THE INSTITUTE OF FUNDAMENTAL STUDIES

THIRD ANNUAL SCIENCE CONFERENCE

REVIEW OF 1988

AT THE IFS AUDITORIUM

30 January - 01 February, 1989

INSTITUTE OF FUNDAMENTAL STUDIES
HANTANA ROAD - KANDY

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Director : Cyril Ponnamperuma

Institute of Fundamental Studies
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C O N T E N T S

ABSTRACTS OF PAPERS

DIVISION OF PHYSICAL & CHEMICAL SCIENCES

DIVISION OF PHYSICAL & CHEMICAL SCIENCES

PHOTOCHEMISTRY 1988

K. Tennakoon

In the year 1988, the photochemistry programme has carried out studies on photofixation of nitrogen, photodecomposition of water, photoreduction of carbon dioxide and photochemical decontamination of water. Japanese equipment was installed and the laboratory facilities improved significantly. Dr. O.A. Ileperuma received U.S. aid grant 114,000$ for a project on photofixation of nitrogen.

Photodecomposition of water

A large number of unconventional semiconducting materials were tested for photocatalytic activity and flat band potentials were determined. Silver phosphate was found to photodecompose water without the necessity of having electron or hole transfer catalysts.

Photofixation of nitrogen

The hydrous oxides of heavy metals were screened for the photocatalytic activity towards nitrogen fixation. Apart from hydrous ferric oxide that was detected earlier, the hydrous oxide of Cu(I) was found to be highly active. Composite systems based on hydrous cuprous oxide were also investigated. To a lesser degree, the hydrous oxide of Ti(III) was also found to have the ability to photoreduce nitrogen to ammonia. One of the limiting factors in photoreduction of nitrogen is the reverse photodecomposition of ammonia. A separate

study was conducted to elucidate the mechanism of photodecomposition of ammonia. The activity of Mg doped TiO_2 in N_2 reduction was found to depend strongly on the mode of doping. The surface doped powder gave higher quantum yields.

Photoreduction of Carbon dioxide

Hydrous cuprous oxide was also found to photoreduce carbon dioxide. An important fact noted was that with this material, the quantum yield of methanol was higher than that of formaldehyde.

Photochemical purification of water

Irradiated and oxygen purged suspension of TiO_2 are known to photodegrade organic compounds (eg, agro-chemicals). This phenomenon was studied quantitatively using methyl violet as the degrading material. It was also observed that nitrite in water can be oxidised to nitrate by a photochemical methods.

Biomass Conversion

Experiments were conducted to determine the photo-synthetic efficiencies of Water Hyacinth and Azolla under local conditions.

BIOCHEMICAL CHIRAL SELECTION IN THE PRESENCE OF INSTABILITIES, CHAOS AND NOISE

S.W.M.S. Wickramanayaka

Models of dynamical systems exhibiting competitive selection have attracted much attention in the context of ecology, evolution, cellular differentiation and autocatalytic chemical reactions. In this work, a mathematical model is constructed to illustrate that an arbitrarily small difference in the rate constants for parallel autocatalytic reactions involving L and D isomers, are sufficient to cause chiral selection in biochemical evolution. It is shown that selection is not suppressed by instabilities leading to chaos or heavy external noise.

SOME SYNTHETIC MODIFICATIONS OF PRISTIMERIN, A NATURAL PRODUCT WITH ANTI-TUMOUR ACTIVITY AND STUDIES ON THE EFFECTS OF KALUKAMBERIYA (Solanum nigrum) ON THE SLEEP AWAKE CYCLE OF RATS

A.A. Leslie Gunatilaka

During the year under review, the IFS programme on Natural Products and Medicinal Chemistry concentrated its efforts to deal with two primary objectives initially intended in the programme. These were,

1. Structural modification of natural products with a view to enhancing their biological activity, and

2. Isolation of biologically active constituents from medicinal and related plants of Sri Lanka.

In the first project we have carried out structural modification of pristimerin, a quinone -methide triterpenoid with moderate cytotoxic activity abundant in plants of Celastraceae, in order to obtain its structural analogues with enhanced anti-tumour activity and less toxic effects. Several of these analogues have been prepared and characterised. The second project was directed towards the isolation of the constituent(s) responsible for the 'sleep inducing' effect of Kalukamberiya (Solanum nigrum). The freeze-dried methanol extract of the fresh twigs

of S. nigrum has been confirmed to have effects on the sleep awake cycle of rats. In this study we collaborated with Prof. Guenter Rose of Bowdoin College, U.S.A.

PHOTOCATALYTIC OXIDATION OF NITRITE IN WATER TO NITRATE

S. Punchihewa

Recently the photochemical methods for decontamination of water have received a great deal of attention. It has been found that organic matter and agrochemical contaminants in water can be completely mineralized by irradiation with sunlight in the presence of semiconductor photocatalysts. We have found that the nitrite in water is converted into the nitrate by irradiation in the presence of oxygen and titanium dioxide. As nitrate is a less hazardous contaminant, this method could be adapted in the treatment of water.

OPTIMIZATION OF PHOTOPRODUCTION OF NH_3 FROM SEMICONDUCTOR BASED CATALYSTS

O.A. Ileperuma

Photocatalytic activity of metal doped TiO_2 catalysts for N_2 reduction was found to depend on a member of variables. The following factors were studied in order to determine the optimum conditions; dopant level, doping temperature and heating time. It was found that conditions which favour surface doping of the TiO_2 lattice by Mg^{2+} give higher quantum yields compared to lattice doping. The importance of Ti^{3+} in the photocatalytic properties of TiO_2 has been postulated. Photoreduction of N_2 by Ti^{3+} in both homogeneous and heterogeneous media support this hypothesis.

SEARCH FOR NEW SUPERCONDUCTING PHASES IN THE Y-Ba-Cu-O AND Bi-Ca-Sr-Cu-O MIXTURES

S. Samarappuli

The discovery of high temperature superconductivity by Bednorz and Muller in 1986 has resulted in finding a number of superconductors based on Y, Bi and Tl compounds with Tc above 77K. It is also interesting to search for new superconductors in mixed phase systems consisting of these high Tc compounds. We have found a new superconducting system in the mixture prepared from the $YBa_2Cu_3O_{70x}$ and $Bi_2CaSr_2Cu_2O_{9-x}$ superconductors at 1 : 1 cation molar ratio. The new superconductor shows an onset of resistivity transition at 100 K and zero resistivity below 55 K. Powder diffraction pattern of the new system differs completely from those of the original Y and Bi superconductors. The compound prepared using the oxides/carbonates with identical cation molar ratios, on the other hand, does not exhibit superconductivity.

SOLID STATE PHYSICS - 1988

M.A.K.L. Dissanayake

Solid State Physics Programme of the IFS, initiated in early 1987, entered a new phase, with the installation of low temperature facilities, X-ray diffractometer, SEM and high temperature furnaces at the IFS laboratories in April 1988. The research project on High Temperature Superconductivity during 1988 focussed on preparation and characterization of new superconducting materials and understanding their physical properties.

Much of the work done in 1988 was based on already known ceramic oxide materials, Y-Ba-Cu-O and Bi-Ca-Bi-Ca-Sr-Cu-O. We have prepared these and related materials successfully and studied their electrical and magnetic properties. Structure has been characterized by X-ray power diffraction and electron microscopy. All these materials had their superconducting transition temperatures in the 90K-100K range.

We have found a new superconducting phase in a mixed system prepared from the $YBa_2CU_3O_{7-x}$ and Bi CaSr Cu 09 high Tc materials. The new material had an onset of resistivity at ~ 100 K and zero resistivity ~ 50 K. The material prepared from the corresponding metal oxides and carbonates with identical cation stoichiometry, on the other hand, did not exhibit superconductivity.

Several more ceramic oxide systems are being investigated at present for possible high temperature superconductivity.

Among them are Bi-Ca-Sr-Cu-O systems doped with Pb, Sb and Sn and also some Bi free and Cu free systems.

Studies on the CuBr system was continued and a number of related non-oxide systems were also investigated to search for the possibility of superconductivity.

A National Symposium on Solid State Physics was held on 23 January, 1988, at the IFS auditorium. Six senior scientists and 34 junior scientists from universities and research institutions in Sri Lanka participated in this activity.

Arrangements have been finalised to hold the Second International Symposium on Solid State Physics in May, 1989. 14 invited speakers and 12 foreign participants have already confirmed their participation. Local participants will be selected soon.

Dr. M.A.K.L. Dissanayake and Dr. O.A. Ileperuma participated in the Experimental Workshop on High Temperature Superconductors held at the ICTP, Trieste, Italy, in April 1988.

Publications:-

1) Preparation and characterization of Y-Ba-Cu-O and Bi-Ca-Sr-Cu-O High Temperature Superconductors. M.A.K.L. Dissanayake, O.A. Ileperuma, S.H.S.P. Samarappuli, P.A.G. Dharmasena and K. Premaratne. Proc. SLAAS 44 (1988) 151.

2) A new Superconducting Material in a Y-Ba-Cu-O and Bi-Ca-Sr-Cu-O mixed system - M.A.K.L. Dissanayake, K. Tennakoon, O.A. Ileperuma and S.H.S.P. Samarappuli. Mod.Phys. B (Submitted).

3) Superconductivity in the Bi-Ca-Sr-O and Bi-Sn-Ca-Sr-Cu-O systems. M.A.K.L. Dissanayake, S.H.S.P. Samarappuli, O.A. Ileperuma and K. Tennakoon. (in preparation)

PHOTOLYSIS OF AZIDE ION IN AQUEOUS SOLUTION

A.C. Jayasuriya

The photolysis of azide ion aqueous medium purged with argon is found to genarate ammonia and nitrogen whereas oxygen purged solutions generate nitrite and nitrogen. Quantum yield measurements are given and possible reaction mechanisms are suggested.

