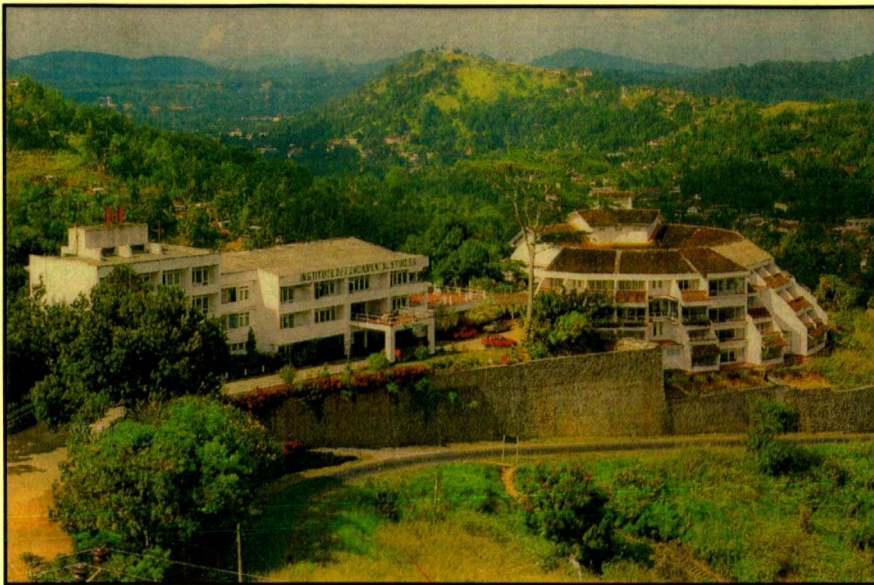


ANNUAL RESEARCH REPORT 2008



**INSTITUTE OF FUNDAMENTAL STUDIES
HANTANA ROAD
KANDY**

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INSTITUTE OF FUNDAMENTAL STUDIES

ANNUAL RESEARCH REPORT 2008

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PUBLICATIONS IN REFEREED JOURNALS IN 2008

1. Baillie I.C., Gunatilleke I.A.U.N., **Seneviratne G.**, Gunatilleke C.V.S., and Ashton P.S. Preliminary characterization of the physiography and soils of the 25 ha long-term forest ecological research plot at Sinharaja, south-western Sri Lanka. *Sri Lanka Forester* **29**, 2008 (*in press*).
2. **Bandara J.** and Pradeep U.W. Tuning of the flat-band potentials of nanocrystalline TiO₂ and SnO₂ particles with an outer-shell MgO layer. *Thin Solid Films*, **517**: 952-956 (2008)^{1,2}.
3. Fernando J.M.R.C. and **Senadeera G.K.R.** Natural anthocyanins as photosensitizers for dye-sensitized solar devices. *Current Science*, **95 (5)**: 663 (2008)^{1,2}.
4. *Fernando J.M.R.C. and **Senadeera G.K.R.** Synthesis and characterization of thiophene co-polymers and their use in photovoltaic cells. *Current Science*, **95(6)**: 743 (2008)^{1,2}.
5. **Kehelpannala K.V.W.** and Yoshida M. Permo-Triassic Ultra High Temperature Metamorphism, Mesozoic Magmatism and Pleistocene Volcanisms and Gold Mineralization in the Kyushu Island, SW Japan: An Excursion. Episodes, *Journal of International Geoscience*, 2008 (*in press*)^{1,2}.
6. **Magana-Arachchi D.**, Perera J., Gamage S., and Chandrasekharan V. Low Cost In House PCR for Routine Diagnosis of tuberculosis. *International Journal of Tuberculosis and Lung Disease*, **12(3)**: 275-280 (2008)^{1,2}.
7. **Magana-Arachchi D.N.**, Wanigatunge R.P., and Jeyanandarajah P. Setting up a Polymerase Chain Reaction Assay for the detection of toxic cyanobacteria. *Journal of National Science Foundation of Sri Lanka*, **36(3)**: 229-233 (2008)².
8. Milligan, Lauren A; Rapoport, Stanley I; Cranfield, Micheal R; **Dittus, Wolfgang**; Glander, Kenneth E; Oftedal, Olav T; Power, Michael L; Whittier, Christopher A; Bazinet, Richard, P. Fatty acid composition of wild anthropoid primate milks, *Comparative Biochemistry and Physiology, Part B*. **49**: 74-82 (2008)^{1,2}.
9. **Nanayakkara A.** Semiclassical Quantization of 2-D non-Hermitian Systems: Classical (Lie Transform) Perturbation theory. *Journal of the National Science Foundation*, 2008 (*in press*)².
10. **Ramanayake S.M.S.D.**, Maddegoda K.M.M.N., Vitharana M.C., and Chaturani G.D.G. Root induction in three species of bamboo with different rooting abilities. *Scientia Horticulturae*, **118**: 270-273 (2008)^{1,2}.

11. Samarasinghe P., Nguyen D., Behm M. and **Wijayasinghe A.** Electrochemical behaviour and material characteristics of $\text{Li}(\text{Ni}_{1/3}\text{Ni}_{1/3}\text{Mn}_{1/3})$ synthesized by Pechini method for positive electrode in Lithium ion battery. *Electrochimica Acta*, 2008 (in press)^{1,2}.
12. **Seneviratne G.** Biological nitrogen fixation: potential biotechnological applications beyond biofertilizers. *Current Science*, **95**: 7 (2008)^{1,2}.
13. **Seneviratne G.**, Zahir J. S., Bandara W.M.M.S. and Weerasekara M. L. M. A. W. Fungal-bacterial biofilms: their development for novel biotechnological applications. *World Journal of Microbiology and Biotechnology*, **24**: 739-743. (2008)².
14. Shankar K., **Bandara J.**, Paulose M., Wietasch H., Varghese O.K., Gopal K. Mor, LaTempa Thomas J., Thelakkat M., and Grimes C.A. Highly efficient solar cells using TiO_2 nanotube array sensitized with a donor-antenna dye. *Nano Letters*, **8**: 1654-1659 (2008)^{1,2}.
15. Yasomanee J. P. and **Bandara J.** Multi-electron storage of photoenergy using $\text{Cu}_2\text{O-TiO}_2$ thin film photocatalyst. *Solar Energy Materials and Solar Cells*, **92**: 348-352 (2008)^{1,2}.
16. Yoshida M. and **Kehelpannala K.V.W.** Gondwana to Asia: Forth international symposium. *Episodes, Journal of International Geoscience*, 2008 (in press)^{1,2}.
17. Zahir J.S., Jayasekara A.P.D.A., **Seneviratne G.**, and De Silva M.S.D.L. Potential application of biofilms: a new approach for tea gardens. *Tea Bulletin (TRI Sri Lanka)*, **20**: 1-6. (2008).

* Reported as "in press" in Annual Report 2007

¹ Listed in the Science Citation Index in 2008

² Listed in the Science Citation Index-expanded in 2008

**IMPACT FACTORS OF JOURNALS IN WHICH, THE ARTICLES ARE
PUBLISHED**

*(Impact factors are computed to an accuracy of three decimal places,
X-Impact Factor not computed for the year 2007)*

JOURNAL	IMPACT FACTOR
<i>Comparative Biochemistry and Physiology, Part B</i>	2.345
<i>Current Science</i>	0.8
<i>Electrochemica Acta</i>	2.848
<i>Episodes, Journal of International Geoscience</i>	0.868
<i>International Journal of Tuberculosis and Lung Disease</i>	2.24
<i>Journal of National Science Foundation of Sri Lanka</i>	X
<i>Nano Letters</i>	9.627
<i>Scientia Horticulturae</i>	0.694
<i>Solar Energy Materials and Solar Cells</i>	2.002
<i>Sri Lanka Forester</i>	X
<i>Tea Bulletin (TRI Sri Lanka)</i>	X
<i>Thin Solid Films</i>	1.693
<i>World Journal of Microbiology and Biotechnology</i>	X

**PROJECT: COMPUTATIONAL MATHEMATICS
AND PHYSICS
(I) BRAIN COMPUTER INTERFACE**

COMMENCEMENT: 2006

INVESTIGATORS (2008):

Nanayakkara A., *Associate Research Professor (Project Leader)*
Zahmeeth Sakkaff, *Research Assistant*

PROGRESS ACHIEVED (Since inception):

Scope of the Project:

This project is aiming at building a Brain Computer Interface (BCI) system, which provides communication link between the human brain and a computer, especially for patients who suffer from severe motor impairments (late stage of Amyotrophic Lateral Sclerosis (ALS), severe cerebral palsy, head trauma and spinal injuries). This way, the patients who are with severe physical disabilities can control equipments such as Wheel chairs, TVs, etc. and communicate with computer voice in his or her native language (in Sinhala, Tamil or English).

Overview:

For many years, several research laboratories around the world and various research groups in Europe and USA have been working on systems, which allow for a direct dialog between man and machine. One of the outcomes of these efforts is "Brain Computer Interface" (BCI). A brain-computer interface (BCI) or direct neural interface is literally a direct technological interface between a brain and a computer not requiring any motor output from the user. That is, neural impulses in the brain are intercepted and used to control an electronic device such as computer. The Electroencephalogram (EEG)-based Brain Computer Interface is one of the methods used in BCI, which measures the brain activity in order to control a device just by thoughts. EEG - based Brain-Computer Interface (BCI) system is a an alternative communication software channel, which allows people to use scalp-recorded EEG activity to control a device such as a computer cursor to give paralyzed patients greater ability to interact with their environment.

Aim of this project is two fold. The first is to develop a working BCI system with existing and new signal processing techniques. The second is to find new cognitive tasks which change EEG patterns such that they can be used for improving BCI system.

