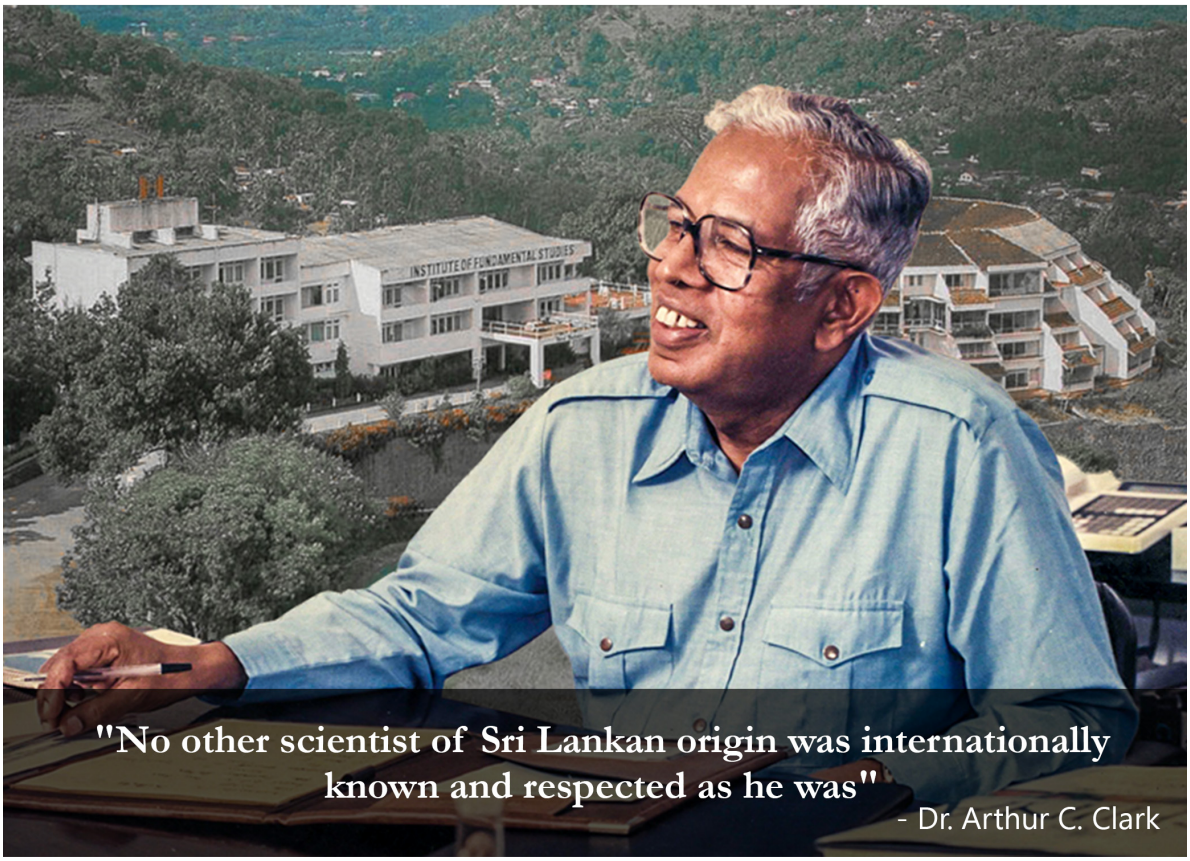
Cyril Ponnamperuma Memorial International Conference on

Multidisciplinary Research

21st January 2020

PROCEEDINGS



National Institute of Fundamental Studies
Kandy, Sri Lanka

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Compiled and edited by

M.A.K. Lakshman Dissanayake

National Institute of Fundamental Studies

Kandy, Sri Lanka

Cyril Ponnamperuma Memorial International Conference
21st January 2020

Inauguration Programme

21st January 2020

08:00	Registration
08:55	Arrival of the Chief Guest
09:00	National Anthem Lighting of the Oil Lamp
09:05	Welcome Address by the Director National Institute of Fundamental Studies
09:15	Video Presentation
09:30	Address by the Chairman National Institute of Fundamental Studies
09:35	Address by the Hon. Thilanga Sumathipala State Minister of Technology & Innovation
09:45	Address by the Hon. Dr. Bandula Gunawardana Hon. Minister of Information and Communication Technology and Hon. Minister of Higher Education, Technology and Innovation
10:00	Keynote Address by Prof. Rohan Samarajiva
10:30	Vote of Thanks Chairman, Organizing Committee
10:35	Opening of the Centre for Advanced Battery Research
10:55	Refreshments
11:15	Technical Sessions

Naming the NIFS auditorium as
"Professor Cyril Ponnamperuma Auditorium"
and
"Ceremonial opening of the National Battery Laboratory"
will also take place during the day of the conference

Cyril Ponnamperuma Memorial International Conference

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Programme of Technical Sessions

11:15 AM - 12:45 PM ***Technical Session - I***

11:15 - 11:45 **Fundamental Studies in Sri Lanka: History and the Future**
Prof. Kirthi Tennakone
Georgia State University, Atlanta, Georgia, USA

11:45 – 12.15 **Prof. Cyril Ponnamperuma: A passionate champion of Public Science**
Mr. Nalaka Gunawardene
Journalist, Science Writer, Colombo, Sri Lanka

12:15 - 12:45 **Organic semiconductor distributed feedback (DFB) lasers**
Prof. Atula Sandanayaka
Center for Organic Photonics and Electronics Research (OPERA), Kyushu University, Japan

12:45 PM - 01:45 PM ***LUNCH***

01:45 PM - 03.15 PM ***Technical Session - II***

01.45 - 02:15 **The challenge of non-communicable diseases in Sri Lanka**
Dr. Prasad Katulanda
University of Cololmbo, Colombo, Sri Lanka

02:15 – 02:45 **Targeted therapies for cirrhosis and portal hypertension**
Prof. Chandana Herath
University of Melbourne, Melbourne, Australia

02:45 - 03:15 **Nano –fertilizer for urea slow release: concept to technology development**
Prof. Veranja Karunaratne
University of Peradeniya, Peradeniya, Sri Lanka

03:15 PM - 03:45 PM **TEA**

03:45 PM - 04:45 PM ***Technical Session - III***

03:45 - 04:15 **Biofertilizer Production: A major outcome of the Biological Nitrogen Fixation Project of the National Institute of Fundamental Studies**
Prof. S.A. Kulasooriya
National Institute of Fundamental Studies, Kandy, Sri Lanka

04:15 - 04:45 **CRISPR/Cas9 Gene Editing to Improve Crop health in the Arms Race Between a Host and Pathogen**
Prof. Dilantha Fernando
University of Manitoba, Winnipeg, Manitoba, Canada

04:45 -05:45 **Panel Discussion**

CONTENTS

Message from the Director

It is a tremendous honour and privilege to write this message as the Director of the National Institute of Fundamental Studies, Kandy for the Professor Cyril Ponnamperuma Memorial Conference. This year marks the 25th death anniversary of Professor Ponnamperuma, the architect of this great Institute. It is our bounden duty to acknowledge and honour this great visionary leader who paved the way for basic science research, popularization of science amongst the general public, training of high-quality postgraduates in multidisciplinary science and laying the foundation for minimizing brain drain from this country.

Professor Ponnamperuma's ability to 'see the big picture' resulted in the setting up of the then IFS at its current, spacious, research complex in Kandy. He had very ambitious goals for this Institute. Professor Ponnamperuma's charisma, exuberant enthusiasm and dynamic energy ensured that we had every high-end instrument available over 40 years ago at our disposal. He firmly believed that the level of talent this country could achieve within ten years is what India had achieved in 40 years, if provided with the required resources. He made every attempt both, nationally and internationally, to achieve this goal and was successful in obtaining major grants including more than a 6 million USD grant from Japan to fund research in the basic sciences in Sri Lanka.

Professor Ponnamperuma was an excellent role model, and it was my great fortune to work at the IFS during his leadership. His oratorical skills were legendary and enthused his listeners, including me to pursue a career in science. He dreamt of an institute that produced the highest quality research and postgraduates who not only possessed research skills but also leadership skills to address burning national issues and thereby improve the standard of living of the 'ordinary' citizens of this country.

Professor Ponnamperuma always emphasized that the NIFS is an institute that conducts research in the basic sciences while playing a major role in addressing many national problems. In the current scenario, there are many acute problems faced by the Sri Lankan people: chronic kidney disease, dengue, lack of clean water resources in rural communities, limited access to renewable energy resources, lack of food production at a national level, waste management, human-animal conflict etc. All these issues can be successfully addressed, only through a basic understanding of individual issues at the fundamental level. It is my sincere hope that the scientists at the NIFS are able to take on these massive challenges and come up with innovative solutions to alleviate the problems of our countrymen.

We are now at a very crucial juncture in the Institute's history to carry forward with momentum the ambitious goals set out for us by Professor Ponnamperuma. We need to ensure that we fully utilize the resources that we have for the country's development. We are well placed within the new government's theme of "*savbhagyaye dekma*", in which our contributions not only facilitate the advancement of scientific knowledge but also helps to scale up the development of human resources, particularly high caliber postgraduates that this country desperately needs.

I take this opportunity to wish every success for the conference.

