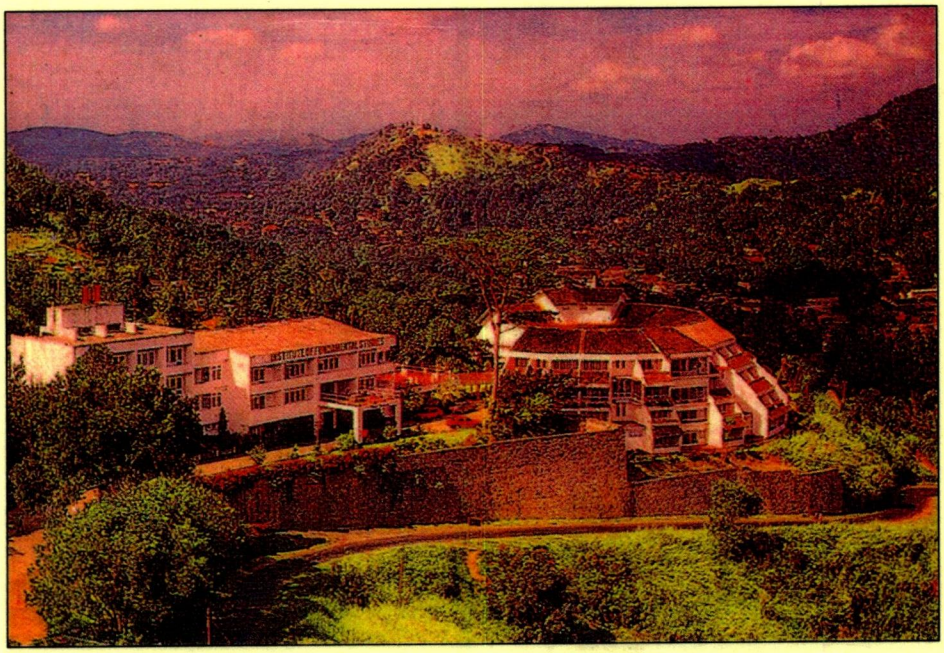
ANNUAL RESEARCH REPORT 2001



Institute of Fundamental Studies
Hantana Road
Kandy

ANNUAL RESEARCH REPORT
2001

CONTENTS

PUBLICATIONS IN REFEREED JOURNALS 2001

(° Journals listed in the Science Citation Index 2001, Please refer page 6 for the Journal Impact factors)

1. *Athukoralage P.S., Herath H.M.T.B., Deraniyagala S.A., Wijesundera R.L.C., and Weerasinghe P.A. Antifungal constituent from *Gordonia dassanayakei*. ***Fitoterapia,*** **72,** 565-567 (2001).

2. *Ayers A. E., Klapötke T. M., and **Dias H. V. R.** Azido Derivatives of Germanium(II) and Tin(II): Syntheses and Characterization of $[(Mes)_2DAP]GeN_3$, $[(Mes)_2DAP]SnN_3$, and the Corresponding Chloro Analogues Featuring Heterocyclic 6-π-Electron Ring Systems {where $[(Mes)_2DAP]=\{N(Mes)C(Me)\}_2CH\}$. ***Inorganic Chemistry*** °, **40**, 1000-1005 (2001).

3. **Bandara J.,** Mielczarski J.A., and Kiwi J. Adsorption mechanism of chlorophenols on iron oxides, titanium oxide and aluminum oxide as detected by infrared spectroscopy. ***Applied Catalysis B:Environmental*** °, **34,** 307-320 (2001).

4. **Bandara J.,** Mielczarski J.A., Lopez A., and Kiwi J. Sensitized degradation of chlorophenols on iron oxides induced by visible light - Comparison with titanium oxide. ***Applied Catalysis B: Environmental*** °, **34,** 321-333 (2001).

5. ***Bandara J.** and **Tennakone K.** Interparticle Charge Transfer in Dye-sensitized Films Composed of Two Kinds of Semiconductor Crystallites. ***Journal of Colloid and Interface Science***°, **236**, 375-378 (2001).

6. **Bandara J., Tennakone K.**, and Binduhewa P. Probing the tunneling of electrons from SnO_2 to ZnO in dye sensitization of composite SnO_2/ZnO by use of generated H_2O_2 via reduction of O_2. ***New Journal of Chemistry***°, **25** (10), 1302-1305 (2001).

7. **Bandara J., Tennakone K.**, and Kiwi J. Surface mechanism of molecular recognition between aminophenols and iron oxide surfaces. ***Langmuir***°, **17**(13), 3964-3969 (2001).

8. **Dharmaratne H.R.W.,** Nanayakkara N.P.D, and Khan I. A. Kavalactones from *Piper methysticum*, and their ^{13}C NMR spectroscopic studies. ***Phytochemistry*** ° (in press).

9. **Dharmaratne H.R.W.**, Tan G.T., **Marasinghe G.P.K.**, and Pezzuto J.M. Inhibition of HIV-1 Replication by *Calophyllum* Coumarins and Xanthones. ***Planta Medica*** ° (in press)

10. Goldman D. I., Shattuck M., Swinney H. L., and **Gunaratne G.H.** Characterization of the emergence of Order in an Oscillated Granular Layer. ***Physica A*** ° (in press).

11. **Gunaratne G. H.**, Mohanty K. K., and Wimalawansa S. J. A model of Bone and applications to Osteoporosis. ***Physica A*** ° (in press).

12. **Iqbal M.C.M.,** Meiyalaghan S., **Wijesekara K.B.,** and Abeyratne K.P. Antifungal activity from water extracts of some common weeds in Sri Lanka. ***Pakistan Journal of Biological Sciences,*** 4(7), 843-845 (2001).

13. **Iqbal M.C.M., Wijesekara K.B.,** and Hapukotuwa A. Fruits in *Brugmansia x candida* Pers. ***Ceylon Journal of Science,*** **28,** 19-20 (2001).

14. **Iqbal M.C.M.** and **Wijesekara K.B.** Cells of the connective tissue differentiate and migrate into pollen sacs. ***Naturwissenschaften*** ° (in press).

15. **Jayasinghe U.L.B.,** Bandara A.G.D., Hara N., and Fujimoto Y. A new norneohopane caffeate from *Filicium decipiens.* ***Fitoterapia,*** **72,** 737-742 (2001).

16. **Jayasinghe U.L.B., Jayasooriya C.P.,** Oyama K., and Fujimoto Y. 3-Deoxy-1β,20hydroxyecdysone from the leaves of *Diploclisia glaucescens.* ***Steroids***° (in press).

17. ***Jayasinghe U. L. B., Kumarihamy B.M.M.,** Nadeem M., Choudhary M.I., Attta-ur-Rahman and Weerasooriya A. *iso*-N-formyl-5-en-chonemorphine, A Steroidal alkaloid from *Sarcococca zeylanica.* ***Natural Product Letters,*** **15**,151-155 (2001).

18. ***Jayasinghe U. L. B.**, Vithana H.S., Wannigama G.P., and Fujimoto Y. 24-Methylenecycloartenone from *Bhesa nitidissima.* ***Fitoterapia,*** 72, 594-595 (2001).

19. Jayaweera P.M, Palayangoda S.S., and **Tennakone K.** Nanoporous TiO_2 solar cells sensitized with iron(II) complexes of bromopyrogallol red ligand. ***Journal of Photochemistry and Photobiology: A***°, **140**(2), 173-177 (2001).

20. *Kumara G.R.R.A., Konno A., **Senadeera G.K.R., Jayaweera., P.V.V.**, De Silva D.B.R.A., and **Tennakone K.** Dye-sensitized solar cell with the hole collector p-CuSCN deposited from a solution in n-propyl sulphide. ***Solar Energy Materials and Solar cells***°, **69** (2), 195-199 (2001).

21. Kumara G.R.R.A., Konno A., Shiratsuchi K., Tsukahara J., and **Tennakone K.** Dye-sensitized solid-state solar cells: use of crystal growth inhibitors for deposition of the hole collector. ***Chemistry of Materials, American Chemical Society***° (in press).

22. *Kumara G.R.R.A., Konno A., and **Tennakone K.** Photoelectrochemical cells made from SnO_2/ZnO films sensitized with Eosin dyes. ***Chemistry Letters***°(2), 180-181 (2001).

23. *Kumara G.R.R.A., **Tennakone K., Perera V.P.S.**, Konno A., Kaneko S., and Okuya M. Suppression of recombinations in a dye-sensitized photo electrochemical cell made from a film of tin IV oxide crystallites coated with a thin layer of aluminium oxide. ***Journal of Physics D-Applied Physics***, **34** (6), 868-873 (2001).

24. ***Kehelpannala K.V.W.** and **Ratnayake R.M.J.W.K.** Polyphase migmatization of layered basic rocks in the Wanni Complex of Sri Lanka. ***Gondwana Research,*** **4** (2), 174-178 (2001).

25. ***Kehelpannala K.V.W.** Scapolite-bearing pyroxenites from the high-grade gneiss terrain of Sri Lanka. ***Gondwana Research,*** **4** (2), 223-226 (2001).

26. **Kehelpannala K.V.W.** and Francis M.D.P.L. Vein graphite deposits of the Kegalle District, Sri Lanka: Further evidence for post-metamorphic, fluid deposited graphite. ***Gondwana Research,*** **4** (4), 655-656(2001).

27. *Kröner A., Collins A.S., Hegner E., Willner A.P., Muhongo S., and **Kehelpannala K.V.W.** The East African Orogen: New zircon and Nd ages and implications for Rodinia and Gondwana supercontinent formation and dispersal. ***Gondwana Research,*** **4** (2), 179-181 (2001).

28. *Miransky V.A., Shovkovy I.A., and **Wijewardhana L.C.R.** Bethe-Salpeter equation for diquarks in color flavor locked phase of cold dense QCD. ***Physical Review D***, **63,** 056005 (2001).

29. **Nanayakkara A.** A new asymptotic energy expansion method. ***Physics Letters A***, **289,** 39-43 (2001).

30. Nathanael S. and **Silva E.I.L.** The role of Non-cichlid exotics in the fishery of the Victoria reservoir in Sri Lanka. ***Journal of Aquatic Science*** (in press).

31. Nathanael S. and **Silva E.I.L.** Some aspects of the reproductive biology of three exotic cichlid species that colonize the Victoria Reservoir in Sri Lanka. ***Journal of Aquatic Science*** (in press).

32. **Ramanayake S. M. S. D.,** Wanniarachchi W. A. V. R., and Tennakoon T. M. A. Axillary shoot proliferation and in vitro flowering in an adult giant bamboo, *Dendrocalamus giganteus* Wall. Ex Munro. ***In vitro Cellular and Developmental Biology-Plant***, **37**, 667 – 671 (2001).

33. Rasamny M., Weinert M., **Fernando G. W.,** and Watson R. E. Electronic structure and thermodynamics of defects in $NiAl_3$. ***Physical Review B***, **64**, 144107 (2001).

34. **Senadeera G.K.R., Jayaweera P.V.V., Perera V.P.S.,** and **Tennakone K.** Solid State Dye sensitized photocell based on Pentacene as a hole collector. ***Solar Energy Materials and Solar cells*** (in press).

35. ***Seneviratne G.** and Ekanayake E.M.H.G.S. A simple method of producing green manure *Sesbania rostrata* to achieve N synchrony in lowland rice. ***International Rice Research Notes*, 26**, 34-35 (2001).

36. **Seneviratne G.** Mitigating nitrous oxide emission in tropical agriculture: Myths and realities. ***Current Science*°, 80**, 117-118 (2001).

37. **Silva E.I.L.,** Amarasinghe M.D., and Kularatne M. Catchment Characteristics, Morphometry, Hydrology and Ecosystem Structure of Three Reservoirs (Minneriya, Udawalawe and Victoria) in Sri Lanka. ***Hydrobiologia*°** (in press).

38. **Silva E.I.L.,** Schiemer F., and Rott E. Regulation of Primary Productivity of Sri Lankan Reservoirs. ***Hydrobiologia*°** (in press).

39. **Silva E.I.L.,** Amarasinghe U.S., De Silva S.S., Nissanka C., and Schiemer F. Photosynthetic activity of eleven perennial irrigation reservoirs in Sri Lanka. ***Hydrobiologia*°** (in press).

40. **Silva E.I.L.** and Shimizu A. Concentrations of Traces Metals in the Flesh of Nine Species Found in a Hydropower Reservoir in Sri Lanka. ***Asian Fisheries Science*** (in press).

41. ***Silva E.I.L.,** Shimizu A., and Matsunami H. Salt Pollution in a Japanese Stream and its Effects on Water Chemistry and Epilithic Algal Chlorophyll-*a*. ***Hydrobiologia*°, 437**, 139-148 (2000).

42. *Smith K. K., **Dharmaratne H. R. W.**, Feltenstein M. W., Broom S. L., Roach J. T., Nanayakkara N. P. D., Kahn I. A., and Sufka K. J.Anxiolytic effect of kava extracts and kavalactones in the chick social separation paradigm. ***Psychopharmacology*°, 155**, 86-90 (2001).

43. ***Tennakone K.** and **Bandara J.** Photocatalytic activity of dye-sensitized tin(IV) oxide nanocrystalline particles attached to zinc oxide particles: Long distance electron transfer via ballistic transport of electrons across nanocrystallites. ***Applied Catalysis A: General*°, 208**, 335-341 (2001).

44. **Tennakone K., Bandara J., Bandaranayake K.M.P.,** Kumara G.R.R.A., and Konno A. Enhanced efficiency of a dye-sensitized solar cell made from MgO-coated nanocrystalline SnO_2. ***Japanese Journal of Applied Physics*°, 40** (7B), L732-L734, (2001).

45. **Tennakone K.,** Kumara G.R.R.A., **Bandaranayake K.M.P., Jayaweera P.V.V.,** and Kono A. Dye-sensitized semiconductor nanostructures. ***Physica E*** (in press).

46. **Tennakone K., Perera V.P.S., Kottegoda I.R.M.,** de Silva L.A.A., Kumara G.R.R.A., and Konno A. Dye-sensitized solid-state photovoltaic cells: Suppresion of electron-hole recombination by deposition of dye on a thin insulating film in contact with a semiconductor. ***Journal of Electronic Materials*°, 30,** 993-996 (2001).

47. **Tennakone K., Senadeera G.K.R.,** and **Jayaweera P.V.V.** Enhancement of the energy and quantum conversion efficiencies of a photoelectrochemical cell sensitized with a combination of cationic and anionic dyes. ***Current Science***, **81** (1), 76-77 (2001).

48. †Wijesundara T.I.L., Van Hom L.H.J., and Kulasooriya S.A. Rhizobiology and nitrogen fixation of some tree legumes native to Sri Lanka. ***Biology and Fertility of Soils***, **30,** 535-543 (2000).

49. ***Weerasooriya R.,** Dharmasena B., and **Aluthpatabendi D.** Copper-gibbsite interactions: an application of 1-pK surface complexation model. ***Colloids and Surfaces***, **170,** 65-77 (2000).

50. **Weerasooriya R., Aluthpatabendi D.,** and Tobschall H.J. Charge distribution multi-site complexation modeling of Pb(II) adsorption on gibbsite. ***Colloids and Surfaces*** (in press).

51. ***Weerasooriya R.** and Dharmasena B. Pyrite assisted degradation of trichoroethene(TCE) ***Chemosphere***, **42,** 389-396 (2001).

52. **Weerasooriya R., Wijesekara D.,** and Bandara A. Surface complexation modeling of cadmium adsoprtion on gibbsite. ***Colloids and Surfaces*** (in press).

❖ *Names of the **IFS staff members** are in bold letters*

† Not listed in Annual Research Report 2000.
**Reported as "in press" in the Annual Research Report 2000.*

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 2000)

JOURNAL	IMPACT FACTOR
Applied Catalysis A: General	1.576
Applied Catalysis B: Environmental	3.026
Asian Fisheries Science	X
Biology and Fertility of Soils	1.307
Ceylon Journal of Science	X
Chemistry Letters	1.633
Chemistry of Materials, American Chemical Society	3.580
Chemosphere	1.033
Colloids and Surfaces	0.888
Current Science	0.512
Fitoterapia	0.278
Gondwana Research	0.452
Hydrobiologia	0.582
In vitro Cellular and Developmental Biology-Plant	0.750
Inorganic Chemistry	2.712
International Rice Research Notes	X
Japanese Journal of Applied Physics	1.157
Journal of Aquatic Science	X
Journal of Colloid and Interface Science	1.494
Journal of Electronic Materials	1.501
Journal of Photochemistry and Photobiology A	0.940
Journal of Physics D-Applied Physics	1.179
Langmuir	3.045
Natural Product Letters	0.662
Naturwissenschaften	1.261
New Journal of Chemistry	3.009
Pakistan Journal of Biological Sciences	X
Physica A	1.205
Physica E	0.878
Physical Review B	3.065
Physical Review D	3.835
Physics Letters A	1.122
Phytochemistry	1.112
Planta Medica	1.831
Psychopharmacology	2.804
Solar Energy Materials and Solar cells	1.097
Steroids	1.831

PROJECT: **APPLIED MATHEMATICS**

DEVELOPMENT OF DIAGNOSTICS FOR OSTEOPOROSIS

COMMENCEMENT: 1999

INVESTIGATORS:

Gunaratne G.H. (1997- to date), *Visiting Research Professor*
Tennakone K. (1987- to date), *Research Professor*

PROGRESS ACHIEVED (*Since inception*):

Osteoporosis is a major socio-economic problem in an aging population. Unfortunately, therapeutic agents which can prevent and even reverse osteoporosis often induce adverse side effects. Hence, non-invasive diagnostic tools to determine the need for therapeutic intervention are essential for optimal management of osteoporosis. Diagnostics currently in use, such as the bone mineral density (BMD), cannot be used to identify patients who require therapy with sufficient accuracy. Factors complicating the estimation of bone strength include anisotropy of the porous bone, thinning of struts forming the porous medium, and variations in bone quality. It is impossible to analyze such subtle details in clinical studies or in experiments on ex-vivo bone samples. Mathematical models have been used successfully to extract such details in many physical systems. A corresponding analysis of bone can provide a deeper insight on causes underlying loss of bone strength, and aid decisions on treatment options and the development of more accurate diagnostic tools.

