

Bose Research Institute

ANNUAL REPORT

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Report of the Bose Research Institute for 1949-50

Governing Body—Two meetings of the Governing Body of the Bose Institute were held in which the Audited Accounts of the Governing Body, Bose Institute for 1948-49 and the Budget Estimates for 1949-50 were passed. The Governing Body received a donation of Rs. 50,000/- from the Trustees of the Sir J. C. Bose Trust Fund No. I, for furtherance of the objects of the Institute. The sum was earmarked for the erection of a laboratory above the lecture hall of the Institute, for providing additional accommodation for research work.

Council—Two meetings were held of the Council during the year. The principal items considered were (i) sanctioning the Budget Estimates for 1949-50, (ii) adopting the annual report for 1948-49, and (iii) passing the audited accounts for 1948-49.

Meetings of the Finance Committee and of the Building Committee were also held during the year. The Building Committee met several times to recommend to the Governing Body the name of a suitable Consulting Engineer to scrutinize the plans and estimates for the construction of the proposed structure prepared by the latter and to forward them to the Governing Body with their recommendations.

Government Grant—During the year under review the Institute received the following grants from the Central Government :

(i) Recurring Grant	...	Rs. 96,250/-
(ii) Special Grant for reorganisation	...	Rs. 25,000/-
(iii) Non-recurring grant for equipment of laboratory and workshop	...	Rs. 96,250/-
(iv) Special non-recurring grant for the implementation of the recommendations of the Scientific Manpower Committee	...	Rs. 30,000/-
Total		Rs. 2,47,500/-

The receipt of the special grant for organisation has enabled the Council to sanction increases in the pay of the Research, Administrative and Subordinate staff members of the Institute. In a large number of cases the emoluments received is considerably lower than those received by workers of similar status employed in other Institutes of all-India standing. In the

absence of any implementation of the scale of pay recommended by the Vallarta Committee, no regular scale of pay could be introduced so far, and the increments paid in any year, have to be deferred until the total recurring grant sanctioned by the Central Government is known.

Rs. 60,000/- from the non-recurring grant (iii) has been utilized for the purchase of some urgently needed workshop appliances and laboratory instruments and equipments. The facility offered to Research Institutes by the Ministry of Education for the purchase of articles from the Disposals at ten per cent of listed price, has enabled the Institute to purchase a fair amount of American goods which cannot be now obtained from the U.S.A.

Rs. 36,250/- from (ii), and the whole of Rs. 30,000/- in (iv) have been earmarked for the completion of the erection of the laboratory extension, and for its equipment.

Building Construction—Plans for the new laboratory extension were prepared by the Consulting Engineer Sri S. Ghosh and sanctioned by Calcutta Corporation by the end of June. Due to difficulty in procuring the necessary building materials work of construction could not be commenced before January 1950; it was further delayed due to communal disturbances. It is expected that the outer structure will be completed by the end of May 1950. A large amount of material necessary for the completion of the laboratory building and for its equipment has been stocked.

The staff accommodation in Falta Experiment Station is being increased by building a set of rooms on the top of the existing one-storied laboratory building. It is expected that the rooms will be ready for occupation during the middle of 1950. These rooms will provide accommodation for additional staff which will be recruited under a grant received from the Oil Seeds Committee.

Extension of agricultural research is being handicapped for want of suitable agricultural land in the locality of Falta. Several proposals for leasing of suitable land within Falta area or in the outskirts of Calcutta have been explored, none of them have so far materialised.

Acharya Jagadish Chandra Memorial Lecture—The eleventh lecture of the series entitled 'Wheat Rust in India—A National Problem' was delivered by Dr. K. C. Mehta, D.Sc. (Cantab.), Principal, Agra College on the 30th of November 1949, under the presidency of H.E. the Governor of West Bengal, Dr. K. N. Katju. In his annual report presented before the meeting the Director reviewed the progress of the work in the Institute during the previous year. A monograph was published early this year entitled 'J. C. Bose's Plant Physiological Investigations in relation to modern Biological Knowledge.' In the last chapter of this monograph the claim of J. C. Bose as precursor of the new discipline of cybernetics has been discussed.