Saman Seneweera
Director, NIFS

Message from the Organizing Committee

For the first time at the NIFS, we are pleased to organize this conference in memory of late Professor Cyril Ponnamperuma. Indeed, this has been a long overdue activity from the part of NIFS. Professor Ponnamperuma created a new scientific culture in Sri Lanka. Almost thirty years ago, he proposed the concept of a digital library for Sri Lanka, which has become a reality today. He also played an important role in promoting North-South and South-South dialogue within Sri Lanka, offering a platform through the "Kandy School of Sciences" programme of the IFS for scientists to interact with each other and to disseminate their research findings through conferences and workshops in a variety of disciplines. Professor Ponnamperuma gave a great impetus for mathematics, the queen of sciences and a forgotten discipline in Sri Lanka, at the NIFS. At the same time, he also initiated a very strong Social Science Programme creating a truly multi-disciplinary scientific environment in our country. We wanted to emphasize Professor Ponnamperuma created this model to quickly lift science, innovation and education in the country.

We thank the Honourable Ministers, Ministerial Secretaries and other Ministry officials who participated in this important event and facilitated financial and other assistance. The technical contributions made by invited speakers, participation by invitees, alumni and other distinguished participants are highly appreciated. The support received by the state and private sector agencies to make this event a reality is recorded with thanks. The untiring role played by the present Director and the Secretary of the NIFS to make this event a reality is truly appreciated. We thank the support extended by the research scientists, research assistants, technical and administrative staff and other supporting staff of the NIFS to make this event a great success. Any lapses in the organization of this activity rest with us. To us, it has been a privilege to organize this commemoration of this unique person and his contributions to science in Sri Lanka.

We conclude this message with Prof Ponnamperuma's famous and timeless phrase, "*Once a member of IFS, is always a member of IFS*."

Organizing Committee

Saman Seneweera (Director, NIFS), Patron
Rohan Weerasooriya (Co-chair)
Siril Wijesundera (Co-Chair)
Lakshman Dissanayake
Deepal Subasinghe
M.C.M. Iqbal
Kumari Tilakaratne
Shalini Rajakaruna

Message for the Hon. Minister

It gives me great pleasure to write this message to commemorate the 25th death anniversary of the late Professor Cyril Ponnamperuma, a visionary in science, who launched the scientific careers of many of you here today. Having himself succeeded in the international arena of science, he came back to Sri Lanka to build this unique institute, which has motivated and inspired many of you to launch a career in science and contribute to national development as well as to the advancement of scientific knowledge.

Professor Ponnamperuma personified an impeccable character, devotion and commitment towards uplifting science in our country. He was charismatic and able to inspire scientists young and old. Indeed, many of you who passed through the NIFS, are now contributing to the scientific and national development of Sri Lanka.

The NIFS is a fitting and lasting memory for the indefatigable spirit of Professor Ponnampeuma to take science forward. Let us celebrate his unique contributions to this unique institute and carry forward his dreams of a science and technology based national economy for Sri Lanka.

Dr. Bandula Gunawardena

Hon. Minister of Information and Communication Technology and Hon. Minister of Higher Education, Technology and Innovation

Message from the Hon. State Minister

I am pleased to send this message for the Cyril Ponnamperuma Memorial International Conference arrananged by the National Instititute of Fundamental Studies to commemorate the 25th death anniversary of Professor Ponnamperuma.

Professor Cyril Ponnamperuma is undoubtedly the most eminent internationally recognised Sri Lankan scientist in our time. It is high time we commemorate his service to the country for fetching fame and for establishing the National Institute of Fundamental Studies, the only research institute in Sri Lanka dedicated for research on basic and advanced science.

In this modern era, knowledge is the power. A knowledge-based society and a knowledge-based economy is a must for development. Countries that reached the "developed" status in recent times did so mostly by investing on knowledge. Generating new knowledge and addressing national issues, especially in the context of Sri Lanka, are some of the priorities in our journey towards development. It is also of utmost importance to reduce the brain drain and to provide opportunities to those who wish to pursue their curiosity driven, knowledge-seeking research. In early 1980's, Professor Ponnamperuma realized this and had the vision, for establishing the NIFS to achieve these objectives.

I am aware that over the past three and half decades, the NIFS has immensely contributed to the society by generating cutting-edge knowledge, uplifting it'svisibility in international scientific arenas, investigating nationally important scientific issues, training thousands of young postgraduates and undergraduates, and reducing the brain-drain in within it's capacity. One of the unique and strongest points of the NIFS is the multidisciplinary approach, which is not usually facilitated in many other state institutes. Thanks to the efforts of Prof. Ponnamperuma, as well as the other directors and scientists that lead the institute in the past, modern scientific equipment and leading scientists from different disciplines are grouped to carryout nationally important basic scientific research in a conducive environment at the NIFS.

I wish this conference every success.

Hon. Thilanga Sumathipala

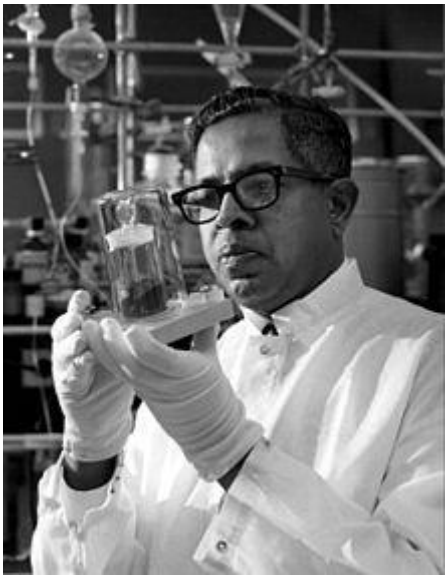
State Minister of Technology and Innovation

Cyril Andrew Ponnamperuma (1923-1994): A legend in Sri Lankan Science

Vidya Jothi Professor Cyril Andrew Ponnamperuma was born in Galle, Sri Lanka in 1923. After completing his early education with flying colours at St. Aloysius' College, Galle and subsequently at St. Joseph's College, Colombo, he obtained a B.A. degree in philosophy from the University of Madras, India in 1948. Subsequently he moved to the United Kingdom and obtained a B.Sc. degree in chemistry from the University of London in 1959. His interest in the origin of life began to take clear shape at the Birkbeck College of the University of London, where he studied with J. D. Bernal, a well-known crystallographer. Afterwards, he proceeded to the United States, where he received a Ph.D. in chemistry in 1962 from the University of California, Berkeley working under the direction of Nobel Laureate Professor Melvin Calvin.

Professor Cyril Ponnamperuma was an eminent researcher in the field of chemical evolution. From 1963 he rose through several National Aeronautics and Space Administration (NASA) divisions as a research chemist to head the Laboratory of Chemical Evolution at the University of Maryland, College Park. His career focused on explorations into the **origin of life** and the "primordial soup" that contained the precursors of life. In this search, he took advantage of discoveries in such diverse fields as molecular biology and astrophysics. He was the principal investigator for analysis of lunar soil brought to earth by Project Apollo. Subsequently, he was closely associated with the Viking and Voyager programmes at NASA and was a member of the Space Science Advisory Council and Life Sciences Advisory Council of NASA.

During the 1960's, Ponnamperuma began to develop his ideas about chemical evolution, which he explained in an article published in *Nature,* (**201**, pages 337-340(1964)). Chemical evolution, he explained, is a logical outgrowth of centuries of studies both in chemistry and biology, culminating in the groundbreaking 1953 discovery of the structure of deoxyribonucleic acid (DNA) by James Watson and Francis Crick. Evolutionist Charles Darwin's studies affirming the idea of the "unity of all life" for biology could be extended, logically, to a similar notion for chemistry: protein and nucleic acid, the essential elements of biological life, were, after all, chemical.



In the same year that Watson and Crick discovered DNA, two researchers from the University of Chicago, Stanley Lloyd Miller and **Harold Urey**, experimented with a primordial soup concocted from the elements thought to have made up Earth's early atmosphere—methane, ammonia, hydrogen, and **water** . They sent electrical sparks through the mixture, simulating a **lightning** storm, and discovered trace amounts of amino acids.

During the early 1960's, Ponnamperuma began to delve into this primordial soup and set up variations of Miller and Urey's original experiment. Having slightly changed the proportions of the elements from the original Miller-Urey specifications slightly, Ponnamperuma and his team first sent high-energy electrons, then ultraviolet light through the mixture, attempting to recreate the original conditions of the earth before life. They succeeded in creating large amounts of adenosine triphosphate (ATP), an amino acid that **fuels** cells. In later experiments with the same concoction of primordial soup, the team was able to create the nucleotides that make up nucleic acid-the building blocks of DNA and ribonucleic acid (RNA).

In addition to his work in prebiotic chemistry, Ponnamperuma became active in another growing field: exobiology, or the study of extraterrestrial life. Supported in this effort by NASA, he was able to conduct research on the possibility of the evolution of life on other planets. Theorizing that life evolved from the interactions of chemicals present elsewhere in the universe, he saw the research possibilities of spaceflight. He experimented with lunar soil taken by the *Apollo 12* space mission in 1969. As a NASA investigator, he also studied information sent back from Mars by the unmanned Viking, Pioneer, and Voyager probes in the 1970's. These studies

suggested to Ponnamperuma that Earth is the only place in the solar system where there is life.

In 1969, a meteorite fell to Earth in Muchison, Australia. It was retrieved still warm, providing scientists with fresh, uncontaminated material from space for study. Ponnamperuma and other scientists examined pieces of the meteorite for its chemical make-up, discovering numerous amino acids. Most important, among those discovered were the five chemical bases that make up the nucleic acid found in living organisms. Further interesting findings provided tantalizing but puzzling clues about chemical evolution, including the observation that light reflects both to the left and to the right when beamed through a solution of the meteorite's amino acids, whereas light reflects only to the left when beamed through the amino acids of living matter on Earth.