WORK PLAN FOR 1989

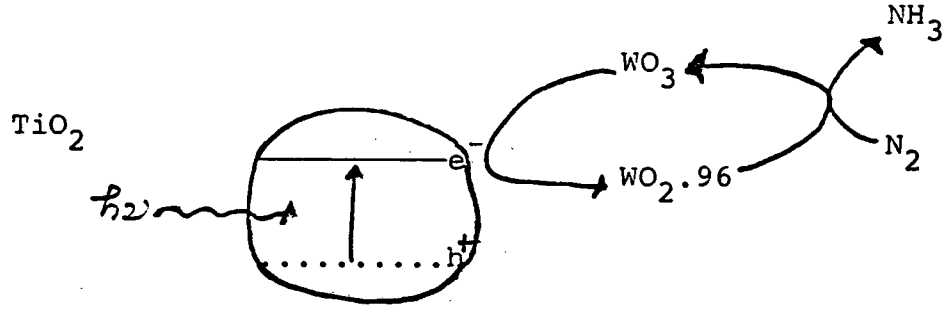
J.M.S. Bandara

The conversion of solar energy into chemical energy or electrical energy is great challenge in this century.

There are several pathways to do this conversion. Such as photolysis of H_2O, photoreduction of CO_2 and photoreduction and oxidation of N_2. In this paper, I am to discuss the photoreduction and oxidation of N_2 in the presence of semiconductor catalyst.

In the last few years, several research groups have been done some work in this area. Schrauzer[1] is the first person who reported that TiO_2 and its surface modified forms can photocatalyticall produce NH_3. Now it is well establish that Ti^{4+} ion of the lattice capture these excited electrons and gets reduced to Ti^{3+}, which the active component of the system. Later Bard[2] found that WO_3 can thermally fix N_2.

However, the yield of NH_3 was very low and these catalysts lose their activity with time.



This diagram describes our proposed system for photo-fixation of N_2. Since TiO_2 itself is not a good

catalyst, we are going to use WO_3 coated TiO_2. When TiO_2 is irradiated it goes to excited state generating hole and electron pairs. These electrons are taken by WO_3 and reduced form is capable of fixing N_2 to NH_3 and it oxidize to WO_3 again. Since it is a cyclic process we are confident that it will act as a good catalyst.

By studying the variation of the following factors we expect to optimize the NH_3 yield.

1. Amount of dopent
2. Heating time and temperature
3. pH of the medium

Heteropolyanions are compounds that contain more than one anion. Among these heteropolyanions molybdenium and tungstate are the major elements that form heteropoly compounds. So we expect to try various heteropolyanions of tungstate in our future experiments.

References

1. Photolysis of water and photoreduction of Nitrogen on Titanium Dioxide, Journal of the Am. Chem. Soc./99:22/October 26 1977.

2. Heterogeneous photoreduction of Nitrogen to Ammonia on tungstate oxide. J. Phys. Chem. 1986, 90, 6223-6226.

WORK PLAN FOR 1989

S. Gunewardena

Title:

Photochemical nitrogen fixation through semi-conductor catalysts.

Introduction:

TiO_2 is a semiconductor material capable of photo-reducing dinitrogen (N_2) into ammonia (NH_3).

Metal doped TiO_2 catalysts have been reported to enhance photoreduction of nitrogen to ammonia. These doped catalysts have generally been prepared by heating at 1000°C for several hours. Investigations in our laboratories revealed that the conditions of preparation affect the ammonia yields significantly. Thus it was foudn that with Mg/TiO_2 catalyst, when doping was carried out at 500°C the activity is higher than with the same catalyst heated at 1000°C. In order to extend these investigations to other metal doped systems, we hope to carry out a detail investigation on the M/TiO_2 systems, where M= Cr, Mn.

Objective:

Investigating for efficient, low cost and sustainable photocatalytic systems and the optimal conditions for the reduction of nitrogen to ammonia.

Methodology:

(a) Preparation of catalyst

Commercially available TiO_2 powders are mixed with the aqueous solution of metal sulphate (dopant) according to the required molar ratio. The resulting slurry is evaporated to dryness and powdered in a motar. Then it is heated to the required temperature for the required amount of time and kept in contact with water.

(b) Irradiation

200 mg of catalyst is dispersed in 300 ml of dis. water in a cylindrical reactor. The sample in the reactor is irradiated for the required amount of time with a 400 W mercury lamp. The solution temperature at irradiation is maintained at room temperature. During irradiation water saturated nitrogen gas that is purified by chromic acid solution, HCl and NaOH solutions is passed through the solution.

(c) Analysis and estimation of ammonia

The irradiated solution is distilled to collect ammonia produced. The distillate is analysed for ammonia with the Indo-Phenol blue method and estimated spectrophotometrically by measuring the absorbance at 630 nm.

The variables to be studied include:

(i) Heating temperature of catalyst.
(ii) Heating time.
(iii) Molar percentage of doping. (dopant level)
(iv) pH of solution
(v) Irradiation time

In all these cases, dark controls are run.

WORK PLAN FOR 1989

N. Hathurusinghe

Superconductors are materials with zero resistance to passage of electric current. This property can be obtained at a certain temperature and it is called critical temperature (Tc). At critical temperature they also have the property of repelling magnetic fields (Meisner effect).

Our goal is to increase the Tc using many oxides which have not been tried so far.

Metal oxides like Bi_2O_3, Sb_2O_3, CuO, etc., and carbonates like $CaCO_3$, $SrCO_3$, $BaCO_3$ can be used to make a superconductor. After selecting proper components they are weighed according to a proper stoicheometric ratio. Then they are well mixed and ground in a agate mortar and pestle. The powders are prefired in air around 820°C for 12 to 60 hours, then reground and pressed into pellets.

Pellets are sintered around 860°C for 12 to 60 hours followed by furnance cooling or air quenching.

These temperatures and periods of time depend on the components we use.

Meisner effect of these pellets is checked using liquid nitrogen. Resistance at different temperature is measured using closed cycle refrigerator. Finally the structure is determined using X-ray defraction.

WORK PLAN FOR 1989

S. Abeysinghe

INTRODUCTION :

The characteristics of semiconductors is very important in order to apply them for photovoltaics or photocatalytic systems. We have studied the Iodine dope CuI.

METHOD :

The CuI was prepared by using $CuSO_4$ and KI in 1:2 molar ratio. This CuI was used to prepare pellets consisting of CuI doped with Iodine. The doping levels of Iodine was changed by 5% starting from pure CuI. The pellets were prepared by kBr disc method. The thickness and diameter of pellets were measured by using a vernier caliper. The resistance of the pellets were measured by using a computer digital multimeter.

Diffuse reflectance spectra also obtained as a function of Iodine concentration.

RESULTS :

It was found that there is no consistent pattern in specific resistance with amount of Iodine. The resistance of the pellets were always decreased when increasing the temperature, suggesting the semiconductor behaviour. Also the pellets were subjected to find the maysnor effect by cooling in liquid nitrogen.

CONCLUSION :

Doping Iodine was found to decrease the resistivity of CuI, the optimum concentration being on 0.5. In the presence of Iodine diffuse reflectance spectrum shows an additional edge.

NITROGEN FIXATION :

INTRODUCTION :

Homogeneous systems capable of converting nitrogen to Ammonia are very rare. We found that solution of CuCl in HCl has some ability to photoreduce nitrogen to Ammonia.

METHOD :

The CuCl catalyst was prepared by boiling Cu granules and copper oxide in HCl media. The catalyst was then added to 225 ml of water and 10 ml of HCl. This solution was predicted by using a mercury lamp. After a determined time interval 150 ml of the solution was taken out and alkalined. This was then distilled out for investigation of Ammonia. The test used was indophenol blue test. The dark reactions were also runned.

CONCLUSION :

There was no comparable increase of Ammonia concentration in the light reaction.

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SOME IMPORTANT BIOCHEMICAL PROPERTIES OF A DIAZOTROPH ISOLATED FROM THE RHIZOSPHERE OF RICE GROWN IN A LOCAL FIELD

M. Gunatilaka

An experiment to evaluate the metabolic processes which determine the survival ability of a diazotroph in a wet land soil was simulated in the laboratory. The significant metabolic processes chosen for investigation are listed below:

1. Assimilatory reduction of nitrate
2. Dissimilatory reduction of nitrate or the ability to use nitrate as an electron acceptor
3. Ability to use ammonium as a source of nitrogen for growth

These investigations showed that this organism is an alkali producer capable of utilizing ammonium as the only source of nitrogen and capable of utilizing nitrate in both assimilatory and dissimilatory pathways. However, the dissimilatory nitrate reduction occurs only under anaerobic conditions producing nitrite. Nitrite thus formed is not reduced further even under anaerobic conditions. Hence this organism could be performing nitrate respiration.

The assimilatory nitrate reductase in this organism could be a constitutive enzyme while the dissimilatory nitrate reductase could be an inducible enzyme.

The association of this organism at several selected cell concentrations with the rhizosphere or rice was

observed microscopically under sterile conditions. This diazotroph was seen to concentrate in large numbers, embedded within the mucilagenous sheath around the rice roots. Inoculation tends to increase the secretion of mucilage by the rice roots and induce a characteristic curvature of root primordia.