Other Lectures—Several of the distinguished foreign delegates to the Poona session of the Indian Science Congress visited the Bose Institute,

including Prof. Sir Robert and Lady Robinson, Prof. Joliot Curie and Madame Irene Joliot Curie. Prof. J. D. Bernal, F.R.S. from England, Prof. Engelhardt from Russia and Prof. Herman Mark from the U.S.A. delivered several lectures in the hall of the Institute. Several anniversary meetings, memorial lectures, and a symposium, convened under the auspices of learned societies, were held in the hall of the Institute.

Staff—Sri A. K. Ghosh M.Sc. has been confirmed in his post as Registrar and Sri P. C. Chakraborty as Librarian of the Bose Institute. Sri S. R. Das M.Sc. and Dr. B. K. Kar have resigned their posts as Research Fellows, on their appointment as Radiologist, Anthropological Department, Government of India and as Plant Physiologist, Jute Agricultural Research Institute, Hooghly. Dr. H. K. Acharya D.Sc. and Dr. Amitabha Sen Ph.D. officiated as Research Fellows during last year. Both of them have subsequently secured good posts elsewhere. The two vacant Research Fellowships were advertised; permanent appointments have been made, which will take effect from 1st April 1950.

Sri Amar Mohan Naha M.Sc., Sir J. C. Bose Research Fellow of the Calcutta University attached to the Bose Institute, has been appointed Physicist, Forest Research Institute, Dehra Dun. Sri Ramprasad Chatterjee M.Sc., Sri T. C. Bhadra M.Sc. and Sri S. P. Sen M.Sc. were appointed Sir J. C. Bose Research Scholars in Chemistry, Physics and Microbiology respectively. Sri Kantilal Chowdhury M.Sc. has been appointed Botanist under the Oil Seeds Scheme and Sri R. K. Basu M.Sc. has been appointed Cytologist in the Jute Research Scheme in the place of Sri Kantilal Chowdhury resigned.

Dr. S. D. Chatterjee, Senior Research Fellow of the National Institute of Sciences (India) proceeded to Ottawa during October 1949 under a National Research Fellowship award from Canada. Dr. Chatterjee met with an unfortunate accident in Ottawa from which he is recovering slowly. Dr. M. S. Sinha, Senior Research Assistant, has been accepted as guest research worker in M.I.T. to work in the Prof. B. Rossi's Cosmic Ray Laboratory of the M.I.T. Sri P. K. Sen Chowdhury M.Sc. has been appointed an I.C.I. Research Fellow of the National Institute of Sciences of India and is attached to the Bose Institute. Sri Sen Chowdhury has been awarded the D. Phil. degree of the Calcutta University.

Grant-in-aid Schemes—The Indian Central Oilseeds Committee have sanctioned a grant of Rs. 60,000/- for a period of three years for an investigation 'On the effect of X-ray irradiation on Brassica and Sesamum'.

The scheme of investigation on 'Desulphurisation of Coal' which was being financed by the C.S.I.R. will be terminated with effect from the 30th April 1950. It is understood that work on this scheme will be continued in the Fuel Research Institute at Digwadih. The other grant-in-aid schemes are being continued.

RESEARCH ACTIVITIES

A. 1. PHYSICS

Cosmic Rays — An air-conditioned room with a light top has been installed on the roof of the main building of the Institute; the temperature of the room is kept close to 80°F. summer and winter; the humidity of the room will also be kept constant. The room is specially suited for continuous record of cosmic ray intensity by means of the pressure ionisation chamber described in the previous reports. The continuously recording counter controlled Wilson chamber will be removed into this room.

A small pressure ionisation chamber for recording of cosmic ray bursts has been installed in this room. Difficulty has been encountered in adjusting the recording string galvanometer to the required range of sensitivity suitable for recording both small and large bursts.

A counter telescope system has been installed in a small hut in the Institute gardens for investigation of secondary radiations produced under cosmic ray absorption in different thicknesses of lead. This apparatus after suitable arrangement may be utilized for continuous measurement of cosmic ray intensity. Due to large variation in temperature inside the hut, the sensitivity of the counter telescope arrangement alters, so that work has to be stopped during the midday period. It is proposed to instal counter telescope in the air-conditioned room for continuous record of cosmic ray intensity.