BCI systems consist of two components; hardware and software. With the hardware, EEG signal is amplified and then digitized. Then the digitized EEG signal is analyzed by a digital computer. According to the outcome of the analysis, the computer will take actions using pre-programmed instructions.

One of the major noise contaminations in EEG recordings is due to the electrooculographic (EOG) artifacts. The EOG signal is generated by electrical eye activity such as eye blink or eye moment which propagates all over the body through volume conduction and can be recorded at the body surface. Since eye moments are difficult to suppress over the period of EEG recording, almost all the EEG recordings get contaminated with EOG artifacts. Therefore it is very important to remove ocular artifacts from scalp recorded EEG's, leaving underlying background signals due to brain activity intact. The first part of the project involved in investigating existing EOG artifacts removal methods and developing new techniques to remove artifacts efficiently. A new nonlinear method was implemented for removing EOG artifacts from EEG signals. The method was tested with data down loaded from Artificial Intelligence Group, Department of Computer Science, and University of Colorado, USA. It was found that quadratic regression method which we developed performed the best among many methods tested.

The theoretical and computational parts of the project have been carried out. The existing signal processing methods developed for EEG were studied. Also we developed software for analyzing EEG data with Short time Fourier transforms and Linear predicting coding techniques. From the internet, large amount of event specific EEG data has been down loaded and used for testing the software which we are developing.

PROJECT OUTPUT 2008:

Due to malfunctioning of the EEG Hardware experimental part of the project was not carried out in 2008. The equipment was sent back to the manufacturer for repair.

Software for preprocessing multi-channel EEG signals using band pass filtering, construction of feature vectors using band powers and downsizing of data and classifications using linear discriminant analysis have been implemented in 2008.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

1. **Sakkaff Z. and Nanayakkara A.**
Removal of ocular artifacts from EEG signals in Brain Computer Interface
Proceedings of the Technical Sessions, 24 (2008) 51-57 Institute of Physics Sri Lanka.

OTHER CONTRIBUTIONS IN 2008:

Until March 2008, the project leader was working as a Course Director at Uva Wellassa University (UWU) on sabbatical leave. Major work carried out at UWU during 2008 was

- (a) Development of courses for new Industrial Information Technology degree program.
- (b) Development of new courses for Computational Chemistry
- (c) Preparing exam papers and conducting examinations for second year students
- (d) Various administrative and academic activities at the University

**PROJECT: COMPUTATIONAL MATHEMATICS
AND PHYSICS**

(II) QUANTUM CHAOS

COMMENCEMENT: 2000

INVESTIGATORS (2008):

Nanayakkara A., *Associate Research Professor (Project Leader)*

PROGRESS ACHIEVED (*Since inception*):

Scope of the Project:

This is purely a theoretical project to investigate the peculiar behavior of multi dimensional systems in the semiclassical limit. (i.e. limit between quantum mechanics and classical mechanics)

Overview:

In recent years, the manifestation of chaos in quantum mechanics has been of great interest. In particular, quantum systems which are classically chaotic have been investigated intensively. In order to study signature of chaos in quantum mechanics, we have been developing various theoretical and computational methods for multidimensional systems which bridge classical mechanics with quantum mechanics in a transparent manner. Also we have been investigating quantum mechanical quantities which contain information on chaos in the corresponding classical system. Major achievements of this project since its inception (till end of the year 2007) can be summarized as follows:

- (1) A new powerful asymptotic energy expansion method was developed for 1-D systems. This method is based on power series expansion of the quantum action variable J in energy and can be applied to a wide range of potentials. Contour integrals involved in the method are much simpler than that in WKB methods.
- (2) A new quantization condition was developed for 1-D systems. This new method is a computational method which can be applied to large number of 1-D systems.
- (3) The semi-classical concepts and methods which are normally used for studying semi-classical chaos in real phase-space were extended to complex phase-space for studying both PT-symmetric and pseudo Hermitian systems. It is found that most of the semi-classical methods which have been developed for quantizing multi-dimensional real Hermitian Hamiltonian systems can be successfully employed for complex non-Hermitian PT-symmetric systems with suitable extensions
- (4) Several 1-D and 2-D pseudo Hermitian Hamiltonian systems have been studied. The Lyapunov exponents and classical phase space trajectories were used to distinguish regular motion from chaotic ones. The quantum energy

level statistics were used to identify quantum signatures of classically chaotic motion.

- (5) A new analytical method was developed for locating zeros of wave functions. In this method locating zeros of the wave function is converted to finding roots of a polynomial whose coefficients are obtained as analytical expressions.
- (6) Distribution of zeros of quantum wave functions and second differences of energy at avoided crossings were investigated. We developed new approximation and numerical methods for locating zeros of wave functions. Hermitian systems have been studied to establish a connection between classical chaos and behavior of quantum eigen states at avoided crossings.
- (7) Non-PT symmetric systems were studied with non-perturbative action angle theoretical methods. Semiclassical Lie transformation methods were modified for complex non-Hermitian systems.
- (8) Asymptotic energy expansions of general cubic polynomial complex potentials were derived using new integration techniques. Both complex and real eigen values of the above system are obtained using the asymptotic energy expansion. Quantum eigen energies obtained by the above method are found to be in excellent agreement with the exact eigen values.
- (9) Complex symplectic structure of phase space of non-Hermitian Hamiltonian systems were studied and for several systems Birkhoff normal forms were derived and reality of constants of motion of multidimensional systems was studied with Birkhoff normal forms and Lie Transform methods.

PROJECT OUTPUT 2008:

Periodic and quasiperiodic nature of classical trajectories of 2D non-Hermitian Hamiltonian systems were investigated using classical perturbation theory. Approximate expressions for classical frequencies were found in analytic form in terms of the second constant of motion. It was found that the classical trajectories are quasiperiodic if both quantum spectra and the second constant of motion are real.

Behavior of trajectories of PT symmetric Henon Heiles system was investigated with surfaces of section, power spectral methods and Lyapunov exponents. It is revealed that unlike in real Henon Heiles oscillators, no chaos was present in the PT symmetric version and only the regular and the escaping trajectories exist. It was found that for certain initial momentum values, regular quasiperiodic motion can be observed for energies as high as $E=10^6$ although the escape energy of the system is $1/6$. It was also found that the trajectories of real Henon Heiles oscillators starts with complex initial conditions do not show any chaotic behavior but regular and escaping behavior as in the PT symmetric case. Results from this investigation indicate that chaos in complex phase space of multi dimensional systems may be rare.

This project has produced 24 research papers and 3 research communications during last seven years.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

1. *Title:* Semiclassical Quantization of 2-D non-Hermitian Systems:
Classical (Lie Transform) Perturbation theory
Author: **Nanayakkara A.**
Journal: ***Journal of the National Science Foundation*, 2008 (in press)²**

² ***Listed in the Science Citation Index-expanded in 2008***

PROJECT: PHOTOCHEMISTRY

COMMENCEMENT: 1999

INVESTIGATORS (2008):

Bandara J., *Senior Research Fellow (Project Leader)*
Pradeep U.W., Volunteer Research Assistant

PROGRESS ACHIEVED (Since inception):

- The project successfully demonstrated use of n-p junction electrode for the control of charge recombination in dye-sensitized solar cells.
- Investigated the effect of coating of thin insulating oxide layer on semiconductor electrode materials on performance on solar cell efficiency and photocatalytic activities. The mechanistic aspects of these processes were established.
- The use of p-type oxide semiconductors in dye-sensitized solid-state solar cells was successfully demonstrated.
- Electrochemical and photochemical methods for the purification of water were developed.
- Photochemical and photoelectrochemical methods for the production of renewable energy such as H₂ were investigated.

Number of Publications during 1999 - 2008 in SCI journals: 34

PROJECT OUTPUT 2008:

Work on solid-state dye-sensitized solar cells and Photosplitting of water using dye sensitized solar cells with tandem structure were continued. A dye-sensitized solar cell with TiO₂ nanotube arrays was initiated.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

1. *Title:* Highly efficient solar cells using TiO₂ nanotube arrays sensitized with a donor-antenna dye
Authors: Shankar K., **Bandara J.**, Paulose M., Wietasch H., Varghese O.K., Mor G.K., Tampa T.J., Thelakkat M.A., and Grimes C.A.
Journal: *Nano Letters*, 8: 1654-1659 (2008)^{1,2}

2. *Title:* Tuning of the flat-band potentials of nanocrystalline TiO₂ and SnO₂ particles with an outer-shell MgO layer
Authors: **Bandara J.** and Pradeep U.W
Journal: ***Thin Solid Films*, 517: 952-956 (2008)^{1,2}**

3. *Title:* Multi-electron storage of photoenergy using Cu₂O-TiO₂ thin film photocatalyst
Authors: Yasomanee J.P. and **Bandara J.**
Journal: ***Solar Energy Materials and Solar Cells*, 92: 348-352 (2008)^{1,2}**

¹ *Listed in the Science Citation Index in 2008*

² *Listed in the Science Citation Index-expanded in 2008*

RESEARCH GRANT:

NRC research grant was awarded to the Photochemistry Project in 2008.