PRELIMINARY STUDIES ON NODULATION AND NITROGEN FIXATION OF GRAIN LEGUMES

P. Tirukkumaran

The effect of Molybdenum on nodulation, nitrogen fixation, growth and yield of green gram was investigated. The experiment was carried out in pots with soil collected from Mahaweli system - 'C' (Girandurukotte) where green legumes are extensively cultivated. Addition of 4 ppm Mo to the soil increase the nitrogenase activity by 40% and the nitrogen content by 95% respectively than the control plants. However, the nodule number and their dry weight did not increase significantly. Although highest plant dry weight was registered under 6 ppm Mo, maximum grain yield was obtained under 4 ppm Mo. possibly indicating that increase in Mo beyond 4 ppm stimulates vegetative growth of the plant.

The infectivity of single strains and the mixed rhizobial strains against green gram, black gram, and cow pea were studied using serology. In all experiments the inoculation increased nitrogenese activity and the nitrogen content over the uninoculated controls. Both these parameters were significantly lower under mixed strain inoculation than under single strain inoculation. Nodule smears treated with FITC conguated antigens for the inoculated strains were examined under UV microscope. The results showed that 60-70% infection was achieved though single strain inoculation, where as the mixed strain inoculation produced only 15-20%. The competition among the productive strains in a mixed inoculant possibly resulted in less infectivity in the plants compared to single inoculation.

STUDIES WITH SESBANIA ROSTRATA
A STEM NODULATED FLOOD TOLERANT LEGUMINOUS PLANT

I.M. Samarakoon

The flood tolerant leguminous species Sesbania rostrata, exhibits high nitrogen fixation due to profuse stem nodulation. It has been reported in Senegal that this could be used as a green manure for wetland rice cultivation. An ideal green manure should exhibit the following characteristic: high rates of biological nitrogen fixation with minimal extraction of available soil nitrogen with considerable rates of biomass production.

It has been shown that under laboratory conditions injecting a suitable rhizobial culture to vascular system of Sesbania rostrata resulted in profuse stem nodulation (1988). Apical dormancy prevents the growth of auxillary buds, resulting in the production of less vegetative plant material. This could be overcome by pruning the plants which would stimulate branching that could result in higher biomass production.

A field experiment was conducted to examine, whether vegetative growth and stem nodulation in Sesbania rostrata could be improved by pruning and stem inoculation. Surface sterilized, seeds were planted in $3m^2$ plots in 3 rows, each having 20 seeds, 10 cm apart. Plots were flooded when the plants were about 30cm in height. Pruning and stem inoculation was done when the plants were 50cm in height. The plants were harvested at 55 days, fresh and dry weights of plants, nodule number, nodule biomass per plant were recorded. Nitrogenase activity of the plants were measured by

Acetylene reduction activity.

Results indicate the percentage increase in plant biomass and nodule biomass was highest in plots where the plants were pruned and inoculated showed increase in plant and nodule biomass which was less than the above mentioned treatment. Lowest percentage increase was observed in plots treated with inoculation without pruning.

EVALUATION OF ASSOCIATIVE NITROGEN FIXATION IN LOCAL RICE FIELDS AND EFFECTS OF INOCULATION ON RICE SEEDLINGS

Y. Abhayawardhane

The effect of a diazotroph, isolated from local rice fields, on the growth of rice seedlings was investigated. Root surface area, fresh weights of roots and shoots and dry weights of roots and shoots were determined. They showed an increase with increase in inoculum density.

Associative nitrogen fixation of several new improved rice varieties, growing under smilar climatic and edaphic conditions was tested, using cut plant-soil acetylene reduction assay (Barraquio et al., 1986). No significant differences were seen among the different rice varieties.

It has been observed that some traditional rice varieties grown in Kalutara district give consistent, satisfactory yields of rice without any fertilizer application. Associative nitrogen fixation of two traditional rice varieties were tested and attempts were made to isolate diazotrophs from their root systems. Root associated ARA was higher than that of a new improved rice variety.

Eventual aim of this research is to introduce selected diazotrophs to the field. A pot experiment was designed with four treatments to examine the effect of inoculation of rice plants with and without fertilizer application. Results so far obtained from this experiment will be discussed.

SOME LABORATORY INVESTIGATIONS ON A RHIZOSPHERIC DIAZOTROPH ISOLATED FROM A LOCAL PADDY FIELD

S. Pathirana

Several Diazotrophs were isolated from the rhizosphere of paddy using the Cut-plant soil technique. These isolates were tested for associative nitrogen fixing activity using the Spermosphere model. As a preliminary investigation on characterization of the isolated diazotroph, an antibiotic resistance test was performed with chloramphenicol, lyramycin, tetramycin, penicillin, streptomycin and ampicillin. The resistance and susceptibility levels obtained for this wide range of antibiotics used could be employed for identification of the diazotroph for later studies.

The diazotroph isolated from the rhizosphere of rice was shown to be capable of better growth in pure culture when supplied with tryptophan than with ammonium chloride alone. Hence, it was decided to find out whether this enhancement effect was due to the ability of the organism to convert tryptophan to a growth promoting factor like indole acetic acid and the ability of the cells to grow better when indole acetic acid is present in the growth medium. The TLC investigations showed the presence of sports corresponding to the authentic sample of indole acetic acid. This will have to be confirmed using HPLC.

BIOLOGICAL NITROGEN FIXATION RESEARCH PROGRESS AND PROSPECTS

S.A. Kulasooriya

The BNF research programme is conducted along four main themes and the progress under them during 1988, will be reviewed.

Cyanobacteria and flood tolerant, stem nodulated N_2-fixing plants as biofertilizer for rice

Field surveys conducted in 1987 revealed *Nostoc sp.* to be dominant in rice soils of Sri Lanka, with *Anabaena* and *Calothrix* as sub-dominant species. Selected *Nostoc* strains were screened for tolerance to pH, under laboratory conditions. The results showed an optimum pH of 7.5 for all the strains, with two strains having relatively wider tolerance. However cyanobacteria seldom produce biomasses of agronomic significance in rice fields. It is therefore planned to produce mutants of selected strains capable of secreting part of their Nitrogen and axenic cultures are currently being prepared prior to their treatment with mutagens.

The flood tolerant, stem nodulated legume *Sesbania-rostrata* introduced to Sri Lanka in 1984, has a tremendous potential as a fertilizer for rice. One limitation however is its photoperiodic sensitivity which make the plant to flower early at the expense of vegetative growth. A field experiment showed that a significant increase in nitrogen fixation activity, dry matter production and N-yield can be brought about by pruning the plants just

prior to stem inoculation. Experiments are planned to study the effect of this green manure on the growth and yield of rice.

Associative N_2-fixation on rice

'In situ' field measurement of N_2-fixation has shown that certain rice varieties are capable of significant fixation and that the activity tends to be highest prior to flowering certain traditional varieties grown without fertilizer-N did not show higher activity than BG400-1, a new improved, high N-responsive variety. A local isolate which gave consistently high nitrogenase activity in association with BG400-1 has also increased the shoot and root biomass and N-yield of rice plants under laboratory conditions. This isolate can live on NH_4 as its sole source of N, has an inducible nitrate reductase enzyme, but will denitrify only under anaerobic conditions. Its a member of the Enterobacterizceae and further, accurate identification is been done at the University of Gent, Belgium.

Rhizobiology of grain legumes

Studies on the competitive ability of a recommended Niftal strain of rhizobium and a selected local strain on mung bean has shown moderate infectivity over the indigenous population. Better infectivity and higher Nitrogen fixation was shown when single strain inocula were used than mixed strains, perhaps indicating competition between the selected strains. Moderate additions of Molybdenum gave better nodulation, higher nitrogenase activity and increased N-yield in mung plants grown on soil from Girandurukotte, in the Mahaweli 'C' area, where this legume is widely cultivated.

Occurence and uses of N_2-fixing trees

Focus of the survey during 1988 was the central Province, in which three species were recorded for the 1st time. A few other species were also observed in localities where they have not been recorded earlier. Multivariate analysis of the distribution did not show a clear, natural pattern, indicating human interference on their distribution. This was confirmed by the data on uses which showed that many of the tree-species in this province are domesticated than growing naturally. Very few of the tree species are used as food, the major use being as a source of timber. Quite a number are used for medicinal purposes, but such uses are higher from indigenous species than from the exotic ones. Use as green manure if at all, was quite occasional.

STUDIES ON THE OCCURRENCE AND USES OF CERTAIN LEGUMINOUS TREE SPECIES IN THE CENTRAL PROVINCE OF SRI LANKA

S.A.S. Pathmasiri

Of the 86 species of tree legumes recorded in Sri-Lanka, only 30 are reported to occur in the Central Province (Trimen, 1983 - 1900; Dassanayake and Fosberg, 1980).

In the present study, data on leguminous tree species in the Central Province were re-evaluated by reference to published literature and established herbaria. In addition, several field visits were made to representative areas, during which local people were interviewed with regard to the presence of these species and their local uses. Information obtained in this manner was verified by field observations during which, herbarium material, seeds and root nodules, where present, were collected.

We report here, of the occurrence of three species which have not been recorded so far in the central province. While a wider variety of leguminous trees now appear to be utilized as timber, firewood and shade trees, their use for medicinal purposes and to obtain chemical substances like gums and tanins have declined.

WE NEED TREES

Ranjit Mulleriyawa

At the turn of this century approximately 80 per cent of Sri Lanka was covered by forest. The consolidation of British Colonial rule over the Island and the advent of plantation agriculture resulted in widespread de-forestation. Extensive chena (slash and burn) cultivation, extraction of timber, agricultural settlement schemes and increasing demands for fuel wood by a rapidly increasing population began to take a heavy toll on our forests. Today, Sri Lanka's forest cover is believed to be as low as 22 per cent of the land area. Inadequate public awareness of the need for environmental conservation is a matter for grave concern. The Ecology & Conservation Program has produced a short video film designed for use in environmental education programmes. Critical comments and suggestions with a view towards improving this film are encouraged from participants.