Pressure ionisation chamber — Continuous recording with this apparatus suffered interruption due to building construction being carried out in the adjoining portion of the Institute building. During certain periods of the year during November 1949 and March 1950, when there were reports of large increase in cosmic ray intensity or of large magnetic storms, of which records could not be taken. Continuous records made during the period, February 14 to March 3, 1950, showed evidence of increase of cosmic ray intensity on February 20 and 22, followed, after a period of about 20 hours, by a large magnetic storm of sudden commencement type and a corresponding depression of cosmic ray intensity. This coincided with the movement of a large group of sunspots which was brought into view by the sun's rotation on February 14, and which passed out of sight on February 27. In the northern latitude of 11°N, the centre of the complex group crossed the central meridian on Feb. 26. 2UST. It was expected during this passage of sunspots will be accompanied by large geomagnetic and ionospheric disturbances. Our observations are in agreement with this prediction.

Another sudden increase in cosmic ray intensity was noticed on February 28, which was not accompanied by the usual concomitants of solar flare, viz., radiofade out, delayed magnetic storm accompanied by diminution of cosmic ray intensity. Isolated cases of such increase have been observed in Germany by Ehmert, in the U.S.A. by Forbush, and in Canada by Rose.

Whether they are of solar origin or produced in the galactic region remains to be established.

Counter telescope measurements — The secondary radiations produced in different thicknesses of lead absorbers was investigated by an arrangement similar to that employed by Clay. A second maximum in Rossi's curve under about 17cm. of lead was established in confirmation of Clay's finding. The existence of a third maximum under 23cm. of lead as obtained by other investigator could not be confirmed. The experiment is being repeated several times to determine the mean error of observation. The importance of the result lies in the fact that the same investigator had observed an anomalous absorption τ -rays from RaC under a similar thickness of lead.

During a series of counts taken on February 28, with the counter electroscope under 10 cm. of lead, a sudden increase of count frequency of about 100 per cent, was observed between 1-2 p.m., i.e., about an hour and half before a 8 per cent rise in intensity of ionisation was observed with the unshielded pressure ionisation chamber. Clay had also found that on certain dates in which an increase in cosmic ray intensity was recorded there was about an hour's difference between the times of increase in ionisation current in a pressure ionisation vessel shielded under 110 cm. and in an unshielded vessel. Clay interprets the result as due to the more penetrating radiation which affected the shielded chamber consisted of particles which travelled faster than the particles which affected the unshielded chamber.

Wilson Chamber — Rossi and other investigators using a Wilson Chamber arrangement have found that close nuclear interaction with penetrating particles, not only lead to multiple production of penetrating particles of the nature of protons and mesons, but as well to a simultaneous production of electron showers. This mechanism of mixed shower production is being studied here also. A fourfold coincidence counter system, with two counters above and two counters below is used to trigger the expansion of a Wilson Chamber, above which different thicknesses of lead are placed. The counters are so arranged that only showers produced in the lead shield above will trigger the expansion. Inside the chamber are put three lead plates of total thickness 4 cm., which serve to distinguish the nature of the particles constituting the showers.

Already photographs have been taken with 5 cm. and 10 cm. of lead above the chamber, and the photographs are being analysed. One unusual photograph of meson shower initiated by a π -meson was published last year. Recently an explosive shower of a mixed type generated in one of the plates inside the chamber has been obtained; this consists of two cones of particles one going upwards and the other downwards. The upper cone contains probably soft particles only, while the lower one consists of both soft and penetrating particles.

Delayed coincidence circuit — Delaying circuits for the control of Wilson

Chamber expansion are being studied. At present a circuit has been constructed based upon the specifications of Montgomery and Montgomery. A constant frequency oscillator circuit of frequency 1 mc and controlled by a quartz oscillator is being assembled. Using a double beam cathode ray oscilloscope, the delay time will be directly measured by comparison with the crystal controlled frequency. For this purpose a more precise multivibrator circuit than the present one is required. The work is being held up due to the delay in obtaining some of the valves and oscilloscopes from the Disposals.