PROJECT : SOLID STATE CHEMISTRY

(Chemistry, preparation and characterization of semiconducting materials, conducting organic solids and polymers)

COMMENCEMENT : 1999

INVESTIGATORS (2008):

Senadeera, G.K.R. *Senior Research Fellow (Project Leader)*
Thotawatthage C., *Volunteer Researcher*

PROGRESS ACHIEVED (since inception):

Solid-state chemistry by its nature, with its interdisciplinary history, has the ability to prepare and educate its graduates to excel in a wide variety of industries including the fields of energy, pharmaceuticals, optical materials and all manner of electronic devices, and nano and biotechnology. Since these emerging technologies depend on the discovery of new materials and their properties, the Solid-State Chemistry project at IFS, which was initiated in 1999, deals with the investigations on the determination of fundamental physico-chemical aspects that are centered to polymeric/organic materials and conventional semiconductors, which have been the object of increasing academic and technological interest during the last 10-15 years. The chemical aspects of the project specifically target at novel ways of synthesising, new organic, inorganic, layered or porous semi-conducting solids, and hybrid organic-inorganic compounds which were synthesized either in the bulk or as thin films or nano particles. The structural and the surface properties are be addressed both from *in situ* and *ex situ* experimental methods in the physical aspects of the project. A particular emphasis is paid on electrical (metallic or semiconductors, ionic and mixed conductors) features associated with the microstructures of these solids. The Standard characterization methods such as (CV) cyclic voltametry, SEM, TEM, XPS, FTIR, AC impedance and photocurrent techniques are being used to characterize the materials involved in these investigations.

Research and development achievements that can be used in industry:

1. The identification of complexes of Cu(I) bromide with sulfides which could be used as a novel hole conducting material in low cost solid state solar cells (*Sri Lankan Patent No. 11982*).
2. Construction of a fully automated spray pyrolysis unit (equipment) to prepare homogenous nanocrystalline oxide semiconducting thin films.
3. Successfully fabricated efficient solar photovoltaic device comprising with chemically attached poly 3-thiopnyl acetic acid as the sensitizer for several nanocrystalline semiconductors, (*An international patent No. NKS 2624-2003-36805*).

NIPPON KAYAKU CO.,LTD. Functional Chemical Res. Lab. 26-8,Shimo 3-Chome,Kita-Ku,Tokyo,Japan Tel:03-3598-5101(direct) Fax:03-3598-5431.

4. For the first time in the field of polymer sensitized solid state solar cells , novel, volatile solvent free, solar cells were fabricated with mesoporous TiO₂ electrodes. derivatives.(*Chem.Com. Royal Society of Chemistry UK, 2005,17,2259*).

5. Discovery of a new method for deposition of CuSCN on dye coated TiO₂ films.

Total No. of articles published (since inception, 1999-)

(a) In refereed journals cited in Science Citation Index + expanded = 24

(b) In other refereed journals = 5

(c) Abstracts and conference proceedings: 24

(d) Conference proceedings full papers: 10

(e) Patents : (1) Sri Lankan Patent No. 11982,

(2) International Patent No. NKS 2624-2003-36805

(f) Presidential Awards for Research Publications in Science Citation Index- 1999, 2000, 2001 and 2002

(g) Research Grants :

(i) National Science Foundation, Sri Lanka

(ii) National Science Foundation, Sri Lanka (for spare parts)

(iii) TWAS (The academy of sciences for the developing world) Trieste, Italy

(iv) National Research Council – Sri Lanka

PROJECT OUTPUT 2008:

1. Quasi-solid, natural rubber polymer electrolyte for dye sensitized solar cells

G.K.R. Senadeera and C. Thotawatthage

Recently, the use of modified natural rubber in polymer electrolyte systems has received much attention. This is due to their distinctive characteristic such as low glass transition temperature, T_g, soft elastomer characteristics at room temperature, good elasticity and adhesion that making them a suitable candidate in polymer electrolyte systems. With these characteristics, it is predicted to give excellent contact between an electrolytic layer and an electrode in batteries.

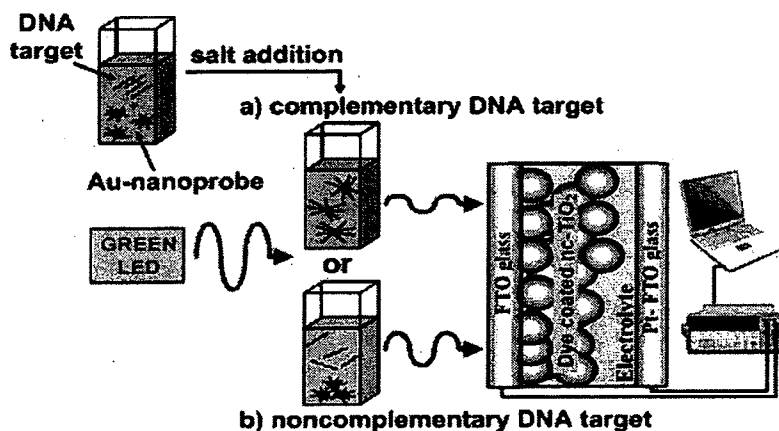
Keep this in mind and, since Sri Lanka having one of the worlds best natural rubber, in this study, we have focused our investigations to explore the possibilities of use of natural rubber in novel power devices such as in dye sensitized solar cells and rechargeable batteries.

(Manuscript in preparation)

2. A novel, opto-electrical DNA sensor based on inkjet printed dye sensitized TiO₂ device and gold nanoparticles

Rohan Senadeera, Iwona Bernacka-Wojcik, Pawel Jerzy Wojcik, Leonardo Bione Silva, Gonçalo Doria, Pedro Baptista, Hugo Aguas, Elvira Fortunato and Rodrigo Martins

A novel, low cost, colorimetric sensor, based on a dye sensitized TiO₂ photo-device and gold nanoparticles, has been fabricated for the specific DNA detection. Moreover, we demonstrate here for the first time the use of ink-jet printing technology for the deposition of the active layers of the dye sensitized photo-devices. This sensor comprises a dye-sensitized nanocrystalline TiO₂ device as a photodetector for sensing of colorimetric changes in the DNA-functionalized gold nanoparticles solution. Due to its integrating mode of operation, this sensor can clearly distinguish between complementary and non-complementary target DNA. This combination of three modern technologies leads to significant cost and time savings in nucleic acid detection assays, allowing genetic diagnostics at point of care, without compromising specificity and sensitivity.



(Manuscript is ready for submission)

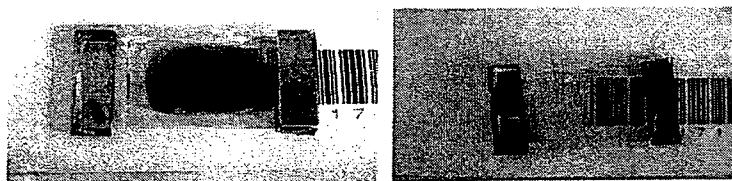
3. Ionic Liquid based tertiary inorganic salt mixtures as efficient solid electrolytes for electro-chromic devices.

Rohan Senadeera, Claudia Costa, Alexandra Gonçalves, Rodrigo Martins and Elvira Fortunato

A new preparation method was developed to produce WO₃ nano particles(which can be used with novel inkjet printing technique on conducting papers) for electrochromic displays and an efficient new polymer electrolyte was discovered with ionic liquids to employ in these devices .

(Planning to patent both works.) (Manuscript is ready for submission)

Colored (a) and Bleached (b) state of Electrochromic device



(a)

(b)

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

1. **Title:** Natural anthocyanins as photosensitizers for dye-sensitized solar devices
Authors: Fernando J.M.R.C. and **Senadeera G.K.R.**
Journal: *Current Science*, **95(5): 663 (2008)**^{1,2}
- 2*. **Title :** Synthesis and characterization of carboxylated thiophene co-polymers and their use in photovoltaic cells
Authors: Fernando J.M.R.C. and **Senadeera G.K.R.**
Journal: *Current Science*, **95(6): 743 (2008)**^{1,2}

*** Reported as "in press" in Annual Report 2007**

¹ **Listed in the Science Citation Index in 2008**

² **Listed in the Science Citation Index-expanded in 2008**

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

1. **Senadeera G.K.R., Martins R., Fortunato E.**
Hybrid dye sensitized solar cells: Photovoltaic devices employ inorganic-organic semiconducting materials and their applications
Meeting abstracts,¹⁰ ENCONTRO-13N meeting, October, 2008, Fatima, Portugal, page 42.

PROJECT:**ELECTROCHEMICAL MATERIALS**

(Materials Science and Engineering, Synthesis and characterisation of inorganic materials, Materials for electrochemical energy conversion, Batteries and fuel cells, Fundamental studies on synthesizing Nano-materials and feasibility of Sri Lankan minerals for these applications)

COMMENCEMENT: 2005**INVESTIGATORS (2008):**

Wijayasinghe H.W.M.A.C., *Research Fellow (Project Leader)*

Samarasinghe P.B., *Research Assistant*

PROGRESS ACHIEVED *(since inception):*

The increasing demand for energy has made it extremely important to develop high efficient electrochemical energy conversion devices such as fuel cells and batteries. This project mainly emphasizes the synthesis and characterization of low-cost and performance enhanced materials for these electrochemical energy conversion applications. In going along this direction, investigation of Sri Lankan minerals for these potential high tech applications and applying Nano-Technology to enhance performance of these materials are also being investigated. So far, this project engaged with the research and development work under five sub-projects involving three types of fuel cells; Molten Carbonate Fuel Cell (MCFC), Intermediate Temperature Solid Oxide Fuel Cell (ITSOFC) and Microbial Fuel Cell (MBFC), and two types of batteries; Silver-ion Batteries (AIB), Rechargeable Li-ion batteries (LIB).

Some of the achievements;

A novel idea of devising a "Sri Lankan Li-ion battery" has been investigated with the electrodes developed at IFS and the electrolytes developed at Solid State Ionics Research Group, University of Peradeniya. The preliminary cell devising work has resulted in promising performances. Further, under the work on Microbial Fuel Cell (MBFC), a novel idea of devising a "Biological Fuel Cell" has been investigated with the microbes developed at IFS. The preliminary work of assembling this Microbial Fuel Cell (MBFC) has shown promising results.