WHY FISH YIELD IS HIGH IN PIMBURETTEWA

E.I.L. Silva

Chlorophyll-a biomass and fish yield of five manmade lakes were investigated for a period of one year within the Polonnaruwa irrigation district. A highly significant correlation was found between Ch-a biomass and the yield of *S. mossambicus.* Pimburettewa lake has the highest fish yield and Giritale lake has the lowest. Colonization success of *S. mossambicus* in manmade lakes is discussed in relation to its feeding habits and physical features of those water bodies.

NEW INFORMATION CONCERNING VOCAL COMMUNICATION AND THE CREATION OF NEW SOCIAL GROUPS IN TOQUE MACAQUES

Wolfgang P.J. Dittus

A. Analysis of Toque Macaque Cohesion Calls from an Ecological Perspective

The vocal repertoire of Sri Lankan toque macaques (Macaca sinica) is rich and varied. Research focused on one class of vocalizations, so called "contact calls", which are the most commonly used by the macaques. This class embodies three acoustically and functionally distinct sounds: (1) cohesion calls, (2) food calls, and (3) lost calls. These calls share the role of guiding individuals in their chronic selection of social partners, but differ in their additional specialized functions.

Thus, food calls serve to advertise the discovery of a superabundant source of food in the forest and attract other group members to feed at the site. Cohesion calls play an important role in identifying individuals, particularly during foraging progressions, and thus contribute to the foraging efficiency of individuals.

Lost calls are given by individuals when they are visually and spatially separated from their social group. There are essentially two kinds of lost calls that differ in acoustic structure and social function. The first are loud calls whose physical properties are well suited for distance propagation

but having few directional cues. They serve as low energy, often repeated, "sound beacons" advertising that the caller is lost and is seeking to reestablish contact with its group. The second type of lost call complements the first. It is also loud, but its acoustic properties communicate the direction of the caller in the forest. These calls are given briefly at junctures when vocal contact is first reestablished between separated parties, and serve to guide individuals in their movements towards each other through the forest where visibility is limited.

B. Group Fission Among Wild Toque Macaques as a Consequence of Female Resource Competition and Environmental Stress

At Polonnaruwa, Sri Lanka, four out of 29 groups of toque macaques (Macaca sinica) divided in a period of 16 years. Temporary peripheral subgroups of varying sizes and compositions preceded fission by 9 to 40 months. Fission crystallized within one month through an increase and stabilization of subgroup membership and permanent division. All members in the newly seceded groups had been frequent participants in pre-fission subgroups, and belonged to subordinate matrilineages. Subgroups, and hence group divisions, were initiated by cores of mutually loyal females and occurred mostly along kinship lines. In the year of fissions, the rate of change in female dominance relations was significantly greater among groups othat divided than among those which did not. I hypothesize that low ranking females secede to form new groups when the costs, especially of intragroup competition

for food resources, outweigh the benefits of group membership. Such seceding females were easily available and familiar mates for group males which had recently lost rank. Final division, therefore, resulted from a coalition of subordinate females and males acting according to their respective interests. It was triggered in this population by rapid growth of some groups to large size and environmental stress (the reduction and fragmentation of food resources caused by drought and a cyclone), which accentuated the costs of resource competition. Male aggression, such as infanticide, which negatively affects female fitness, also might have contributed to one group fission.

PLANT BIOTECHNOLOGY

A. Kovoor
S. Karunaratne
M.C. Gunasekera
M.C.M. Iqbal
S. Ramanayake

Soon after completing installation for basic plant tissue culture we initiated the first of our programmes on the zygotic embryo culture of certain meliaceae for reforestation.

Meliaceae embryo culture

Seeds from mature and immature fruits of Azadirachta indica (kohomba) and Melia composita (lunumidella) collected from various locations were dissected to determine the most suitable manipulation for excising embryos. In fact, seed anatomy is quite specific for each species and the procedure has to be formulated afresh whenever a new species is taken up for study. The optimal culture medium has also to be determined for each species. Since media are usually made up of about thirty constituents, each one at a critical concentration, an empirical determination would entail trying out an impossibly large number of tentative media at first. Thus, in the scheme of broad-spectrum trials as proposed by de Fossard, about 4000 different preparation have to be assayed before further improvement to obtain the ideal medium. However, by grouping constituents into categories and varying the concentration of categories to a minimum, preliminary trials

can be done in manageable series. Thus, with three categories (e.g. inorganic salts, carbon compounds and phytohormones) and two concentrations (high and low) only 8 trials are necessry (i.e. 2). If constituents are grouped into five categories (inorganic macro elements, micro elements, carbon sources, vitamin like factors and phytohormones) 32 media have to be prepared (i.e. 2) and if their concentrations are to be assayed at three levels (high, low and zero) then 243 are media required (i.e. 3). Using this strategy we divised media which induced 90% germination of the excised embryos of lunumidella and 100% of kohomba (Details of excision procedures and germination in vitro are given in Ms. Gunasekera's report).

Germplasm conservation by inducing slow growth

Paradoxically, once embryos grow profusely on optimal media, it is often desirable to slow down their growth artificially for practical purposes, such as when planting stock has to be held over for several seasons later, or when planting operations in a forest are delayed several months for reasons beyond our control. Embryos should be maintained in vitro as healthy as possible, with only their actual growth rate reduced to a minimum, which may be achieved by reducing the temperature or by devising specific slow growth media. We have adopted both low temperatures and the incorporation of mannitol in place of sugar in the culture medium. Mannitol is a carbohydrate which cannot be assimilated by plant tissues; it however maintains the osmolality and other physico-chemical properties of the medium so that tissues are not harmed while being deprived of their energy

source. This and the reduced temperature bring down metabolism to a basal rate until such time as the temperature is raised and sucrose is provided to restore normal rate of growth (Details of slow growth in the presence of mannitol and at low temperatures appear in Ms. Gunasekera's report).

Albinism

A significant number of lunumidella embryos developed a form of albinism in vitro, that is, the first two leaves were white and devoid of chlorophyll. This is a somewhat widespread and ill-understood phenomenon particular to certain species. It occurs in androgenetic embryos (haploid progeny from unfertilized pollen) of some cereals like wheat and rice and has also been reported in the chestnut, but never in other families like the Solanaceae. A tentative molecular explanation is that the chloroplasts of albino leaves lack ribosomal RNA following an extra-nuclear mutational event during androgenesis, but this cannot yet be proved for want of sufficient albino material to test with the appropriate DNA probes. Chinese workers claim that the cause is purely phenotypical and can be remedied by suitable modifications of nutrients. (Ms. Gunasekera's report will show that albinism in lunumidella may be correlated with the stage of maturity of the excised embryos. Hopefully, a sufficient number of albinos may be prepared in the future for looking into their RNA and DNA).

Jacaranda and Nutmeg

We have added the embryo culture of the Jacaranda

and the Nutmeg to this programme. The Jacaranda is one of the six ornamental trees with which we hope to border the Institute grounds. Its propagation by embryo culture has presented no particular difficulty, and we shall apply the same technique the next season to another of the six species, Tabebuia, which is also a Bignoniaceae.

The natural germination in the soil of nutmeg seeds is extremely poor. From our observations it appears that the hard ruminated endosperm in which the embryo lies is very susceptible to fungal infection during maturation. Very young seeds are however free from infection and are furthermore soft and convenient to dissect. But at this stage embryos are so juvenile that they require a medium heavily supplemented with nutrients. We were able to obtain growing plantlets of nutmeg under sterile culture; these are intended for Brazilian scientists who will provide us, in exchange, germplasm of one of their species Anacardium microcarpa which is a particularly a drought-resistant relative of the cashew and not found in Sri Lanka (Details of Jacaranda and Nutmeg appear in the report of M. Iqbal and S. Ramanayake).

Bamboo

The second of our programmes involves the propagation of the giant bamboo, Dendrocalamus giganteus by in vitro methods. The choice of explants, difficulties of surface sterilization and the growth response on various culture media are given in the report of M. Gunasekera. One of our immediate aims is to obtain the multiplication of shoots from axillary buds by using high cytokinin in the medium as reported

elsewhere by Chaker-Barzanov for a temperate bamboo; Pseudosasa japonica. He was however unable to induce roots in them and we are also confronted with the same difficulty in Dendrocalamus. Dr. Chaker is expected to join our group in the IFS later in the year.

Introduction of Forest tree germplasm

One of our long-term projects concerns the 900 odd tropical forest trees from all over the world whose edible fruit are under-utilized at present. About 80 of these are found in Sri Lanka, while there is no reason to think that the others will not thrive here if introduced, since all types of tropical habitats are found in some part of the island or other.

Our technique of explanting in the field and transporting sterile cultures has been described previously. It provides one of the best phyto-sanitary guarantees known so far. We made use of the opportunity of a recent visit to Kenya to collect about twenty species of forest fruit trees. All of them were species which we saw for the first time. Very often we had much difficulty in deciding on suitable sampling and dissection procedures on the spot in the forest itself. After transport of in vitro embryos to Sri Lanka, some species are now growing in pots or poly bags and will soon be transplanted to a suitable location here. This our first and though a badly prepared attempt to introduce germplasm from a distant country, is quite encouraging for future expeditions.

Winged bean

This is our latest programme. A general objective is to produce a bush-type of plant instead of a straggling creeper. Obviously such a spontaneous mutant is being widely searched for, and attempts have also been made to induce mutations by irradiation and chemical agents in other laboratories.

One of our approaches is to obtain androgenetic plants, which will necessarily be homozygous. All recessives will therefore be expressed and there are chances that a bush-type recessive which had remained masked right throughout the evolution of the winged bean from a wild ancestor may come out for the first time. When we cultured anthers to obtain embryos from the pollen it was however the surrounding tissue that grew into a callus (see report of M. Iqbal and S. Ramanayake). Therefore the very small microspores will have to be isolated from the surrounding tissues before culturing in the next attempts. Incidently, the callus we obtained can be maintained for use as a substrate for mutation studies now.