We have recently introduced a model of porous bone which consists of a disordered network of fragile elastic springs. The advantage of using model systems is illustrated through a surprising observation on the nature of load transmission on a network. It is seen that, as a network loses trabeculae, it is only able use a systematically smaller fraction of the remaining segment for stress propagation. As a consequence of this inefficiency, bone strength decreases nonlinearly with BMD, and a new expression for it is derived on the basis of our model. It has been validated using previously published data. More sensitive and comprehensive tests of the expression using samples rat bones with varying levels of therapeutically induced bone loss are proposed.

Analysis of the model allowed us to propose a new explanation for the remarkable efficacy of certain therapies (e.g. bisphosphonates, salmon-calcitonin) in reducing fracture incidence. It relies on the assumption that the efficiency of a treatment is based on its ability to regenerate bone mass preferentially in the most critical locations. In this view, less efficient therapies such as fluoride treatment do not induce bone growth to focus on the required locations. Results from numerical integration of our model confirms these suggestions; specifically, small variations in algorithms for mass deposition are seen to have dramatic effects on the enhancement of the ultimate strength of a network.

Studies of mathematical models can be used to estimate the relative contributions from distinct factors to loss of bone strength in a relatively short time frame. This

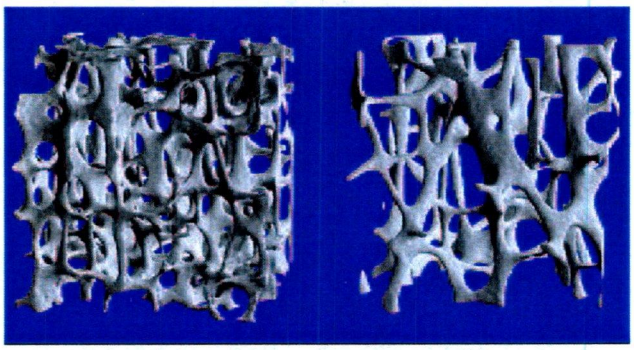
information can be used to deduce new diagnostics of bone strength. The most promising of these can then be subjected to studies on animal bones. We expect such a coordinated approach to provide new and reliable diagnostic tools for bone strength. By helping to determine the need and optimal time for therapy, they can reduce fractures in patients and improve the cost-effectiveness of medical therapy.

Progress:

(1) Numerical studies show a fundamental difference between stress propagation in ``healthy" and ``weak" networks. Elastic elements experiencing large stresses lie on a dense subset in the former and along a few coherent pathways in the latter.

(2) Increase of bone density by 1-2% using bisphosphonate therapy has been shown to reduce fracture incidence by about 50%. There was no satisfactory explanation for this remarkable efficacy. Using the analysis of our model system, we were able to provide such an explanation.

(3) We have introduced a new diagnostic tool that predicts the strength of model systems very reliably. Tests on animal bones are being designed to check if the measure continues to predict the strength of animal bones accurately.



(a) *(b)*

(a) shows porous bone from a healthy (non-osteoporotic) person and (b) shows a sample from an older person suffering from osteoporosis. Notice that the structure resembles a cubic network and the principle effect of aging is the loss of connectivity.

PROJECT OUTPUT 2001:

Parts (2) and (3) of the Progress

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

(1) *Title:* Characterization of the Emergence of Order in an Oscillated Granular Layer
Authors: Goldman D. I., Shattuck M., Swinney H. L., and **Gunaratne G. H.**
Journal: ***Physica A*** (in press)

(2) *Title:* A model of Bone and applications to Osteoporosis
Authors: **Gunaratne G. H.**, Mohanty K. K., and Wimalawansa S. J.
Journal: ***Physica A*** (in press)

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Gunaratne G.
Development of Non-Invasive Diagnostics for Osteoporosis: A Model Based Approach
Keck Center Seminar, Rice University, November 2001.

2. Gunaratne G.
Development of Non-Invasive Diagnostics for Osteoporosis
Annual Meeting of the Texas Section of the American Physical Society, Huntsville, March 2001.

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**
(I) QUANTUM CHAOS

COMMENCEMENT: 2000

INVESTIGATORS:

Nanayakkara A. (2000- to date), *Senior Research Fellow*
Ranatunga N. (2001- to date), *Research Assistant*
Udalagama C. (2000), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

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 the signature of chaos in quantum mechanics, we have been developing a Quantum Action Variable theory for multidimensional systems which bridges classical mechanics with quantum mechanics in a transparent manner. We have also been investigating quantum mechanical quantities which contain information on chaos in the corresponding classical system.

We have investigated both 1-D and 2-D systems classically and quantum mechanically. A new powerful asymptotic energy expansion method was developed for 1-D systems. This method is based on a 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 those in WKB methods. Since each term in the series can be evaluated analytically, the energy expressions produced by this method provide analytic insight into the problem of interest. We then applied this method to obtain almost explicit formulae for asymptotic eigen energy expansions of general polynomial potentials. Further the behaviour of energy level spacing and other properties of double well potentials and energy eigen expressions of general rational power potentials were also obtained with the above method.

We examined quantization conditions which can be used in a multidimensional environment. A new quantization condition was developed for 1-D systems. This is a computational method which can be applied to a large number of 1-D systems. An important finding is the applicability of this method to predict distributions of zeros of quantum mechanical wave functions semiclassically. The distribution of zeros of wave functions in multidimensions are believed to contain signatures of chaos in the corresponding classical system.

The extension of the methods described above to 2-D and multidimensional systems are being investigated intensively.

PROJECT OUTPUT 2001 :

The asymptotic expansion method developed in the year 2000 was applied to various systems, as described above. A method was developed to predict the distribution of zeros of the quantum mechanical wave function semiclassically. The extension of this new asymptotic method and the new quantization method to 2-D systems were investigated.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1. *Title:* A new asymptotic energy expansion method
   Authors: **Nanayakkara A.**
   Journal: ***Physics Letters A*, 289**, 39-43 (2001)

PROJECT: **COMPUTATIONAL MATHEMATICS AND PHYSICS**
(II) DENSITY FUNCTIONAL THEORY

COMMENCEMENT: 2001

INVESTIGATORS:

Nanayakkara A. (2000- to date), *Senior Research Fellow*
Ranatunga N. (2001- to date), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

In this project we are developing new exchange-correlation functionals which provide accurate exchange and correlation contributions to molecular systems, specially to nano clusters. The nanoclusters are intermediate between solid-state and molecular systems and have properties distinct from both.

As the first step, we are developing a density functional theory based molecular electronic structure code which uses different types of basic functions. The method is based on the Kohn-Sham equation and the code is developed using C++ . Half of the electronic structure code has been completed and tested. When the code is completed, different forms of exchange-correlation functionals will be studied.

PROJECT: **PARTICLE PHYSICS AND QUANTUM FIELD THEORY**
PHYSICS OF HIGH DENSITY QUARK MATTER

COMMENCEMENT: 1997

INVESTIGATORS:

Wijewardhana L.C.R. (1997-to date), *Visiting Research Professor*

PROGRESS ACHIEVED (*Since inception*):

During my visits to the I.F.S. I have worked on three research projects in Particle Physics and Quantum Field Theory. In 1997 and 1998 I collaborated with Anuradha Ratnaweera . We mapped out the behaviour of gauge theories as a function of the number of quark flavors. Anuradha performed the required numerical computations using the computer facilities at the I.F.S. This led to a publication in Physical Review D.

During my next visits in 1998, 1999, and 2000 I worked on analyzing the properties of high density quark matter and published a paper on this. It was on the gap equation and color flavor locking in cold dense QCD with three massless flavors. We developed an effective potential method to formally analyze the stability of various phases that occur in such dense systems of hadronic matter.

PROJECT OUTPUT 2001:

Quark matter at high density is a colour superconductor. It has been the subject of many studies for the last few years. This recent increased activity was initiated by the observation that the colour superconducting order parameter could be much larger than previously thought.

Because of asymptotic freedom, QCD becomes a weakly interacting theory at high densities. This allows one to obtain some rigorous results for dense quark matter in the asymptotic limit. Of course, from the viewpoint of phenomenology, it is desirable to have a theory valid at intermediate densities that could be produced in heavy ion collisions or could exist in nature (for example, inside neutron or quark stars). This dilemma is partially resolved by studying predictions of the theory at high densities and, then, extending their validity as far as possible to the region of interest. Notice that all the heavy quark flavors could be safely omitted from the analysis when probing the quark matter at realistic intermediate densities. As a result, one arrives at a model of dense QCD with either two ("up" and "down") or three ("up", "down" and "strange") flavors.

In the past year, we have analyzed the properties of diquark states with the quantum numbers of the Nambu-Goldstone (NG) bosons, in cold dense QCD with two and

three flavors. Part of this research was carried out during a visit to the IFS. We have published a paper in Physical Review D on this subject.

We have also analyzed a model field theory , namely 2+1 QCD at large densities to map out its phase structure. We have derived and solved the gap equation in the leading, hard-dense loop improved, one-gluon exchange approximation . The magnitude of the order parameter is proportional to a power of the coupling constant. For an asymptotically large chemical potential, a qualitatevely new (with respect to the 3+1 dimensional case) phenomenon of nondecoupling of the fermion pairing dynamics from the infrared one is revealed and discussed.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Bethe-Salpeter equation for diquarks in color-flavor locked phase of cold dense QCD
Author: Miransky V.A., Shovkovy I.A., and **Wijewardhana L.C.R.**
Journal: ***Physical Review D,* 63,** 056005 (2001)

* *Reported as "in press" in the Annual Research Report 2000.*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Wijewardhana L.C.R.
Workshop on Lattice Field Theory, Trinity College Dublin in June 2001.
(Invited Talk).

2. Wijewardhana L.C.R.
Contributed talk at the *Lattice 2001* meeting held in Berlin, August 2001.

3. Wijewardhana L.C.R.
Seminar at the Dublin Institute for Advanced Studies June 2001.

PROJECT: CONDENSED MATTER THEORY

COMMENCEMENT: 1999

INVESTIGATORS:

Fernando G.W. (1997-to date), *Visiting Research Professor*

PROGRESS ACHIEVED (*Since inception*):

We examined the fundamental aspects of first principles of many body theory, including density functional theory. Work carried out with (current and former) students M. Rasamny and M. Valiev at the University of Connecticut and UC San Diego, respectively. During the summer 2000, we had an undergraduate student from Cornell working on transport properties of magnetic heterojunctions. We also have a project related to developing systematic interatomic potentials and studying diffusion of actinides in metallic systems. This is in collaboration with Prof. B. R. Cooper at West Virginia University and Dr. Elena Sevilla at the University of Connecticut (UConn). We have a joint collaboration on catalytic systems with the IMS (Institute of Materials Science - UConn) and PCI (Precision Combustion Inc. in New Haven, CT) on a Critical Technologies Initiative. A post-doctoral fellow, Marwan Rasamny and a graduate student have been working on this project. Over the past few years we have also worked on magnetic properties of selected transition metal compounds (oxides, nitrides etc.) in collaboration with several research groups from UConn (Profs. J. Budnick, D. Pease, B. Sinkovic), IFS (Prof. K. Tennakone and A. Ratnaweera), Brookhaven National Laboratory (Drs. R.E. Watson and M. Weinert) and JNC Bangalore (Dr. S. Narasimhan). Some of the above work is still in progress.

PROJECT OUTPUT 2001:

We have been examining selected regions of various phase diagrams from a theoretical point of view. One such system is the Al rich region of the Ni-Al binary alloy phase diagram. In addition to energetics at zero temperature, we have been able to probe defect formation energies and free energies by including configurational entropy terms at non-zero temperature.

Another project that is currently underway has to do with identifying various inadequacies of the local (spin) density approximation used in electronic structure calculations. We have examined multiplex level structure of transition metal atoms and identified various trends and problems associated with methods used in such calculations.

A third project is centered around nanoscale systems such as thin multilayered films and nanoparticles. We are examining electronic and magnetic properties of such systems and related size dependencies, from a theoretical point of view.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1) *Title:* Electronic Structure and Thermodynamics of Defects in $NiAl_3$
Author: Rasamny M., Weinert M., **Fernando G. W.**, and Watson R. E.
Journal: ***Physical Review B,* 64**, 144107 (2001)

PROJECT: **CONDENSED MATTER PHYSICS**

COMMENCEMENT: 1987

INVESTIGATORS:

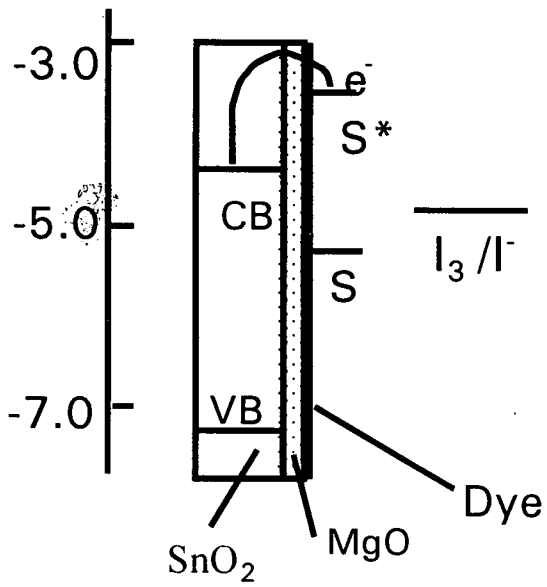
Aponsu G.M.L.P. (1996-1997), *Research Assistant*
Bandaranayake K.M.P. (2000-to date), *Research Assistant*
De Silva D.B.R.A. (1999-2000), *Research Assistant*
De Silva L.A.A. (1997-1999), *Research Assistant*
Jayaweera P.V.V. (2000- to date), *Research Assistant*
Kottegoda I.R.M. (1996-2001), *Research Assistant*
Kumara G.R.R.A. (1995-1999), *Research Assistant*
Kumarasinghe A.R. (1992-1996), *Research Assistant*
Perera V.P.S. (1996-1999 and 2000- to date), *Research Assistant*
Senadeera G.K.R. (1999-to date), *Research Fellow*
Sirimanne P.M. (1992-1996), *Research Assistant*
Tennakone K. (1987-to date), *Research Professor*
Wijayanthe K.G.U. (1994-1997), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

The aim of the project initiated around mid nineteen eighties was to conduct research in major areas of condensed matter physics depending on the available facilities and personnel. In the first few years, a considerable effort was diverted to studies on high temperature superconductivity which was then a fashionable theme of research. Subsequently, the project moved in the direction of semiconductor physics overlapping with the project on photochemistry. The Project continues to conduct research on semiconductor thin films, nanostructures and dye-sensitization covering both experimental and theoretical aspects. The work completed has given rise to nearly 130 publications in international journals. The project has gained recognition from the world community of peers as a focus of activity in this field.

PROJECT OUTPUT 2001:

In the year 2001 the project conducted investigations on nanostructured semiconductor films where the crystallites are covered with ultra-thin outer shells. Electron microscopy, energy dispersive x- ray analysis, x-ray diffractometry and scanning tunnelling microscopy were used to characterize the films. Transient photoresponse measurements were carried out using a home made experimental set-up. Work enabled the construction of a theoretical model to explain electron transport and recombinations in semiconductor nanostrucures. Another achievement was the discovery of a method of controlling cuprous iodide crystal growth in making dye-sensitized solid-state solar cells. The mechanism of crystal growth inhibition was elucidated. This project overlaps with the projects on Photochemistry and Solid State Chemistry.



Schematic energy level diagram indicating the positions (vacuum scale) of the bands of SnO_2, ground and excited levels of the dye (S, S*) and the I_3^-/I^- redox level (CB; conduction band, VB: valance band).

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Suppression of recombinations in a dye-sensitized photo electrochemical cell made from a film of tin IV oxide crystallites coated with a thin layer of aluminium oxide
Authors: Kumara G.R.R.A., **Tennakone K., Perera V.P.S.,** Konno A., Kaneko S., and Okuya M.
Journal: ***Journal of Physics D Applied Physics*, 34** (6), 868-873 (2001)

2.* *Title:* Photoelectrochemical cells made from SnO_2/ZnO films sensitized with Eosin dyes
Authors: Kumara G.R.R.A., Konno A., and **Tennakone K.**
Journal: ***Chemistry Letters (2)***,180-181 (2001)

3.* *Title:* Interparticle Charge Transfer in Dye-Sensitized Films Composed of Two Kinds of Semiconductor Crystallites
Authors: Bandara J. and **Tennakone K.**
Journal: ***Journal of Colloid and Interface Science,* 236**, 375-378 (2001)

4.* *Title:* Photocatalytic activity of dye-sensitized tin(IV) oxide nanocrystalline particles attached to zinc oxide particles: Long distance electron transfer via ballistic transport of electrons across nanocrystallites
Authors: **Tennakone K.** and Bandara J.
Journal: ***Applied Catalysis A: General*, 208**, 335-341 (2001)

5. * *Title:* Dye-sensitized solar cell with the hole collector p-CuSCN deposited from a solution in n-propyl sulphide
Authors: Kumara G.R.R.A., Konno A., **Senadeera G.K.R., Jayaweera P.V.V., De Silva D.B.R.A.,** and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar cells***, **69** (2), 195-199(2001)

6. *Title:* Surface mechanism of molecular recognition between aminophenols and iron oxide surfaces
Authors: Bandara J., **Tennakone K.,** and Kiwi J.
Journal: ***Langmuir***, **17** (13), 3964-3969 (2001)

7. *Title:* Probing the tunneling of electrons from SnO_2 to ZnO in dye sensitization of composite SnO_2/ZnO by use of generated H_2O_2 via reduction of O_2
Authors: Bandara J., **Tennakone K.**, and Binduhewa P.
Journal: ***New Journal of Chemistry***, **25**(10), 1302-1305 (2001)

8. *Title:* Dye-sensitized solid-state photovoltaic cells: Suppresion of electron-hole recombination by deposition of the dye on a thin insulating film in contact with a semiconductor
Authors: **Tennakone K., Perera V.P.S., Kottegoda I.R.M., de Silva L.A.A.,** Kumara G.R.R.A., and Konno A.
Journal: ***Journal of Electronic Materials***, **30**(8), 993-996 (2001)

9. *Title:* Enhanced efficiency of a dye-sensitized solar cell made from MgO-coated nanocrystalline SnO_2
Authors: **Tennakone K.,** Bandara J., **Bandaranayake K.M.P.**, and Kumara G.R.R.A.
Journal: ***Japanese Journal of Applied Physics***, **40(7B),** L732-734 (2001)

10. *Title:* Enhancement of the energy and quantum conversion efficiencies of a photoelectrochemical cell sensitized with a combination of cationic and anionic dyes
Authors: **Tennakone K., Senadeera G.K.R.,** and **Jayaweera P.V.V.**
Journal: ***Current Science***, **81** (1), 76-77 (2001)

11. *Title:* Nanoporous TiO_2 solar cells sensitized with iron(II) complexes of bromopyrogallol red ligand
Authors: Jayaweera P.M., Palayangoda S.S., and **Tennakone K.**
Journal: ***Journal of Photochemistry and Photobiology A:Chemistry,*** **140**(2): 173-177 (2001)

12. *Title:* Dye-sensitized semiconductor nanostructures
Authors: **Tennakone K.,** Kumara G.R.R.A., and **Bandaranayake K.M.P., Jayaweera P.V.V.,** and Kono A.
Journal: ***Physica E*** (in press)

13. *Title:* Dye-sensitized solid-state solar cells: use of crystal growth inhibitors for deposition of the hole collector
Authors: Kumara G.R.R.A., Konno A., Shiratsuchi K., Tsukahara J., and **Tennakone K.**
Journal: ***Chemistry of Materials, American Chemical Society*** (in press)

14. *Title:* Solid State Dye-sensitized photocell based on Pentacene as a hole collector
Authors: **Senadeera G.K.R., Jayaweera P.V.V., Perera V.P.S.**, and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar cells*** (in press)

* *Reported as "in press" in the Annual Research Report 2000.*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Tennakone K.
Semiconductor Nanostructures
International Workshop on Nanostructures in Photovoltaics,
Dresden, Germany , July 2001 (invited lecture).