Total number of articles published;

- (a). In refereed journals cited in Science Citation Index = 1
- (b). Conference proceedings (abstracts) = 2

PROJECT OUTPUT:

Under the work on electrode materials for carbonate fuel cells and modern Li-ion batteries, a number of new compositions have so far been synthesized under NiO-LiCoO₂, LiCoO₂-LiFeO₂ and LiFeO₂-NiO binary systems and, NiO-LiCoO₂-LiFeO₂ and LiNiO₂-LiCoO₂-LiMnO₂ ternary systems. The outcome of the study shows promising characteristics of these materials for these applications. Specially, this study reveals the ability of improving the electrochemical properties and the stability of the material while preserving the desired crystal and microstructure. Further, the investigations on oxygen-ion conducting, lanthanum galates, and Ag-ion conducting fast-ion-conductors for oxide fuel cells and low-cost Ag batteries are in progress now.

Under a research collaboration with the Department of Materials Science and Engineering in Royal Institute of Technology (KTH) Sweden, some of the advanced characterizations of these materials have been performed at KTH, during a three month research fellowship given to Mr. P. B. Samarasinghe from November 2007 - January 2008.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

- Title:** Electrochemical behaviour and material characteristics of Li(Ni_{1/3}Ni_{1/3} Mn_{1/3}) synthesized by Pechini method for positive electrode in Lithium ion battery

Authors: Samarasinghe P., Nguyen D., Behm M., and Wijayasinghe A.

Journal: *Electrochimica Acta*, 2008 (in press)^{1,2}

¹ *Listed in the Science Citation Index in 2008*

² *Listed in the Science Citation Index-expanded in 2008*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

- H. W. M. A. C. Wijayasinghe**
LiCoO₂- NiO- LiFeO₂ ternary materials for the Molten Carbonate Fuel Cell cathode
Proceedings of the 64th Annual Sessions of the Sri Lanka Association for the Advancement of Science, December 2008, Page 127
- Samarasinghe P. B., Pansalawatte P.W. and Wijayasinghe H.W.M.A.C.**
Synthesis and electrical characterization of Li(Ni_{1/3}Co_{1/3x}Mn_{1/3}Mg_x)O₂ and Li(Ni_{1/3}Co_{1/3-x}Mn_{1/3-x}Mg_x)O₂ for lithium ion rechargeable battery positive electrodes
Proceedings of the 64th Annual Sessions of the Sri Lanka Association for the Advancement of Science, December 2008, Page 130

PROJECT: PLANT CELL BIOLOGY

COMMENCEMENT: 2001

INVESTIGATORS (2008):

Magana-Arachchi D.N., *Research Fellow (Project Leader)*

Wanigatunge R.P., *Research Assistant*

Meegahakumbura M.K.M., *Research Assistant-NSF*

Ambalavanar V., *Research Assistant – Volunteer*

PROGRESS ACHIEVED (from 2004 December):

Microorganisms are the most numerous and important organisms on Earth which are of great importance in biological systems. During the past four years, the thrust of this project was to combine the molecular-genetic approaches with state-of-the-art microscopy to determine the role of microbes in nature. The principle objective of the research carried was to isolate cyanobacterial and archaeal species in Sri Lankan waters both fresh and marine, and to determine the phylogenetic relationship using the 16S rDNA sequences.

In addition, investigation on bacteria, both from environmental and clinical samples were carried out.

Scope of the project:

- a. Isolation and identification of cyanobacteria to ascertain their biodiversity
- b. Development of assays for water –borne toxicants.
- c. Study on *Mycobacterium tuberculosis* strains
- d. Study of aspects of bio control and formulation of methodologies for the isolation of *cry* genes in *Bacillus thuringiensis*
- e. Innovation of methods to isolate genomic DNA

PROJECT OUTPUT 2008:

Study on Cyanobacteria

The studies started in previous year were continued. Experiments were carried out with field /cultured samples collected from Gregory Lake, Nuwara Eliya to isolate cyanobacterial species and to determine the phylogenetic relationship using the 16S rDNA sequences. Extraction of toxin was carried out for *Chroococcidiopsis* YRS4a (EU310420), *Chroococcidiopsis* D3 (EU310430), *Chroococcidiopsis* L5 (EU276383), *Chroococcidiopsis* 1R (EU276382), *Chroococcidiopsis* Batti 6.2. (EU310432), *Microcystis aeruginosa* (PCC 7941) and *Microcystis aeruginosa* (EF051238). HPLC and FTIR analysis were performed for the above extracted toxins.

Study on *Mycobacterium tuberculosis* strains

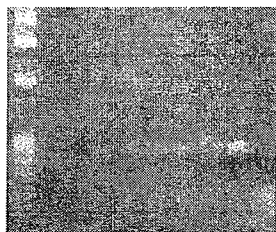
Two research projects on tuberculosis were continued.

1. Restriction Fragment Length Polymorphism (RFLP) analysis and Spoligotyping on *Mycobacterium tuberculosis* strains isolated from patients attending the Central Chest Clinic Kandy – NSF Grant –RG/2006/HS/07
2. Rapid Detection of multidrug – resistant *Mycobacterium tuberculosis* strains using PCR assays.

Around 185 sputum specimens were collected from smear positive TB patients for analysis. Biochemical tests, Antibiotic sensitivity testing for the two drugs isoniazid and rifampin, Southern blot hybridizations and Restriction Fragment Length Polymorphism (RFLP) detections were carried out for *Mycobacterium tuberculosis* isolates. PCR procedures were developed to identify the resistant strains of *Mycobacterium tuberculosis* originating from patients clinical specimens for the two drugs isoniazid and rifampin.



248 bp



158 bp

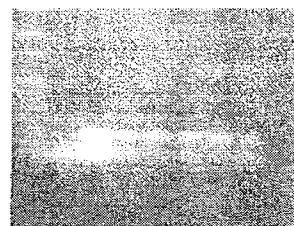


Figure 1: RFLP Analysis Figure 2: *inhA* gene

Figure 3: *rpoB* gene

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

1. **Title:** Low Cost In House PCR for Routine Diagnosis of tuberculosis
Authors: **Magana-Arachchi D.**, Perera J., Gamage S. and Chandrasekharan V.
Journal: ***International Journal of Tuberculosis and Lung Disease***, 12 (3): 275-280 (2008)^{1,2}
2. **Title:** Setting up a Polymerase Chain Reaction Assay for the detection of toxic cyanobacteria
Authors: **Magana-Arachchi D.N.**, Wanigatunge R.P, and Jeyanandarajah P.
Journal: ***Journal of National Science Foundation of Sri Lanka***, 36(3): 229-233 (2008)²

¹ **Listed in the Science Citation Index in 2008**

² **Listed in the Science Citation Index-expanded in 2008**

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008 :

1. **Magana-Arachchi D.N.** and Wanigatunge R.P.
Molecular and morphological characterization of cyanobacteria and archaea in hot water springs Mahapelessa (**full paper**)
Aries Kovoov Memorial Symposium: Innovations in Plant Sciences through Multidisciplinary Research, Pragna, IFS Science Bulletin (Special Issue) Vol.XIX (1): 51-59. (2008)
2. **Magana-Arachchi D.N.**, Perera A.J., Senaratne V., and De Silva K.
Antimicrobial Resistance Among Re Treatment TB Patients; Sri Lankan Experience
Proceedings of the Ehrlich II, 2nd World Conference on Magic Bullets, Page A-192; Abstract 224 (2008)
3. **Wanigatunge R.P.**, Gnanakkan D.T., and **Magana-Arachchi D.N.**
Detection of potential microcystin-producing cyanobacterium, *chroococcidiopsis* sp. with *mcyA* molecular marker.
Proceedings of the Society for General Microbiology (SGM) UK 162nd Annual Sessions, 96: SE07. (2008)
4. Meegahakumbura M.G.K.M., Ambalavanar V., Madegedara R.M.D, Thevanesam V., **Magana-Arachchi D.N.**
Socio-demographical features among the tuberculosis patients attending the Central Chest Clinic, Kandy – A Preliminary study
Proceedings of the Kandy Society of Medicine, 30th Annual sessions, 30; Pages 95-96:47. (2008)

Dissemination of knowledge;

- (1) M.Sc. Programme in Medical Microbiology - 2007/2008 University of Peradeniya, Sri Lanka
- (2) A Resource person to the School Science program of the IFS, prepared course notes, conducted laboratory demonstrations and delivered a lecture on “Molecular Biology in daily life” - August 2008

Research Grants

- (1) RG/2006/HS/07 –National Science Foundation – Rs 1,616,387.00
Project titled “Restriction Fragment Length Polymorphism (RFLP) analysis and Spoligotyping on *Mycobacterium tuberculosis* strains isolated from patients attending the Central Chest Clinic Kandy”.
- (2) NRC/06/47 – National Research Council – Grant letter was awarded in 2008.

Research collaborations with recognized institutions

- Institutes:**
- (i) Department of Microbiology, Faculty of Medicine, University of Peradeniya. - Prof.V.Thevanesam
 - (ii) Central Chest Clinic, Kandy - Dr.D. Medagedara

PROJECT:**BASIC FOOD CHEMISTRY****COMMENCEMENT:**

2005

INVESTIGATORS (2008):Ellepola S.K.W., *Research Fellow (Project Leader)*Banneheka B.M.N.M.S., *Research Assistant***PROGRESS ACHIEVED** (*Since inception*):

The aim of this project was to explore unique physicochemical properties, nutritional properties and health benefits of underutilized fruits and vegetables in Sri Lanka. Preliminary studies were mainly concentrated on cereals with special emphasis on nutrient-rich rice proteins (*globulins*). This work has given rise to 04 publications in international journals. Subsequently, the project moved in the direction of antioxidant activity and health benefits of underutilized plant foods in Sri Lanka. In this context, antioxidant activities of red rice (*Oryza sativa* L.) and Dan (*Syzygium caryophyllatum*) fruit have been investigated. Studies revealed that these foods possess high antioxidant activities, which help to reduce excess cholesterol levels in blood serum.