To isolate microspores of the right stage, which is generally the uninucleate stage just after the first mitosis following meiosis, we examined cytological preparations and correlated this stage with the size of the bud. Buds of length 3.5 to 4.0 mm seem to be the ones in which microspores are in the proper stage. Our next trials will therefore involve the micro-dissection of the minute anthers of these buds at the right time [Cytological observations are described in the report of M. Iqbal and S. Ramanayake].

Apart from the genotypic selection of a bush-type, manipulation of the phenotype by *in vitro* micrografting could also lead to the same result. But this will require more skilled effort. The best scion for micrografting is indeed the dome of the apical meristem which rarely exceeds 0.1 mm, but which carries the morphogenetic potential of the whole shoot. Unfortunately, like in all the Papillionaccae, the apex of the winged bean is covered tightly by several successive large stipules of the youngest leaves. Removing them with a microscalpel damages the fragile dome invariably. We have nevertheless found that when the epicotyl of a germinating seedling is decapitated, the dormant buds in the axils of the two cotyledons (cotyledons are morphogenetically equivalent to leaves) could develop sometimes in a matter of hours. These buds are indeed naked shoot meristem and are easily excised and will be used as scions for grafting (see also report of M. Iqbal and S. Ramanayake).

ZYGOTIC EMBRYO CULTURE OF THE MELIACEAE AND AXILLARY BUD CULTURE OF THE GIANT BAMBOO

M.C. Gunasekera

Zygotic embryo culture is an ideal technique to overcome problems of low seed viability and germination. Our objective is to develop techniques for large scale germination of Kohomba and Lunumidella seeds using in vitro culture technology. The two principal aspects of the technique are the determination of an appropriate condition for explanting the embryo and development of a suitable medium for it's growth. Techniques have been already developed for successful germination of immature and mature seeds of Lunumidella and Kohomba in vitro.

Conventional vegetative propagation of Giant Bamboo is done by digging and planting portions of rhizomes. In a large scale undertaking this is hardly feasible. Therefore in vitro culture techniques need to be developed. Different aspects such as, type of explant, method of sterilization, dissection of explant and composition of media are studied at present.

EMBRYO CULTURE OF NUTMEG AND JACARANDA AND PRELIMINARY STUDIES ON ANDROGENISIS AND MICROGRAFTING IN WINGED BEAN

M.C.M. Iqbal and S.M.S.D. Ramanayake

Embryos of Jacaranda were cultured at various stages of fruit maturity. The plantlets were successfully transplanted in the soil.

Nutmeg (Myristica fragrans) embryos excised from immature seeds were successfully cultured on a nutrient medium. Although locating embryos in immature seeds was difficult aseptic transfer of embryos had no problems.

In winged bean (Psophocarpus tetragonolobus L.(D.C.) preliminary studies in attempts to change its twining habit to a bush type have been initiated. One such approach being attempted is through androgenesis which can bring to expression recessive genes hitherto unexpressed. Uninucleate microspores have been reported to give good results in other species. Our studies showed that flower buds of size about 4 mm in length contained newly formed uninucleate microspores. Aseptic transfer of anthers or pollen proved difficult. However, callus was obtained from the tissues surrounding the microspores.

Another approach to a bush type plant is through micrografting of apical meristems. Excision of apical meristems from buds in the axils of cotyledons in young seedlings proved easier than their excision from shoot apices. Therefore these buds will be used in future work.

THE MORPHOLOGICAL AND ANATOMICAL STUDY OF ADULT SRI LANKAN HUMAN HEARTS

H. Gamage

Among the coronary heart diseases, Atheroscelerosis is the most important, common heart disease in Sri-Lanka. The main source of fat intake among the Sri-Lankans is coconut oil and milk. The excess fats that are consumed, are deposited along the arterial walls, thus blocking the smooth flow of blood. The Atheroscelerosis project aims at finding the connection between the intake of fats and the fluctuating fat level in the body.

The morphological and anatomical study of adult Sri-Lankan human hearts is a project directed towards reaching a conclusion of the various measurements of adult Sri Lankan hearts.

Two hundred and fifty human hearts, stored in formalin were dissected to take measurements for previously decided variables. e.g. The thickness of the left ventricle. These values have been noted down under a tag no: of each heart.

This data will now be analyzed with the help of SAS (a statistical package) - in order to produce meaning-ful results.

From November 1988 - Transferred to the Computer Division - Involved with the various administrative functions of the computer division. Learning the various soft-ware packages installed in the Micro computers and Mini computer.

DIVISION OF EARTH & SPACE SCIENCES

DIVISION OF EARTH & SPACE SCIENCES

EDITORIAL WORK ON PUBLICATIONS OF THE GEOLOGICAL SURVEY DEPARTMENT

P.G. Cooray

This is a Joint Project between the IFS and the GSD, in which the IFS edits and prepares for publication material supplied by the Geological Survey Department. The scheme of publication includes Sheet Memoirs, Professional Papers, Economic Bulletins and Technical Records.

The Project began in May 1988 and progress is reported on the following:

1. Memoir No.4 - Geology of the Country around Chilaw - L.K. Seneviratne & P.S. Kumarapeli

2. Memoir No.5 - Geology of the Country around Battulu Oya and Puttalam - by P.G. Cooray

3. Economic Bulletin No.4 - Mineral Resources of the Western Province.

4. Economic Bulletin No.5 - Mineral Resources of the N.W. Province.

5. Other planned publications.

IRON TOXICITY IN WETLAND RICE (Oryza sativa L.) A PROBLEM OF LOW SOIL FERTILITY?

P. Deturck

Iron toxicity is a widespread nutritional disorder of wetland rice in the tropics. Phenotypic expression, occurence, yield loss and geographical distribution have been repeatedly described in the literature.

Early reports attributed this physiological problem to a variety of factors including low pH combined with high active iron %, H_2S toxicity, and Al toxicity.

Since, several authros have stressed on the importance of nutrient deficiencies such as K deficiency, Ca deficiency and Mn deficiency as the primary cause of iron toxicity. Recently a mechanism has been proposed where a multiple nutritional soil stress is considered an essential prerequisite for iron toxicity. Due to this multiple nutritional stress, more root exudates would be released in the rhizosphere, which would stimulate the microbial activity. This would cause a depletion of oxygen and an increase in iron reducing micro-organisms. Consequently, iron reduces would continuously solubilize the Fe-hydroxide root coatings, resulting in an incontrolled influx of Fe^{++}.

In our study, a large number of soil samples have been analysed in order to examine the presence of the multiple nutritional soil stress in iron toxic rice soils. Besides, the occurence of an increased microbial activity as a consequence of higher root exudation of K- deficient iron toxic plants was investigated.

Results indicate that iron toxicity is caused by a multitude of factors of which the most pronounced is a strong deficiency of K. K fertilization results in a reduced Fe uptake by the plant, a declined total microbial activity and a decreased number of iron reducing micro-organisms in the rhizosphere of iron toxic soils.

However, the interaction of low, CEC, acid pH, Mg and Mn deficiency and high active Fe levels could certainly aggravate this disorder.

The function of P, Ca and Zn in the iron intoxification mechanism could not clearly be established and urges further investigation.

THE ENHANCED FORMATION OF N-NITROSOAMINES IN FULVIC ACID MEDIATED ENVIRONMENT

S.V.R. Weerasooriya

This paper reports observed evidence for the role of fulvic acids in mediating the formation of N-nitrosamines from nitrite and secondary amine precursors. The N-nitrosamines are of particular environmental and health importance, because as a class these compounds have the potency for mutagenic, teratogenic and carcinogenic activity. The formation of nitrosamine depends generally on the direct nitrosation of secondary amines. However primary and tertiary amines are also potent precursors since they may be converted to secondary amines. Direct nitrosation occurs optimally at pH 3.40, the pK_a of HNO_2, but another reaction pathway catalyzed by certain carbonyl compounds (for example HCHO and Cl_3CHO) can produce nitrosamines under neutral or even basic conditions. Results of the present study have indicated the catalytic effect of fulvic acids in the nitrosation process. We have found that significant quantities of NDBA (N-nitrosadibutylamine) are formed even at pH 5.50, in the presence of fulvic acids. However the exact mechanism of fulvic acid mediated nitrosation is inherently so complex, that it is a subject which requires a comprehensive investigation.

INTRODUCING THE SAS COMPUTER PACKAGE FOR STATISTICAL ANALYSIS TO THE IFS

Asanka Beligaswatte

The SAS (Statistical Analysis System) computer package was installed on a Data General microcomputer in August 1988. A program of familiarizing IFS scientists with this package was started with a two-hour demonstration of some of its important procedures. More demonstrations of the general principles of using SAS, and if possible a discussion/demonstration on using the General Linear Model (GLM) procedure is anticipated for December.

An instance where SAS was used for statistical analysis in a project studying the effects of green manure in iron toxic soils will be discussed. Plans to enhance the SAS system at the Institute will also be outlined.

GEOSPHERE - BIOSPHERE INTERACTIONS

C.B. Dissanayake

The International Council of Scientific Unions (UGSU) which is a federation of about twenty scientific unions covering all disciplines of science and of about seventy national academies, has recently been addressing itself to a very important question of global importance.

"Is the time ripe to launch a cooperative, inter-disciplinary, international programme to illuminate the complex and synergistic physical, chemical and biological processes in, the Sun-Earth system that determine its changes? These processes not only govern but are also profoundly influenced by living things - especially by human activity. As the number of humans increases, and their demands on the environment of a finite earth grow, a deepened understanding of anthropogenically induced global change is becoming an imperative of contemporary society".