Ponnamperuma's association with NASA continued as he entered academia. In 1979, he became a professor of chemistry at the University of Maryland and Director of the Laboratory of Chemical Evolution-established and supported in part by the US National Science Foundation and by NASA. He continued active research and experimentation on meteorite material. In 1983, an article in the science section of the *New York Times* explained Ponnamperuma's chemical evolution theory and his findings from the Muchison meteorite experiments. He reported the creation of all five chemical bases of living matter in a single experiment that consisted of bombarding a primordial soup mixture with electricity.

Ponnamperuma's contributions to scholarship include hundreds of articles. He wrote or edited numerous books, some in collaboration with other chemists or exobiologists, including annual collections of papers delivered at the University of Maryland College Park Colloquium on Chemical Evolution. He edited two journals, *Molecular Evolution* (from 1970 to 1972) and *Origins of Life* (from 1973 to 1983). In addition to traditional texts in the field of chemical evolution, he also co-authored a software program entitled "Origin of Life," a simulation model intended to introduce biology students to basic concepts of chemical evolution.

He produced over 400 scientific publications and held a number of prestigious academic posts during his lifespan.

Although Professor Ponnamperuma became an American citizen in 1967, he maintained close ties to his native Sri Lanka, even becoming an official governmental science advisor. His professional life included several international appointments. He was a visiting professor of the Indian Atomic Energy Commission (1967); a member of the science faculty at the Sorbonne (1969); and Director of the UNESCO Institute for Early Evolution in Ceylon (1970).

Prof. Ponnamperuma’s participation in the Sri Lankan scientific arena began in 1984 when he became the Science Advisor to the late Sri Lankan President J. R.

Jayewardena. As the 2nd Director of the Institute of Fundamental Studies (now NIFS), he was instrumental in setting up the permanent home for the institute in the Hantana Hills with a modern laboratory complex to pursue basic research to improve the quality of life of people. Under his directives, the IFS basic science discoveries reached schools, professional associations, the media, and the local community. He also served as the first Director of the Arthur C Clarke center for Modern Technologies in Sri Lanka established in the name of the world-renowned science fiction writer, Sir Arthur C. Clark, a British born Sri Lankan resident. He worked on several professional fronts covering science policy, institutional building, fund raising, capacity building and public engagement in Sri Lanka.

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Ponnamperuma was a member of the Indian National Science Academy, the American Association for the Advancement of Science, the American Chemical Society, the Royal Society of Chemists, and the International Society for the Study of the Origin of Life, which awarded him the A. I. Oparin Gold Medal in 1980. In 1991, Ponnamperuma received a high French honor-he was made a Chevalier des Arts et des Lettres. Two years later, the Russian Academy of Creative Arts awarded him the first Harold Urey Prize. In October 1994, he was appointed to the Pontifical Academy of Sciences in Rome. He married Valli Pal in 1955; they had one child. Ponnamperuma died on December 20, 1994.

According to Arthur C. Clarke, "*No other scientist of Sri Lankan origin was internationally known and respected as he was".*

IFS Moves to Kandy……

Rohan Weerasooriya

National Institute of Fundamental Studies, Sri Lanka

The National Institute of Fundamental Studies (NIFS), formerly known as the Institute of Fundamental Studies or IFS, is the premier institute of basic and applied research in Sri Lanka. It was established in 1981 by an act of parliament and initially located in Colombo under the Directorship of Prof. Chandra Wickramasinghe. In 1985, the Board of Governors of the IFS led by the President of Sri Lanka, H.E. J.R.Jayawardhane, and the new Director Professor Cyril Ponnamperuma , decided to move the institute to Kandy. The IFS was relocated at Hotel Hantana which was purchased by the government for this purpose. The hotel rooms were converted to research laboratories and other major alterations were done under the supervision of Professor Cyril Ponnampeuma to have a modern auditorium, library and information unit. During the same period an outright JICA grant received from the Government of Japan enabled acquisition of modern research equipment ranging from electron microscope, XRD machine to pH meters. In addition, Professor Ponnamperuma was instrumental in winning major international research grants through BADC (Belgium), IDRC (Canada), USAID (USA), World Laboratory (Switzerland), UNU(Japan), COSTED (India), TWA (Italy) and UNDP.

Initiation of IFS Research Programmes

Several nationally important research programmes were initiated at the IFS during mid 1980's under the directorship of Prof. Ponnamperuma. The **IFS Biological Nitrogen Fixation (BNF) Programme** was initiated aimed at understanding how microorganisms and plants are successful in utilizing the atmospheric nitrogen. There is a real possibility that this knowledge if applied to crop production could save millions of rupees spent on fertilizer. Of the three thousand five hundred species of flowering plants in Sri Lanka around seven hundred and fifty are used as medicinal plants in ayurvedic medicine. The **IFS Natural Products Chemistry Programme** was established to examine the efficacy of these medicinal herbs, to isolate active constituents in them to enhance biological efficacy. Large scale denudation of forests, poor management of marginal rubber and tea plantations and repeated slash and burn cultivation practices have given rise to extensive areas of degraded lands in the wet zone of Sri Lanka. The **IFS Ecology and Conservation Programmme** identified new species of fast-growing multi-purpose trees to restore the ecosystem and to meet the ever-increasing demands for fodder, fuel and timber by the community. However,

methods for rapid propagation of plant species was a challenging problem. The **IFS Biotechnology Programme** initiated studies on propagation of selected trees using molecular methods. Iron toxicity in soils of the low and mid regions of the wet zone resulted reduced paddy yield. The **IFS Iron Toxicity Programme** was aimed at investigating the iron toxicity to the nutrient status of soils to provide information to the farmer. Although endowed with a massive rock phosphate deposit at Eppawala, Sri Lanka imports its entire requirement of phosphate fertilizer for its short term crops including rice. The **IFS Fertilizer Programme** suggested chemical and biological methods to controlled release of P fertilizer to plants. Sri Lanka has nine out of the ten orders of soils. Since over seventy-five people are living in the villages, **IFS Soil Vegetation and Health Programme** was started in order to understand the relationships between mineral distribution and endemic diseases paving path for new medical geology research paradigm. Coronary heart disease is still a major cause of death and incapacity in Sri Lanka. The **IFS Atherosclerosis Programme** was aimed at identifying the factors such as coconut in diet, patient's history and trace elements etc. which make people susceptible to this disease. Sri Lanka is world famous for gemstones. Yet, techniques for discovering gem bearing deposits do not take advantage of modern scientific techniques. The **IFS Gem Exploration Programme** was focused on seeking state of art methods to unravel precious gemstone deposits hidden underneath. Countries without coal and petroleum and lacking sufficient hydro-electric power must utilize the sun as a major source of energy. The **IFS Solar Energy Conversion Programme** was aimed at developing novel materials to capture solar photons and generate electricity. Major discoveries in Solid State Physics have revolutionized modern technology and modern industry. The **IFS Solid State Physics Programme** was focused on developing high temperature superconductors and photovoltaic devices both of which have direct significance to the developments of Sri Lanka. The **IFS Philosophy programme** intended to use Philosophy to illuminate empirical studies in other disciplines. The **IFS Archaeology Programme** was focused on identifying major problems of Sri Lankan archeology. The **IFS Mathematics Programme** operated at two levels. While it involves research exploring theoretical problems and encouraging interactions between national and international mathematicians, some of the efforts were directed towards improving the understanding mathematical concepts among younger generation. The **IFS Cosmology Programme** promoted in depth understanding of the universe we live in using the wealth of astronomical data available in the world.

During the implementation of the above research programmes initiated and carried out during the1980's the IFS at Hanthana became a vibrant and dynamic research centre with a dedicated pool of senior and young scientists and equipped with modern research equipment.

Professor Ponnamperuma with H.E. President J.R. Jayawardena during the inauguration of a research conference and Opening of the new Research Laboratory Complex of the Institute of Fundamental Studies at Hanthana Road, Kandy in 1985.

Prof. Ponnamperuma with some of the delegates from JICA and Prof Stanley Kalpage, then Secretary, Higher Education and Chairman, UGC.

Bulky research equipment arrived from Japan (JICA) are lifted from Hanthana road to nearby research labs (former hotel bedrooms).

The Kandy School of Science: A platform for Science Dissemination

Lakshman Dissanayake

National Institute of Fundamental Studies, Sri Lanka

Professor Ponnamperuma was a great scientist with a broad vision who emphasized the importance of organizing regular research conferences, symposia, workshops and seminars in order to disseminate new research findings and new scientific knowledge among the scientific community and the general public. To implement these ideas successfully he initiated the Kandy School of Science in 1986 in line with the International Centre for Theoretical Physics (ICTP) and the Third World Academy of Sciences (TWAS) in Trieste, Italy. He was also associated very closely with Professor Abdus Salam, the 1979 Noble Laureate in Physics and the Founding Director of the ICTP and TWAS. He was a Fellow and a Deputy Director of TWAS for several years.

Professor Ponnamperuma was very keen to organize international research conferences and symposia at the IFS and always encouraged and trained young research staff to take up these responsibilities. He was successful in attracting funds from UNESCO, ICTP, TWAS and other local and international funding agencies to support these events. Three major International Solid State Physics (SSP) symposia held in 1987, 1989 and 1991 at IFS were very successful with participation of over 100 local and foreign scientists. Prof. Abdus Salam was the Chief Guest at the SSP conference in 1987. Professor Ponnamperuma was also instrumental in getting the printed proceedings of these three symposia published by Nova Science Publishers, USA free of charge. There were many more such conferences and workshops under different themes, including the Ramanujan International Conference on Number Theory held in 1988. The Astronomy workshops aimed at not only popularizing astronomy but also promoting serious research in astronomy were conducted by Prof. George V. Coyne from the Vatican Observatory on invitation by Prof. Ponnamperuma. All these science dissemination activities made the IFS and the Kandy School of Science activities immensely popular not only among the local and international scientific and academic community but also among the general public and high school students.