2. Tennakone K.
Studies on Novel Solar Cells
Symposium on Thin Film Deposition,
Shizuoka University, Japan, June 2001, Abstract, p.11 (invited lecture).

3. Tennakone K.
Dye-sensitized solar cells based on porous semiconductor composites
Proc. Meeting of the Union of Chemistry,
Gifu University, October 2001, Abstract, p.35 (invited lecture).

4. Tennakone K.
Novel Dye Sensitized Solar Cells
Proc. Meeting of the Japanese Electrochemical Society,
Osaka, June 2001 (invited lecture).

5. Tennakone K.
New materials of dye-sensitized solar cells
Proc. Symposium Lectures on Photoelectrochemical Solar Cells
Ibaraki University, Japan, November 2001, Abstract, p.16 (invited lecture).

6. Tennakone K.
Dye-sensitized Solar Cells
Sharp Company Research Laboratories, Nara, Japan, September 2001
(invited presentation).

7. Tennakone K.
How to optimize dye-sensitized solar cells
Department of Materials Science, Osaka University, November 2001(invited presentation).

8. Tennakone K.
Dye-sensitized Solar Cells: Theory and Experiment
Proc., International Workshop on Photochemistry,
Tokyo International Forum, Tokyo, Japan, Abstract, p.10 (invited lecture).

PROJECT: **PHOTOCHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS:

Bandara J. (1999-to date), *Research Fellow*
Bandaranayake P. (2000 – to date) *Research Assistant*
Tennakone K. (1987-to date), *Research Professor*

PROGRESS ACHIEVED (*Since inception*):

The mechanisms of charge separation, transport and recombinations in dye-sensitized (DS) photoelectrochemical cells (PECs) based on nanocrystalline semiconductor films have attracted much attention. One of the most important factors that controls the light-to-energy conversion efficiencies, is the kinetics of recombination process i.e. nanocrystalline SnO_2 based dye-sensitized photo-electrochemical solar cells. These have very low open-circuit voltages (325-375 mV) and efficiencies (~1%) due to rapid charge recombination. In order to minimize the charge recombination, a new bilayer SnO_2/MgO nanoporous electrode was fabricated in which the thin layer of insulating MgO acts as an energy barrier for recombination, enhancing the overall cell performance. This process can be applied successfully for several other thin nonporous oxide films as well as photocatalytic applications, which are under investigation.

It has been reported that the catalytic activity of SnO_2/ZnO originates from a ballistic injection of energetic electrons generated in the sensitization of SnO_2 to the conduction band of ZnO, enabling wide charge separation. Further experiments were performed to confirm the involvement of energetic electrons in the sensitization of composite SnO_2/ZnO by the use of generated $OH^{\bullet}$ radicals.

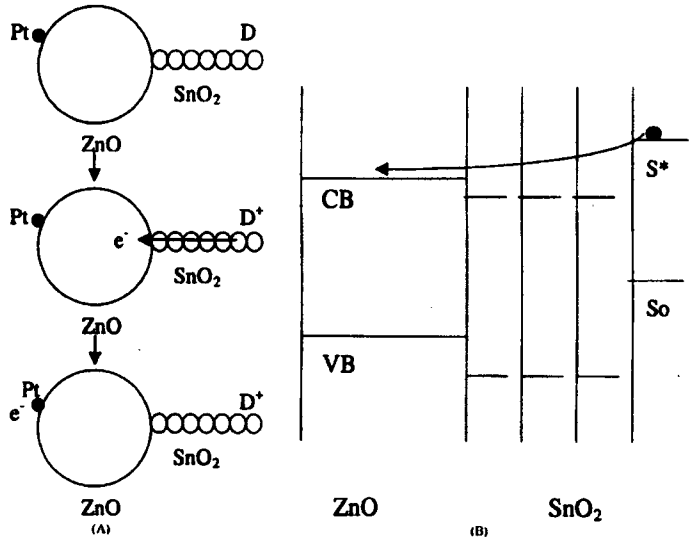
PROJECT OUTPUT 2001:

The effect of a thin insulating layer on semiconducting nanocrystalline particles for dye-sensitized (DS) photoelectrochemical cells (PECs) and photocatalytic applications were investigated further. Earlier we reported (publication 4) the construction of a bilayer SnO_2/MgO nanoporous electrode for dye-sensitized PEC cells, in which the thin layer of insulating MgO acts as an energy barrier for recombination enhancing the overall cell performance.The SnO_2 crystallises with a thin film of MgO, when the voltage and the efficiency are increased to 650-700 mV and ~6.5% respectively. The use of MgO on other nanocrystalline oxide semiconductors was tested (i.e. CdS, ZnO) and it was found that the insulating MgO layer enhances cell performance by minimizing the charge recombinations.

For several years, TiO_2 has been used as an active photocatalyst in the chemical treatment of organic pollutants in an aqueous phase under UV irradiation. TiO_2 and other wide-band gap semiconductors are found to be the most suitable photocatalysts

owing to their photostability. The coating of a thin layer of MgO on TiO_2 particles was investigated as a means of minimizing charge recombinations. It was found that the MgO traps the photogenerated charge carriers resulting in an increase in overall photocatalytic activity of TiO_2. i.e. the rate of degradation of the model compound 2,4 Chlorophenol on TiO_2/MgO is three times faster than on TiO_2.

This project overlaps with the projects on Condensed Matter Physics and Solid State Chemistry.



(A) A schematic diagram illustrating the transfer of an electron injected into SnO_2 crystallites by a excited dye molecule adsorbed at the SnO_2 crystallite and transfer of the electron to the CB of a ZnO particle in contact and then to the Pt islet on ZnO (for clarity only one chain of SnO_2 attached to ZnO is shown); B Energy level diagram indicating the band positions of SnO_2, ZnO and the ground (S_o) and exited (S) levels of the dye and the tunneling of the injected electron to a large ZnO particle.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Interparticle Charge Transfer in Dye-sensitized Films Composed of Two Kinds of Semiconductor Crystallites
Authors: **Bandara J.** and **Tennakone K.**
Journal: ***Journal of Colloid and Interface Science*, 236**, 375-378 (2001)

2.* *Title:* Photocatalytic activity of dye-sensitized tin(IV) oxide nanocrystalline particles attached to zinc oxide particles: Long distance electron transfer via ballistic transport of electrons across nanocrystallites
Authors: **Tennakone K.** and **Bandara J.**
Journal: ***Applied Catalysis A: General*, 208**, 335-341 (2001)

3. *Title:* Surface mechanism of molecular recognition between aminophenols and iron oxide surfaces
   Authors: **Bandara J., Tennakone K.,** and Kiwi J.
   Journal: ***Langmuir*, 17** (13), 3964-3969 (2001)

4. *Title:* Enhanced efficiency of a dye-sensitized solar cell made from MgO-coated nanocrystalline SnO_2
   Authors: **Tennakone K., Bandara J., Bandaranayake K.M.P,** Kumara G.R.R.A, and Konno A.
   Journal: ***Japanese Journal of Applied Physics*, 40** (7B), L732-L734, (2001)

5. *Title:* Probing the tunneling of electrons from SnO_2 to ZnO in dye sensitization of composite SnO_2/ZnO by use of generated H_2O_2 via reduction of O_2
   Authors: **Bandara J., Tennakone K.,** and Binduhewa P.
   Journal: ***New Journal of Chemistry*, 25**(10), 1302-1305 (2001)

6. *Title:* Adsorption mechanism of chlorophenols on iron oxides, titanium oxide and aluminum oxide as detected by infrared spectroscopy
   Authors: **Bandara J.,** Mielczarski J.A., and Kiwi J.
   Journal: ***Applied Catalysis B: Environmental*, 34,** 307-320 (2001)

7. *Title:* Sensitized degradation of chlorophenols on iron oxides induced by visible light - Comparison with titanium oxide
   Authors: **Bandara J.,** Mielczarski J.A., Lopez A., and Kiwi J.
   Journal: ***Applied Catalysis B: Environmental*, 34,** 321-333 (2001)

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Bandara J.,** Mielczarski, J., and Kiwi J.
   Molecular Mechanism of Surface Recognition During the Adsorption/ Degradation of Organic Compounds on Iron Oxides
   Conference Proceeding in Studies in Surface Science and Catalysis, Elsevier, 130, p 2765 - 2770, 2001.

BOOKS AND MONOGRAPHS:

1. Sun Y.-P.; Rollins H. W., **Bandara .J.,** Meziani M. J., and Bunker C. E. "Preparation and Processing of Nanoscale Materials by Supercritical Fluid Technology" in *Supercritical Fluid Technology in Materials Science and Engineering: Synthesis, Properties, and Applications*; (ed. Sun Y.-P., and Dekker M.) New York, (in press).

PROJECT : **SOLID STATE CHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS:

Jayaweera P.V.V. (2000- to date), *Research Assistant*
Senadeera G.K.R. (1999 to date), *Research Fellow*
Tennakone K. (1987-to date), *Research Professor*

PROGRESS ACHIEVED (*Since inception*):

The Solid State Chemistry project, initiated in 1999, is mainly directed towards the understanding of fundamental physico-chemical processes in electrically conducting polymers and inorganic semiconductors.

In this context,

1. Investigations were directed towards assessing the feasibility of using solid polymer electrolytes as alternative hole collecting materials for dye-sensitized solid state photo cells.

2. New methods for fabricating dye-sensitized solid-state cells based on copper halides and copper thiocyanates were discovered. We succeeded in identifying 4 CuBr.3SR2 (R= C_4H_9, C_3H_7) , i.e complexes of Cu(I) bromides with n-butyl and n-propyl sulfides, as p-type semiconductors suitable for positive hole collection in photocells.

3. A simple model system, where the broadening of the spectral response, enhanced charge separation and the consequent increase in the energy and incident photon to current efficiencies was demonstrated into a photo electrochemical cell by ionic linkage of Bromopyrogallol Red anions surface-complexed to TiO_2 with Acridine Orange cations.

PROJECT OUTPUT 2001:

1. *Physico-Chemical properties and photovoltaic effects of nanocrystalline SnO_2 particles covered with thin MgO layer.*

   SEM, TEM, FTIR, X-RD, and AC impedance studies were carried out with different composites fabricated with nanocrystalline SnO_2 particles covered with thin MgO layers. As an application of these materials, dye sensitized solid state photocells were fabricated using p-type inorganic semiconductors.

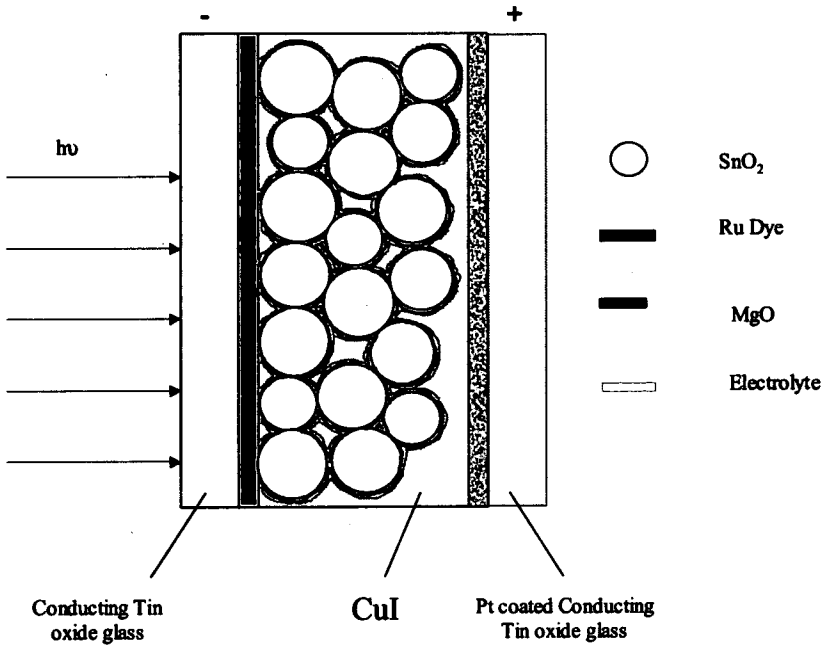
2. *Solid State dye-sensitized photovoltaic based on Pentacene as a hole collector.*

We have found that thin film of I_2 doped pentacene that can be employed as the hole collecting material in dye sensitized solid state photo cells.

3. *Electrochemical synthesis and characterization of poly(3-methyl thiophene) films and their evaluation as electrode material for photovoltaic devices based on nanocrystalline SnO_2 covered with a thin layer of MgO.*

The optical and electrical properties of poly(3-methyl thiophene) films, prepared by electrochemical polymerization at different current densities, were studied by means of cyclic voltammetry, *in-situ*-UV-visible spectroscopy, *in-situ* AC impedance spectroscopy and scanning electron micrography techniques. Quasi-solid photovoltaic cells have been fabricated and tested for their performance.

This project overlaps with the projects on Condensed Matter Physics and Photochemistry.



Cross section of SnO_2/ MgO composite Solar cell

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Dye-sensitized solar cell with the hole collector p-CuSCN deposited from a solution in n-propyl sulphide.
Authors: Kumara G.R.R.A., Konno A., **Senadeera G.K.R., Jayaweera P.V.V.**, De Silva D.B.R.A., and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar cells*, 69** (2), 195-199 (2001)

2. *Title:* Enhancement of the energy and quantum conversion

2. *Title:* Enhancement of the energy and quantum conversion efficiencies of a photoelectrochemical cell sensitized with a combination of cationic and anionic dyes
Authors: **Tennakone K., Senadeera G.K.R.,** and **Jayaweera P.V.V.**
Journal: ***Current Science*, 81** (1), 76-77 (2001)

3. *Title:* Solid-state dye-sensitized photocell based on pentacene as a hole collector
Authors: **Senadeera G.K.R., Jayaweera P.V.V.,** Perera V.P.S., and **Tennakone K.**
Journal: ***Solar Energy Materials and Solar cells*** (in press)

* *Reported as "in press" in the Annual Research Report 2000.*

PROJECT: **METAL COORDINATION CHEMISTRY**

COMMENCEMENT: 1999

INVESTIGATORS:

Dias H. V. R. (1999- to date), *Visiting Research Professor*

PROJECT OUTPUT 2001:

Metal complexes are widely used in a variety of applications ranging from catalysis, materials chemistry to medicine. Properties of metal complexes are directly related to the nature of ligands around the metal site. Thus the development of new ligands with useful steric/electronic properties is of particular interest. Current efforts are focused on the design, synthesis and applications of nitrogen and oxygen based ligands such as tris(pyrazolyl)borates, tropolone derivatives, and aminotroponimines. We are using these new ligands to prepare metal catalysts for oxygen activation, isolate reaction intermediates, develop transition metal containing drugs, and to control photochemical processes of metal coordination compounds.

We have been able to isolate and characterize several key intermediates of metal mediated processes. These include intermediates in silver salt metathesis and nitrene transfer reactions. We have also isolated several copper ethylene complexes. They are useful as models for ethylene binding sites in plants. The unique features of the highly fluorinated tris(pyrazolyl)borates are particularly important to the stability of these silver and copper complexes. Copper adducts serve as active catalysts in aziridination processes.

With the aid of nitrogen containing donors, thermally stable azido derivatives featuring germanium(II) and tin(II) have been synthesized. Usually they tend to decompose easily with the elimination of nitrogen. Interestingly, these azides are stable even in the presence of silver(I) ions.

PUBLICATIONS IN REFEREED JOURNALS 2001:

1.* *Title:* Azido Derivatives of Germanium(II) and Tin(II): Syntheses and Characterization of $[(Mes)_2DAP]GeN_3$, $[(Mes)_2DAP]SnN_3$, and the Corresponding Chloro Analogues Featuring Heterocyclic 6-π-Electron Ring Systems {where $[(Mes)_2DAP]=\{N(Mes)C(Me)\}_2CH$}.

Authors: Ayers A. E., Klapötke T. M., and **Dias H. V. R.**

Journal: ***Inorganic Chemistry***, **40**, 1000-1005 (2001)

* *Reported as "in press" in the Annual Research Report 2000*

ABSTRACTS/CONFERENCE PROCEEDINGS (2001):

1. **Dias H. V. R.** and Ayers A. E.
Azido Derivatives of Low Valent Group 14 Elements
American Chemical Society, National Meeting,
San Diego, April 2001.