Sri Lanka is ideally suited as a study case in the Geosphere-Biosphere programme. With a population of over 16 million occupying a relatively small landmass and with the vast majority living in close association with the 'soil', Geosphere - Biosphere interactions are obviously important. Apart from the geographical distribution of health problems caused by the varied compositions of the geosphere, the changes of the geography of the country, induced by large scale anthropogenic activities has also shown an upward trend. Research activities of the

Environmental Geochemistry Group of the Institute of Fundamental Studies focusses attention on these interactions and their direct and indirect effects on the human population.

The ultimate goal of the International Geosphere -Biosphere Programme (IGBP) would be to assess trends in natural and anthropogenic global change anticipated for the next 50 - 100 years, thus providing governments with information needed for the development of long-term plans to relieve the ever-increasing stresses on human life-support systems.

EPPAWALA PHOSPHATE DEPOSIT - AN EXAMPLE OF A TERRESTRIAL PHOSPHORITE

Kapila Dahanayake

During the year under review, petrological, mineralogical and geochemical studies were continued on the Eppawala phosphate deposit. The studies were carried out using polarization microscopy, scanning electron microscopy, X-ray diffractometry, differential thermal analysis and electron microprobe analysis. For the purpose of these studies, samples collected in the field as well as those from bore holes were used. Logging of bore holes samples available at the Geological Survey Department was also carried out.

The studies so far indicate that the phosphate material used for fertilizers is concentrated in weathering profiles of thickness varying from a few meters to as much as 100m developed principally on apatite marble formations supposed to be of Precambrian age. Our observations show that the phosphate enrichment is mainly confined to the lower leached zone of the weathering profile. The composition of the material in this zone is comparable to phosphorites which are characterized by the presence of coated grains, intraclasts and peloids in stromatolitic groundmasses. It is noted that the main source of phosphate in the terrestrial phosphorite at Eppawala has derived from Precambrian chlor fluor hydroxyl apatite crystals. These have undergone diagenesis within the close confines of the thick weathering profiles developing in a tropical environment characterized by percolating solar-heated waters and microbial activity.

Eppawala phosphate deposit can be regarded as an example of a phosphorite forming in a terrestrial environment due to the weathering and diagenetic processes active on a phosphate-rich marble formation. The fact that the phosphate-rich nutrients emanate exclusively from single Precambrian primary apatite crystals makes it a rare if not unique example of phosphorite genesis.

A DEGRADING PHENOMENON IN THE EPPAWALA PHOSPHATE DEPOSIT

S.M.N.D. Subasinghe

Tropical weathering processes active on the Eppawala phosphate deposit have caused both enrichment and degradation of the ore. Thin section observations suggest silicification as the most critical process of degradation.

Due to diagenetic activity in the tropical weathering profile of the Eppawala deposit, primary apatite crystals seem to undergo processes of dissolution and replacement which eventually transform them to a multitude of finer quartz grains. The silicification process initiates along the fractures of apatite crystals and gradually spread to their centres. The chemical analyses reveal that the P_2O_5 content is extremely low in regions affected by silicification. At some points of the deposit, P_2O_5 content could be as low as zero and in the field, the degraded ore shows as fine grained dark patches interspersed with rare apatite grains. These observations were confirmed by a number of tests carried out with the DTA, XRD, and EPMA.

COLOUR CHANGES IN THE TRANSFORMATION OF GEUDA TO SAPPHIRE

M.S. Rupasinghe

The colour of corundum is mainly due to traces of impurities. The colour is dependent not only on the impurities, but also on other factors such as:

thickness of the specimen;
cut shape of the specimen;
axis of the specimen etc.

The blue colour of sapphire as seen in natural specimens is derived from a subtle interaction between two impurities, iron and titanium. This colour can be further modified by the presence of other impurities, such as red, causing chromium. The exact shade of blue also depends not only on the relative amount of iron and titanium present, but also on the valency state involved, namely Fe^{2}_{+}, Fe^{3}_{+} as well as Ti^{3}_{+} and Ti^{4}_{+}.

A few dark sapphire "black ottu" specimens were heated up to 1800^{o} under an oxidising environment. The colour of the specimen became lighter.

The specimens were heated again under reducing condition. A colour that is acceptable for Gems was obtained. Analysis of the specimens show the high Fe distribution in the surface.

WORKPLAN FOR 1989

V. Manoharan

I have joined the Iron Toxicity project on October 1988. For the first two months I have assisted the ongoing laboratory research work to get familiarize with the instruments and the methods involved in the soil and plant analysis.

From December to January I have done the literature survey and prepared the research proposal for my Ph.D. The proposal entitled with "Balanced Nutritional Approach to Iron Toxicity in Rice".

For the first two months literature survey will be carried out to find appropriate techniques for the proposed experiment. Rest of the period Preliminary studies on the proposed experiments will be carried out. First of all an initial study will be done to characterise some important phycio-chemical properties of the iron toxic soils. In the first stage of the experiment studies will be carried out in the culture solution and parallel with the sand culture experiment to find out the balanced combination of the N P K levels and their effects on the occurance of iron toxicity, root oxidizing power, iron exclusing power, iron translocation.

Second stage of the preliminary studies will use the N P K combinations which minimise the iron intoxication with the various levels of Ca, Mg, Mn in relation to iron intoxication.

Note: content of this work plan is to be confirmed.

WORK PLAN FOR 1989

K. de Silva

I joined this project in October, 1988. During the first two months I had to familiarize with the techniques and equipments which are used in this project while supporting to carry out ongoing research studies in the project. Then I had to go through literature to plan my future research study during the month of December.

The summary of my work plan for the year 1989, will be as follows:

My study will be on iron toxicity as related to N, P, K application. Some preliminary studies will be carried out before doing the main experiment to get some information.

Initial studies will be done to study the fertilizer status of different iron toxic soils and to get information on the N,P,K levels to be applied to these soils to maintain the soil at non toxic levels.

According to the findings of preliminary studies main experiment will be designed. Main experiment will be carried out to study the effect of N, P, K on iron toxicity. Solution culture experiments will also be carried out to study the effects of N, P, K on some criteria of microbial activity and finally a pot experiment will be done to confirm the above findings.

DIVISION OF SOCIAL & PHILOSOPHICAL SCIENCES

DIVISION OF SOCIAL & PHILOSOPHICAL SCIENCES

THE LOGIC OF ATTEMPTED SUICIDE AND ITS LINKAGE WITH HUMAN EMOTIONS

Padmasiri de Silva

Attempted suicide is a "non-fatal act of self-injury undertaken with conscious self-destructive intent". While the sample of 25 cases of attempted suicide examined out of an over all target of 100 cases pointed towards the seriousness of the intention to commit suicide rather than merely threaten some one, the cross currents which have a bearing on driving them to attempt suicide are more complex and number of variables were evident. This study which is basically concerned with "Family response patterns to attempted suicide" is focussed on the interpersonal relations in the family setting, as other people become objects of both love and hatred. While the family gives the individual a sense of anchorage and belonging, it also generates intense conflicts and stress.

Thus while factors like poverty,unemployment,disappointed love, marital conflict, examination failures, alchoholism, family disputes etc may be strong pre-disposing factors, the "straw that breaks the camel's back" is the break-down of family relations and the closure on the individual to search for alternative paths to deal with stress and conflict, than attempt suicide. My own analysis is concerned with the emotional dimensions of the psycho-social context which have a bearing on attempted suicide. It includes a criticism of the "frustration-aggression" theory of suicide and emphasize the centrality of hostile relations along with emotions, hopelessness

(a facet of what may be called "depression"), anger and shame. Shame as a cross-cultural factor in the Sri Lankan context is considered as an important revelation of the study. Shame emerges out of a social context, of status concepts, lively gossip (though with a bitter flavour), the fear of being "talked about" and exposure. The study of emotions in relation to attempted suicide brings out useful insights regarding personal, familial and social factors which have a bearing on attempted suicide.

LANDUSE CHANGE AND HYDROLOGY OF THE UPPER MAHAWELI BASIN

C.M. Madduma Bandara

Since the advent of plantation agriculture in the hill country hydrology of the Upper Mahaweli basin has undergone considerable changes. The extent and magnitude of landuse changes that have been taking place since early 1950s can be quantified through sequential aerial photography. An attempt made in this direction recently as part of the IFS Mahaweli studies programme, indicates a significant reduction in the extent of land under tea in the Upper Mahaweli basin. Much of these lands were either converted to homestead gardens or reverted back to patana grasslands. There had also been some attempts by the Forest Department to establish forest plantation in patana grasslands.

The hydrological implications of landuse changes is only poorly understood in most tropical countries. This is particully so in the Upper Mahaweli basin which is the source area for the newly constructed Cascade of Mahaweli reservoirs. The conventional belief that, reafforestation of barren lands necessarily leads to an increase in the quantity and quality of streamflow is now under challenge. However, the results of the studies undertaken at the IFS tend to suggest that low flows of Mahaweli have decreased over the years as a result of landuse changes in its catchment area. Further research studies in this theme are now being planned for the catchment above Nawalapitiya which records the highest annual rainfall in Sri Lanka.

ASPECTS OF HYDROLOGICAL REGIME CHANGES IN THE UPPER KOTMALE OYA

Tilak Kuruppuarachchi

Annual discharge records available for the Kotmale Oya Basin prior to the construction of the Kotmale Dam together with long-term rainfall series available for selected locations, were analysed by using time-series methods to detect temporal trends. This reveals a declining trend of rainfall over the basin, particularly in the upstream areas. The declining trend of annual discharge of the Kotmale Oya basin can be attributed to a considerable extent, to the overall changes of rainfall regime of the watershed areas. Human modification of the environment can be seen as a primary cause of hydrological regime changes in this basin.