Professor Ponnamperuma realized the importance of disseminating scientific information and inculcating scientific thinking among school students, because, one

day, they will be the country's future scientists, doctors, engineers and technologists. The very popular School Science Programme initiated by him to disseminate the importance of science and scientific thinking among high school students who excelled at G.C.E. O/L examination is yet another successful programme in this direction which is still continuing at the IFS very successfully. The Pre-university Research Assistants programme and the Volunteer Research Studentship programme for university undergraduates are among other programmes initiated by Professor Ponnamperuma to impart research skills and scientific way of thinking among the youth of this country.

Photograph of the late Professor Cyril Ponnamperuma with Prof. Abdus Salam, Noble laureate in Physics at IFS in 1987. Professor Abdus Salam, Director of the International Centre for Theoretical Physics (ICTP), Trieste, Italy was the Chief Guest at

Prof. Ponnameruma and Dr. Arthur C. Clarke at an opening ceremony of a IFS research conference in 1987.

Prof. Ponnamperuma with some of the IFS scientific staff at a social event in 1987

Prof. Ponnamperuma and Dr. Arthur C. Clarke posing for a group photo with IFS RA's and PRA's in 1987.

Keynote Address

Professor Cyril Ponnamperuma: Multidisciplinary Institution Builder

Prof. Rohan Samarajiva

LIRNE*asia, Colombo, Sri Lanka*

Abstract

Based on the speaker's first-hand experiences at the inception of the National Institute of Fundamental Studies, the presentation examines the challenges faced by Professor Cyril Ponnamperuma in establishing a pioneering multidisciplinary research institute in an inhospitable environment. Core issues of multidisciplinary research such as reward systems that are capable of transcending disciplinary frames, challenges of maintaining focus and priorities, and communication within the organization and to external stakeholders are discussed. The tension between the appeal to political authority to overcome bureaucratic inertia in the short term and the resultant resistance generated among the stakeholders whose cooperation is essential in the long term is described, with some thoughts from the speaker's later experiences in institution building within and without government.

Multidisciplinarity is the theme of the conference. It is being organized by the National Institute of Fundamental Studies (NIFS) an institution Professor Ponnamperuma built. At the time, he was also Science Advisor to the President of Sri Lanka[1] and Director of the Arthur C. Clarke Centre for Modern Technologies (ACCMT). I was privileged to work under him at the NIFS and ACCMT, and to observe his work as science advisor in 1985-1986. I learned much in those 11 months which influenced many things I did subsequently. My intention today is to distil some

[1] As he described in an interview in 1987: "I'm science adviser to the president of Sri Lanka. It is a one-to-one relationship. There is no office and organization. When the president has a problem, I give him advice. Or I can bring things to his attention—say, in science policy. It is nothing like the kind of organization that you have here, or that India has now. That is a bureaucratic apparatus, whereas in Sri Lanka it is simply that he wants somebody to turn to when things have to be done." https://www.the-scientist.com/news/ponnamperuma-on-promoting-third-world-science-63669

of what I learned from him to shed light on the challenges we face today in Sri Lanka and elsewhere.

Multidisciplinarity

Professor Ponnamperuma was not involved in the original design of the NIFS. Others were responsible for its enabling statute and name. But he was truly the founder of the institution, bringing it from a converted house in Colombo to the present location in Kandy, scaling it up, and setting its core values and direction through his leadership and early recruitments. He envisioned an institution that would not only do good science, but would do science that would have an impact on the economy and society.[2] I recall asking him why we had "fundamental" in our name and about the mismatch between what we were actually doing and what is commonly understood as fundamental science. He said we have to do what needs to be done and not worry about labels. If one looks at the early days of NIFS, one will find work on gemology, hydrogeology, mathematics, natural products chemistry and theoretical physics among others. He created an environment where different disciplines co-existed and there was no privileging of basic science over applied or vice versa. It depended on the available resources, human and financial.

It is clear that the major problems of the world require solutions that transcend traditional disciplinary silos.[3] The question is whether this is best done though interdisciplinary approaches where the theory and methods are novel or through teams that bring to bear multiple traditional approaches to common problems. The answers differ depending on the nature of the problem and circumstance. But unless the conditions exist for those from different disciplines to have these conversations, the question will not even come up. In the way many universities are organized and the reward systems are structured, the conditions do not exist; everything happens within silos. With his knowledge of the conduct of cutting-edge research, Professor

[2] As he said in the 1987 interview: "If primitive people did not think in terms of trying to answer questions, they would still be polishing stone tools. On the other hand, there is also a great misconception that fundamental studies is up in the clouds somewhere, that it has no relationship to life today. So whatever is done at the Institute Fundamental Studies must affect the quality of life." https://www.the-scientist.com/news/ponnamperuma-on-promoting-third-world-science-63669

[3] See for example, Samarajiva, R. (2018 December 21). Contributions from research to solve Sri Lanka's problems, *Daily FT*. http://www.ft.lk/opinion/Contributions-from-research-to-solve-Sri-Lanka-s-problems/14-669293 ; සමරජීව, රොහාන් (2017ජනවාරි 1). ජනතාව සවිබල ගැන්වීමට දායක විය හැක්කේ කෙසේද?*රාවය*, https://www.facebook.com/notes/rohan-samarajiva/ ජනතාව-සවිබල-ගැන්වීමට-දායක-විය හැක්කේ-කෙසේද /1168867473190291/

Ponnamperuma set about creating those conditions in the green-field setting of the IFS. Even in the seating and eating arrangements, he tried not to allow for too much segregation.

I had come to NIFS from a Faculty of Interdisciplinary Studies at Simon Fraser University and went on to earn tenure in a College of Social and Behavioral Sciences at Ohio State University. My own work has never neatly fit within disciplinary boundaries. LIRNEasia, the regional research organization that I set up in 2004, started off at the intersection of law and economics, but has now brought in ethnomethodogy, data analytics, and even design thinking. What I learned at NIFS influenced the new organization, including even in things like seating arrangements.[4] We are multidisciplinary for sure, and in some cases, we are interdisciplinary as well. Even 30 years ago, I was comfortable with what was being attempted at NIFS.

The real test of multidisciplinarity is the reward system. Usually, we reward researchers on the basis of publications. There are high-impact publications and those that are not. Especially with the proliferation of predatory journals, the quality of the journal in which a researcher publishes has become important. It is easier to get through peer review in disciplinary journals which also tend to have better reputations. Novel methods and findings that draw from outside the discipline's established knowledge have a hard time.[5] Having co-founded a multidisciplinary journal with a high impact factor[6] and currently serving as editorial board member and referee on several others, I am well aware of the challenges of ensuring fairness and quality in multidisciplinary journals. I cannot speak to the reward structure set up by Professor Ponnamperuma because I left before my first one-year contract expired. If you wish to see if today's NIFS is truly a multidisciplinary research organization the first place to look is its reward system.

Keeping focus

Pursuing multidisciplinarity carries with it the danger of losing focus. It is a truism that one cannot do everything well. There is always the hope that the subset of research programs that are undertaken will generate synergies, that two plus two will be greater than four. Just taking on research because money is attached to itis never a good idea. What an organization does not undertake defines it even more than what

[4] I once ordered fresh flowers for the common spaces in the office. When I asked why, I said that's what Professor Ponnamperumadid. Money was tight, so we did not continue for too long.

[5] For an example of difficulties with peer review, see Arthur, W. Brian (1994). *Increasing returns and path dependence in the economy*, Ann Arbor MI: University of Michigan Press, pp. xvii-xvii.

[6] On the impact factor, see: https://clarivate.com/webofsciencegroup/essays/impact-factor/. In 1999, I with three others co-founded *New Media and Society*, a Sage journal.

it does. If one wanders too far afield from one's core competencies, the safeguards that are used almost unthinkingly to assess quality cease to be very effective. LIRNEasia does multidisciplinary research but it extends the scope of its activities with care. I have turned down very large amounts of money because they did not fit our priorities.

The usual method of maintaining focus and managing priorities is strategic planning. My recollection is that Professor Ponnamperuma did not engage in formal planning processes in those early days in Hantana. He had more than enough experience and knowledge to set the priorities for the nascent organization. It is better to engage in these processes after the principal positions have been filled and there is a greater understanding of the external factors at work, both in terms of supply of resources and demand for research output. I assume NIFS did put in place the relevant mechanisms as it matured.[7] Strategic priorities must determine what research is undertaken and who is recruited.

People who know of my interests and expertise must by now be asking what I was doing at NIFS if Professor Ponnamperuma had a coherent strategic plan in his head. Based on what Dr Sarath Amunugama who was then at UNESCO in Paris told me about a new technology center they had established, I applied to the Clarke Centre from Canada. The response under Professor Ponnamperuma's signature came on ACCMT letterhead. I had no interest in the NIFS, and did not even know about it. I returned to Sri Lanka within a week of my PhD defense, hoping to build a policy-relevant research program in ICT applications at the Clarke Centre. Even working part time at ACCMT, I initiated several projects such as the potential of ICTs in disaster risk reduction.