Photographic Emulsion—Different brands of nuclear sensitive plates manufactured by Ilford and Kodak are being used. Kodak NT4 electron sensitive plates have been tried; such plates due to its sensitivity to β -radiations must be utilized immediately after their manufacture, otherwise they acquire a background of tracks due to absorption of β and γ -rays from radioactive contaminants. From a batch of such plates imported from England half were sent to Sundakphu and brought back after several months; they were found after development to be so blackened that cosmic ray tracks could not be clearly distinguished. Some plates kept in a refrigerator in Calcutta, and developed within a month after arrival were found to contain tracks of lengths up to $3000\ \mu$, which show certain amount of scattering. For purpose of measurements such tracks require to be magnified 1500 to 2000 times. Tracks due to α -particle protons etc. can be successfully photographed at such magnification, but not the long tracks, due presumably to fast mesons. Attempt is being made to enlarge such tracks in two stages, for which a point source light (Phillips 6 watts 4.5A) have been found to be suitable. Other types of plates, Ilford C₂, Kodak NTA loaded with lead salts as well as controls were sent to Sundakphu (12000 ft.) and kept there for four months. It was found that

(i) the number of nuclear disintegration were larger in loaded plates, than in controls.

(ii) in a lead loaded C₂ plate three ionizing tracks appear which when produced backwards meet at a point a few microns above emulsion in the air and represents a primary disintegration in air. Each of these secondary particles had produced further heavy nuclear disintegration, whose tracks were propagated in cones each originating from a secondary particle.

(iii) in a NTA plate, a number of instances have been observed of disintegration of a nucleus in air just above the emulsion surface; and the emitted particles are contained in a cone directed downward. If a similar cone of particles were emitted upwards away from the emulsion the case would be similar to what has been observed in a Wilson Chamber photograph, discussed previously. The difference being that the photographic emulsion only records mesons and other heavy particles,

(iv) in one instance the disintegration or nuclear evaporation has its origin inside the emulsion. The number of particles emitted was so large that the central region was almost black and it was not possible to count the total number of particles ejected, which included protons and mesons.

(v) many instances of four pronged stars were observed, each of the track being due to an α -particle. It probably represents the disintegration of a O¹⁶ nucleus, as previously reported by Powall.

2. NUCLEAR PHYSICS

Separation of transuranic elements from Pitchblende—Pitchblende from Canada was found to contain about 21.04% of U₃O₈. Last year a preliminary attempt was made to precipitate transuranic element as a fluoride along with LaF₃. The amount obtained was so small as to be not measurable with an α -ray electroscope. This year separation of Pu 239 from 250 gms. of pitchblende was carried out. The precipitate was found to produce a measurable ionisation with an α -ray electroscope. Subsequently the number of α -particles emitted from the precipitate was determined by means of an α -particle counter; 14 counts per hour over the background count was obtained. Assuming the α -particle emitter to be Pu²³⁹ with half life of 24,000 years, the concentration of the latter in pitchblende was found to be 1 part in 3.14×10^{13} , while Seaborg found with his specimen of pitchblende a concentration of 1 part in 10^{14} . The precipitate of Pu F₃ was converted into a soluble salt and nuclear emulsion plates have been impregnated with the solution; it will be developed in a few months time, when from a measurement of their ranges it will be known whether the α -particle emitting atoms in the precipitate were only Pu²³⁹ or there was an admixture of other radioactive elements.

Spectroscopically pure U₃O₈ and Carbon—The possibility of obtaining spectroscopically pure U₃O₈ from commercial Na₂UO₄ and carbon from sugar is being investigated. The purified specimen of U₃O₈ has been sent for spectroscopic examination.

A solution of Thorium nitrate which has been freed from Uranium is being irradiated with a 160 mc Ra Be source of neutrons, to find out whether evidence of the production of U²³³ according to the reaction $\text{Th}^{232} + n_0 \rightarrow \text{Th}^{233} \rightarrow 91^{233} + \beta \rightarrow 92\text{U}^{233} + \beta$ is detectable. Previously an attempt was made to find out whether Uranium separated from Monazite contained a detectable amount of U²³³, using Wilson Chamber method of measuring the length of α -particle tracks emitted from a source of Uranium so isolated; the result was inconclusive.