2. Chen Y., Wu H., Lovely C. J., and **Dias H. V. R.**
Synthesis and Intramolecular Diels-Alder Reactions of 4-Vinylimidazoles
American Chemical Society, 57th Southwest regional meeting,
San Antonio, Texas, October 2001.

3. Browning R.G., Polach S.A, Goh T.K.H.H., **Dias H.V.R.**, and Lovely C. J.
New Catalysts for Aziridination and Cyclopropanation: Tris(pyrazolyl)borate Copper(I) Complexes with Fluorinated Ligands
American Chemical Society, 57th Southwest regional meeting,
San Antonio, Texas, October 2001.

4. Polach S. A. and **Dias H. V. R.**
Synthesis of Silver(I) and Copper(I) Pyrazolates $[(3,5\text{-}(CF_3)_2Pz)Cu]_3$ and $[(3,5\text{-}(CF_3)_2Pz)Ag]_3$ and their Reactions with Triphenylphosphine
American Chemical Society, DFW Section, 34th Meeting-in-miniature,
Stephenville, TX, August 2001.

PROJECT: **NATURAL PRODUCTS CHEMISTRY**

(I) CHEMISTRY, ANTI VIRAL/HIV ACTIVITY AND ANTIMICROBIAL ACTIVITY STUDIES OF SRI LANKAN PLANTS

COMMENCEMENT: 1994

INVESTIGATORS:

Dharmaratne H.R.W. (1993 - to date), *Associate Research Professor*
Marasinghe G.P.K. (1997 - 2000), *Research Assistant*
Perera D.S.C. (1996), *Research Assistant*
Tennakoon S.B. (2000 - 2001), *Research Assistant*
Wanigasekera W.M.A.P. (1994 - 1996), *Research Assistant*
Wickramasinghe C.S. (1998 - 2000), *Research Assistant*
Wijesinghe W.M.N.M. (1996 - 1999), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*)**:**

Cordatolide A and cordatolide B, isolated from *Calophyllum cordato-oblongum,* were found to be anti HIV 1 RT active. Cordatolide B-OMe, oblongulide, cordato-oblongic acid, cordato-oblongic acid methylester, isocordato-oblongic acid methylester, inophyllum A, thwaitesixanthone, calothwaitesixanthone and calozeyloxanthone, isolated from different *Calophyllum* species of Sri Lanka, were tested for inhibitory activity against HIV-1 and its virally-encoded reverse transcriptase (RT). These compounds were found to be inactive in both the HIV-1 RT and whole virus systems. In contrast, cordatolide A and B demonstrated IC50 values of 19.3 and 11.7 MM, respectively, against HIV-1 replication in a novel green fluorescent protein (GFP)-based reporter cell assay (HOG.R5) [bio assays were carried out in the USA]. Structure-activity relationship of coumarins were studied using the above results.

Further investigation on *Calophyllum cordato-oblongum* extracts yielded three pyranocoumarin derivatives, cordatolide A-OMe, cordatolide B-OMe and cordatolide C-OMe. Methylation of cordatolode B and the attempted methylation of cordatolode A under acidic conditions gave the methyl ether of cordatolide B and 11,12-anhydrocordatolide. Methyl ether of cordatolide A, methyl ether of cordatolide B and methyl ether of cordatolide C are new compounds. 11,12-anhydrocordatolide is a new synthetic compound. A reaction mechanism was proposed, via a carbonium ion, for the format ion of methyl ether of cordatolide B and 11,12-anhydrocordatolide in the above methylation reactions. A new chromen acid, iso-cordato-oblongic acid, was isolated from the hexane extract of the stem bark of *C. cordato-oblongum* and its structure was established.

A chemical investigation of the buds of *C. moonii, C. bracteatum* and *C. thwaitesii,* afforded pyranocuoumarins and other compounds. This is the first report of a coumarin from *C. thwaitesii.* The presence of pyranocoumarins in the buds of the

above four species, including *C. cordato-oblongum*, indicated a possible role of these coumarins in the defence mechanism of *Calophyllum* species.

Extracts from different plant parts of four *Calophyllum* species were tested for pepsin inhibitory activity and two plants showed activity. Chemical investigation of some of the above plants afforded xanthones, chromen acids and triterpenoids. Three of the isolated xanthones were found to be new prenylated compounds, and some of the secondary metabolites were reported for the first time from these plants. Seven prenylated xanthones and two chromen acids isolated from *Calophyllum thwaitesii* and *C. mooni,* were subjected to antimicrobial activity studies using the minimum inhibitory concentration method (MIC) with a special reference to methicillin resistant *Staphylococcus aureus* (MRSA). Our results showed that calozeyloxanthone isolated from *C. mooni* was highly active against MRSA.

Calozeyloxanthone was found to be active against vancomycin resistant enterococci (VRE) and vancomycin sensitive enterococci (VSE) with MIC values of 6.25 mg/ml and 12.5 mg/ml respectively. A marked synergism between calozeyloxanthone and vancomycin hydrochloride (VCM) against VRE was also observed (bio assays on VRE were carried out in Japan).

Extracts and pure compounds from the leaves and root bark of *Garcinia mangostana* were subjected to anti-microbial assays with a special reference to methicillin resistant *Staphylococcus aureus* (MRSA) using the agar dilution method. Results indicated activity in a number of extracts against 15 MRSA strains, including a standard. Activity guided farctionation showed that their activity is mainly due to the presence of α-mangostin.

Extracts from different parts of *Calophyllum* species of Sri Lanka were subjected to anti-microbial assays with a special reference to methicillin resistant *Staphylococcus aureus* (MRSA) and methicillin sensitive *Staphylococcus aureus* (MSSA) strains using an agar dilution method. Some of the extracts showed activity against a number of MRSA and MSSA strains. The above activity may be due to the presence of calozeyloxanthone in *Calophyllum moonii* and *Calophyllum lankaensis,* and 6-deoxy-γ-mangosteen in *Calophyllum thwaitesii* extracts.

Thwaitesixanthone, calothwaitesixanthone, trapezifolixanthone, calabaxanthone and calozeyloxanthone were subjected to anti-cancer screening assays using human cell lines from malignant melanoma, epidermoid carcinoma (oral), ductal carcinoma (breast) and ovary carcinoma. A cell line from the kidney of an African green monkey was used as the normal cell line. In the above assays, calozeyloxanthone showed moderate activity for entire cell lines except epidermoid carcinoma, while trapizifolixanthone and calabaxanthones showed activity against only malignant melanoma. (bio assays were carried out in the USA).

A considerable amount (1.14%) of an anti-inflammatory active lupeol and few unidentified compounds were isolated from the hexane extract of *Zanthoxylum rhesta.*

The following postgraduate degrees have been completed.

Wanigasekera W.M.A.P. - Chemistry and search for antiviral/anti-HIV activity of some Sri Lankan *Calophyllum* species. M. Phil, University of Peradeniya (1996).

Wijesinghe W.M.N. - Chemistry and antimicrobail activity of *Calophyllum moonii* M. Phil, University of Colombo (1999).

Marasinghe G.P.K. - Chemistry and antiviral/anti-HIV activity of family Clusiaceae). M. Phil, University of Peradeniya (2000).

The following awards have been received by researchers of our project for some of the above work.

I. TWAS/NARESA Award for the best young scientist of the year 1996 (Chemistry Award) - Wanigasekera W.M.A.P.

II. Kandiah Memorial Award (11) 1997 for the best piece of research carried out by a postgraduate student in Sri Lanka 1997 - Wanigasekera W.M.A.P.

III. Kandiah Memorial Award (11) 1999 for the best piece of research carried out by a postgraduate student in Sri Lanka 1999 - Wijesinghe W.M.N.M.

IV. Visiting Scholar(2000/2001), National Center for Natural Products Research University of Mississippi, University, MS, USA. - Dharmaratne H.R.W.

PROJECT OUTPUT 2001:

Extracts and pure compounds from the leaves and root bark of *Garcinia mangostana* were subjected to anti microbial assays with a special reference to methicillin resistant *Staphylococcus aureus* (MRSA) using the agar dilution method. Results indicated activity in a number of extracts against 15 MRSA strains including a standard. Activity guided farctionation showed that their activity is mainly due to the presence of α-mangostin.

Bioassays of extracts from different parts of *Calophyllum* species showed activity against a number of MRSA and MSSA strains. The above activity may be due to the presence of calozeyloxanthone in *Calophyllum moonii* and *Calophyllum lankaensis,* and 6-deoxy-γ-mangosteen in *Calophyllum thwaitesii* extracts.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Anxiolytic effects of kava extracts and kavalactones in the chick social separation stress paradigm

Authors: Smith K.K., **Dharmaratne H.R.W.**, Feltenstein M.W., Broom S.L, Roach J.T., Nanayakkara N.P.D., Kahn I.A., and Sufka K.J.

Journal: ***Psychopharmacology***, **155**, 86-90 (2001)

2. *Title:* Kavalactones from *Piper methysticum*, and their ^{13}C NMR spectroscopic studies
Authors: **Dharmaratne H.R.W.**, Nanayakkara N.P.D., and Khan I.A.
Journal: ***Phytochemistry*** (in press)

3. *Title:* Inhibition of HIV-1 Replication by *Calophylulm* Coumarins and Xanthones
Authors: **Dharmaratne H.R.W.**, Tan G.T., **Marasinghe G.P.K.**, and Pezzuto J.M.
Journal: ***Planta Medica*** (in press)

** Reported as "in press" in Annual Report 2000*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Khan S.I., Ganzera M., **Dharmaratne H.R.W**, Nanayakkara D. Khan I.A., and Walker L.A.
Transport of Kavalactones across CACO-2 cell monolayers - A model of Human Intestinal absorption. Botanical Dietary Supplements: Natural Products at Crossroads
American Society of Pharmacognosy and Council for Responsible Nutrition, 2001 Interim Meeting, , Asilomar, California, P-48, November, 2001.

2. Sufka K.J., Kahn I.A., Feltenstein M.W., Lambdin C., Ganzera M., **Dharmaratne H. R.W.**, Broom S.L., Roach J.T., and Nanayakkara N.P.D.
Screening Anxiolytic activity of Kava extracts. Botanical Dietary Supplements: Natural Products at Crossroads
American Society of Pharmacognosy and Council for Responsible Nutrition, 2001 Interim Meeting, , Asilomar, California, P-49, November, 2001.

3. **Dharmaratne H. R.W.**, Nanayakkara N.P.D., and Khan I.
Terpenodial saponi from Caulophyllum thalictroides (Blue Cohosh), Botanical Dietary Supplements: Natural Products at Crossroads
American Society of Pharmacognosy and Council for Responsible Nutrition, 2001 Interim Meeting, Asilomar, California, P-30, November, 2001.

4. Ganzera M., **Dharmaratne H.R.W.**, Nanayakkara N.P.D., and Khan I.A.
Determination of saponins and alkaloids in Caulophyllum thalictroides (Blue Cohosh) by high performance liquid chromatography and evaporative light scattering detection. Botanical Dietary Supplements: Natural Products at Crossroads
American Society of Pharmacognosy and Council for Responsible Nutrition, 2001 Interim Meeting, Asilomar, California, P-22, November, 2001.

5. Ganzera M., Bedir E., Zhao J., **Dharmaratne H.R.W.**, and Khan I.A.
Evaporative light scattering detection – A versatile technique for the analysis of natural products with low UV absorption. Botanical Dietary Supplements: Natural Products at Crossroads
American Society of Pharmacognosy and Council for Responsible Nutrition, 2001 Interim Meeting, Asilomar, California, C-8, November, 2001.

6. Smith K.K., **Dharmaratne H.R.W.**, Feltenstein M.W., Broom S.L., Roach J.T., Nanayakkara N.P.D., Kahn I.A., and Sufka K.J.
Screening Piper methysticum and its compounds for anxiolytic properties
The Mississippi Academy of Sciences, February 2001.

7. **Dharmaratne. H.R.W.**, Nanayakkara N.P.D., and Kahn I.A.
Isolation and 13C NMR spectroscopic studies of Kavalactones
42nd Annual Meeting of the American Society for Pharmacognosy, Oaxaca City, Mexico, 2001.

8. **Dharmaratne H.R.W.**, Nanayakkara N.P.D., and Kahn I.A.
A new sesquiterpene acid from Valeriana officinalis
42nd Annual Meeting of the American Society for Pharmacognosy, Oaxaca City, Mexico, 2001.

PROJECT: **NATURAL PRODUCTS CHEMISTRY**

(II) SEARCH FOR BIOACTIVE COMPOUNDS IN SRI LANKAN PLANTS AS POTENTIAL RESOURCES FOR TREATMENT AND CONTROL OF DISEASES.

COMMENCEMENT: 1992

INVESTIGATORS:

Balasooriya B.A.I.S. (2001-to date), *Research Assistant*
Bandara A.G.D. (1996-1999), *Research Assistant*
Jayasinghe U.L.B. (1992-to date), *Senior Research Fellow*
Jayasooriya C.P. (2000-to date), *Research Assistant*
Kumarihamy B.M.M. (1997-to date), *Research Assistant*
Marikkar J.M.M.N. (1996- 1997), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*)**:**

Pometia eximia **(Sapindaceae):** Preliminary screening of the methanol extract of the stem of the plant showed strong molluscicidal activity against *Biomphalaria glabrata* snails and larvicidal activity against *Aedes albopictus* larvae. Chromatographic separation of the methanol extract gave hederagenin and nine saponins containing hederagenin as aglycone. Five saponins showed strong molluscicidal activity against *Biomphalaria glabrata* snails and one of them showed strong insecticidal activity against the brown rice plant hopper *Nilaparvata lugens*.

Filicium decipiens **(Sapindaceae):** Preliminary investigation of the stem/leaves of the plant showed antibacterial and antifungal activity. Chemical investigation of these extracts furnished a new norneohopene ester of caffeic acid, three flavonol glycosides and sitosterol-D-glucoside.

Sarcococca brevifolia **(Buxaceae):** Chemical investigation of the aerial part of the plant furnished four new steroidal alkaloids. Two of them showed strong antibacterial activity.

Uncaria elliptica **(Rubiaceae):** We have revised the previous structure assignments of uncaric acid, diketouncaric acid and diacetouncaric acid which were reported from the same plant. A quinovic acid glycoside has been reported for the first time from this plant. Re-investigation of the alkaloid fraction of the plant gave ajmalicine, farmosanine, isomitraphylline and mitraphylline.

Terminalia catappa **(Combretaceae):** Extracts of the plant showed preliminary antiviral activity in the pepsin A inhibition assay and molluscicidal activity against *Biomphalaria glabrata*_snails. Chemical investigation of this plant gave six compounds including two glycosides.

***Diploclisia glaucescens* (Menispermaceae):** Chemical investigation of a methanol extract of the leaves of *D. glaucescens* furnished an unusual ecdysone; 1β-hydroxy-3-deoxy-20-hydroxyecdysone and 20-hydroxyecdysone. Structures were established on detailed analysis of spectral data. This unusual ecdysone showed 40% of the potency of 20-hydroxyecdysone in the spiracle index assay against the 4th instar larvae of the silkworm *Bombyx mori*.

We have identified some antifungal active extracts of the plants belong to the family **Rubiaceae** and **Meliaceae**.

PROJECT OUTPUT 2001:

A chemical investigation of the high polar fraction of a methanol extract of the leaves of *Diploclisia glaucescens* furnished two oleanane saponins 3-*O*-β-D-glucopyranosyl (1→3)-β-D-glucopyranosyl-28-O-β-D-glucopyranosyl-oleanolic acid(**1**) and 3-*O*-β-D-xylopyranosyl (1→2)-β-D-glucopyranosyl-28-O-β-D-glucopyranosyloleanolic acid(**2**). Further chemical investigation of the high polar fraction of the methanol extract of the fruits of *D. glaucescens* furnished two other oleanane saponins 3-*O*-β-L-rhamno pyranosyl(1→2)-β-D-glucopyranosyl(1→2)-β-D-glucopyranosyl-28-*O*-β-D-glucopyra nosylphytolaccagenic acid(**3**) and 3-*O*-β-L-rhamnopyranosyl(1→2)-β-D-glucopyranosyl (1→2)-β-D-glucopyranosyl-28-*O*-β-D-glucopyranosylserjanic acid(**4**), and two ecdysones; 2-deoxy-20-hydroxyecdysone(**5**) and makisterone C(**6**). Compound **3** has not been identified earlier, while all others are reported for the first time in the family Menispermaceae.

Antifungal activity guided fractionation of solvent extracts of the stem bark of *Bridelia retusa* of the family Euphorbiaceae against *Cladosporium cladosporioides*, furnished new bisabolane sesquiterpenes, (*E*)-4-(1,5-dimethyl-3-oxo-1-hexenyl) benzoic acid, (*E*)-4-(1,5-dimethyl-3-oxo-1,4-hexadienyl)benzoic acid, 4-(1,5-dimethyl-3-oxo-4-hexenyl)benzoic acid and (+)-isochaminic acid, together with the known 4-(1,5-dimethyl-3-oxo-1,4-hexyl)benzoic acid (ar-todomatuic acid), 5-allyl-1,2,3-trimethoxybenzene (elemicin), (+)-sesamin and 4-isopropylbenzoic acid (cumic acid). All these compounds showed antifungal activity on TLC bioautography method, the minimum amount for activity raging from 25 µg - 5 µg.

The antifungal principle of *Ageratum conyzoides* shoots was identified as precocene II. (This work was conducted in colloboration with Dr M. C. M. Iqbal, Biotechnolgy Group)

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

*1. *Title:* *iso*-N-formyl-5-en-chonemorphine, A Steroidal alkaloid from *Sarcococca zeylanica*
Authors: **Jayasinghe U.L.B., Kumarihamy B.M.M.**, Nadeem M., Choudhary M.I., Attta-ur-Rahman and Weerasuriya A.
Journal: ***Natural Product Letters*, 15**(3),151-155 (2001)

2*. *Title:* 24-Methylenecycloartenone from *Bhesa nitidissima*
Authors: **Jayasinghe U.L.B.**, Vithana H.S., Wannigama G.P., and Fujimoto Y.
Journal: ***Fitoterapia,*** **72**, 594-595 (2001)

3. *Title:* A new norneohopane caffeate from *Filicium decipiens*
Authors: **Jayasinghe U.L.B., Bandara A.G.D.**, Hara N., and FujimotoY.
Journal: ***Fitoterapia,*** **72**, 737-742 (2001)

4. *Title:* 3-Deoxy-1β, 20hydroxyecdysone from the leaves of *Diploclisia glaucescens*
Authors: **Jayasinghe U.L.B., Jayasooriya C.P.**, Oyama K., and Fujimoto Y.
Journal: ***Steroids*** (in press)

** Reported as " in press" in the Annual Research Report 2000*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Iqbal M.C.M., **Jayasinghe U.L.B.,** Mallikarachchi G.S., and Dharsheiya M.
Antifungal activity in seeds of Carica papaya (Caricaceae)
Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

2. **Jayasinghe U.L.B.**, **Jayasooriya C.P.**, Bandara B.M.R., Ekanayake S.P., Merlini L., and Assante G.
Antimicrobial activity of some Sri Lankan Rubiaceae and Meliaceae
Annual Sessions, University of Peradeniya.