PROJECT OUTPUT 2008:**Past research:****Antioxidant activity in colored fruits and red rice:**

Submitted manuscripts in 2008

1. Antioxidant activity of Dan (*Syzygium caryophyllatum*); A rare indigenous fruit in Sri Lanka
2. Cholesterol lowering ability of red rice pigment (*proanthocyanidins*) extracted from red rice seeds

Current research:**1. Chemical characterization of Lawulu (*Cryosophyllum lancheolatum*) occurring in the home gardens of Sri Lanka**

Lawulu (*Pouteria campechiana*) is an important underutilized fruit tree introduced to Sri Lanka, which is grown for food, medicine and aesthetic value. In the preliminary study, the chemical composition of Lavulu (*Pouteria campechiana*) pulp was investigated. The pH value, 5.2 and the low titratable acidity level give the non-sour taste to the fruit. The fruit pulp contains fairly high levels of carbohydrates and sugars, which gives the sweet taste. Protein, fiber, fat levels were also investigated. The results showed that the fruit pulp is rich source of minerals especially phosphorous (29.6mg/100g), calcium (41mg/100g) and iron (17.8mg/100g). Antioxidant activity of the fruit pulp will be investigating by measuring free radical scavenging activity, reducing power, and ferrous ion chelating ability.

2. Nutritional information and health benefits of Bitter Gourd (karawila) (Momordica charantia) extracts

Bitter gourds are very low in calories but dense with precious nutrients. Our study revealed that Bitter gourd is an excellent source of vitamins B1, B2, and B3, C, magnesium, folic acid, zinc, phosphorus, manganese, and has high dietary fiber. It is rich in iron, contains twice the beta-carotene of broccoli, twice the calcium of spinach, and twice the potassium of a banana. Bitter gourds contain a unique phyto-constituent that has been confirmed to have a hypoglycemic effect called charantin. There is also another insulin-like compound known as polypeptide P that has been suggested as insulin replacement in some diabetic patients. Collaboration with Food Chemistry Department, University of Hong Kong has extended laboratory facilities to conduct this research.

3. Chemical-biological modification of starch properties

This project is underway on interaction of environmental and chemical factors affecting starch modification. Collaboration with Dr. David Phillips (Chemistry Department, University of Hong Kong) has extended the study to use of FT-Raman spectroscopy for the analysis of diverse modified starches.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008

1. Ellepola S.K.W. and Bannehaka N.

Effect of cooking and cooking-methods on physical chemical and nutrient properties five rice types in Sri Lanka
Proceedings of the Aries Kovoov Memorial Symposium, Innovations in Plant Sciences through multidisciplinary Research. 3rd March 2008. Kandy, Sri Lanka. Pragna, IFS Science Bulletin (Special Issue)

2. Ellepola S., Ma-C.Y., and Zee S.Y.

Study of structural changes of rice (*Oryza sativa* L) proteins during cooking by FTIR spectroscopy
IFT Annual Conference, June 2008. Illinois. Chicago, USA

Research Grants:

Received the NRC grant No: 06-71 for the project titled “*Identification and characterization of seed proteins from rice varieties*”.

Research Collaborations:

Department of Food chemistry, University of Hong Kong, Hong Kong, China

PROJECT: PRIMATE BIOLOGY

COMMENCEMENT: 1983

INVESTIGATORS(2008):

Dittus W., *Senior Visiting Scientist (Project Leader)*

PROGRESS ACHIEVED (*Since inception*):

The overall aim of the program is to establish new knowledge concerning the biological foundations for social behaviour in non-human primates (and by inference, man). This aim has interdisciplinary ramifications. Hence, past research and publications have addressed the interrelationships among factors concerning social organization, matrilineal kinship, ecology, environmental change and their effects on demography (Darwinian fitness). For example, our research was the first to establish an actuarial life-table for primates and showed that social behaviour influences individual differences in survival, breeding success, and morphological development. Our aims and data collection protocols require consistency over many years.

In practice, to investigate such phenomena we have identified more than four thousand macaque individuals (living plus dead), distributed among 34 different social groups at our dry evergreen forest study site, at Polonnaruwa. For each macaque, we have traced its behavioural, genealogical, ecological and demographic history. In addition we have recently completed the patrilineal identification of about 1,500 macaques. Such large samples are required to assure statistical soundness.

It was not clear by which physiological and similar mechanisms behaviour affected mortality. Therefore, the research was expanded (with the aid of collaborators from a variety of institutions) to investigate the potential role of disease (parasitism) and physiology (milk composition, blood chemistry, hormone levels) in relation to behaviour and demography. Different aspects of physiology and disease have been more intensively investigated in the primates at Polonnaruwa particularly in association with of the Faculty of Veterinary Medicine, University of Peradeniya. In addition, we have become more active in aspects of nature conservation and in outreach educational programs to local communities to assist in mitigating the human-monkey conflict.

PROJECT OUTPUT 2008:

(a) *Routine demographic, ecological and behavioral monitoring.* The entire population of over 1,100 identified macaques was censused on a nearly monthly basis. New recruits (newborns & immigrants) were identified. The hierarchical relationships within groups was tested and documented. Intergroup relations, shifts in ranging pattern, and diets were recorded.

(b) *Ecology of three sympatric primates.* On a regular monthly schedule we sampled the diets, home ranges and interspecific interactions among the toque macaque, and

the two langur species *Semnopithecus entellus* and *Trachypithecus. vetulus*. The aim of this study is to clarify the ecological relations that allow these three potentially competing species to co-exist in sympatry.

(c) **Paternity analyses:** With collaborators from the Faculty of Veterinary Medicine and Animal Science, University of Peradeniya and the Cologne Centre of Genomics (Germany), we completed the genetic typing of 1,500 toque macaques. The genetic work is critical to identifying paternity among toque macaques. These data are now being prepared for publication.

(d) **Professional activities:** (i) I reviewed manuscripts for international peer reviewed journals. (ii). I supervised two graduate students, Kerstin Becker of Germany and Rasika Kumaratunga (Univ Peradeniya) in their dissertation research (iii) I visited and conferred with collaborating institutions in Germany and the USA.

(e) **Documentary Film Production:** My team of assistants at Polonnaruwa and I were key to the production of a series of 13 half-hour films about monkey behaviour. The films are docu-dramas; a new style for nature films, and will be show internationally in a 13-part series entitled "Dark Days in Monkey City" on the Animal Planet, Discovery Channel.

(f) **Nature Conservation:** Our project did education programs in rural schools in and around Polonnaruwa.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

- Title:** Fatty acid composition of wild anthropoid primate milks
Authors: Milligan, Lauren A; Rapoport, Stanley I; Cranfield, Micheal R; **Dittus, Wolfgang**; Glander, Kenneth E; Oftedal, Olav T; Power, Michael L; Whittier, Christopher A; Bazinet, Richard, P.
Journal: *Comparative Biochemistry and Physiology, Part B.* **49:** 74-82 (2008)^{1,2}.

¹ *Listed in the Science Citation Index in 2008*

² *Listed in the Science Citation Index-expanded in 2008*

PROJECT:

PLANT BIOTECHNOLOGY

COMMENCEMENT:

1988

INVESTIGATORS (2008):

Ramanayake S.M.S.D., *Senior Research Fellow (Project Leader)*

Chaturani G.D.G., *Research Assistant*

Maddegoda M., *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

Problems associated with the recalcitrance to in vitro responses in selected woody perennials were investigated.

Bamboo: These belong to the family of grasses but unlike other grasses are woody and different from other woody trees. Unlike other flowering plants, their flowering and seeding rhythms are unpredictable and some flower after long intervals of many years. With all these unorthodox characteristics they are valuable. The objective of this project is to use tissue culture techniques to investigate the unique behavior in bamboos, develop protocols for propagule production and taxonomically identify different Sri Lankan species.

Different plant parts from field grown clumps of the two species, *Dendrocalamus giganteus* and *Bambusa vulgaris* were used to study their responses to in vitro manipulations. The phenology and development of selected clumps of these species were studied to correlate the in vitro responses of plant parts of mother clumps with developmental stages and phenology.

Plantlets were produced from seedling explants that responded to axillary shoot proliferation in two species *D. giganteus* (M. C. Rajapakse, M.Phil. thesis) and in *D. asper*. Plantlets were produced from field plants of *D. giganteus*, even from a 70-year-old field plant, *D. hookeri*, *B. vulgaris*, *B. atra* and *B. ventricosa*. The factors that contribute to shoot proliferation and in vitro rooting were identified. In vitro flowering was also induced in axillary shoots of *D. giganteus*, *D. hookeri* and *B. atra*.

Callus, which exhibited an embryogenic potential, was also induced from explants of the adult clumps of *D. giganteus* of 70-years age. It was possible to regenerate a few plantlets. Although seedlings are reported to respond to such behaviour in vitro, this is the first time an adult bamboo of over 70-years behaved in this manner.

Cultures were also established from seeds of giant bamboo collected from three clumps that flowered in Kandy, Pilimalawa and Daulagala. Studies in callus induction and somatic embryogenesis resulted in the formation of embryogenic callus that gave rise to somatic embryos that germinated to produce plants that were soil established. DNA from these plants as well as those from seed germinated plants and those raised by axillary shoot proliferation were used to study their genetic diversity using RAPDs. This study showed that micropropagation by axillary shoot

proliferation of somatic embryogenesis could be safely used to produce true to type plants of this species.

It is now possible to develop continuously proliferating shoots from many species of bamboo of different ages. Induction of axillary shoots in other species such as *Giganticloa atrovioleacea*, *D. asper* and *Schizostachium brachyladum* field plants were also attempted.