Study of Nuclear Fission—Photographic Emulsion Method—Different types of Ilford Nuclear Emulsion plates C₂, E, D, etc. were impregnated with

different concentrations of uranium salts and exposed to slow neutrons. Besides bipartition, tripartition of U nucleus are usually observed, in which the third particle emitted has a long track and has a mass approximating to that of α -particle. The two heavy fragments in such instances are emitted more or less along the same straight line, in opposite directions. A particular plate was dipped in a solution of uranyl nitrate (> 10 per cent); such a treatment makes the emulsion insensitive to α -particles. In this plate a tripartition of U nucleus was observed, in which the ranges of the heavy fragments was large compared to those observed in normal types of tripartition. The angles between the three emitted particles were all between 150° - 90° and the light particle had a mass greater than 4. The total ionisation energy of the three emitted particles was found to be much greater than that of the energy of fission of a U^{235} nucleus under slow neutron absorption; it is surmised that the above fission was due to the absorption by the U nucleus of a high energy neutron. Attempt is being made by method of trial and error to estimate the mass and energy of the three emitted particles, as well as the energy and direction of motion of the incident neutron.

Low pressure Wilson Chamber—This mechanically operated chamber whose expansions are controlled by a clock-work mechanism is now working at a pressure of 20 cm. Hg. In the middle of the chamber is attached a thin mica foil with a fine deposit of U_3O_8 ; it is irradiated with slow neutrons from a Ra-Be (160 mc) source. The apparatus is filled with H_2 which at this pressure reduces the tracks due to α -particles to a minimum.

Slow neutrons absorption cross section—A new method has been developed for determination of slow neutron absorption cross section for various materials. In the usual methods for this determination a direct or indirect knowledge of scattering cross section is necessary. In the present arrangement the effect of scattering has been entirely eliminated by using a spherically symmetrical disposition of the neutron absorbing layer.

The apparatus consists of two concentric spheres, the inner sphere has at its centre a Ra-Be source of neutrons embedded in paraffin. The hollow space between the concentric spheres contains the material whose cross section is to be determined.

The detector of slow neutrons is a G. M. counter with silver anode; corrections were made for counting loss and radioactive decay in silver.

Absorption cross section of uranium oxide has already been determined with this apparatus, by determining the neutron intensity-distance curve, with and without uranium oxide in the hollow space between the spheres. In both the cases the neutron intensity was found to obey the inverse square law. From these curves the absorption cross section of uranium oxide for slow neutrons has been determined.

To increase the efficiency of the apparatus, attempt is being made to use scintillation counters for neutron counting, using a RCA 931 photomultiplier

tube in conjunction with a boron loaded phosphor. Construction and testing of the necessary electronic circuits are in progress.

3. *High frequency Positive Ray Discharge tube*—The apparatus consists of two parts (i) a pyrex glass tube through which Hydrogen at low pressure is circulating. An electrodeless discharge is maintained across the tube by means of a high frequency electric oscillations of 40 Mc/s frequency. By means of an axial longitudinal magnetic field the efficiency of yield of atom ions is increased. The ion beam so produced is accelerated by a steady voltage V_1 between two electrodes, the positive electrode being fused in a side tube attached to the main pyrex tube and through which hydrogen at low pressure is circulated. The other electrode is an aluminium block on which the flat of the pyrex tube is sealed. (ii) A hole bored in the axis of the aluminium block introduces the accelerated ion beam into the discharge space, where by means of a special cylindrical hollow electrode the beam is accelerated through a voltage V_2 and strikes a screen at the other end of the discharge tube. Through a side tube connection is made to evacuate the system by means of diffusion pumps etc. The aim of the investigation is to obtain a maximum atom ion current for a given flow of Hydrogen gas and to focus it on the receiving target. For purpose of discharge current measurement the latter is connected to earth through a galvanometer. By means of an arrangement, a fluorescent screen can be placed in front of the collecting plate, which enables one to judge the sharpness of focussing of the beam.