3. **Jayasinghe U.L.B., Jayasooriya C.P.,** and Fujimoto Y.
1β-hydroxy-3- deoxy-20-hydroxyecdysone, an unusual ecdysone from the leaves of Diploclisia glaucescens
Proceedings of the Institute of Chemistry, Sri Lanka 30th Annual Sessions.

4. Iqbal M.C.M. and **Jayasinghe U.L.B.**
Antifungal activity in seeds of some selected Sri Lankan plants
13th International Reinhardsbrunn Symposium – Modern fungicides and antifungal compounds, Friedrichroda, Germany.

5. **Jayasinghe U. L. B.**, **Jayasooriya C. P.,** and Fujimoto Y.
Structure of a new phytoecdysteroid, 3-deoxy-1β,20-hydroxyecdysone, isolated from Diploclisia glaucescens (Japanese language)
Proceedings – 120th Annual Meeting of Pharmaceutical Society of Japan, Sapparo.

PROJECT: **BIOCHEMISTRY**

COMMENCEMENT: 1997

INVESTIGATORS:

Dharmaratne H.R.W. (1993-to date), *Associate Research Professor*
Rajapakse R.G.S.C. (1998 - 2000), *Research Assistant*

PROJECT OUTPUT 2001:

Two acid proteinases present in the juice of pitchers of *Nepenthes distillatoria* were purified to near homogeneity. Purification steps used were DEAE cellulose chromatography, sephacryl S-200 chromatography, pepstatin-sepharose chromatography and mono Q chromatography. Enzymes obtained after purification were analysed using SDS-PAGE to confirm the purity and to determine their molecular weights. Enzymatic properties of purified proteinases such as time dependency, enzyme concentration dependency, pH dependency, temperature dependency, stability at different temperature and pH, and effect of proteinase inhibitors were studied. Partial amino terminal amino acid sequences of both proteinases were determined and compared with reported sequences of other known plant aspartic proteinases such as rice, barley and cardoon.

Antibodies to both enzymes were produced by immunizing rabbits with purified enzymes. Antibodies were purified by ammonium sulphate saturation and affinity chromatography on protein - A sepharose. Histochemical staining using both antibodies was performed using transverse sections of fresh *Nepenthes* pitchers obtained under freezing conditions. Proteolytic action of *Nepenthes* major proteinase at different pH levels was investigated on natural proteins.

Purification fold and yield obtained after mono Q chromatography step were 59 times and 26.1% with the major proteinase and 44 times and 15.6% with minor proteinase. Based on the characteristics, it is suggested that both proteinases have similar properties. Purified enzymes are likely to be aspartic proteinases as reflected by the complete inhibition of proteolytic activity by 0.1mM pepstatin. Both proteinases were inhibited by diazoacetyl-DL norleucine methyl ester (DAN) and the pattern of inhibition is completely different with that of porcine pepsin suggesting that they are non-pepsin type aspartic proteinases. Molecular weights of major and minor enzymes are 43 kDa and 35 kDa as per SDS-PAGE separation. Purified enzymes have an optimum pH of 3.0 with 2% denatured haemoglobin as substrate. Optimum temperatures for activity of major and minor enzymes are 55^0C and 45^0C respectively. Both enzymes show a remarkable stability at higher temperatures (50^0C) and at a wide pH range (pH 2-10) compared to porcine pepsin. Low homology of both major and minor proteinases with the amino acid sequences of known aspartic proteinases suggests the unique structural features of *Nepenthes* proteinases.

Immunohistochemical staining suggests that both enzymes are produced by the cells located in the inner wall of the lower third of the pitcher. Proteolytic action of

Nepenthes major acid proteinase on dhal and other proteins at acidic as well as neutral pH levels were found to be remarkable.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Athauda S.B.P., Rajapakshe R.G.S.C.,** Wijeratne S.R., **Dharmaratne H.R.W.,** and Takahashi Kenji.
   Comparative Stability of minor acid proteinase of Nepenthes distillatoria L. at different temperatures and pH levels.
   Page 256. Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

POST-GRADUATE DEGREES COMPLETED IN 2001:

1.	Rajapakse R.G.S.C.-		Purification and characterization of Acid Proteinases from *Nepenthes distillatoria* L.
	M. Phil Degree	-	Awarded by the University of Peradeniya, Sri Lanka.

PROJECT: **PLANT BIOTECHNOLOGY**

COMMENCEMENT: 1988

INVESTIGATORS:

Iddagoda N. (1989-1997), *Research Fellow*
Iqbal M.C.M. (1988-1989, 1994), *Visiting Scientist*
Karunaratne S.M. (1988-1991), *Visiting Research Fellow*
Kovoor A. (1988- to date), *Honorary Research Professor*
Kumari W.M.G.C. (1995-1997), *Research Student Fellow*
Meemaduma V. (1999-to date), *Research Assistant*
Nilmini Deepika P.K.D. (1993-1995), *Research Assistant*
Rajapakse M.C. (1988-1992), *Junior Research Fellow*
Ramanayake S.M.S.D. (1988-to date), *Senior Research Fellow*
Tennakoon T.M.A. (1997-2000), *Research Assistant*
Wanniarachchi V.A.V.R. (1996-1999), *Research Assistant*
Weerawardene E. (2000-to date), *Research Assistant*
Wickramasinghe W.M.T.D. (1995-1996), *Research Assistant*
Yakandawala K. (1994-1996), *Research Student Fellow*

PROGRESS ACHIEVED (*Since inception*)**:**

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

Bamboo: 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.

The axillary buds of *B. vulgaris* proliferated but it was not possible to attain continuous and rapid proliferation. Some factors responsible for the recalcitrance in this species were identified.

Plantlets were produced from seedling explants that responded to axillary shoot proliferation in the species *D. giganteus* (M. C. Rajapakse, M.Phil. thesis) and in *D. asper*.

The axillary shoot proliferation for plantlet production with the use of explants from 6 – year old and a 70-year old field grown clumps was achieved. In vitro flowering was also induced in these axillary shoots. The factors that may have contributed to in vitro flowering were studied. Callus, which exhibited an embryogenic potential, was also induced from explants of the adult clump. 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.

Total DNA extraction in bamboo was effected and the selection of primers for RAPDs in *D. giganteus* was carried out. This will be used to determine genetic diversity in populations.

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 and from May 1994 – October 1997.

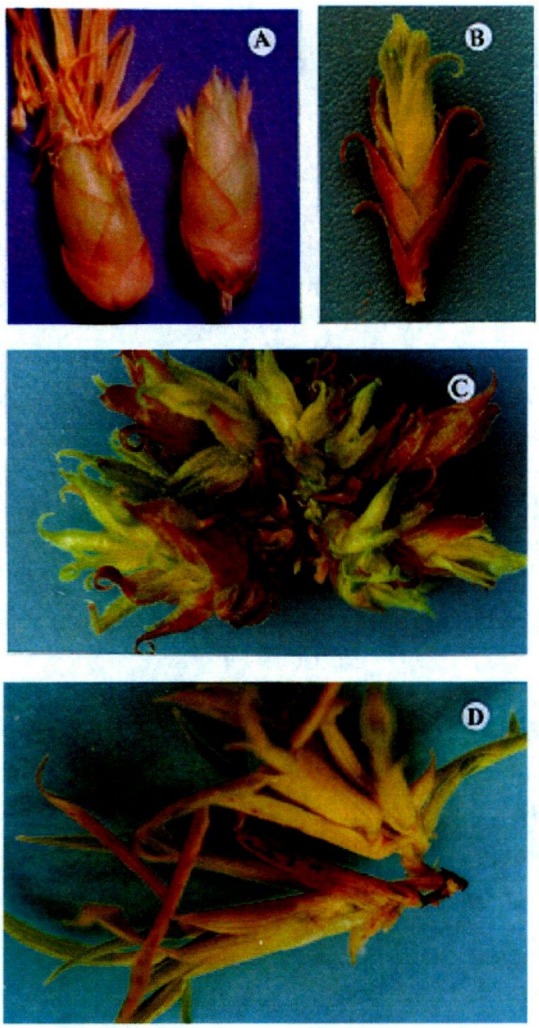
In vitro micrografting and compatibility studies: This study was suspended in 1994 and revived in 1997. Culture conditions for the establishment of in vitro cultures required for grafting were determined for selected species, *Anacardium occidentale, A.microcarpum, Garcinia mangostana, Pentadesma butyracea, Durio zebethinus* 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 2001:

Further studies in the improvement of somatic embryogenesis, rhizogenesis and flowering in *D.giganteus* are ongoing.

Total DNA from 130 individuals of *D. giganteus* was extracted and RAPDs were performed with six selected primers. DNA from 25 allied species was extracted for a study in identification and characterization of species. Most of these species have not been taxonomically defined.

Axillary shoots of *Bambusa atra* were proliferated and flowering induced. Causes of flowering are under investigation. Rooting of the axillary shoots yielded plantlets that were acclimatized to field conditions. This could be used for large-scale plantlet production in this species.



Flowering in an adult 20-year old *Dendrocalamas giganteus.* (A) Fully developed *in vivo* spikelets with anthers exserted (x2.5);
(B) fully developed *in vitro* spikelet (there is no anthesis) (x3);
(C) a cluster of *in vitro* spikelets (x3);
(D) vegetative shoots formed during floral reversion (x3)

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1. *Title:* Axillary shoot proliferation and in vitro flowering in an adult giant bamboo, *Dendrocalamus giganteus* Wall. Ex Munro
   Authors: **Ramanayake S. M. S. D., Wanniarachchi W.A.V.R.**, and **Tennakoon T.M.A.**
   Journal: ***In vitro Cellular and Developmental Biology-Plant,* 37**, 667 – 671 (2001)

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Ramanayake S.M.S.D., Wanniarachchi W.A.V.R.**, and **Weerawardene T.E.**
   Flowering in the giant bamboo, Dendrocalmus giganteus
   Programme and Abstract Book of the "EMBO workshop The Molecular basis of the floral transition". John Innes Centre, Norwich, UK, July 2001.

2. **Ramanayake S. M. S. D., Weerawardene T.E.**, and Amarasekera V. N.
   Micropropagation and in vitro flowering in Bambusa atra
   Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

PROJECT: **PLANT REPRODUCTIVE BIOLOGY**

COMMENCEMENT: 1997

INVESTIGATORS:

Iqbal M.C.M. (1997- to date), *Research Fellow*
Kovoor A. (2001- to date), *Honorary Research Professor*
Wijesekera K.B. (1998-to date), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

A. **Androgenesis:** Pollen grains contain the haploid number of chromosomes and are destined to fertilize the egg (also haploid) and produce seeds. Under certain *in vitro* conditions it is possible to induce immature pollen to undergo embryogenesis and produce haploid plants. Our attempts at androgenesis with the perennial species tea *Camellia sinensis* and coconut *Cocos nucifera* were unsuccessful. Haploids were induced in *Solanum pseudocapsicum* for the first time but were inconsistent. Experimental conditions were successfully established for androgenesis in *Datura metel.* Investigating the role of temperature stress on androgenesis, a brief temperature gradient applied to the anthers before culture significantly enhanced embryogenesis. The control of somatic embryogenesis on the primary haploid embryos by the apical meristem was also studied.

B. **Haploid embryo development:** Angiosperm seedlings have a simple body organization where two patterns – axial and radial – are superimposed on each other. This basic pattern is determined by genes that control pattern formation during embryogenesis. Haploid embryos can be expected to express recessive alleles that are not expressed in the diploid state due to dominance effects. We found androgenetic embryos with the following deletions in the apical – basal pattern: Apical (no cotyledons and apical meristem), Central (hypocotyl absent), Basal (hypocotyl and root meristem absent), and Terminal (apical and root meristem absent).

C. **Pollen development in *Gordonia* species:** The unusual development of parenchyma cells in the connective tissue of anthers in *G. dassanayakei* and *G. ceylanica* was studied. These cells with a distinct surface architecture eventually entered the anther sacs before anther dehiscence. These were characterized morphologically and chemically to determine the presence of reserve food products. These cells termed pseudopollen, did not germinate on a pollen germination medium.

D. **Antifungal activity in plant products** (in collaboration with Dr. U.L.B. Jayasinghe, Natural Products project): Organic solvent extracts from shoots of *Ageratum conyzoides* was tested for antifungal activity. The *n*-hexane extract completely inhibited the growth of *Rhizoctonia solani* and *Sclerotium rolfsii* in vitro. Activity-guided fractionation was used to separate the active compounds. Experiments were continued with organic solvent extracts from seeds of local plant species.

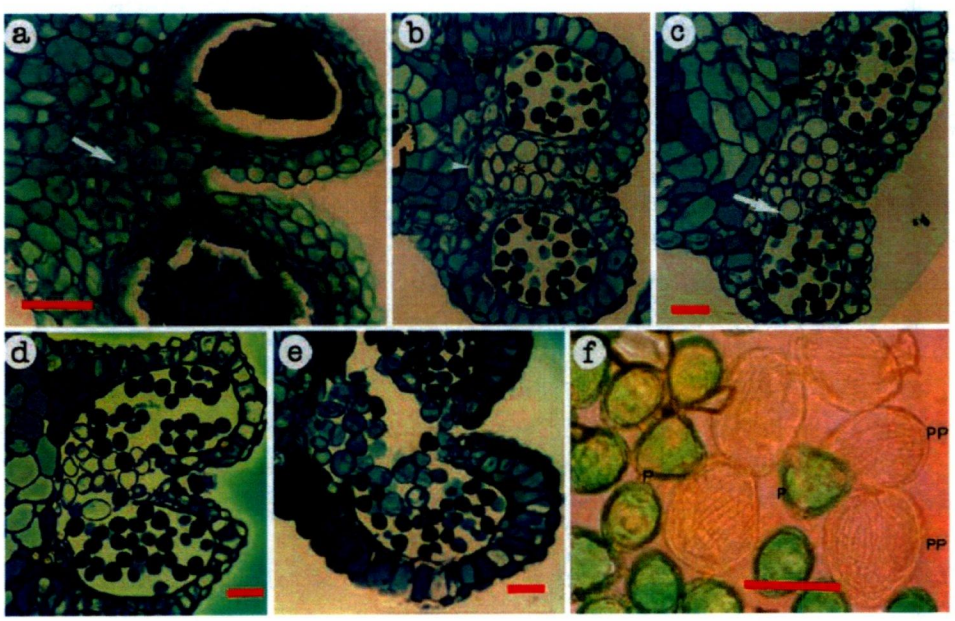
PROJECT OUTPUT 2001:

A. **Androgenesis** – Haploid induction occurred only in the presence of the anther wall. Culture of isolated microspores from the same anthers did not produce embryos. The induction of embryos was significantly enhanced by subjecting the anthers to two temperatures in quick succession before incubation.

B. **Haploid embryo development:** The different embryo abnormalities were characterized and microtome sectioning of fixed tissue was done to determine the origin of the embryos. Preliminary evidence suggests the origin to be sub-epidermal. Spontaneous secondary embryogenesis also occurred on some of the defective embryos.

C. **Pollen development in *Gordonia* species:** The normal and pseudopollen types were distinguished by morphology and staining. The pseudopollen were significantly larger, and transparent with a furrowed surface. They reacted negatively to histochemical tests for starch lipids and proteins while the normal pollen were positive. This study was completed and the results published.

D. **Antifungal activity in plant products:** The active compound from *A. conyzoides* inhibited fungal growth at a concentration of 80 – 100 ppm. Extracts from one of the seeds assayed showed fungicidal activity against some of the fungi assayed. Experiments are in progress.



Cross section of *Gordonia dassanayakei* anthers during microsporogenesis embedded in resin and stained with toluidine blue **(a-e).** **a** Arrow shows area of connective tissue destined to differentiate into pseudopollen. Pollen contain regular pollen in the tetrad stage. **b.** Intercellular spaces are formed (*) and cells are rounded in the connective tissue and pseudopollen (*arrow head*). A thin layer of tapetal cells bounds the pollen sac. **c.** The tapetum breaks (*arrow*) and pseudopollen enter the pollen sac containing mature pollen. **d,e** Pollen sacs harbouring pseudopollen which are not stained. **f** Pollen (*P*) and pseudopollen (*PP*) stained with malachite green; the latter are not stained and show parallel ridges on the wall. *Scale bar* 100 µm.

Research for undergraduate degrees completed:

1. The role of temperature and division symmetry on haploid induction of *Datura metel*. U.P. Pelawatte, Faculty of Agriculture, University of Peradeniya 2001.

2. Screening antifungal activities of organic solvent extracts of selected Sri Lankan plants. T. Abarajitha, Eastern University, Sri Lanka 2001.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1. *Title:* Antifungal activity from water extracts of some common weeds
   Authors: **Iqbal M.C.M.,** Meiyalaghan S., **Wijesekara K.B.**, and Abeyratne K.P.
   Journal: ***Pakistan Journal of Biological Sciences,*** **4**(7), 843-845(2001)

2. *Title:* Fruits in *Brugmansia x candida* Pers
   Authors: **Iqbal M.C.M., Wijesekara K.B..**, and Hapukotuwa A.
   Journal: ***Ceylon Journal of Science (Biological Sciences),*** **28,** 19-20(2001)

3. *Title:* Cells of the connective tissue differentiate and migrate into pollen sacs.
   Authors: **Iqbal M.C.M.** and **Wijesekara K.B.**
   Journal: ***Naturwissenschaften*** (in press)

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Iqbal M.C.M.,** Jayasinghe U.L.B., Mallikaarachchi G.S., and Dharsheiya M. Antifungal activity in seeds of *Carica papaya* (Caricaceae)
   Page 105. Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

2. **Wijeysekara K.B.** and **M.C.M. Iqbal**
   Secondary embryogenesis in pollen derived embryos of *Datura metel* L
   Page 49. Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

3. Rupika L.A.S., **Wijeysekara K.B.**, and **Iqbal M.C.M.**
   Callusing and plant regeneration in *indica* rice
   Page 75. Proceedings of the Sri Lanka Association for the Advancement of Science. Part I-(Abstracts) 57th Annual Session, 26 November- 01 December 2001, Moratuwa.