SOME FEATURES OF ATTEMPTED SUICIDE IN SRI LANKA

Chamindra Weerackody

Suicidal behaviour is viewed as a "coping mechanism used to deal with stress and undesirable life situations. From the perspective of the individual, it is a purposeful and meaningful response to a crisis situation in life.

A rapid increase in the incidence of 'suicide' has occurred in Sri Lanka since the 1950s. In 1984, 6609 cases of suicides were reported, which was 13 times higher than what was reported in 1950. No one has so far tried to investigate or assess the incidence of 'suicidal attempts' in Sri Lanka. There seems to be a consensus, however, in the west that there are approximately ten attempts for every successful suicide. Both suicides and suicidal attempts in Sri Lanka are numerous among teen-agers and young adults.

This paper discusses some of the important social and phychological characteristics associated with suicide attempters who had been admitted to the Kandy General Hospital. The data are derived through interviews conducted with suicidal attempters and their family members. In addition, three standard psychological scales were used to measure the levels of depression, loneliness and hopelessness experienced by the attempters. The respondents were in the age group 15-30 years and consisted of males and females.

88 percent of the attempters committed the act with the motive of destroying themselves while the rest had the intention of threatening or manipulating the significant other individuals.

The study attempts to show that suicidal behaviour is likely to occur when there is increased stress accompanied by hostility from family and significant others, when the other person is unable to retaliate and when he perceives that external help is either unavoidable or withdrawn from him and death is the only solution to what appears to him as an intolerable situation. The feelings of depression, hopelessness, loneliness or lack of social support and shame function as precipitating factors in suicidal attempts.

Most families view a suicidal attempt as a 'stupid' or a 'foolish' act and never consider it as having any long-term ramifications and implications. A number of discrepancies could be observed in understanding and interpreting acts of suicidal attempts by the victim and the family.

Suicide attempts place a heavy strain on the health care system, a system that already suffers from a very limited capacity. It is a burden on the family too. However, due to inadequate medical facilities, families of the victims have to bear the responsibility of providing after-care for their members who have attempted to end their lives.

WORK PLAN FOR 1989

M. Gunaratne

During the months of December and January I have closely observed and gained experience in conducting the field interviews with the suicidal patients as well as their family members. I have also spent time in reading literature relevant to the project and in participating in discussions held in connection with the research findings. I hope to conduct independent field interviews from the month of February.

I have attended to an learnt the processing, quantification and coding of data. Arrangements are being made to computerize the data obtained from the study, using SAS (statistical analysis system) computer package installed in the micro-computer.

I have already started gathering information on basic statistics about the status of science and technology, for the Third World Academy of Sciences.

I have been involved in the organization of the Library.

Computer - I have been engaged in the study of TeX- a new typesetting system used for high quality technical manuscripts.

THE SETTLEMENT ARCHAEOLOGY OF THE SIGIRIYA - DAMBULLA REGION

Senake Bandaranayake

The "archaeological Landscape" of the Sigiriya - Dambulla region is one that largely dates from the early and middle historical period (EMHP : circa 3rd century BC to AD 13th century). Straddling the national East-West watershed, this area formed an important focus of communications. It is an intermediate or transition zone between the ancient core regions around the Anuradhapura, Polonnaruva and 'Kurunegala' systems" and also between the dry zone plains and the central mountains.

In this area, as in other parts of Sri Lanka, previous archaeological and epigraphical studies have provided us with an extensive knowledge of the EMHP.

However, this has been largely confined to the study of monumental complexes, royal and elite inscriptions and political and religious history -- mostly relating to the apex or superstructure of the historical society. Similarly, excavations were almost invaribaly limited to the study of monumental remains and, more recently, to stratigraphic investigations of sites associated with such remains. The present project can be seen as one of the pioneering attempts to develop a research strategy to investigate the ancient 'settlement network' and man-environment relationships in a diagnostic micro-region of the Sri Lankan dry zone, around the major historical and archaeological centres of Sigiriya and Dambulla.

It includes the identification an analysis of habitational sites, irrigation systems, and craft production and distribution centres, as well as the study of relevant aspects of central foci such as the 5th century AC politico-urban complex at Sigiriya, the major monastic

centres such as Dambulla and Pidurangala, the monastery and fortress sites at Nuvaragalkanda, and the megalithic cemetery complex at Ibbankatuva.

The project will progressively employ multi-disciplinary research methodologies incorporating the historical, social and natural sciences, and is based on a diachronic and multilinear view of social dynamics.

The preliminary fieldwork was restricted to the upper catchment areas of the Kiri-Oya, Sigiriya-Oya and Mirisgoni-Oya basins, to the urban habitation site in the eastern precinct at Sigiriya and some selected, rock-shelter monastery sites.

The results obtained far exceeded expectations. 85 archaeological sites, 79 of them previously unknown, were identified. Most of them are ancient village settlements, based on either tank irrigation or spring water sources. Nearly 80 village irrigation tanks and a number of iron production and stone quarry centres were recognized and investigated.

The presentation at the annual review will include an overview of the survey and an examination of the theoretical and problematic concerns that form the conceptual basis of the project.

HISTORY OF SCIENCE AND TECHNOLOGY PROGRAM
PROGRESS AND PROSPECTS

Martha Prickett

The IFS History of Science and Technology in South and Southeast Asia Program begun in July 1988, following earlier discussions by Prof. Cyril Ponnamperuma. The purpose of the program is to develop for South and Southeast Asia a coordinated study and compilation of the region's scientific and technological heritage, such as has been done already for China and other world regions. This study will help to rediscover lost ancient techniques, clarify important questions relating to the study of historical dynamics, pinpoint resources forgotten and no longer exploited, and document the processes of invention and technological transfer between regions. It will also foster the growth of a fuller awareness of the region's scientific and cultural heritage, the enormous time-depth of that heritage and the global significance of its contribution to man's accumulated scientific and technological knowledge. The program will define the field in its broadest sense, and will include such topics as materials science (metallurgy, ceramics, plasters, glass); agricultural and irrigation technologies; engineering, mining and construction technologies; arts and crafts; textiles, weaving and dying, medicine and vetinary sciences; food storage and preservation; ship building, navigation and astronomy; mathematics, even philosophy as related to science.

The IFS program is both organizational and research oriented. The major initial thrust is on the organizational

aspect. It is proposed that the IFS program do the the following :-

1. Develop and maintain a world-wide data base of both historical and scientific researchers dealing with aspects of this topic, together with their research interests and the bibliographic information of all relevant publications.

2. Serve as a clearing house for bibliographic information in response to queries by researchers, especially to provide print-outs of the relevant portions of the data base to researchers and to provide photocopies of any journal article or out-of-print work listed in the data base upon request.

3. Coordinate the publication of a one-to-two volume collection of commissioned papers synthesizing the current state of research knowledge concerning the history of South and Southeast Asian Science and Technology.

4. Hold a series of about a dozen (ca. four per year) one-week intensive seminars by researchers actively working in a specific field, and publish the papers and results of the discussions of these seminars.

5. Encourage the collection of ethnographic information concerning traditional technologies by anthropologists and others dealing with groups in technological transition.

The initial meeting of an international organizing

committee of researchers from within the region and outside will be held from July 24th to 30th, 1989 at IFS, Kandy. This meeting will include interested scientists, anthropologists, historians, and archaeologists. The meeting will discuss the feasibility and modalities of the project, will formulate a working program and will establish a Steering Committee, especially for the publication and seminar programs. Travel support for the regional representatives to this meeting has been solicited from the Third World Academy of Sciences.

The research aspect of the History of Science and Technology Program will involve both historical and linguistic studies of ancient documents, as well as scientific investigations, especially in Archaeology and Materials Science. It is anticipated that the overall program will stimulate research on ancient manuscripts by historians and linguistic scholars. At the same time, the IFS program itself has begun physical research, especially in collaboration with the Earth Sciences, in the fields of ancient ceramics and plasters, in the use of ceramic technology as an indicator of international contacts, in maritime technologies, and in ancient irrigation technology. The purpose of the IFS research program is to stimulate not only archaeological research, but to develop multi-diciplinary collaborative research between archaeologists and other scientists to rediscover our scientific heritage.

MICRO STUDIES ON THE PATTERN OF SITE DISTRIBUTION ALONG THE UPPER MAHA OYA VALLEY

C. Rambukwella

This is a continuation of the research conducted on the Environmental archaeology of the archaeological sites situated along the Upper Maha Oya valley.

An approximate number of 100 archaeological sites from the Upper Maha Oya and its fringe areas were mapped. In addition, the whole valley was also carefully mapped for future studies. The main thrust of the research work concluded this year was directed at:

(a) Understanding the locational pattern in micro regions;

(b) Understanding the dynamics related to regional connections.

The first of these indicated some useful patterns related to the micro location of sites and the significance of micro clusters. These apparently had a variation during different chronological periods.

The regional connection indicated the possible significance of the Upper Maha Oya as an extremely important link-zone connecting primary catchments of three major river systems, in addition to giving access to the Bay of Bengal.

The program for 1989 is expected to substantiate some of these Historical - archaeological findings with a greater amount of data from environmental studies.

AN ARCHAEOLOGICAL DATA BASE

Sivam Krishnapillai

An efficient means of storing, recalling and analyzing large amounts of data is essential for the study of archaeology.

The advantages of computerizing are many. It facilitates quick and efficient data storage and retrieval. It allows to be updated easily. It could serve as a powerful research resource base that gives the user access to large amounts of data, that can be searched, compiled and analyzed efficiently.