Professor Ponnamperuma wanted my primary affiliation to be NIFS and insisted that I move to Kandy within a short time of assuming duties. This did not mean that he intended to make social and economic aspects of ICTs a focus area at NIFS. My first assignment was to connect Sri Lankan researchers at NIFS and hopefully others to the scientific databases then available to US researchers through the precursors of the Internet, such as the National Science Foundation Network (NSFNET) that had just come online. I thought of it as a bounded project, which when completed, would allow me to switch my primary affiliation back to the Clarke Centre. When he found that I was good in communication, he wanted me to stay on at NIFS to lead the

[7] At LIRNEasia, the research organization I established in 2004, we set priorities at a high level through intensely debates on values and vision and mission statements in the early years. Formal strategic planning began after about seven years and is now a regular annual activity.

communication work. So basically I was seen in terms of support for the mainline researchers, rather than as a researcher per se. Of which more will be said below.

But there was one attempt, which did not fully take hold, to include a research stream outside the hard sciences which had few obvious synergies with the other research. This was represented by the bringing in of Professor Ralph Buultjens, an internationally well-connected (to the Nehru family, among others) American academic of Sri Lankan origin, as a Senior Research Fellow (or some such title) in mid-1986. As I was departing in August 1986, Rohan Gunaratne who had done some not-fully-explained work at the National Aquatic Research Agency (NARA), took over my desk. He later went on to earn a Master's degree from Notre Dame University in the US and a PhD from St Andrews University in the UK. The understanding among the research professionals at NIFS was that this was the beginning of a work-stream on the ethnic conflict that had taken center stage since the unfortunate events of July 1983.

The fact that the above development was not explained to the staff led to speculation, and possibly contributed to the problems of the work stream. Professor Buultjens' unfortunate interactions with the Sri Lankan media, including an alleged kidnapping incident in 1988, may have contributed. It appears that two books were produced by Gunaratne as part of his work at NIFS, with effusive forewords by Buultjens.[8] It appears that this work stream continued outside the mainstream of the Institute, until Professor Ponnamperuma's departure. This aberration illustrates the value of maintaining organizational focus. It is also possible that the Director was constrained by his distance from the methods and measures by which quality in research in contemporary history should be assessed.

Communication

One reason disciplines persist, despite their known weaknesses, is that they are proven mechanisms for effective communication among the members of the disciplinary community. Each discipline has its own language and common frames. Not only can those within the community communicate to each other effectively, they can communicate their work to the outside world better using those frames and language. In a multidisciplinary research organization, the senior leadership has to deal with the challenges of speaking multiple disciplinary languages to the outside world, especially to funders of research and to decision makers who can utilize the findings of the research. In large universities, still structured in disciplinary form,

[8]Gunaratne, R. (1987). *War & Peace in Sri Lanka*. Kandy: Institute of Fundamental Studies; Gunaratne, R. (1990). *Sri Lanka. A Lost Revolution? – The Inside Story of the JVP*. Kandy: Institute of Fundamental Studies.

these tasks are delegated to heads of disciplinary units such as faculties and colleges or departments and institutes. In a small organization such as NIFS, which is explicitly designed as a multidisciplinary institution, this is not always possible. Especially when it comes to sensitive negotiations about funding or in speaking to the media about the organization, it is necessary for the head of the organization to speak.

Professor Ponnamperuma was a great communicator. He strongly believed in taking science to the people. He excelled in the entire range of relevant skills, from effective interpersonal communication with potential donors and partners to devising communication plans to speaking on television.

I recall participating in an early morning briefing for the Director on an esoteric subject (possibly on some mineral deposits) that had funding potential. The Japanese funders were due in one hour or less. I sat in on the meeting with the potential funders and was stunned by the fluency with which he communicated material he had been briefed on just that morning. He had perfect command of the subject. Whenever I am briefed prior to an important meeting, I think of that sunny morning in Hantana. That has always been my benchmark.

He well understood the value of news events. Haley's Comet did one of its once-in-seventy-five-years visitations to our solar system in 1986, a few months after NIFS moved to Kandy. Due to the sudden departure of the communications lead, Sunil Govinnage, I stepped in to organize the comet-viewing event at Hotel Topaz, high above the city. Professor Nalin de Silva, who was technically in charge of the astronomy program at IFS, not yet having abandoned "Western" science, was present as were many other invitees. All went well, except for the clouds did not fully cooperate. I was happy to see our hard work paid off.

My project to connect Sri Lanka to the proto-Internet was being ground to a stalemate by the then Director of the Department of Telecommunications. I began making plans to return to the Clarke Centre. But my perceived talent for managing communication caused a problem. Instead of replacing the communication person he had lost, Professor Ponnamperuma sought to make me his communication lead. "I'll make you the Walter Sullivan of Sri Lanka," he said, indicating the scope of the communication tasks he had in mind.[9] I was flattered, knowing who Sullivan was, but declined.

[9] Sullivan wrote Professor Ponnamperuma's obituary: Sullivan, W. (1994 December 24). "Cyril Ponnamperuma, Scholar of Life's Origins, is Dead at 71," *New York Times*, p. 10. It

I was not willing to deviate from my planned career path to perform a support function for others.[10]I was already getting invitations to speak on and write about topics within my areas of expertise. The Clarke Centre was the right kind of platform for me. Professor Ponnamperuma was stepping down from his role there to devote his attention fully to NIFS and wanted me in Kandy. There was no middle ground to be found. My resulting departure from NIFS (and concomitantly from ACCMT as well) did not allow me to observe initiatives such as the Science for Youth program that can be better described by others present here.

The key point is that Professor Ponnamperuma placed great weight on the need to communicate science and rational thinking in general, and the work of NIFS in particular. Even in the United States, he would have been seen as unusual in the weight he gave to outreach, but in the rather hidebound Sri Lankan environment, he was a complete outlier. He wanted to communicate, but in actual fact he was not very impactful in Sri Lanka. The main reasons were language and the still-state-controlled media. He may have realized these limitations, so he focused on the long term by educating and nurturing a new generation of science journalists. The success of those efforts may be assessed by the level of scientific discourse in the popular media today.

Institution building

The NIFS was the first of its kind, more or less. The colonial-era research institutions funded by "cesses" on exports of tea, rubber and coconut existed. Now there is SLINTEC, the nano technology research institute that was established a few years back.

In 1981 two statutes were enacted, one for NIFS and the other for the National Aquatic Research Agency (NARA). NARA had several advantages. It was the successor to a going concern called the Fisheries Research Division of the Ministry of Fisheries which had land, buildings and people. Its founder was Dr Hiran Jayewardena, an international law expert who also happened to be the nephew of President J.R. Jayewardene. NARA was created to lay claim to the maritime zone Sri Lanka was entitled to under the Law of the Sea Treaty, in addition to the tasks of

had the most inches on the obituary page that day. It only mentioned his role as Science Advisor to the President of Sri Lanka.

[10] I did, however, leverage the work I did at NIFS into a funded research project through NARESA, as the National Science Foundation was then known, and a peer-reviewed academic article: Samarajiva, R. (1989). Appropriate high tech: Scientific communication options for small third world countries, *The Information Society*, 6(1/2): 29-46.

its predecessor organization as well. When Professor Ponnamperuma was invited to take over NIFS, it had been spinning its wheels for three years.

It had a converted government house off Bauddhaloka Mavatha, a skeleton staff, two luggable computers (the famous Kaypros) and not much else.

The scaling up started with the relocation to a former hotel in Hantana in late 1985. New staff were recruited from Kandy; a few who were not from Kandy, including myself and Mr. Dayaratne, a retired senior administrative officer tasked to help the Director navigate government procedures, were given temporary accommodation in the unconverted part of the hotel. Plans were being made for a designed-for-purpose building in upper Hantana. The foremost architect in the country, Geoffrey Bawa, had been given the commission.[11]

The key relationships that had to be managed were with government for resources (capital costs to purchase the hotel as well as operational costs that kept increasing as recruitment increased) and with the universities. It seemed that the first aspect had been brought under control by the placement of a senior and respected former administrative official by the side of Professor Ponnamperuma. There was also the possibly apocryphal saying that was bandied about: "I don't need AR and FR, I've got JR."

The other relationship was highly problematic. Professor Ponnamperuma had significant interactions with university academics in the context of his role as Science Advisor to the President. He had managed to recruit several senior academics such as Professor C.B. Dissanayake as non-resident fellows and also arranged for some to spend their sabbaticals at NIFS. If anything, he appeared to have been too generous in accommodating the various requests from senior academics for resources and titles. This may have been partly because he lacked the means to assess the quality of their scholarship, and partly because he thought he was "buying" their loyalty, or at least preempting their attacks. But this did not work. Many who took the titles and money had no compunction in attacking him and the NIFS behind his back.

There was tremendous opposition to everything he proposed. I witnessed a marathon exchange at the Sri Lanka Association for the Advancement of Science (SLAAS) where he was assailed by critics led by Professor P.W. Epasinghe. One man versus the multitude, reminding me of the Kandyan General Lewke battling multitudes all by himself in a field in Avissawella.[12] I was impressed by how Professor

[11] I recall visiting the Bawa firm's office in Colombo to discuss the preliminary drawings.

[12] පුන්සඳ සේම පායලා රට මැද්දේ
රන්කෙඳි සේම පීරාලා පිට මැද්දේ
මාර සෙනහ වටකරගෙන යම යුද්දේ
ලෙව්කේ මැනිදු අද තනියම වෙල මැද්දේ

Ponnamperuma responded, substantively and calmly. Most of the opposition appeared to me to be ideological. They did not like the government's policies; they did not like the United States where he came from; they did not like him. He was an outsider; they knew better. He could give no right answers.