4. **Iqbal M.C.M.** and Jayasinghe U.L.B.
   Antifungal activity in seeds of some selected Sri Lankan plants
   13th International Reinhardsbrunn Symposium, May 14-18, 2001, Friedrichroda, Germany (in press).

PROJECT: **PLANT CELL BIOLOGY**

COMMENCEMENT: 2001

INVESTIGATORS:

Jeyanandarajah P. (2001- to date), *Research Fellow*
Kovoor A. (2001- to date), *Honorary Research Professor*
Magana-Arachchi D. (2001-to date), *Research Fellow*
Wimalasena T. (2001- to date), *Research Assistant*

PROGRESS ACHIEVED (*Since inception*):

Cyanobacteria: Isolations of phytoplanktonic forms from the Kandy lake water were made on different selective media using various methods such as dilution plate, tube dilution, etc.

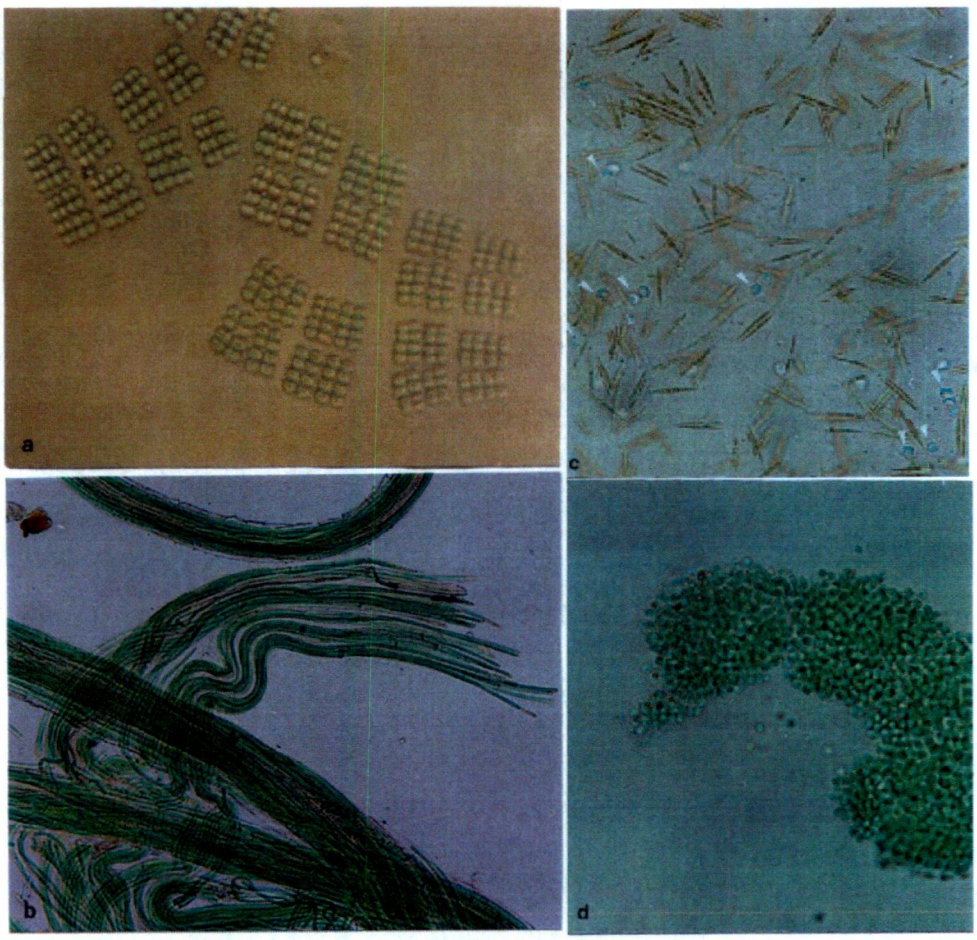
The use of 0.03M phosphate buffer, pH 7.0 as diluent gave good results on BG 11 medium with Oxoid bactoagar supplemented with vitamins. Media prepared with agar agar powder gave poor results. The type/brand of agar, their concentration and the procedure of sterilization affected colony growth considerably.

Isolates in general showed hyaline growth initially from the point of inoculation. It was circular with the margin either smooth or wavy. In other instances the hyaline growth was in the form of either straight or curly filaments traversing through the media. The development of the green colour took several weeks. This may be attributed to the fact that the cultures were incubated at room temperature under normal daylight conditions in a room instead of a phytotron with cool-white fluorescent lights on all four sides and temperature control.

Microscopic observations revealed the presence of the following microorganisms tentatively identified to their genus level using illustrations from references: *Chlorococcum, Scenedesmus, Kirchineriella, Ankistrodesmus, Pediastrum, Eudorina, Vaucheria, Melosira, Cyclotella, Microcystis, Merismopedia and Schizothrix.* Two types Bacillariophytes were also detected.

Investigations were carried out with different substrates (e.g. granite, migmatite) left submerged at a depth of 1.5m below the surface of the water in the Kandy lake for a period of 24h to determine the type of microorganisms forming the biofilm around them. Surface association is an efficient means of lingering in a favourable microenvironment and biofilm-associated cells are more resistant to adverse conditions (e.g. toxic chemicals). Isolation studies revealed the presence of chlorophytes and cyanophytes in the biofilm formed.

Mycorrhiza: Investigations were initiated to determine whether mycorrhizal fungi were associated with the roots of bamboo. In anatomical studies, fungal mycelia were detected in critical tissues. However, their identity and significance have to be determined of their possible application to achieve specific objectives.



a. *Merismopedia* - multicelled cyanophyte which can vary the colour of its cells in reaction to the alteration in the colour of light.
b. *Schizothrix* - filamentous cyanophyte.
c. An unidentified bacillariophyte (diatom); lunate cells of *Kirchineriella* are also seen.
d. An unidentified phytoplakton.

PROJECT: **BIOLOGICAL NITROGEN FIXATION**

COMMENCEMENT: 1986

INVESTIGATORS:

Ekanayake S. (1994-1998), *Research Assistant*
Karagaswewa M. (1991-1996), *Research Assistant*
Kulasooriya S.A. (1986-1996), *Visiting Scientist, IFS*
Liyanarachchi L.A.W. (1997-1998), *Research Assistant*
Pahalawatta V. (1999), *Research Assistant*
Premaratne R.R. (1993-1997), *Research Assistant*
Ratnayake R. (2001-to date), *Research Assistant*
Rizvi E.M.J.M. (1991-1997), *Research Assistant*
Seneviratne G. (1994-to date), *Senior Research Fellow*
Sepalika J.A.H. (1998-to date), *Research Assistant*
Van Holm L. (1991-1997), *Team Leader*
Van Nieuwenhove C. (1991-1997), *Research Associate*
Vlassak K. (1991-1997), *Project Coordinator*
Wedisinghe S. (1996-1997), *Research Assistant*
Weerasinghe A. (1994- 2000), *Research Fellow*

PROGRESS ACHIEVED *(Since inception)*:

The original aim of the project was to improve the livelihood of rural Sri Lankan farmers through improved soil fertility by biological nitrogen fixation and balanced nutrient application. A variety of research programs were conducted during this period. However, the project is presently oriented to basic research on biological nitrogen fixation and related topics.

a) A *rhizobium* inoculant (bacterial fertilizer) was produced for grain legumes and leguminous trees, based on a substrate made of a special mixture of organic waste materials. These studies were concluded after testing a liquid formulation of them at Maha Illuppallama. This was done in collaboration with the Department of Agriculture. A 26% of seed yield increase of soybean was achieved with the liquid formulation, as compared to uninoculated controls. It is concluded that these microbial fertilizers can increase soybean yield by at least 26%, even up to over 100% under different soil conditions in the dry zone of Sri Lanka. A similar inoculant for a nitrogen fixing leguminous tree, *Albizia,* was tested on tea estates and an 84% plant growth increase was obtained in comparison to the non-inoculated control. This inoculant is now used for grain legumes in Sri Lanka, and is also being tested in Bangladesh.

b) A novel *ex situ* method of green manuring for lowland rice was tested in farmers' fields. This involves high density planting of green manure crops (eg. *Sesbania rostrata)* in small areas of marginal paddy lands. The method considerably

c) Thirteen leaf isozymes were assessed by gel electrophoresis for identification of elite trees in a heterogeneous population of *Pericopsis mooniana* (Nadun). Such an identification is important for efficient management of reforestation programmes with slow growing, high quality timber species like the tree under consideration. Out of the isozymes tested, formate dehydrogenate showed promising results.

d) Foliar application of chelated micronutrients to rice and tea showed potential for increasing their yields. A mixture of micronutrients when applied to farmers' fields in the dry zone increased panicle and grain formation of rice by 25% and 32%, respectively. Hundred seed weight was increased by 18%. The same mixtures increased tea yields by about 30% in tea estates over a year with a net extra benefit of around 30,000 Rs/ha.

e) Micropropagation of "Nadun" (*Pericopsis mooniana)* was experimented in a project funded by NORAD. Satisfactory results were obtained for the problem of browning, by reducing pH in the culture medium. In addition, dipping leaf explant in 300 mg/l of cefotaxime increased the regeneration up to 50%. Callus induction was noted to be optimum in a medium supplemented with 2 mg/l of 2.4-D and 0.5 mg/l of BAP.

f) Polyphenols are known as disinfectants and act as bactericides. Soil polyphenols therefore affect the growth and activity of rhizobia in soils, threatening their survival. In a study of polyphenolic inhibition of rhizobia, a method for fractionation and identification of polyphenols in soils was developed using One Dimensional Sodium Dodecyl Sulphate Polyacrylamide Gel Electrophoresis (1 D SDS PAGE), with urea and SDS as denaturing agents.

g) Studies on litter turnover in ecosystems led to discover that soil surface mulch application mitigates soil N_2O emission. This was published and established now. Underlying mechanisms of this mitigation were also identified.

PUBLICATIONS IN REFEREED JOURNALS: 10

PROJECT OUTPUT 2001:

1. A study on the interaction between phenolic compounds and rhizobia was conducted and the results have been submitted for publication. Effects of phenolic compounds on nitrogenase activity in rhizobia and plant-microbe interaction have also been studied. A manuscript is being prepared.

2. Soil organic matter decomposition was studied under different land-use patterns of Sri Lanka. Soils were collected and analyzed for a number of soil parameters and soil respiration, CH_4 and N_2O emissions. Data have now been analyzed and a manuscript is being written.

3. An experiment was commenced to examine soil carbohydrate controls on nutrient dynamics. Soil samples are being collected from different agroclimetic zones of the country. They are analysed for basic soil parameters and macro and micronutrients.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* A simple method of producing green manure *Sesbania rostrata* to achieve N synchrony in lowland rice
Authors: **Seneviratne G.** and **Ekanayake E.M.H.G.S.**
Journal: ***International Rice Research Notes*, 26**, 34-35 (2001)

2. *Title:* Mitigating nitrous oxide emission in tropical agriculture: Myths and realities
Author: **Seneviratne G.**
Journal: ***Current Science*, 80**, 117-118 (2001)

* *Reported as "in press" in the Annual Research Report 2000.*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Seneviratne, G.
^{15}N enrichment in upper oceanic N_2O reveals the existence of a novel N_2O sink
Proceedings of the Global Change Open Science Conference of the IGBP, Amsterdam, The Netherlands, July (2001). (Abstract).

PROJECT: **PRIMATE BIOLOGY**

COMMENCEMENT: 1983

INVESTIGATORS:

Dittus W. (1983- to date), *Honorary Senior Research Fellow*

PROGRESS ACHIEVED *(Since inception)*:

The overall aim of the project 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.

In practice, to investigate such phenomena we have identified more than three thousand macaque individuals (living plus dead), distributed among 33 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. 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 number of institutions) to investigate the potential role of disease (parasitism) and physiology (milk composition, hormone levels) in relation to behaviour and demography.

Furthermore, genetic studies (begun 1987) have shown how behaviour affects population genetic structure. Currently, we are continuing to monitor this population with a special emphasis to establish patrilineal genealogies, using DNA fingerprinting techniques. This allows us to define the role of paternal (father-son, etc.) behaviours on the survival and breeding success of males and females, and so on the overall genetic distributions. Recent work has focused on conservation management as well.

PROJECT OUTPUT 2001:

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

(b) ***Morphometric, genetic and epidemiological sampling.*** About 300 macaques were trapped and released unharmed. Extensive simiamorphometric measures were taken, as were blood samples for genetic and epidemiological testing. We began a

new initiative of examining anatomical asymmetry in relation to cumulative injuries and age, sex and social factors in macaques.

(c) ***Parasitism.*** I initiated a new collaboration with Ms. Dilrukshi Ekanayake, Madura Sanjeevani, and Dr. Neil Horadagoda of the Veterniary Faculty, University of Peradeniya. Special emphasis was placed on the identification and quantification of protozoan parasites that may be either zoonotic or anthroponotic agents among the three diurnal primate species living under different habitats at Polonnaruwa. The occurrence of protozoan parasites differed by habitat and species. At least three pathogens were found based on their gross morphology: cryptosporidia, microsporidia and cyclospora-like organisms. For positive identification of these pathogens, using genetic typing, samples had been sent to experts at the US Food and Drug Administration (Washington, DC, USA).

(d) ***Professional activities:*** In my role as Associate Editor for the American Journal of Primatology, I delegated and supervised the peer review of several submitted manuscripts. I also taught a session at the PGIS course for M. Sc. students in Wildlife Management in Giritale and Polonnaruwa.

(e) ***Data analyses.*** By way of preparing research results for publication, I examined the relationship between male reproductive success and known social factors. Paternity had been determined from genetic fingerprinting techniques. Some of the results had been presented at the IPS Congress and are still under preparation for publication.

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Dittus W.P.J.,** Keane B. and Melnick D.
The effects of age and rank on the reproductive success if wild toque macaques
The XVIIIth Congress of the International Primatological Society. Adelaide, January 2001. Pp. 256.

2. **Dittus W.P.J.** and Diaz T.
Primate conservation and the management of people at the Polonnaruwa Nature Sanctuary, Sri Lanka
The XVIIIth Congress of the International Primatological Society. Adelaide, January 2001. Pp. 135.

3. **Dittus W.P.J.**
Demography: a window to social evolution.
Workshop on: Macaque Society and Evolution. Mysore, March 2001.

PROJECT: **ECOLOGY AND ENVIRONMENTAL BIOLOGY**

COMMENCEMENT: 1989

INVESTIGATORS:

Ariyananda T. (1994-1995), *Research Assistant*
de Silva N.R.N. (1998 -1999), *Research Assistant – FISHTRAT*
Ekanayake R. (1999 - 2000), *Research Assistant*
Ekanayake M.P.B. (1999 – to date), *Research Assistant*
Gamlath R. (1996 – 1999), *Research Student Fellow*
Gamlath R. (1999 – 2000), *Research Assistant – FISHTRAT*
Manuweera L. (1993 – 1995), *Research Assistant*
Nathaneal S. (1989 - 1995), *Research Assistant*
Samaradiwakara S. (1996 –1999), *Research Student Fellow*
Sharaff F.F. (2001 – to date), *Research Assistant*
Silva E.I.L. (1999 – to date), *Associate Research Professor*
Withana D. (1989 – 1992), *Junior Research Assistant*

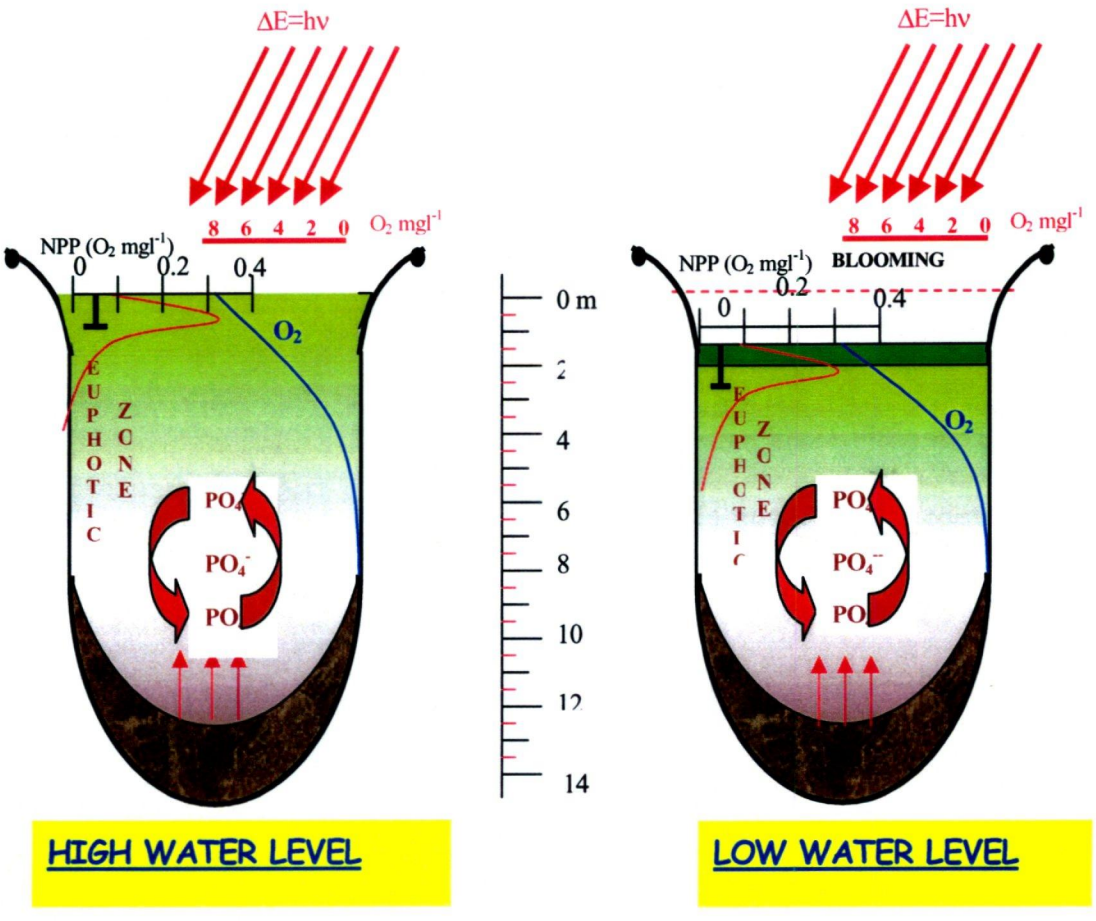
PROGRESS ACHIEVED *(Since inception)*:

The project initiated as Ecology and Conservation in 1989 was renamed as Ecosystem Analysis and Impact Assessment, in 1992. The name of the project was changed again in 1996 as Ecology and Environmental Biology with a view to restructuring research activities towards basic ecological studies in aquatic ecosystems. Although this project is broadly named as Ecology and Environmental Biology with an intention of future expansion, studies were primarily focused on aquatic environments with emphasis on aquatic ecology in both lotic and lentic ecosystems.