History is a complex puzzle, which is solved by putting together bits of information from literary and archaeological records. The history of a society, or a country has to be pieced together from large amounts of information that cannot be handled efficiently by manual methods. The advent of computers has made it possible to analyse large amounts of data - easily, intelligently and scientifically.

The computer data base will make it possible to study large amounts of data. It will open up possibilities that are beyond the abilities of the human brain. For example, the data base can handle uncertain data (say a monument whose period is subject to argument, and has two or more possibilities). And in fact the data base could help to reduce these uncertainties by intelligent data analysis (by cross references and AI techniques).

An island in reasonable isolation like Sri Lanka, which is reasonably small will be most suitable for the study of internal dynamics. The computer data base will be able to provide data necessary for such a study, mainly the study of ancient agrarian society.

The challenge in Social Sciences is to understand Social Systems the way we understand. Electrical, Mechanical, Biological Systems. Unfortunately in the Social Sciences the laws that govern society and social development are yet to be understood. It is only by analysing the large amounts of data left behind by ancient society, that we can understand and formulate the laws that govern social development.

DIVISION OF MATHEMATICAL & COMPUTER SCIENCES

DIVISION OF MATHEMATICAL & COMPUTER SCIENCE

USE OF STATISTICAL COMPUTING IN THE FIELD OF SCIENTIFIC DISCOVERY

N.D. Yatawara

Since early this century routine statistical analysis of experimental data has been a part of agricultural and biological research; more recently it has become so in medical and industrial research. These analyses were greatly hampered, however, by having to perform large calculations manually or with the aid of desk calculators. The advent of modern high speed electronic computers having mass storage capacities have helped to alleviate this problem. Computers have to be controlled by a sequence of instructions called software programmes. At present there are so many high level languages such as BASIC, FORTRAN, PASCAL, APL, available, for software programming. Yet, how best to organise statistical computing is a problem faced by many researchers. One can organize statistical computing broadly under three main approaches, (a) single programmes, (b) using statistical packages (c) using a collection of sub-routines. Whichever method a researcher follows, he must understand the steps involved in the computations and realistically judge the validity of the computer analysis before drawing concrete conclusions.

USE OF EXTERIOR CALCULUS IN FIELD EQUATIONS

L. P. Perera

In working with field equations it is necessary to deal with quantities which have a large number of components such as tensors. Although they can be worked with coordinate dependent components in some cases generally it is a tedious process.

Using exterior calculus and concepts in modern differential geometry they can be expressed in an elegent form and can be worked with more conveniently.
Differential geometry and use of exterior calculus in field equations were studied and used in solving some problems.

AN ESTIMATOR FOR THE FUNCTIONAL $\int F^2(x)dH[F(x)]$

P.S.S. Thewarapperuma

The density functional $I = \int F^2(x)dH[F(x)]$ plays an important role in nonparametric statistics. For 'smooth' H, various estimators have been proposed by many authors. They also have shown the consistency and the asymptotic normality of these estimators under mild conditions on the function H and density F.

When H^1 is not bounded, for example $H^1(x) = \frac{1}{x(1-x)}$ XE [0,1], we have proposed an estimator for I. Using one sample model a kernel type estimator was used (for unknown f) for this purpose. Presently we are considering possible extensions of these results for the case of the general linear model $Y = x^1B + e$.

TABLE OF RESEARCH PROGRAMMES

RESEARCH PROGRAMME 1988

DIVISION : Life Sciences

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTIONS INVOLVED
Biological Nitrogen Fixation	Prof. S. A. Kulasooriya	Resource Centre for N_2 fixing Micro Organisms	Prof. S. A. Kulasooriya Ms. I.M. Samarakoon	IFS & Univ. of Peradeniya IFS
		Associative N_2 fixation in rice	Prof. S.A. Kulasooriya Ms. M. Gunatilaka Ms. Y. Abhayawardhene	IFS & Univ. of Peradeniya IFS IFS
		Distribution of N_2 fixing	Prof. S.A. Kulasooriya Mr. S. Padmasiri	IFS & Univ.of Peradeniya IFS
		Improvement of N_2 fixation in grain legumes	Prof. S.A. Kulasooriya Mr. P. Thirukkumaran	IFS & Univ. of Peradeniya IFS
Ecology & Conservation	Prof. S. Balasubramaniam	Tree mortality in a montane Forest	Prof. S. Balasubramaniam Ms. S. Ratnayake	Univ. of Peradeniya & IFS IFS
		Rehabilitation of degraded lands in the Midcountry	Prof. S. Balasubramaniam Prof. I. Balasooriya Prof. D. Parkinson	Univ. of Peradeniya & IFS IFS Univ. of Calgary

DIVISION : Life Sciences

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTIONS INVOLVED
Biotechnology	Prof. A. Kovoor	Tissue Culture for improvement and propagation of selected plants	Prof. A. Kovoor Ms. S. Karunaratne Ms. M.C. Gunasekara	IFS/CISIR CRI IFS
Atherosclerosis	Dr. S. Mendis	Effect of coconut oil in Serum Lipid Profile of Sri Lankans	Dr. S. Mendis Prof. R.W. Wirslet Mr. V.R. Kumarasundaran	IFS & Univ. of Peradeniya Univ. of Chicago IFS
Primate Studies	Dr. W.P.J. Dittus	Primate Socio-demography and ecology	Dr. W.P.J. Dittus	IFS
		Primate population genetics	Dr. W.P.J. Dittus Dr. D. Melnick	IFS Univ. of Columbia
		Primate parasitism	Dr. W.P.J. Dittus Dr. Priyanthi Amarasinghe	IFS Univ. of Peradeniya
		Primate immunology	Dr. W.P.J. Dittus Dr. J.S.M. Peiris	IFS Univ. of Peradeniya

RESEARCH PROGRAMMES FOR 1988

DIVISION : Earth and Space Sciences

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTIONS INVOLVED
Soil Toxicity	Dr. F. Ponnamperuma	Iron Toxicity in Paddy Soils	Dr. F. Ponnamperuma Mr. P. Deturck Mr. R. Mulleriyawa Ms. D.A.B.N. Amarasekara	IFS Univ. of Leuven Belgium IFS
Environmental Geochemistry and Health	Prof. C. B. Dissanayake	Incidence of Goitre, dental carries, cancer and its relation to geochemistry	Prof. C.B. Dissanayake Dr. F. Ponnamperuma Dr. R. Weerasooriya	IFS & Univ. of Peradeni IFS IFS
Economic Geology	Prof. C.B. Dissanayake	Exploration for Gem Stones	Prof. C.B. Dissanayake Dr. M. Rupasinghe	IFS & Univ. of Peradeni IFS
Economic Geology	Prof. K. Dahanayake	Utilization of Eppawala Phosphate	Prof. K. Dahanayake Dr. N. Fernando Prof. K.Tennakone Mr. N.D.Subasinghe	IFS & Univ. of Peradeni Univ. of Peradeni IFS IFS

DIVISION : Physical & Chemical Sciences

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTIO INVOLVED
Solar Energy	Prof. K. Tennakone	Electrochemical photo Conduction Properties of Materials	Prof. K. Tennakone Ms. S. Punchi-hewa Mr. S. Wickra-manayake	IFS IFS IFS
		Photochemical Fixation of N_2	Prof. K. Tenn-akone Dr. O.A. Ile-peruma Ms. S. Punchi-hewa	IFS IFS & Univ. of Peradeni IFS
Solid State Physics (Supercon-ductivity)	Dr. M.A.K.L Dissanayake Pro. K.Tenn-akone	High Tempera-ture super-conductors	Dr. M.A.K.L. Dissanayake Prof. K. Tenn-akone Dr. O.A. Ile-peruma Mr. S. Wickra-manayake	IFS & Univ.of Peradeniya IFS IFS & Univ. of Peradeniya IFS
Natural Products Chemistry	Prof. A.A.L. Gunatilaka	Isolation of Biologically Active Constituents from Herbs of Sri Lanka	Prof. A.A.L. Gunatilaka Dr.W.R. Wima-lasiri	IFS & Univ. of Peradeniya IFS

RESEARCH PROGRAMMES FOR 1988

DIVISION : Philosophy and Social Sciences

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTION INVOLVED
Archaeology	Prof. S. Bandaranayake	Settlement Archaeology and Space Archaeology	Prof. S. Bandaranayake Ms. C. Rambukwella	IFS & PGIA IFS
		Environmental Archaeology	Prof. S. Bandaranayake Dr. S. Seneviratne Dr. S. Epitawatte Prof. K. Dahanayake Dr. S. Deraniyagala Dr. M. Prickett Mr. A. Manatunga	IFS/PGIAR Peradeniya PGIAR SJP/PGIAR Peradeniya IFS Archaeolog Dept/PGIAR Peabody Museum, Harvard/PG
Mahaweli Studies	Prof. C.M. Madduma Bandara	1. Hydrological Studies in the Upper Mahaweli catchment area. 2. Analysis of the potential for debris flow hazards in the Kotmale water shed area.	Prof. C.M. Madduma Bandara Mr. T. Kuruppuarachchi	IFS & Univ. of Peradeniya IFS
Philosophy	Prof. Padmasiri de Silva	1. Suicide 2. Emotion Studies	Prof. P. de Silva Prof. J. Maresek Mr. L.C. Weerakkody	IFS & Univ. of Peradeniya Swathmore College U. IFS

RESEARCH PROGRAMMES FOR 1988

DIVISION : Mathematics

PROGRAMME	COORDINATOR	PROJECT	SCIENTISTS	INSTITUTIONS INVOLVED
Pure Mathematics	Dr. P.S.S. Thewarapperuma	Dynamical systems Mathematical modelling,Chaos		IFS IFS

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