This was the other side of the coin. The perception that he had the blessings of the President helped overcome the bureaucratic barriers and enabled the establishment of the NIFS. Without that perception, our bureaucracy and their university allies would have succeeded in grinding it down to mediocrity at birth. But the same perception hurt his efforts to work with the other key stakeholders. The short cuts taken in institution building using access to power hurt long-term change management.

I have seen this over and over again in government. New organizations are created because the existing ones are sclerotic. But the Salaries and Cadre Commission or the Department of Management Services will force the new entities to adopt the same dysfunctional organizational structures and compensation packages bedeviling the rest of government. It is recognized the world over that regulatory agencies require skilled and competent staff who must be paid at rates close to those found in the industries they regulate and that they must have access to training.[13] But the Salaries and Cadre Commission refused to approve the proposed salary structures for the Telecom Regulatory Commission that I played a part in establishing. The result was a brief burst of adrenalin-driven activity at the start, and dormancy and dysfunction after that.

Based on that experience, the Minister for Economic Reforms, Science and Technology obtained special Cabinet authorization to keep the Information and Communication Technology Agency (ICTA) out of the clutches of the Salaries and Cadre Commission in 2003. But the last few years has seen a continuous struggle to maintain that status. When some of my predecessors used political muscle to get things done, the bureaucratic reprisals were slow but merciless. The financial and reputational damage that was caused to ICTA could not be fully repaired, despite the best efforts of the Board I headed.

One cannot get anything new and significant done in this country without the assistance of political authority; but when one does that, the long-term consequences are severe. During my 20 months as Chairman of the ICTA in 2018-2019, I tried to steer the Agency between these two dangers. We achieved some results, but we would have achieved more if not for the considerable effort expended to placate the

[13] Samarajiva, R. (2002). "Why regulate?" chapter 2 of *Effective regulation: Trends in Telecommunication Reform 2002*. Geneva: International Telecommunication Union.

do-nothing officials at the Ministry and at Treasury. In 1985-1986, NIFS did not appear to have cash-flow problems. But nowadays, much of the energies of senior management and of Boards of entities like NIFS are eaten up by matters such as obtaining legitimate operating expense allocations from Treasury in order to pay salaries on time and providing explanations to and seeking approvals from various Ministry officials.[14]

Professor Ponnamperuma did not flaunt his connections. Even when I was being stalemated the state-owned telecom monopoly, he never mobilized the political heavy artillery on my side. He dealt with people as people and always used reason rather than authority. But as I found when I tried to get employment after leaving IFS, perceptions of his power and fears about getting on his wrong side by giving a young man who had dared to cross him were exaggerated in the minds of government decision makers. They may not have hated him, but they were scared to give me a chance. He had nothing against me, as evidenced by the invitation I received after I had left to give a colloquium at NIFS. [15]I had no alternative but to leave the country. That turned out well. In addition to all the other lessons, I am grateful for that.

[14] Samarajiva, R. (2019 December 15). Ensuring good performance by boards of SOEs. *Sunday Times*. http://www.sundaytimes.lk/191215/business-times/ensuring-good-performance-by-boards-of-soes-382642.html

[15]Unfortunately, he could not be present when I spoke. The last time I saw him was when I left NIFS in August 1986.

ABSTRACTS OF INVITED PRESENTATIONS

Fundamental Studies in Sri Lanka: History and Future

Kirthi Tennakone

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The curiosity driven attempts to understand nature in correlating and explaining observations within a theoretical framework is fundamental studies. The theories derived thereby possess predictive capability, verifiable by experimentation. All cultures have indulged in this thinking to a lesser or greater extent. Similarly, empirical technologies evolved everywhere as clever manipulations based on trial and error experience. Those who expanded fundamental investigations and connected them to technology conquered the world, dividing the East and the West.

Ancient Sri Lanka, well ahead in empirical technologies had also embarked on foundations of science. Sri Lankan Royal Courts from Polonnaruwa period onwards had been a forum for not only political affairs but also discussions related to fundamental knowledge. Several Sri Lankan scholars, notably eminent Buddhist monks and even some of our scholar rulers have raised philosophical issues pertaining to scientific inquiry. The question whether the knowledge about a system could be gathered without direct perception via indirect observations was debated in the Court of King Parakramabahu, Kotte. In 1450 CE, Venerable Totagumuwae Sri Rahula, answered question affirmatively to the King. He showed a sword to Parakramabahu and said that it was rusted by keeping immersed in human urine. The acidity and salinity of urine corroded the sword. It is not necessary do the unpleasant task of tasting to prove those qualities of urine. In contrast, more than a century later, when Galileo declared that the earth revolves around the sun, based on indirect evidence. He was prosecuted and punished by the political establishment.

Our literature touches cosmological speculations, indicating we possessed the trait of imagination - absolutely essential to foster fundamental study. Loweda Sagarawa imagines extragalactic objects and universes with different physical laws, just as in the string theory jargon.

Amazing developments which turned indigenous thinking towards science were almost completely curtailed when Portuguese and Dutch occupied the Island. They also did not introduce European scientific knowledge to Sri Lanka, although the British who came later were different. Sri Lanka was largely isolated from advancements of fundamental science in Europe until recent times. The new thinking

that diffused from there was sometimes rejected as Western. Fortunately there were intellectual revolutionaries who acclaimed modern thought while opposing colonialism. These forgotten individuals highlighted the importance of rational thinking and presented scientific concepts to the public. Fundamental studies cannot be promoted solely by researchers. Ideas need to be presented to the public for information, motivation and arousing curiosity. Around 1950 E.W. Adikaram, wrote in a local newspaper "the equation of the atom has already been written". Abraham Kovoor fearlessly came forward against wanton superstition. Venerable Udakendawala Siri Saranakara protested, hearing a nuclear device may be tested in an inhabited island. Venerable Narawila Dhammaratana declared that our religion excludes racial divisions. Presentation of thought provoking scientific and intellectual issues to the general public, subsequently disappeared was revived by Cyril Ponnamperuma who emphasized dissemination of science and the voice of the intelligentsia.

After establishment of the Ceylon University, few Sri Lankans who studied abroad, returned home and successfully pursued advanced research. Jayaratnam Eliezer at the Department of Mathematics, worked on quantum electrodynamics, in the early days of its development gaining international recognition. The success of these efforts and awakening of fundamental science worldwide after the war, prompted a group of Sri Lankans, headed by late Professor Mailvagnam to propose an institute devoted mainly to theoretical physics and mathematics. The implementation of the proposal was delayed for various reasons. Cyril Ponnamperuma, invited to head the Institute in the mid nineteen eighties was a visionary. He consulted two eminent people, both Nobel laureates, Abdus Salam at the International Center for Theoretical Physics and Sir George Porter, Royal Institution. They endorsed the idea that although the primary mandate of the Institute is theoretical studies, it may embark on few selected experimental projects in basic science to attain quick results and gain recognition. This strategy would initially compensate the shortage of persons competent in theoretical research and establish the institute. Unfortunately, pursuits far away from the intended theme entered as projects at the institute duplicating work carried out elsewhere in the country. Attempts to rectify the issue was not quite successful probably because of the shyness of some sectors of the scientific community to the challenge of fundamental studies.

Professor Ponnamperuma wished the Institute to engage in frontier investigations. Today, cutting edge experimental research requires expensive instrumentation beyond our means, but we are not short of brains that could be mentored to take up original fundamental investigations. Persons of the caliber of the genius Totagumuwae Sri Rahula, would do simple experiments at miniscule cost but far

reaching implications. Sri Lanka remains weak in such endeavors as judged from local contributions and needs invigoration. In the present day context, undertaking fundamental research demands thorough prerequisite background acquired by following advanced courses. University curricula need to be updated to serve this purpose. Fundamental studies cost less but require finer minds, first nurtured, then provided opportunities of research. Poor standards of academic performance and instruction and rarity of applied innovation owes much to neglect of this discipline. Fundamental studies strengthen the nation's morale to deal with social issues. It is vitally important Sri Lanka remedy the situation and uplift fundamental studies in its true spirit.

Professor Cyril Ponnamperuma: A Passionate Champion of Public Science

Nalaka Gunawardene

Science Writer and Journalist, Sri Lanka

Professor Cyril Ponnamperuma strongly believed that science and technology, when properly harnessed, could save lives, increase incomes and raise living standards across the developing world. He also advocated that scientists and their institutions should be fully accountable to the public: one way to ensure that was to promote public communication and engagement.

For him, public engagement was not a token exercise in public relations, but an integral part of doing good science. In his view, the best way to sustain the spirit and momentum of science was to make non-scientists understand and appreciate how science was done. Since most scientific research and institutions were supported by public funds, he argued, the tax-paying public had every right to know what scientists were doing. Also, if the public did not appreciate or support science as an enterprise, politicians were unlikely to take much interest in research and development.

Under Professor Ponnamperuma's leadership, all researchers at IFS were required to regularly present their research to peers, journalists and the wider public. The resulting discussion, debate and scrutiny were uncommon at the time elsewhere in the Lankan scientific establishment. That, in turn, created apprehensions and misconceptions. The speaker witnessed these dynamics at close range as he followed the work of IFS from 1986 to 1990 as a young science journalist who had regular access to Professor Ponnamperuma.

A quarter century after his death, Professor Ponnamperuma is remembered and celebrated as an institution builder of science. This presentation suggests that perhaps his biggest accomplishment in Sri Lanka was not so much setting up laboratories or institutions but inspiring a new generation of young Lankans to pursue careers in science, technology and innovation.