A systemic study was carried out on of the Mahaweli river basin since 1989 with emphasis on: colonization of exotic fish species in the Victoria Reservoir, water chemistry of the Nilambe Oya, nutrient loading into Kotmale Reservoir and trophic characteristics of Mahaweli Reservoirs. In addition, the environmental impact of the Kandalama Hotel Complex on the reservoir ecosystem was studied during pre-construction, construction and operational phases. A study was also carried out to determine the rainwater quality and buffer intensities of surface water in Sri Lanka. Further, commercially important fresh water fish species were analyzed for bio-accumulation of trace elements while several pelagic blood fish sold in upcountry market were analyzed for the levels of histamine. A study was also launched to determine the impact of operational activities of shrimp farms in the north western province on brackish ecosystems with an especial emphasis on the Dutch Bay and Mundal Lake. In 1995, an intensive study was carried out to determine the levels of organic and inorganic pollution along the course of the Meda Ela in Kandy during dry weather and unstorm condition.

Towards the end of 1996, an intensive and systemic limnological study was launched in the Kandy Lake with view to answer several questions on limnology of a hypereutropic, tropical urban water body. This study was intensified from May 1999, with the emergence of a cyanobacteria bloom (*Microcystis aeruginosa*) in the Kandy Lake. A parallel study was also started in the Hulu Ganga (one of the major tributaries of the Mahaweli River in the central Mahaweli Valley) to determine the ecological structure and functioning of a tropical stream draining and intensively exploited watershed. Some of the results from this study were analyzed using existing mathematical models and attempts were also made to derive new mathematical models to explain the behaviour of aquatic ecosystems (both lotic and lentic) in the tropics. A study on reservoir limnology was commenced in August 1998 to compare the primary productivity and nutrient dynamics of morphologically and operationally different reservoirs, namely, Victoria, Minneriya and Udawalawe. This is a component of the research project launched to determine the ecological processes and dynamics of Asian reservoirs and lakes funded by the European Union. In addition, studies were conducted on the retention of dissolved silica ($dSiO_2$) in manmade water bodies, which is currently being identified and considered as an important aspect of land-ocean nutrient fluxes. The results that are ecologically significant and scientifically important were published in refereed journals, monographs, and in the proceedings of local, regional and international meetings.

PROJECT OUTPUT 2001:



Vertical profile of the deep basin of the Kandy Lake.

Major emphasis was paid on field studies, laboratory analysis and preliminary data compilation and analysis of the FISHSTRAT Project during the year 2001. Two manuscripts submitted to the FISHSTRAT volume in Developments in Hydrobiology which is simultaneously published in Hydrobiologia have been accepted for publication. In addition, a paper was presented at the 9th international Conference on the Conservation and Management of Lakes held in Otsu, Japan. Two manuscripts submitted to the Sri Lanka Journal of Aquatic Science have been accepted for publication. Papers were presented on limnology and land ocean nutrient fluxes at international meetings. Further presentations on different aspects of ecology and environment (eg. water chemistry, population and environment, conservation of headwater streams, seasonal tanks) were delivered on invitation at universities, schools, government organizations etc. A study tour was made to Mumbai, India on an Invitation by USAID to investigate the Lake Restoration Project carried out by Clean-Flo International.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Salt Pollution in a Japanese Stream and its Effects on Water Chemistry and Epilithic Algal Chlorophyll-*a*.
Authors: **Silva E.I.L.**, Shimizu A., and Matsunami H.
Journal: ***Hydrobiologia,,*** **437**, 139-148 (2000).

2. *Title:* Catchment Characteristics, Morphometry, Hydrology and Ecosystem Structure of Three Reservoirs (Minneriya, Udawalawe and Victoria) in Sri Lanka
Authors: **Silva E.I.L.**, Amarasinghe M.D., and Kularatne M.
Journal: ***Hydrobiologia*** (in press)

3. *Title :* Regulation of Primary Productivity of Sri Lankan Reservoirs
Authors: **Silva E.I.L.**, Schiemer F., and Rott E.
Journal: ***Hydrobiologia*** (in press)

4. *Title:* Concentrations of Traces Metals in the Flesh of Nine Species Found in a Hydropower Reservoir in Sri Lanka
Authors: **Silva E.I.L.** and Shimizu A.
Journals: ***Asian Fisheries Science*** (in press)

5. *Title:* The role of Non-cichlid exotics in the fishery of the Victoria reservoir in Sri Lanka.
Authors: **Nathanael S.** and **Silva E.I.L.**
Journal: ***Journal of Aquatic Science*** (in press)

6. *Title:* Some aspects of the reproductive biology of three exotic cichlid species that colonize the Victoria Reservoir in Sri Lanka
   Authors: **Nathanael S.** and **Silva E.I.L.**
   Journal: ***Journal of Aquatic Science*** (in press)

7. *Title:* Photosynthetic activity of eleven perennial irrigation reservoirs in Sri Lanka
   Authors: **Silva E.I.L.,** Amarasinghe U.S., De Silva S.S., Nissanka C., and Schiemer F.
   Journal: ***Hydrobiologia*** (in press)

* *Reported as "in press" in the Annual Research Report 2000.*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. Schiemer F., Amarasinghe U.S., Frouzova J., Sricharoendhaam B., and **Silva E.I.L.**
   Ecosystem structure and dynamics – a management basis for Asian reservoirs and Lakes
   ACIAR Proceedings No 98 pages 201 - 214.

2. **Silva E.I.L.** and Schiemer F.
   Human Factor : Fourth Dimension of Limnology in the Tropics
   ACIAR Proceedings No 98 pages 111 - 125.

3. **Silva E.I.L.**
   Emergence of a Microcystis bloom in an urban waterbody, Kandy Lake in Sri Lanka
   In the proceedings of the 9th International Conference on the Conservation and Management of Lakes. Session 3-1 pages 493 – 496.

4. Gunatilake P.G.L., Senanayake S.M.H.M.S.K., and **Silva E.I.L.**
   Diatoms and Drowning : A Case Presentation
   Scientific Sessions 2001. Medico-Legal Society of Sri Lanka (Abstract).

5. **Silva E.I.L.** and Jayasinghe P.
   Some aspects of colonization success of three species of exotic cichlids in a hydropower reservoir (Victoria) in Sri Lanka
   6th Asian fisheries forum, Taiwan, November 2001 (Abstract).

POST-GRADUATE DEGREES COMPLETED IN 2001:

1. Nathanael E.S. - Some Aspects of the Biology and the Fishery of Exotic Cichlids in Victoria, a Deep Reservoir in Sri Lanka.
   Ph.D. Degree - Awarded by University of Peradeniya , Sri Lanka.

PROJECT: **CHEMICAL MODELING OF ENVIRONMENTAL SYSTEMS**

COMMENCEMENT: 1992

INVESTIGATORS:

Aluthpatabendi D. (1992 – to date), *Lab Technician*
Dharmasena B. (1998-1999), *Pre-University Student*
Dissanayake C.B. (1992-1996), *Research Professor*
Kasturiarchchi H. (2001- to date), *Volunteer Research Assistant*
Liyanagedara M.L. (1992-1996), *Research Assistant*
Makehelwala M. (2001 – to date), *Volunteer Student*
Namarathna S.Y. (1992-1996), *Research Fellow*
Nanayakkara A. (2001 – to date), *Senior Research Fellow*
Rupasinghe S. (1999 – to date), *Volunteer Research Student*
Weerasooriya R. (1992- to date), *Associate Research Professor*
Wickramaratne U. (1997-1998), *Research Assistant*
Wijesekara D. (2001- to date), *Research Assistant*
Wijetunge A. (1999-2000), *Pre-University Student*

PROGRESS ACHIEVED *(Since inception)*:

1. Retention of lead, cadmium and arsenic on gibbsite was quantified mechanistically.
2. Experimental evidence for site heterogeneity was obtained for gibbsite using a chemical method.
3. In order to account for the finite size of ions, the newly developed charge distribution multi-site surface complexation model (CD-MUSIC) was used to quantify chromium binding on goethite.
4. Chemical characterization of the kaolinite-water interfacial processes was completed. The proton, halide ion binding on kaolinite based on surface complexation was completed.
5. Chemical kinetic modeling for the complexation of copper-organic polymer systems was developed. Kinetic modeling of Fe-F system under acidic conditions was completed.
6. A direct method for the quantification of copper –fulvate complexation was developed.
7. SEM of Cd(II) adsorbtion on model minerals at different experimental conditions was completed.
8. Determination of near-surface solid composition of the goethite-copper system to elucidate Cu-inter-particle diffusion from surface precipitation on external surfaces was completed. X-ray photon spectroscopy was used to achieve these results.
9. Essential unit processes of drinking water treatment for fluoride, nitrate, and selected organic-Cl were completed. These processes have also been modeled with ENVIRONPRO software (Project objectives were revised to meet with the current IFS reorientation towards themes of basic science).

10. A precise mechanistic model was developed to understand the formation of N-nitrosation (project objectives were revised to meet the current IFS reorientation towards basic science)

NUMBER OF PUBLICATIONS IN REFEREED JOURNALS 31

PROJECT OUTPUT 2001:

1. Cadmium adsorption on gibbsite was examined as a function of pH, background electrolyte concentration, temperature, and adsorbate loading. The steric heat of adsorption, ΔH_r showed an indifferent behaviour for the variation of temperature in the range 294 – 308 K. The adsorption data was quantified by charge distribution multi-site ion complexation (CD MUSIC) using the reaction stoichiometry given below:

$$2(>AlOH^{-1/2})_2 + Cd^{2+} = >Al(OH)_2^x Cd^y \; ; \log K = 6.727$$

The charge distribution factor, f is treated as an adjustable parameter in model fitting yielding x = 1.2 vu and y = 0.8 vu.

2. Lead adsorption on gibbsite was examined in batch experiments as a function of pH, adsorption density, initial lead loading, electrolyte type and concentration. The pH_{zpc} in NaCl of gibbsite was 8.35. The Pb(II) and proton adsorption data on gibbsite were interpreted in terms of surface complexation theory using the charge distribution multi-site ion binding approach resulting in the following data:

$>AlOH_2^{+1/2} + Cl^- = >AlOH_2^{+1/2} - Cl^- \quad \log K = -0.59$
$2(>AlOH^{-1/2}) + Pb^{2+} = (AlOH)_2\,Pb$

CD-MUSIC and three plane model (TPM) Log K_{NaCl} = 9.36 or log K_{NaNO3} = 10.07
CD-MUSIC and Basic stern model(BSM) log K_{NaCl} = 9.70 or log K_{NaNO3} = 10.07

The binding constant of the lead surface complex was determined using Pb(II) adsorption data in $NaNO_3$ while NaCl differed only by 0.023 log K units when the CD-MUSIC BSM model combination was used.

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Copper-gibbsite interactions: an application of the 1-pK surface complexation model
Authors: **Weerasooriya R., Dharmasena B.**, and **Aluthpatabendi D.**
Journal: ***Colloids and Surfaces***, **170**, 65-77 (2000)

2.* *Title:* Pyrite-assisted degradation of trichloroethene (TCE)
Authors: **Weerasooriya R.** and **Dharmasena B.**
Journal: ***Chemosphere***, **42,** 389-396, (2001)

3. *Title:* Charge distribution multi-site complexation modeling of Pb(II) adsorption on gibbsite
Authors: **Weerasooriya, R., Aluthpatabendi D.**, and Tobschall H.J.
Journal: ***Colloids and Surfaces*** (in press)

4. *Title:* Surface complexation modeling of cadmium adsoprtion on gibbsite
Authors: **Weerasooriya R., Wijesekara D.**, and Bandara A.
Journal: ***Colloids and Surfaces*** (in press)

* *Reported as "in press" in the Annual Research Report 2000.*

ABSTRACTS/CONFERENCE PROCEEDINGS IN 2001:

1. **Weerasooriya R., Wijesekara D.**, and Bandara A.
Surface complexation modeling of cadmium – gibbsite interactions
Summer School of Ab initio Solid State Chemistry
University of Torino, Italy (abstract).

2. Pathirathna K.A.S., **Weerasooriya S.V.R.,** and De Silva M.H.C.R.
Quantitative assessment of fluoride adsorption on kaolinite mineral-water interface for development of a de-fluoridating methodology for groundwater
Page 237. Sri Lanka Association for the Advancement of Science, Part I – (Abstracts) 57th of Annual Sessions, 26 November- 01 December 2001, Moratuwa.

3. Pathirathna K.A.S., **Weerasooriya S.V.R.**, and Arachchige E.K.A.I.U.K.
Quantitative assessment of arsenic adsorption on mineral-water interface
Page 256. Sri Lanka Association for the Advancement of Science, Part I –(Abstracts) 57th of Annual Sessions, 26 November- 01 December 2001, Moratuwa.

PROJECT: **STRUCTURAL GEOLOGY**

COMMENCEMENT: 1995

INVESTIGATORS:

Kehelpannala K.V.W. (1999 – to date), *Senior Research Fellow*
Ratnayake N.P. (1997), *Research Assistant*
Ratnayake R.M.J.W.K. (1999 - to date), *Research Assistant*

PROGRESS ACHIEVED *(Since inception)*:

The genetic relationship between the structure and some mineralizers (e.g. pegmatites and veins) in the high-grade basement of Sri Lanka was established. The study revealed that the maximum principal palaeostress (σ_1) and the least principal palaeostress (σ_3) during the second strongest deformation (D_5) were nearly E-W and N-S, respectively. By applying this, at least six types of mineralizers were identified in the areas NW of Matale. The anatomy of some mica-bearing veins and pegmatite was also studied. This study led us to identify geometrical features, which are indicative of tensile stress refraction at interfaces between lithologies with contrasting viscosities. The ductile deformation of granulites of Sri Lanka was studied and the deformational history of the Sri Lankan Gondwana fragment was reconstructed from microstructures, mesoscopic structures and from large-scale structures observed in the high-grade gneisses.

The nature of post-metamorphic metasomatism of orthogneisses of diverse bulk compositions through the fluxing of K-bearing fluids along deep to mid crustal shear zones was studied in detail. The mechanisms and the process of large-scale K-metasomatism of granulite facies rocks through shear-controlled fluid fluxing were elucidated. The change in bulk compositions of orthogneisses during post-metamorphic metasomatism was studied in order to characterize their chemical changes. Some mineral reactions involved in the transformation of orthogneisses to metasomatic rocks were studied. It was established that the main mechanism of metasomatic transformation is characterized by the formation of metasomatic microcline feldspar and myrmekites, with diverse geometry, in the presence of externally derived K^+ ions in aqueous fluids. The role of shear zones in controlling fluid-driven metasomatism of high-grade orthogneisses was also investigated. A nomenclature for metasomatic rocks exposed around Ambagaspitiya was proposed. (This work will be continued.)

Preliminary studies on the origin of compositional layering in high-grade gneisses were commenced, and criteria for distinguishing the gneissic layering produced by metamorphic differentiation from the layers produced by the intrusion of magmatic materials were established. (This work will be continued).

The earth tremor which occurred near Kandy on 23.11.98 was investigated. This investigation showed that the tremor might have had a magnitude of about 3-3.5 (Richter scale) and that it was not caused by the Victoria reservoir. The recurrent occurrence of small earthquakes in Sri Lanka may be due to a nearly NNW-SSE compression acting on Sri Lanka, which leads to a slow build up of elastic energy along

some of the brittle faults in the crust of the island. It was also suggested that this type of earth tremor might occur in Sri Lanka in the future as long as the above compression is active. Further research is needed to understand the exact mechanism of neotectonics and the occurrence of earth tremors in countries like Sri Lanka, which have been hitherto considered as aseismic.

Ductile shear zones seem to play a major role in transporting fluids in the earth's crust. However, the mechanism of migration of the fluids along these apparently non-porous structures has not yet been fully elucidated. A detailed study of ductile shear zones in the Kurunegala district and at Digana was undertaken in order to elucidate the role of these structures in the origin of some late-stage, fluid-controlled crustal processes. In addition, the influence of the stress on the formation of in-situ charnockite and retrogression was also established. It was shown that the nucleation and subsequent growth of in-situ charnockite and retrogression of orthogneisses along ductile shear zones and foliation planes, forming irregular patches, are very similar and can be explained by the model presented by Kehelpannala, (1998) and Kehelpannala and Ratnayake (1999). In addition, the criteria for distinguishing relict charnockite from in-situ charnockite were established. (This work will be continued.)

The geology and structure of large vein graphite mineralizations, especially those in the Kurunegala and Kegalle districts, were studied, and their relationship to the graphite deposits was established.