The problems that have led to recalcitrance in rhizogenesis in *D. giganteus* were identified and overcome by the use of certain treatments.

Our findings are now applied on a commercial-scale to produce propagules of bamboo by the Riverine Bamboo Project of the Mahaweli Authority. We have also given away over 3000 plantlets of all species, which were produced during experiments. The field performance of these shows that they grow faster than plants raised by classical methods due to early rhizome development.

DNA extracted from 130 individuals of *D. giganteus* and 25 related species of bamboo were used in studying the genetic relatedness of these which were useful in taxonomic studies. Distances were computed and dendrograms developed. The data have been analyzed and used in identification and characterization and determining relationships within and between species. Most of these Sri Lankan species have not been taxonomically defined.

At the same times, flowering in bamboo in nature were studied with close observations in *D. giganteus* and those in the bamboo collection in the Royal Botanic Gardens, Peradeniya. Interestingly, *Melocanna baccifera*, a species of bamboo introduced from India, in the Botanic gardens, Peradeniya flowered in synchrony with the impending flowering of this species in Mizoram India. The event was used to study the flowering behaviour and taxonomy of this species.

The species *Mormodica dioica* (thumbakarawila) was used in studying callogenesis and regeneration of shoots and rooting. This is a perennial climber that responded well to plant regeneration from callus unlike bamboo and therefore possibly be utilized in studies in bamboo.

Commercial application of the findings related to bamboo: Project Leader designed and developed the tissue culture laboratory in a building allocated to the Riverine Bamboo Project, Mawatura, Kotmale during my leave in 2004 for one year to undertake application of our finding to produce bamboo on a commercial scale. At present, the Riverine Bamboo Project is applying our finding to produce species of bamboo and they seek my advice on propagation of bamboo whenever problems are encountered. These bamboo plants are now distributed and planted along riverbanks to generate a bamboo resource for future use as well as for protecting riverbanks from erosion.

At the same period (in 2004) a private tissue culture laboratory, Ceylinco Biotech Pvt Ltd., was able to apply the findings developed by us, to produce over 100,000 bamboo plants, *D. hookeri* and *B. vulgaris*.

These ventures are the outcomes of a long period basic research and are significant contributions to National development due to the massive potential that bamboo has as an industrial crop for income generation. Furthermore this is the first time that an original research finding of this nature has been applied on a commercial scale in Sri Lanka.

Rattan: In vitro requirements for a high germination percentage of excised embryos of four species of rattan, *Calamus zeylanicus*, *C. ovoideus*, *C. rotang* and *C. thwaitesii* were determined. It was also possible to induce multiple shoots in all four species. *C. zeylanicus* and *C. thwaitesii* showed rapid and continuous shoot proliferation while it was slow in the other two species. The origin of these shoots was studied. Root induction in the proliferated shoots of *C. thwaitesii* was possible and plants have been established in the nursery. The rooting response of *C. zeylanicus* was slow and sufficient plants were not available to carry out rooting experiments in these species due to accidental contamination of cultures. Excised embryos of *Calamus thwaitesii* and *C. rotang* were cultured to study their responses under limited growth conditions either in encapsulated form or as naked embryos.

The study on bamboo and rattan received funding from NORAD for the period October 1993 – May 1994 (Rs. 160,000/-) and from May 1994 – October 1997 (Rs 1,406,650/-). These funds were utilized to purchase chemicals and for purchase of equipment and improving the laboratories.

National Agribusiness Council provided funds for studies in bamboo during the period January – December 2005 (Rs. 1,023,310/-). A green house was constructed with funds received from the National Agribusiness Council estimated for Rs.490,000/-. This is an essential requirement for studies related to plants which was lacking in the IFS.

In vitro micrografting and compatibility studies: This study was suspended in 1994 and revived in 1997. Culture conditions for the establishment of in vitro cultures required for grafting were determined for selected species, *Anacardium occidentale*, *A. microcarpum*, *Garcinia mangostana*, *Pentadesma butyracea*, *Durio zebethius* and *Adansonia digitata*. A technique of in vitro micrografting cashew was determined. It was also possible to achieve multiple shoot proliferation and rooting of cashew and establishment of plantlets in the nursery. After revival of this study in 1997 seeds of *Loranthus* were cultured in vitro for inducing germination but complete plant development did not take place. Mangosteen seeds were induced to produce multiple shoots. Seeds of *Feronia*, *Citrus*, *Adansonia digitata* and *Camellia sinensis* were germinated in vitro. Various plant parts of these in vitro plantlets as well as from field grown plants of *Pentadesma* and *Loranthus* were cultured to induce callus that will be used to study the compatibility between selected scion and root stock species.

PROJECT OUTPUT 2008:

Somatic embryogenesis:

Somatic embryogenesis in *D. giganteus* was possible but further improvements for consistent embryogenic callus proliferation are under investigation. Plants that were

regenerated were soil established. Histological studies on development of somatic embryos are ongoing. The clonal fidelity of somatic embryo derived plants and those from axillary shoot proliferation was confirmed with the use of RAPD technique.

Induction of flowering:

Induction of flowering in *B. atra* is now consistent. Histological studies on transition of the shoot apical meristem from a vegetative to a reproductive state are ongoing.

Chlorophyll mutants:

Four chlorophyll mutants developed during in vitro studies. DNA was extracted from these for identification of genes involved in bringing about these mutations.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

1. **Title:** Root induction in three species of bamboo with different rooting abilities
Authors: **Ramanayake S.M.S.D.**, Maddegoda K.M.M.N., Vitharana M.C., and Chaturani G.D.G.
Journal: *Scientia Horticulturae*, 118: 270-273 (2008)^{1,2}

¹ *Listed in the Science Citation Index in 2008*

² *Listed in the Science Citation Index-expanded in 2008*

ABSTRACT/CONFERENCE PROCEEDINGS IN 2008:

1. **Ramanayake S.M.S.D.**, Maddegoda K.M.M.N., Chaturani G.D.G., Gajanayake W.M.D.K.K.C. and Amarasinghe D.H.
Assessment of genetic stability in micropropagated and seed-raised plants of giant bamboo (*Dendrocalamus giganteus* Wall. ex Munro)
Proceedings of the Aries Kovoov Memorial Symposium: Innovations in Plant Sciences through Multidisciplinary Research. 3rd March 2008, Kandy, Sri Lanka. Pragna, IFS Science Bulletin (Special Issue), XIX (1).
2. **Ramanayake S.M.S.D.** (Editor)
Proceedings of the "Aries Kovoov Memorial Symposium: Innovations in Plant Sciences through Multidisciplinary Research". Pragna, IFS Science Bulletin (Special Issue), XIX (1). (2008)

****PROJECT:****NATURAL PRODUCT CHEMISTRY II**

Search for bioactive compounds from Sri Lankan plants as potential resources for treatment and control of diseases in agricultural crops and humans

COMMENCEMENT : 1992

INVESTIGATORS (2008):

Jayasinghe U.L.B., *Associate Research Professor (Project Leader)*

Gunawardena D.C., *Research Assistant*

Ariyawansa J.K., *Research Assistant*

Silva W.C.De., *Research Assistant*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

1. **Amarasinghe N.R., Gunawardena D.C., and Jayasinghe U.L.B.**
Chemistry and bioactivity of *Artocarpus altilis* and *Averrhoa carambola*
Proceedings of the Aries Kovoov Memorial Symposium: Innovations in plant sciences through multidisciplinary Research, Institute of Fundamental Studies, Kandy, March 2008.
2. **Jayaweera D.S. and Jayasinghe U.L.B.**
Comparison of antioxidant activity of seeds of *Dolichos biflorus* with some edible seeds
Proceedings of the 64th Annual Sessions, Sri Lanka Association for the Advancement of Sciences, 2008

AWARDS:

Amarasinghe N.R.

Kandiah Memorial Award for Basic Research by the Institute of Chemistry, Sri Lanka.

****Excerpt from quarterly and midyear reports submitted by the Project Leader.**

****PROJECT:**

PLANT REPRODUCTIVE BIOLOGY

COMMENCEMENT:

1997

INVESTIGATORS (2008):

Iqbal M.C.M., *Senior Research Fellow (Project Leader)*
Weerasinghe H.A.S., *Research Assistant*
Wijesekera K.B., *Research Assistant*
Samithri Y.A.S. (*NSF grant*)
Perera R.S.M., *Technical Officer*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

1. **Weerasinghe H.A.S., Weerasinghe S.A., Fernando G.W.A.R., and Iqbal M.C.M.**
Soil and Vegetation Heterogeneity on a Serpentine Site in Ussangoda,
Sri Lanka
*Proceedings of the Sixth International Conference on Serpentine
Ecology held at College of the Atlantic, Maine, USA. (16th – 20th June
2008).*

****Excerpt from quarterly and midyear reports submitted by the Project Leader.**

****PROJECT: ECOLOGY AND ENVIRONMENTAL BIOLOGY**

COMMENCEMENT: 1989

INVESTIGATORS (2008):

Silva E.I.L., *Associate Research Professor (Project Leader)*

Balangoda B.M.A.R., *Research Assistant*

Silva W.S.D.K., *Research Assistant*

INVITED LECTURES/CONFERENCES ATTENDED IN 2008:

1. **Silva E.I.L., Rott E., and Thumpela I.**
Composition-Abundance of reservoir phytoplankton in Sri Lanka: an indicator of environment quality and human interventions
International Conference on Biodiversity, Environment and Sustainability: Challenges for Future, September, 2008. New Delhi, India
2. **Silva E.I.L.**
Mountain Streams in Sri Lanka: arteries of the landscapes (key note address) International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June 2008, Colombo, Sri Lanka
3. **Weerasinghe W.M.D., Silva E.I.L., and Dias R.K.S..**
Aquatic Insect fauna in Heen Ganga and Galmal Oya streams draining the Knuckles region: attributes and interactions
International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June, 2008, Colombo, Sri Lanka
4. **Karunathilake K.M.B.S., Silva E.I.L., and Amarasinghe U.S.**
Composition and abundance of aquatic insects in the mid-region of Kala Oya International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June, 2008, Colombo, Sri Lanka
5. **Gamlath G.A.R.K., Silva E.I.L., and Wijeyaratne M.J.S.**
Nutrient loading to Victoria reservoir via Hulu Ganga, draining intensively land used watershed in the Knuckles Range
International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June, 2008, Colombo, Sri Lanka
6. **Silva E.I.L., Dharamaratne S., and Athukorale N.**
Water quality of riverine and lacustrine habitats of Mahaweli River from headwaters to downstream, International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June, 2008, Colombo, Sri Lanka

****Excerpt from quarterly and midyear reports submitted by the Project Leader.**

7. ✓ **Silva E.I.L.,** Bandara W., Athukorale N., and Tumpela I.
Water quality of riverine and lacustrine habitats of Malwathu Oya within Anuradhapura area
International Workshop on Riverscapes in Sri Lanka Current Knowledge and Future Trends, June, 2008, Colombo, Sri Lanka
8. ✓ **Silva E.I.L.,** Silva W.S.D.K., Balangoda B.M.A.R., Ukuwela K.D.W., Athukorale N., and Chandrasekara S.O.K.
Evaluation of water quality and pollution status Kandy surface water network by means of carbon, nitrogen and phosphorous concentrations
14th Annual Sessions, Sri Lanka Association For Fisheries and Aquatic Resources (SLAFAR), June 2008, Colombo Sri Lanka
9. ✓ **Silva E.I.L.**
International Conference on “Biodiversity, Environment and Sustainability – challenges for future”, New Delhi, India, September, 2008
10. **Silva E.I.L.**
Reader, Workshop on Water and Ecosystems, SaciWATERs, Kandy, Sri Lanka, August, 2008
11. **Silva E.I.L.**
Symposium on Water; Research Trends in Sri Lanka, Colombo, Sri Lanka, July, 2008.
12. **Silva E.I.L.**
LOICZ, South Asia Regional Node Workshop on Coastal Zone Management: Emphasis on Negombo Lagoon, Sri Lanka. Colombo, Sri Lanka, July, 2008
13. **Silva E.I.L.**
Water Professional Day, Post Graduate Institute of Agriculture (PGIA), October, 2008, Peradeniya, Sri Lanka

BOOKS AND MONOGRAPHS 2008:

1. *Title:* Water Quality and Ecosystem Linkages: comparative Sri Lankan perspectives
In the Book: Reader”, Water and Ecosystems, Sixth Volume Water in South Asia (WISA) Series, 2008
Author: **Silva E.I.L.**
Publishers: Saga Publications, New Delhi (in print)

****PROJECT:****CHEMICAL MODELING OF ENVIRONMENTAL SYSTEMS****COMMENCEMENT:****1992****INVESTIGATORS (2008):**

Weerasooriya R., *Research Professor (Project Leader)* (1986-June 2008)
Jayarathna I.P.L., *Research Assistant*
Kumara I.G.C.K., *Research Assistant*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2008:

1. **Jayarathna I.P.L., Bandara A. and Weerasooriya R.**
Removal of fluoride by magnetic γ -Fe₂O₃ nanoparticles
Proceedings of the 64th Annual Sessions of the Sri Lanka Association for the Advancement of Science 164 P, 2008
2. **Jayarathna L., Bandara A., and Weerasooriya R.**
Synthesis and Characterization of γ -Fe₂O₃ Nanoparticles
Proceeding, University of Peradeniya, Sri Lanka. Vol.13, 413, 2008
3. **Jayarathna L., Ng W.J., Bandara A., and Weerasooriya R.**
Spectroscopic Investigation of Iodide-nano γ -Fe₂O₃ interactions
Proceeding, University of Peradeniya, Sri Lanka. Vol.13, 463, 2008
4. **Kumara C.K., Bandara A., and Weerasooriya R.**
Modeling Acid - Base Properties of Montmorillonite-water Interface
Proceedings of the 64th Annual Session. Sri Lanka Association of Advancement of Science. 162 P 2008.
5. **Kumara C.K., Kumarasinghe M., NG W.J., Bandara A., and Weerasooriya R.**
Synthesis and Characterization of Gibbsite Nano-particles
Proceeding, University of Peradeniya, Sri Lanka. Vol.13, 466 2008
6. **Kumara C.K., Bandara A., and Weerasooriya R.**
FTIR Analysis of Arsenate-Montmorillonite Interactions
Proceeding, University of Peradeniya, Sri Lanka. Vol.13, 417 2008

****Excerpt from quarterly and midyear reports submitted by the Project Leader.**

****PROJECT: STRUCTURAL GEOLOGY**

COMMENCEMENT: 1995

INVESTIGATORS (2008):

Kehelpannala K.V.W., *Senior Research Fellow (Project Leader)*
Ranaweera L.V., *Research Assistant*

PROJECT OUTPUT 2008:

Continued the study of the structure and geology of areas along and across the boundary between the Wannu Complex and the Highland complex.

Preliminary study of the major structures in the part of eastern Sri Lanka (known as the Vijan Complex) was started using satellite images downloaded from Geology Earth. Since this area was not accessible during the last 20 years due to the terrorist activities, no or very little structural and geological studies have been carried out.

Study of earthquake taking place in and around Sri Lanka from the data provided by the USGS Earthquake Web site. The minor tremor occurred near Sigiriya could not be investigated due to my illness.

Study of fracture zones and fault zones in parts of the central Sri Lanka using satellite images downloaded from Google earth.

PUBLICATIONS IN REFEREED JOURNALS IN 2008:

- Title:** Permo-Triassic Ultra High Temperature Metamorphism, Mesozoic Magmatism and Pleistocene Volcanisms and Gold Mineralization in the Kyushu Island, SW Japan: An Excursion

Authors: **Kehelpannala K.V.W.** and Yoshida M.

Journal: **Episodes, Journal of International Geoscience**, 2008 (in press)^{1,2}
- Title:** Gondwana to Asia: Forth international symposium

Authors: Yoshida M. and **Kehelpannala K.V.W.**

Journal: **Episodes (Journal of International Geoscience)** 2008 (in press)

¹ *Listed in the Science Citation Index in 2008*

² *Listed in the Science Citation Index-expanded in 2008*

****Excerpt from quarterly and midyear reports submitted by the Project Leader.**

ABSTRACTS/CONFERENCES ATTENDED IN 2008:

1. **Kehelpannala K.V.W. and Ranaweera L.**
The nature of the boundary between the Wannai and Highland Complexes, Sri Lanka
Geological Society of Sri Lanka, 24th Annual Session, Colombo, 28th February 2008, pp. 10-11
2. **Kehelpannala K.V.W.**
Sri Lanka from Columbia to Pangae. In: Biswal, T.K., Pandalai, H.S., Pande, K. and Pillai, S.P. (Eds.)
International Conference on Tectonics of the Indian Subcontinent. International Association for Gondwana Research Conference Series 5, pp. 239-242, 2008
3. Nakagawa M., Santosh M., **Kehelpannala K.V.W.**, Matsuura K., Kuwada Y. and Mathew K.J., 2007
Gemstone fields and their exogenetic clays in southern India and Sri Lanka
Abstracts of Annual Meeting of the Clay Science Society of Japan, Vol. 51, pp. 62. (This abstract could not be included in the Annual Report – 2007).

INVITED LECTURES/CONFERENCES ATTENDED IN 2008:

Kehelpannala K.V.W.

1. Delivered an **Invited lecture** on “Post-Gondwana Tectonics and Sedimentation in and Around Sri Lanka” delivered at the International Symposium on “Perspectives on Basin, Basalt and Bumps: Kerala-Konkan Margin, India”, **Bombay, India**, January 06-07, 2008.
2. Delivered an **Invited keynote address** on “Sri Lanka from Columbia to Pangea” delivered at the International Conference on “Tectonics of the Indian Subcontinent (TOIS)” held in **Mumbai, India**, 3-6 March 2008.
3. Participated in a three-day field excursion in the southern Himalayas in the areas of Dehradun, Mussorrie, Rishikesh and Devaprauarag during 28 February – 01 March 2008.
4. Participated in one-day field excursion to the Decan Traps around Bombay, India on 05th March 2008.
5. Participated in a three-day field excursion to the Aravali Fold Belt in Rajasthan, India during 08 - 10 March 2008.

POSTGRADUATE DEGREES COMPLETED IN 2008:

Name: L.W Ranaweera
Title of thesis:: Wannu Complex and Highland Complex Boundary Shear Zone
of Sri Lanka. Field and Structural Evidences
Degree: M. Phil
Degree awarded by University of Peradeniya.

OTHER CONTRIBUTION:

1. Overall organization of the Deyata Kirula Exhibition 2008 for IFS.

Media Presentations

1. A short discussion on "Deyata Kirula Exhibition" in the 16:00 Hr News Bulletin, Rupavahini Government TV Channel, 10th February 2008.

SCIENCE DISSEMINATION

Tilakaratne C.T.K. and Sellam S.

Research colloquia, public lectures, research meetings and the science popularization programme for schools were conducted as in the previous years in keeping with the IFS commitment to fundamental science.

(A) Research meetings, research colloquia, and public lectures

Research meetings were conducted by the research assistants of the IFS. These meetings provide a platform to present their research findings and discuss their research problems with the peers. Scientists with expertise in their fields of research were invited to talk to their colleagues at research colloquia. In addition, public lectures were organised to promote the public understanding of science.