Organic semiconductor distributed feedback (DFB) lasers

Atula S. D. Sandanayaka

Organic, Photonics and Electronics Research Centre, Kyushu University, Japan

Since the discovery of organic solid-state lasers, great efforts have been devoted to the development of continuous-wave (cw) lasing in organic materials, which include small molecules, oligomers, and polymers. However, the operation of organic solid-state lasers under optical cw excitation or pulse excitation at a very high repetition rate (quasi-cw excitation) is extremely challenging. When organic films are optically pumped under such conditions, accumulation of long-lived triplet excitons and charge carriers generally occurs, resulting in an increased absorption loss by the triplet exciton formation and quenching of singlet excitons by triplet excitons (namely, singlet-triplet annihilation). These absorption loss and emission quenching are significant issues that must be solved to achieve cw and quasi-cw operation because they cause the lasing threshold to dramatically increase and, in the worst case, stop the lasing completely.

The molecule 4'-bis[(N-carbazole)styryl]biphenyl (BSBCz)(Figure 1a)has been proven to be extremely promising for organic semiconductor laser devices. Previous work has shown that this material in thin films can exhibit a photoluminescence quantum yield of nearly 100% and a low amplified spontaneous emission (ASE) threshold of about 0.32 μJ/cm^2. Here, we will demonstrate that quasi-cw and cw lasing can be obtained in optically-pumped distributed feedback (DFB) lasers based on BSBCz thin films.

In a DFB structure, a laser oscillation takes place when the following Bragg condition is satisfied: $m\lambda_{Bragg} = 2n_{eff}\Lambda$, where m is the order of diffraction, λ_{Bragg} is the Bragg wavelength, n_{eff} is the effective
refractive index of the gain medium, and Λ is the period of the grating (Figure 1b). When considering a second-order mode ($m = 2$), the grating period is calculated to be Λ = 280 nm using the reported n_{eff} and λ_{Bragg} for BSBCZ. Figures 1c and 1d show SEM images of a representative grating fabricated in this study. We obtained Λ = 280±2 nm and a grating depth of d = 70±5 nm from the SEM images, which are in perfect accordance with our specifications. A 6 wt% BSBCz:CBP blend film or a BSBCz neat film with the thicknesses of 200 nm was prepared on the gratings by vacuum deposition to fabricate the laser devices.

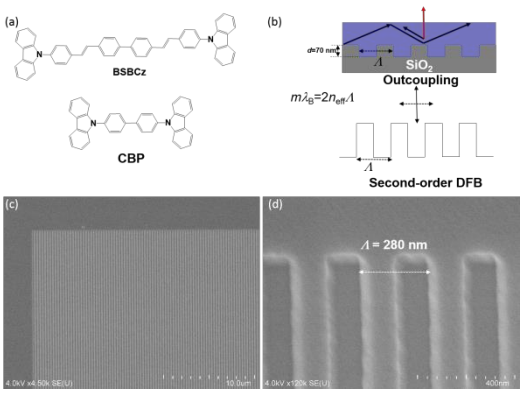

Figure1. (a) Chemical structures of BSBCz and CBP, (b) schematic drawing of a BSBCz:CBP film embedded in a second-order DFB structure, SEM images of the DFB structure at (c) 4500× and (d) 120000× magnification.

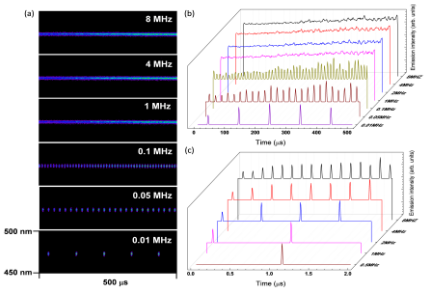

Figure 2. (a) Streak camera images of laser oscillations and (b,c) temporal changes of laser intensities in the BSBCz:CBP blend film. The repetition rate was changed from 0.01 to 8 MHz. The excitation light intensity was fixed at about 0.44 μJ cm^{-2}, which is 1.8-fold higher than E_{th} = 0.25 μJ cm^{-2}. The time scale was 500 μs for (a,b) and 2 μs for (c).

Our devices were operated in the quasi-cw mode using optical pulses with a wavelength of 365 nm and a width of 10 ps from a Ti-sapphire laser. Figure 2 shows the streak camera images of laser oscillations and corresponding temporal changes of laser intensities in the BSBCz:CBP blend film at the lasing wavelength. The

excitation light intensity was fixed at about 0.44 μJ cm^{-2}, which is about two-fold higher than E_{th}. At a repetition rate of 0.01 MHz, lasing oscillations were observed at 100 μs intervals. The time interval between the laser oscillations reduced at higher repetition rates. The neighboring laser oscillations appear continuous at 8 MHz over a wide time scale of 500 μs (Figures 2a and 2b); however, individual laser oscillations at 125 ns intervals could still be identified over a short time scale of 2 μs even at 8 MHz (Figure 2c). We confirmed that similar quasi-cwoperation is possible for the BSBCz neat film.[1]Recently, we show existence of CW lasing and electrically pumped organic laser in BSBCz devices.[1-3]However, electrical characteristics such as charge carrier mobility, charge carrier capture cross section, etc., are also extremely important and will need further investigation and enhancement for electrically pumped organic lasers.

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Facing the challenge of non-communicable diseases in Sri Lanka

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Chronic non-communicable diseases; cardiovascular diseases, diabetes, chronic respiratory diseases and lifestyle related cancers have become the main cause of mortality among adults in Sri Lanka like many high and middle-income countries. This change of epidemiology has occurred within a period of about four decades. The main risk factors for these chronic NCDs are unhealthy diet, tobacco use, sedentary lifestyle and excess use of alcohol.

Diabetes perhaps has the most well described epidemiological data over time. In 1990 diabetes prevalence was around 2.5% among adults and this rose to 10% in 2006. Although a comprehensive countrywide study has not happened since then we are able to have some understanding based on preliminary data from ongoing studies and the small-scale studies. The prevalence of diabetes in the Colombo district in 2006 was 18% and an ongoing study and another small study has indicated this to be above 25% now. This indicates the epidemiological trend and help us to imagine the possible rise in the country.

According to the Ministry of health data cardiovascular diseases are the number one cause of adult mortality. Epidemiological data has confirmed the presence of a significant burden among the adults. Based on the Sri Lanka Diabetes and cardiovascular study in 2006 over 20% adults has hypertension. Recent data from urban adults shows an increasing trend.

Obesity is now defined as a disease and it is a risk factor for many other conditions including all chronic NCDs as well as emerging diseases such as nonalcoholic fatty liver disease. Over 30% of Sri Lankan adults are either obese or overweight and in the recent urban studies the prevalence has been shown to be over 50%.

Primordial prevention, where the interventions are aimed to prevent establishment of risk behaviors is especially applicable to children. In primary prevention, institution of preventive measures in the absence of disease in those with risk factors expected. However, although these approaches are effective, they are at enormous financial costs and widespread applicability in would be a challenge.

Well conducted clinical trials in the west such as the UKPDS has shown the possibility of prevention of complications, disability and death by intensive glycemic control, hypertension control and use of some novel pharmacological agents. Considering the numbers with NCDs it is beyond imagination how our economy and health care system already struggling to provide basic health care would be able to provide high quality care expected in the international guidelines.

Sri Lanka is a good model where remarkable achievements comparable to the developed countries in maternal and child health issues and infectious diseases has been demonstrated at a much affordable cost. Although NCDs pose a different challenge, identification and development of strategies indigenous to Asia would help in winning the battle.

The need of the hour is for to minimize risk factors, prioritize protecting our children and youth, improve surveillance and monitor risk factors, provide an effective multiple risk factor approach in primary health care through the availability of affordable essential drugs and also protecting our communities from unhealthy marketing, through multi-sector action. Novel approaches on screening and community-based prevention considering evidence based and cost-effective approach is essential.

Targeted therapies for cirrhosis and portal hypertension

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There is unmet need for effective medical therapies for end stage liver disease, commonly referred to as liver cirrhosis. The treatment option currently available is liver transplantation but this is hampered by lack of donor livers. Although, there are a number of antifibrotic compounds currently being evaluated in clinical studies in chronic liver disease, the lack of liver specificity of these drugs has raised concerns about their off-target effects and long-term safety and tolerability. A number of experimental studies have provided evidence that the renin angiotensin (Ang) system (RAS) plays a central role in the pathogenesis of liver fibrosis and we have previously shown that in liver disease, drugs that target Ang converting enzyme (ACE) or Ang II type 1 receptor (AT1-R) of the classical RAS can inhibit biliary fibrosis. However, drugs targeting this classic axis of the RAS are poorly tolerated in cirrhosis because they lower peripheral resistance, causing hypotension and renal dysfunction. As a result, there is a lack of clinical studies that have investigated the possible therapeutic role of classic RAS blockers in established chronic liver disease. However, several studies have suggested that the so-called alternate axis of the RAS, which opposes many of the deleterious effects of Ang II, is a potential target for antifibrotic therapies. This alternate RAS axis is driven by ACE2 (a homolog of ACE), which breaks down profibrotic Ang II to antifibrotic heptapeptide Ang-(1-7). We have previously demonstrated that in a short-term model of biliary fibrosis induced by bile duct ligation (BDL) for 2 weeks, Ang-(1-7) infusion inhibited liver fibrosis.