Migmatites with a wide range of chemical compositions occurring in the major doubly plunging synforms in central Sri Lanka were studied. Our field and laboratory studies on these migmatites indicate that they are characterized by a multi-stage development of leucosomes with varying modal compositions and that they have a polygenetic origin. Our study clearly demonstrates that migmatites may be classified or differentiated on the basis of their genetic relationships. The influence of deformation on the development of different types of leucosomes of migmatites in layered basic rocks was studied, and the chemical analysis of layer and vein leucosomes was carried out. It was established that the layer leucosomes in the migmatites have a magmatic origin, and most of the vein leucosomes are controlled by ductile deformation of the host rocks. (This work will be continued).

Magmatic events in Sri Lanka relevant to Rodinia suppercontinent formation and dispersal were studied. (This work is being carried out in collaboration with Prof. A. Kröner, University of Mainz, Germany and is being continued).

A study of the origin of scapolite-bearing pyroxenites was initiated, and the preliminary findings show that pyroxenites with euhedral megacrysts of scapolite and sphene in the lower crustal rocks of Sri Lanka have a magmatic origin. (This work will be continued).

A study of the stable carbon isotope of graphite disseminated in granulite facies rocks of Sri Lanka and vein graphite was started, and some graphite samples sent to Japan have already been analysed at the Shizuoka University, Japan. The carbon isotopic data suggest that graphite disseminated in orthogneisses at Digana have been precipitated from externally derived C-H-O solutions. (This work is being carried out in collaboration with Prof. H. Wada, University of Shizuoka, Japan).

PROJECT OUTPUT 2001:

1. The study of migmatites in basic rocks in the central part of Sri Lanka was continued, and the major and trace element geochemistry of some layer and vein leucosomes was studied at the University of Cologne, Germany. The geochemical analysis confirmed that the different types of leucosomes in these migmatites have diverse chemical compositions.

Field photograph showing how a basic igneous rock (now metamorphosed) has been changed by subsequent lower crustal processes. The basic rock (dark) intruded the lower crust some 970 Ma ago and had later been intruded by quartzo-feldspathic layers (curved white layers) at about 924 Ma ago before it was metamorphosed (underwent high temperatures and pressures) at about 610-550 Ma ago. The whole rock was affected by quartzo-feldspathic veins (vertical white layers) about 550 Ma ago during large-scale folding of the Sri Lankan lower crust. Now this rock is a mixture of older and younger materials and is named as "migmatite". A vertical view from the Ugalla quarry, Nugawela. (Age data from Kröner, A., Kehelpannala, K.V.W. and Hegner, E., 2002. Submitted).

2. The study of magmatic and deformational events in Sri Lanka related to the formation and breakup of the suppercontinent Rodinia (which existed about 750-800 Ma ago) and to the assembly of the supercontinent Gondwana was continued. Our $^{207}Pb/^{206}Pb$ isotope study of zircon from magmatic rocks collected from some parts of the Wanni Complex of Sri Lanka revealed that there were two major magmatic events in the Wanni Complex; the older event occurred at about 1000-1100 Ma ago and the younger one at about 790-750 Ma. The older magmatic event was related to the final assembly of Rodinia, and the second event occurred during or after the breakup of this supercontinent. (This work is being carried out in collaboration with Prof. A. Kröner, University of Mainz, Germany and is being continued).

3. The major and trace element geochemistry of metasomatic rocks from Ambagaspitiya was studied at the University of Cologne, Germany in order to understand the role of shear zones in the lower crust on fluid-controlled metasomatism of high-grade gneisses. (This work will be continued).

4. The polygenetic origin of graphite precipitated from C-O-H fluids in the orthogneiss at Digana was studied on the basis of stable carbon isotopes of graphite from diverse occurrences in the above rock. This study also shows the role of crustal scale shear zones in the precipitation of graphite by the reduction of C-O-H fluids. (This work is being carried out in collaboration with Prof. H. Wada, University of Shizuoka, Japan).

5. The enrichment and depletion of major and trace elements in the wall rock granulites of graphite veins from the Kahatagaha-Kolongaha graphite deposit were studied at the University of Cologne, Germany in order to understand the chemical changes which had taken place during vein graphite mineralization. The mineral chemistry of sulphides associated with the vein graphite mineralization at Kahatagaha-Kolongaha graphite deposit was studied at the University of Mainz, Germany, with a view of establishing the role of sulphur fugacity in the precipitation of carbon as graphite. (This work will be continued).

PUBLICATIONS IN REFEREED JOURNALS IN 2001:

1.* *Title:* Polyphase migmatization of layered basic rocks in the Wanni Complex of Sri Lanka
Authors: **Kehelpannala K.V.W.** and **Ratnayake R.M.J.W.K.**
Journal: ***Gondwana Research,*** **4** (2), 174-178 (2001)

2.* *Title:* The East African Orogen: New zircon and Nd ages and implications for Rodinia and Gondwana supercontinent formation and dispersal
Authors: Kröner A., Collins A.S., Hegner E., Willner A.P., Muhongo S., and **Kehelpannala K.V.W.**
Journal: ***Gondwana Research,*** **4** (2), 179-181 (2001)

3.* *Title:* Scapolite-bearing pyroxenites from the high-grade gneiss terrain of Sri Lanka
Authors: **Kehelpannala K.V.W.**
Journal: ***Gondwana Research***, **4** (2), 223-226 (2001)

4. *Title:* Vein graphite deposits of the Kegalle District, Sri Lanka: Further evidence for post-metamorphic, fluid deposited graphite
Authors: **Kehelpannala K.V.W.** and Francis M.D.P.L.
Journal: ***Gondwana Research***, **4** (4), 655-656 (2001)

* *Reported as "in press" in the Annual Research Report 2000.*

SCIENCE DISSEMINATION

Tilakaratne C.T.K. and Sellam S.

Research Colloquia, Public Lectures, Research Meetings and the Science Popularization Programme for school children were conducted as in the previous years in keeping with the IFS commitment to Fundamental Science.

(A) Workshops, Research colloquia, public lectures, symposia and conferences:

Workshops:
A Workshop on Geoscience was organised.
A Lecture series on "Molecular/Quantum Mechanics" was conducted for the IFS scientists in order to widen their knowledge on Quantum Mechanics.
Another lecture series on "Differential Equations for mathematicians" for IFS scientists was organised to broaden their mathematical knowledge.

Research meetings: Research meetings were conducted by the research Assistants These meetings give them the opportunity to discuss their research problems with experts in the field. It also enables them to get new ideas that help to solve problems encountered.

Research colloquia: Scientists who had expertise in their fields of research were invited to talk to their colleagues at research Colloquia.

Special lectures: These were intended to provide a quick forum for eminent scientists visiting the Institute or other Institutions in the country.

Public lectures: This is to promote the public understanding of science.

(B) Awareness and educational programmes for students

School Science Programme(SSP): This was organized for students who have excelled at the G.C.E.(O/L) examination. This activity is designed to promote thinking, imagination, curiosity, wonder and excitement at new ideas discovered. The focus of the SSP is on scientific creativity. The initial stimuli were lectures, given by scientists specialised in their fields of study followed by laboratory visits and demonstrations. Each topic was accompanied by a set of course notes.

In bringing together students of varied ethnic, religious and economic backgrounds this programme encourages them to understand and respect differences between themselves as individuals. IFS had to limit this year's programme for students from the North Western Province. The selection procedure ensured that students from underprivileged schools were well represented. Although we conduct two programmes each year it had to be limited to one programme for 120 students only due to financial difficulties this year.

Workshops and Seminars : A National workshop on "Computer Music" was organised jointly by IFS and MIDI(Musical Instument Digital Interface) Club of Dharmaraja College, Kandy for A/L Students.

Special lectures were given by IFS scientists at Mayurapada Madya Maha Vidyalaya, Narammala, Rahula College, Katugastota, Dharmaraja College, Kandy and Mahamaya Girls' College, Kandy.

Lab visits : Lab visits were organised for undergraduate students and for school children. A special lecture on IFS and its activities was conducted to enable students to understand the ongoing projects before they visit the labs. In addition, a booklet on ongoing Research Projects at IFS was compiled and distributed among the students.

(C) Publication of reports, papers and proceedings

Year 2000 Annual research report was compiled.

Pragñā- IFS Science Bulletin: Two volumes were published in the year 2001. These were distributed to schools (With A/L classes), Research Institutes, universities and scientists.

Reprints of the published research papers by IFS scientists were collected and compiled in a book form for years 1990-1999. In addition two booklets on IFS research outputs (published research papers, patents, awards, books published, and postgraduate degrees obtained) for 1990-2000 and 1986-1989 were compiled.

EVENTS - JANUARY TO DECEMBER 2001

Research Meetings

17th January **CHEMISTRY AND BIOACTIVITY STUDIES OF *Garcina mangostana***
Mr. Tennakoon S. B., Research Assistant, IFS

21st January **CHEMISTRY AND BIOACTIVITY OF *Gordonia elliptica***
Ms. Samarakoon D., Research Assistant, IFS

18th April **ORIGIN OF STROMATIC MIGMATITES IN BASIC ROCKS: ANOTHER VIEW**
Mr. Ratnayake R.M.W.J.K., Research Assistant, IFS

17th May **QUANTITATIVE ASSESSMENT OF CHARGE TRANSFER OF CU^{+} - 1,10 PHENANTHRALINE COMPLEX**
Ms. Wijesekara H.K.D.K., Research Assistant, IFS

27th June **MICROPROPAGATION AND IN VITRO FLOWERING IN *Dendrocalamus giganteus* AND *Bambusa Atra***
Ms. Weerawardena T.E., Research Assistant, IFS

26th July **HIGH POLAR SECONDARY METABOLITES OF THE LEAVES OF *Diploclisia glaucesceus***
Ms. Jayasooriya C.P., Research Assistant, IFS

27th September **PHYSIOLOGICAL ASPECTS OF MULTIPLE BLOOD FEEDING IN THE MALARIA VECTOR *Anopheles tessellatus***
Ms. Hadjirin N.F., Research Assistant, IFS

17th October **EFFECTS OF PHENOLIC COMPOUNDS ON *Rhizobia***
Ms. Jayasinghearachchi H.S., Research Assistant, IFS

21st December **ENHANCED EFFICIENCY OF DYE SENSITIZED SOLAR CELL MADE FROM MgO COATED NANOCRYSTALLINE SnO_2**
Ms. Bandaranayake K.M.P., Research Assistant, IFS

Research Colloquia

31st January **PLASTICS THAT CONDUCT ELECTRICITY**
Dr. Senadeera G.K.R., Research Fellow, IFS

14th February **ELECTRO CHEMISTRY FOR CHEMICAL ANALYSIS**
Dr. Priyantha N., Department of Chemistry, University of Peradeniya, Peradeniya

10th April **SPRAY PYROLYSIS DEPOSITION OF FUNCTIONAL INORGANIC COMPOUND THIN FILMS - TIN OXIDE. TRANSPARENT CONDUCTIVE OXIDE FILMS AND DYE-SENSITIZED TITANIUM OXIDE SOLAR CELLS**
Prof. Kaneko S., Department of Materials Science and Technology, Faculty of Engineering, Shizuoka University, Japan

10th April **DYE-SENSITIZED PHOTOCELLS WITH MESO-MACROPOROUS TiO_2 FILM ELECTRODES**
Dr. Sego Ito, Department of Materials Science and Physical Chemistry, University of Osaka, Japan

Public Lectures

28th February **THE COSTS AND BENEFITS OF BEING MALE: AN EVOLUTIONARY PERSPECTIVE**
Dr. Dittus W.P.J., Honorary Senior Research Fellow, IFS

08th August **BLACK-HOLES, STRINGS AND QUANTUM PHYSICS**
Prof. Wijewardhana L.C.R., Professor of Physics, University of Cincinnati, USA and Visiting Research Professor, IFS

26th September **QUANTUM MECHANICS, RELATIVITY AND PHYSICAL REALITY: NEW DEVELOPMENTS**
Dr. Nanayakkara A., Senior Research Fellow, IFS

20th November **BIOMARKERS IN TOXICOLOGY VERSUS ENVIRONMENTAL RISK ASSESSMENT**
Prof. Gunaratne R., Associate Professor in Toxicology, Lincoln University, New Zealand

Special Lectures

23rd May **PUBLISHING SCIENTIFIC PAPERS**
Professor Tennakone K., Research Professor, IFS

20th June **SEARCH FOR ANTI-CANCER DRUGS FROM DESERT FLORA AND MICRO-ORGANISMS**
Prof. Gunathilaka A.A.L., Professor, Associate Director of South West Center for Natural Products Research and Commercialization, University of Arizona, USA

17th August **THE AHARONOV-BOHM EFFECT FOR NEUTRAL EXCITONS: HOW QUANTUM MECHANICS WORKS AT THE NANO-SCALE**
Dr. Römer Rudolf A., Institut für Physik, Technische Universität Chemnitz, Germany

Workshops and Seminars

05th March **SUPERCONTINENT FORMATION AND BREAKUP**
Prof. Kröner A., University of Mainz, Germany
Honorary Visiting Research Professor, IFS

05th March **Nd ISOTOPES IN GEOSCIENTIFIC RESEARCH**
Prof. Ernst Hegner, University of Munich, Germany

11th April, *18th April*, *25th April* — Lecture series on **MOLECULAR/QUANTUM MECHANICS** conducted by *Dr. Nanayakkara A., Senior Research Fellow, IFS* at the IFS

30th July, *31st July*, *02nd August* — Lecture series on **DIFFERENTIAL EQUATIONS FOR MATHEMATICIANS** - conducted by *Prof. Wijewardhana L.C.R., Professor of Physics, University of Cincinnati, USA and Visiting Research Professor, IFS*

12th October **LIFE IN THE UNIVERSE** at Mahamaya Girls' College, Kandy
Dr. Nanayakkara A., Senior Research Fellow, IFS

19th October **EARTHQUAKES** at Rahula College, Katugastota
Dr. Kehelpannala W., Senior Research Fellow, IFS

25th October **PLASTICS THAT CONDUCT ELECTRICITY** at Mayurapada Madya Maha Vidyalaya, Narammala
Dr. Senadeera G.K.R., Research Fellow, IFS

25th October **"VISHMITHA LOKAYA"** at Mayurapada Madya Maha Vidyalaya, Narammala
Dr. Nanayakkara A., Senior Research Fellow, IFS

Visit to IFS

13th February Students from Bandaranayake Maha Vidyalaya, Gampaha
15th February Science Teachers from Dehiaththakandiya Educational Zone
26th March Students from President's College, Minuwangoda
03rd April Students from Institute of Chemistry, Ceylon
04th April Students from Aluthgama Maha Vidyalaya
18th April Students from Pakkiyam Maha Vidyalaya, Matale
01st June Students from Ananda Madhya Maha Vidyalaya, Elpitiya

Special Programme for students

08th March Lecture on **COMPUTERS IN ASTRONOMY** for students from Kingswood College, Kandy.
Dr. Nanayakkara A., Senior Research Fellow, IFS

23rd March Lecture on **TIME TRAVEL** for students from Dharmaraja College, Kandy.
Dr. Nanayakkara A., Senior Research Fellow, IFS

11th July Workshop on **COMPUTER MUSIC** for A/L students
(Organised jointly by MIDI Club of Dharmaraja College, Kandy)

14th-16th December **School Science Programme**

14th December

EMBRYOGENESIS IN PLANTS
Dr. Iqbal M.C.M., Research Fellow, IFS

MYSTERIES IN MODERN PHYSICS
Dr. Nanayakkara A., Senior Research Fellow, IFS

SINHALA TEXT TO SPEECH ***(Demonstration)***
Dr. Nanayakkara A., Senior Research Fellow, IFS

About IFS and its activities
Laboratory Demonstration

15th December

HEALTH STATUS OF PLANTING STOCKS
Dr. Jayanandarajah P., Research Fellow, IFS

PLASTICS THAT CONDUCT ELECTRICITY
Dr. Senadeera G.K.R., Research Fellow, IFS

WASTE AS A RESOURCE
Prof. Ileperuma O.A., Professor of Chemistry, University of Peradeniya

GLOBAL WARMING
Dr. Seneviratne G., Senior Research Fellow, IFS

16th December

PRIMATE BEHAVIOUR, ECOLOGY AND CONSERVATION
Dr. Dittus W.P.J., Honorary Senior Research Fellow, IFS

THE ENERGY STORY
Dr. Tilakaratne C.T.K., Coordinator, Science Dissemination, IFS

CONTROLLING APPARATUS BY COMPUTERS
(Demonstration and Lecture)
Mr. P.V.V. Jayaweera, Research Assistant, IFS

RESEARCH STAFF 2001

Kovoor A.	Honorary Research Professor
Kröner A.	Honorary Research Professor
Ramasamy M.S.	Research Professor
Tennakone K.	Research Professor
Yoshida M.	Honorary Visiting Research Professor
Ananthan Jeeva S.	Visiting Research Professor
de Silva A.P.	Visiting Research Professor
Dias H.V.R.	Visiting Research Professor
Fernando G.W.	Visiting Research Professor
Gunaratne G.H.	Visiting Research Professor
Mendis A.D.	Visiting Research Professor
Perera A.G.U.	Visiting Research Professor
Rajasekeran K.N.	Visiting Research Professor
Wijewardena L.C.R.	Visiting Research Professor
Dharmaratne H.R.W.	Associate Research Professor
Keinschrodt R.	Honorary Visiting Associate Research Professor
Silva E.I.L	Associate Research Professor
Weerasooriya S.V.R.	Associate Research Professor
Dittus W.P.J.	Honorary Senior Research Fellow
Jayasinghe J.H.M.U.L.B.	Senior Research Fellow
Kehelpannala K.V.W.	Senior Research Fellow
Nanayakkara A	Senior Research Fellow
Ramanayake S.M.S.D.	Senior Research Fellow
Senevirathne P.R.G.	Senior Research Fellow
Bandara J.	Research Fellow
Iqbal M.C.M.	Research Fellow
Jeyanandarajah P.	Research Fellow
Magana Arachchi D.N.	Research Fellow
Senadeera G.K.R.	Research Fellow

RESEARCH ASSISTANTS 2001

Balasooriya B.A.I.S.
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Ekanayake M.P.B.
Ekanayake R.
Hadjirin N.F.
Jayasooriya C.P.
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Ratnayake R.R.
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Wickramasinghe S.C.
Wijesekara H.K.D.K
Wijesekera K.B.
Wimalasena T.T.

Project Leaders are responsible for the authenticity of information they have provided to compile this document.