(B) Awareness and educational programmes for students

(i) School Science Programme: (SSP)

The School Science Program (SSP) is one of the most important annually conducted programs for the dissemination of science among the younger generation.

(ii) To popularize scientific concepts among school children, competition on scientific concepts was organized for Central Province school children as a pilot project. This was very successful.

(iii) Visits: Lab visits were organised for

Postgraduate students

Undergraduate students

Students from other institutions

School children and teachers

Special lecture on IFS and its activities were prepared in advance to enable these students to understand the IFS activities better.

(C) Preparation of Scientific reports/bulletins:

Annual Research Report 2007 was compiled. Mid year report and three quarterly research reports were prepared.

On request, Statistical and Scientific Reports about IFS were prepared for other institutions (National Science Foundation).

(D) Science and Technology Promotion

- i. Free Electronic version of the **English-Sinhala Chemistry dictionary with an intelligent search engine** was prepared by C.T.K. Thilakaratna with the

help of Prof. A. Nanayakkara and CDs were distributed among the School science programme participants.

- ii. **Electronic English-Tamil Science Glossary** – (Vinghana Padangal “விஞ்ஞான பதங்கள்”) with an intelligent search engine was developed and published in compact disk form jointly with Prof. A. Nanayakkara. This contains 45,000 words in the fields of Biology, Chemistry, Computer Science, Physics, and Mathematics. This glossary was published in end of 2006. The CDs were distributed among the School Science Programme participants and to the others who are interested.

(E) Auditorium was rented out for outsiders on one occasion.

RESEARCH MEETNGS, RESEARCH COLLOQUIA & PUBLIC LECTURES

RESEARCH MEETNGS

- 07.05.2008 **Detection of Potential Microcystin-producing Cyanobacterium, *Chroococcidiopsis* sp. With *mcyA* Molecular Marker**
Ms. R.P. Wanigatunge, Research Assistant, IFS
- 21.05.2008 **Geological and Structural Evolution of Deep part of a Boundary between two Precambrian Plates in Sri Lanka**
Mr. L.V. Ranaweera, Research Assistant, IFS
- 22.07.2008 **Chemistry of some edible fruits**
Ms. D.C. Gunawardene, Research Assistant, IFS
- 06.08.2008 **Development of an improved rice production system in order to address the current fertilizer crisis**
Ms. H.A.J. Sandamali, Research Assistant, IFS
- 03.09.2008 **High efficiency indoline-sensitized solar cell based on nanocrystalline TiO₂ surface doped with copper**
Mr. T.R.C.K. Wijayarathna, Research Assistant, IFS
- 17.09.2008 **Developing a microbial biofertilizer for bean**
Ms. K.R.E. Padmathilake, Research Assistant, IFS

RESEARCH COLLOQUIA

- 14.05.2008 **Potential Biotechnological Applications of Developed Microbial Biofilms**
Dr. P.R.G. Seneviratne, Senior Research Fellow, IFS

PUBLIC LECTURES

25.06.2008 **Emotional Bank Account**
Eng. M.R. Ranatunga, Chief Engineer, Distribution and Maintenance,
Central Province, Ceylon Electricity Board

School Science Programme **19th to 21st August, 2008**

19th August

Science and Mathematics for a comfortable life
Dr. Jayalath Edirisinghe

IFS activities and Science Dissemination
Dr. C.T.K. Tilakaratne

20th August

Molecular Biology in day to day life
Dr. D.N. Maganaarachchi

Can we use scientific method in daily life?
Prof. A. Nanayakkara & Dr. C.T.K. Tilakaratne

Brain Computer Interface
Prof. A. Nanayakkara

21st August

Solar Energy Challenge
Prof. O.A. Ileperuma

What does research mean to us?
(Video Presentation)

Save the Planet: Plant a tree!
Ms. S.M.S.D. Ramanayake

WORKSHOPS AND SEMINARS

03.03.2008 Prof. Aries Kovoov Memorial Symposium at IFS (organized by IFS,
National Research Council and National Science Foundation).

18.11.2008 Workshop on Popularization of Scientific Concepts and Scientific
Method among teachers (G.C.E. Ordinary Level Sinhala medium) in
Central Province sponsored by the Education Department, Kandy at
IFS (Resource Person – Dr. C.T.K. Tilakaratna).

- 19.11.2008 Workshop on Popularization of Scientific Concepts and Scientific Method among teachers (G.C.E. Ordinary Level Tamil medium) in Central Province sponsored by the Education Department, Kandy at IFS (Resource Personal – Mr.S. Periyasamy and Dr. P. Jeyanandarajah).
- 23.12.2008 Workshop on Popularization of Scientific Concepts and Scientific Method among school children (Sinhala medium) in Central Province, sponsored by the Education Department, Kandy and National Savings Bank at IFS (Resource Personal – Dr. C.T.K. Tilakaratna) .
- 24.12.2008 Workshop on Popularization of Scientific Concepts and Scientific Method among school children (Tamil medium) in Central Province, sponsored by the Education Department, Kandy and National Savings Bank at IFS (Resource Personal – Mr.S. Periyasamy and Dr. P. Jeyanandarajah).

EDUCATIONAL VISITS

- 27.03.2008 Visit to IFS – teachers and students from Kg/Mw/Al-Azhar Maha Vidyalaya (Navodya School), Hemmathagama.
- 29.10.2008 Visit to IFS – Students from K/Seethadevi Balika Maha Vidyalaya, Kandy

EXHIBITION

- 07.02.2008 Took part in **Dayata Kirula exhibition** at Bandaranaike Memorial
to
10.02.2008 Hall, Colombo

STAFF LIST 2008

*The period mentioned within brackets shows their stay at IFS
Designations as at 2008*

1. RESEARCH STAFF – As at 31.12.2008

Associate Research Professor		
Nanayakkara A.	(2000-todate)	
Senior Research Fellow ⁴²		
Bandara J.	(1999-todate)	
Senadeera G.K.R.	(1998-todate)	
Research Fellow		
Ellepola S.	(2005-todate)	
Maganaarachchi D.N.	(2004-todate)	
Wijayasinghe A.	(2005-todate)	

2. RESEARCH STAFF - Left IFS during the year 2008

Senior Research Professor		
Tennakone K.	(1988 - 05-05-2008)	
Research Professor		
Weerasooriya S.V.R.	(1986 - 18.06.2008)	
Associate Research Professor		
Dharmaratne H.R.W.	(1992 - 18.06.2008)	
Jayasinghe J.H.M.U.L.B.	(1992 - 17.10.2008)	
Silva E.I.L.	(1988 - 17.10.2008)	
Senior Research Fellow		
Iqbal M.C.M.	(1997 - 17.10.2008)	
Kehelpannala K.V.W.	(1994 - 17.10.2008)	
Ramanayake S.M.S.D.	(1988 - 17.10.2008)	
Senevirathne P.R.G.	(1993 - 17.10.2008)	
Sirimanne P.M.	(2005 - 09.05.2008)	

1. RESEARCH ASSISTANTS – As at 31.12.2008

	Projects	Period of stay at IFS
Grade I		
Piyasena K.G.N.P.	- Natural Products Chemistry (I)	01.06.2002-todate
Sandamali H.A.J.	- Biological Nitrogen Fixation	03.09.2007-todate
Grade II		
Ariyasinghe Y.P.Y.P.	- Condensed Matter Physics	01.11.2006-todate
Balangoda B.M.A.R.	- Ecology and Environmental Biology	01.01.2008-todate
Chaturani G.D.G.	- Plant Biotechnology	03.04.2006-todate
de Silva W.C.	- Natural Products Chemistry (II)	03.09.2007-todate
Kumara G.C.K.	- Chemical Modeling of Aquatic Systems	03.07.2006-todate
Priyanwada N.H.N.	- Natural Products Chemistry (I)	03.07.2006-todate
Samarasingha P.B.	- Electrochemical Material	01.12.2005-todate
Silva W.S.D.K.	- Ecology and Environmental Biology	01.01.2008-todate
Wanigatunga R.P.	- Plant Cell Biology	03.04.2006-todate
Weerasinghe H.A.S.	- Plant Reproductive Biology	15.03.2006-todate
Wijayaratne T.R.C.K.	- Lightning & Plasma Physics	15.08.2007-todate
Zahmeeth S.S.	- Computational Mathematics and Physics	01.06.2006-todate

2. RESEARCH ASSISTANTS – Left IFS during the year 2008

	Projects	Period of stay at IFS
Grade I		
Balasuriya B.M.G.K.	- Biochemistry	03.11.2003-31.01.2008
Padmathilake K.R.E.	- Biological Nitrogen Fixation	03.09.2007-26.09.2008
Premalal E.V.A.	- Condensed Matter Physics	20.05.2004-28.09.2008
Premaratne S.R.	- Natural Products Chemistry (I)	01.09.2005-31.12.2008
Thilakaratne R.M.M.S.	- Biological Nitrogen Fixation	03.09.2007-28.08.2008
Wijesekara K.B.	- Plant Reproductive Biology	16.06.2003-04.01.2008
Grade II		
Ariyawansa J.K.	- Natural Products Chemistry II	03.09.2007-04.12.2008
Banneheka B.M.N.M.S.	- Basic Food Chemistry	08.05.2006-25.02.2008
Gunawardena D.C.	- Natural Products Chemistry (II)	01.03.2006-10.08.2008
Jayaratne I.P.L.	- Chemical Modeling of Aquatic Systems	01.12.2006-31.12.2008
Maddegoda K.M.M.N.	- Plant Biotechnology	03.01.2005-02.01.2008
Ranwala S.N.P.	- Applied Mathematics	01.10.2007-21.08.2008
Ranaweera L.V.	- Structural Geology	03.11.2003-22.10.2008
Weerasinghe W.M.D.	- Ecology and Environmental Biology	01.01.2004-31.12.2007