Portal hypertension (PHT) is a clinical syndrome defined by a pathological increase of pressure within the portal vascular system and is the major cause of morbidity and mortality in patients with cirrhosis. Portal hypertension results from both increased hepatic resistance due to fixed obstruction of portal flow and active contraction of activated stellate cells and vascular smooth muscle cells, and increased portal inflow due to pathological vasodilatation of the splanchnic vascular bed, a consequence of the hyperdynamic circulation secondary to liver cirrhosis. The main therapy used to prevent variceal bleeding in cirrhotic patients with PHT is non-selective beta-blockade (NSBB), which reduces portal pressure by decreasing splanchnic blood flow and increasing mesenteric tone. Randomized clinical trials show, however, that although NSBBs are effective in reducing portal pressure and the risk of bleeding from oesophageal varices, around 15% of cirrhotic patients are intolerant of NSBB treatment, and up to 60% fail to achieve the treatment response required to prevent variceal bleeding defined as a fall in hepatic venous pressure gradient (HVPG) to less than 12 mmHg or a decrease of greater than 20% from baseline. We have previously

shown that Ang-(1-7)/Mas receptor (MasR) axis of the alternate RAS is an important mediator in the development of PHT. We have recently reported that Ang-(1-7)/MasR axis is upregulated in the splanchnic circulation of cirrhotic animals and cirrhotic patients.

With rapidly evolving gene transfer technology, gene therapy applications have rapidly expanded to include a wide range of genetic diseases. A recent approval by the U.S. Food and Drug Administration (FDA) to use adeno associated viral (AAV) vector-based gene therapy for a rare form of childhood blindness, a genetic disorder, has provided impetus for the development of gene therapy approaches for non-genetic diseases. In this presentation, novel anti-fibrotic treatment for liver cirrhosis using newly developed liver-specific AAV vector carrying ACE2 is discussed. Moreover, we have recently identified a novel role for G-protein coupled receptor-type D (MrgD) in splanchnic vascular resistance of cirrhotic animals with PHT. In this presentation, development of small molecule drugs targeting MrgD to reduce portal pressure in PHT is discussed.

Nano –fertilizer for urea slow release: concept to technology development

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Although slow release of chemicals at the nanoscale has been extensively used in drug delivery, there is a paucity of work done using nanotechnology-based principles for delivering plant nutrients. In developing countries, the cost of fertilizers can be significant and is often a hurdle in ensuring food security. Urea is a rich, soluble source of nitrogen and therefore a widely used fertilizer. We focus our work on the synthesis of environmentally friendly nanoparticles coated with urea as the crop nutrient that can be released in a slow and sustained manner for use as a nano fertilizer. In this study, the high solubility of urea molecules has been reduced by incorporating it into a matrix of hydroxyapatite nanoparticles.

Hydroxyapatite nanoparticles have been selected for their excellent biocompatibility and as a rich source of phosphorus. In addition, the high chemically active surface area provided by nanoparticles leads to binding of a large amount of urea molecules. The method reported here is uncomplicated and scalable, allowing the synthesis of a urea-modified hydroxyapatite nanohybrid as fertilizer with a ratio of urea to hydroxyapatite of 6:1 by weight. Specifically, a nanohybrid suspension was prepared by coating of hydroxyapatite with urea at the nanoscale in situ. In addition to the stabilization provided due to the high surface area to volume ratio of the nanoparticles, additional stabilization was provided by flash drying the suspension to obtain a solid nanohybrid with high loading of urea. This nanohybrid with 40% nitrogen provides a platform for its slow release. Its potential application in agriculture for maintaining yields and reducing the amount of urea used has been demonstrated.

Biofertilizer Production: A major outcome of the Biological Nitrogen Fixation Project of the National Institute of Fundamental Studies

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The Biological Nitrogen Fixation (BNF) Project is perhaps the first research project that commenced at the Institute of Fundamental Studies (IFS) in 1983. Pioneering studies on BNF covered a wide range of activities on the conversion of inert atmospheric dinitrogen into a combined form, a process confined to certain prokaryotic microorganisms. The scope of the studies extended from nitrogen fixation by free living, heterotrophic and associative bacteria, phototrophic free living and symbiotic cyanobacteria and rhizobial N_2 fixation in symbiosis with root nodules of leguminous plants. These fundamental studies led to the understanding and elucidation of the mechanisms underlying these processes. While these studies provided important results demonstrating the potential of using some of these organisms in crop production, they also showed the limitations of transferring such technologies for practical applications in large scale agriculture. Among the diverse systems studied, the most promising system easily adaptable for agriculture appeared to be the symbiosis between root nodulating rhizobia and their host legumes. These studies involved the isolation, purification, characterization and authentication of rhizobia from different legume crops grown in Sri Lanka. Selected strains were then screened for rapid nodulation and efficient nitrogen fixation with targeted crops under green house and field experiments. The best strains were mass cultured, embedded in sterilized carrier material and provided to farmers as rhizobial biofertilizers. So far, the Rhizobial Inoculant Research and Production Facility has provided such inoculants for soybean, mung bean, vegetable bean, groundnut and the forage legume white clover. In all these instances it has been possible to replace the application of chemical N-fertilizer (urea) by 100% without any reduction in crop yields.

Another major finding from these studies was the realization that microbial communities develop synergistic biomes which are far more effective than single microbial inoculants to enhance nutrient uptake and growth of associated host plants. Years of extensive studies on such communities led to the development of biofilm-biofertilizers (BFBFs), a novel biofertilizer group introduced to science for the first time. These neo biofertilizer inoculants grow in intimate association with a variety of host plants including cereals like rice and corn, several non-legume vegetable crops, ornamental plants, fruit plants and even plantation crops like tea, rubber and coconut.

Extensive field trials conducted in several locations in Sri Lanka have shown that BFBFs are capable of replacing at least 50% of all three major chemical fertilizers N, P & K added to crops and sometimes bring about even an increase in yields.

The NIFS is therefore confident that provision of such biofertilizers under a National Policy Scheme, could reduce chemical fertilizer use which would not only make a significant saving of foreign exchange, but also lead to a cleaner environment and minimize environmentally related health problems.

CRISPR/Cas9 Gene Editing to Improve Crop Health in the Arms Race between a Host and Pathogen

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The world population is predicted to reach 9.7 billion by 2050 (approx. 2 billion increase in the next 30 years). The agricultural landmass is depleting due to urbanization and farming families giving up cultivation to move to larger cities. Overuse of the same agricultural land is reducing fertility. In addition, global warming is restricting productivity in food crops. Pests and diseases in crops cause an enormous limitation to overall crop yield. With such constraints, it is evident that new technologies that are used in human health discoveries need to be assessed and used in the advancement of agriculture and crop productivity. The interaction between a pest or plant pathogen with its host needs to be better understood in order to control the pests and pathogens. Clustered Regularly Inter Spaced Palindromic Repeats (CRISPR) is a new technology for gene editing, with promising potential in medicine and in agriculture. CRISPR/Cas9 is a tool that helps to edit genes either to improve crop productivity and health, or understand the host-pathogen interactions well. Gene editing is a method in which DNA is inserted, deleted, modified or replaced in the living organism. Genome editing targets the insertions to site specific locations, making the technology and the use of it safe. The CRISPR-Cas9 system was selected by the world's top peer reviewed journal Science in 2015 as the "Breakthrough of the Year". CRISPR technology was used to help patients with blood disorders. A Beta Thalassemia patient has been treated with CRISPR/Vertex CTX001 now a transfusion-independent method. Other human diseases such as certain cancers, other blood disorders, blindness, AIDS, cystic fibrosis, muscular dystrophy and Huntington's disease are undergoing clinical evaluations using CRISPR technology. The evolutionary arms race between plants and fungal pathogens is an important phenomenon to be investigated. Host plants (field crops) elicit compounds as a plant defence mechanism against a pathogen, and these at times could promote or enhance the virulence of other pathogens. Fungi use countermeasures to detoxify plant antimicrobial compounds and to evade host resistance mechanisms. My lab has used the CRISPR-Cas9 system to better understand how plant pathogens interact with its host crop in causing disease and understand the intrinsic defense pathways of host plants and virulence of plant pathogens. Canola (Canada + Oil) is the healthiest edible oil in the market, with only

7% of saturates. In addition, it has 21% of linoleic acid (an omega-6 fatty acid) and 61% of oleic acid (an omega-9 fatty acid), which are both essential and beneficial to human health. In Canada, the annual revenue from canola is 26.5 billion dollars making it the number one cash crop surpassing wheat. A plant pathogen known as *Leptosphaeriamaculans* causes blackleg disease in *Brassica napus* (canola) and is the most devastating disease of canola in the world. My lab has CRISPR technology to knockout key genes responsible for pathogenicity and virulence in the blackleg-pathogen. The knockout mutants were used alongside the wild-type strains to decipher key genes related to virulence using transcriptomic (RNASeq) and genomics approaches. The upregulated genes are further investigated through quantitative real-time PCR (q-RT-PCR) and validated for activity changes. Key genes are further characterized through functional analysis. Therefore, these studies are very much helpful to identify key defense genes in the host plant and understand how these genes function to protect the plant from invading pathogens. The data generated will be useful to develop breeding strategies that will incorporate these known key genes (i.e. for resistance). Breeding programs can utilize the information to have crops resistant to plant pathogens through precision breeding. In turn, it will reduce the reliance on pesticides to control and manage diseases and pests. The overall reduction of pesticide-use will increase the environmental sustainability and food safety while promoting agricultural productivity and yield gain. The use of new biotechnological tools as CRISPR will not only help patience with certain human diseases, but also will help agricultural productivity to feed a growing and an ever-increasing population in the world. In the future, gene-editing technologies as CRISPR-Cas9 will help grow healthier, more sustainable, economically viable, and globally accepted crops that will benefit farmers, processors and consumers everywhere.

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