The current input in the h.f. circuit was increased from $10\mu A$ using a single 826 valve oscillating circuit, to $20\mu A$ with a push pull circuit of two 826 valves. Further when the exit canal aperture was increased from 1.5 to 3 mm. diameter, the ion current increased to $75\mu A$. The amount of power dissipated in the discharged tube was estimated to be 25 watts at 10 micron pressure, increasing to 30 watts at 30-40 micron pressure. At a higher pressure the discharge stopped. Evidently more powerful h.f. tubes are required. By adjusting the rate of leak of the gas an optimum condition was reached, when the path of the beam is marked by a luminous glow. With a ratio of $1/12$ for V_1/V_2 , the ions emerge as a narrow beam of 3 mm. diameter up to a distance of 20 cm. from the exit canal. At present attempt is being made to increase the power output of the h.f. discharge tube, as well as to increase the percentage of atom ions in the beam. For the first, more powerful h.f. tubes are necessary which have been ordered from the Disposals. For the second, some investigators have found that higher percentages of atom ions, up to 90% can be obtained by replacing the electrodeless oscillatory discharge by a magnetic excitation, where the h.f. current is made to circulate through a solenoid wound over the discharge tube.

4. *Ultrasonic investigations*—An efficient source of ultrasonic oscillation of 1 Mc per second can be maintained in a liquid medium, either in water

or preferably in oil a better insulator, by means of an 1 cm² quartz oscillating plate. At present investigations are being carried on (i) to measure the efficiency of generation of u.s. waves in the liquid. For this purpose it is necessary to measure the h.f. current flowing through the vibrating quartz plate, as well as the drop of h.f. voltage between the two electrodes on the quartz plate. The latter is measured by means of an attenuator. The latter consists of 7 condensers of which the first one on the high voltage side and in which the maximum drop of voltage takes place, is a parallel plate air micro-condenser of 2 μ F capacity; 6 condensers each of 100 μ F capacity are connected in series with the latter. The drop of voltage on the last condenser, one of whose terminal is earthed is measured by a calibrated valve voltmeter. The current flowing through the oscillating quartz is measured by a h.f. ammeter. From these measurements the R.F. power input to the transducer is measured. The energy dissipated in the ultrasonics oscillations in the liquid medium is measured by the rise of temperature of the liquid contained in a glass vessel. This is used as a calorimeter, and its heat capacity is measured by means of an immersion heater whose d.c. power input can be measured accurately.

(ii) A comparative study of the efficiency of the two liquids, water and transformer oil, showed that more ultrasonic power can be generated in the latter liquid, because of its better insulating property.

Practical applications—Preliminary studies have been made on the following topics (i) Bactericidal action of ultrasonic oscillation on different kinds of bacteria like *B. coli* and *Staph. aureus*. A glass tube one end of which is closed with a thin cellophane paper is filled with a dilute sterile culture of a given bacteria and is dipped in an oil bath in which u.s. oscillations are generated. The temperature of the liquid suspension is prevented from rising by circulating cold water through a glass spiral immersed in the liquid suspension. The results obtained are reported under Microbiology (D2.). (ii) Treatment of jute seeds immersed in water and subjected to u.s. radiation. The seeds were sown after irradiation, and the morphological changes in the plants are being studied. (iii) The roots of *Allium cepa* (onion) have been subjected to similar u.s. oscillations. The chromosome being comparatively large, chromosome breakages and other changes induced by such radiations can be studied conveniently under the microscope.

B. CHEMISTRY

1. *Chromatographic analysis and its application*—Investigations were undertaken on

(i) Preparation and standardisation of aluminium hydroxide for chromatographic purpose from locally available materials

(a) Aluminium oxide for the above purpose has been successfully prepared by combining 'Brockmann' and 'Dupont' methods.

(b) Of the six azodyes required for the standardisation of the Aluminium oxide, four were prepared in the laboratory and two purchased.

(ii) Chromatographic separation of irritability substance (IS) from aqueous extract of *Mimosa pudica*. Preliminary studies of chromatographic purification the Mimosa IS have been completed. Four distinct zones appear separated in a column of Brockmann alumina. Each zone was separately eluted with 2N Acetic acid. The last trace of the acid was removed under reduced pressure. The residue was taken up in water and tested for its physiological activity. Maximum activity was observed in the third zone from the top. Due to the lateness of the season when the physiological tests on *Mimosa* cuttings were tried, the plants were not in their most active conditions; a quantitative estimation of the activities of the extracts was not possible. This portion of the investigation will be taken up again during the next rains, when the *Mimosa* plants are in a vigorous condition.

(iii) *Partition chromatography on filter paper*—This recently introduced method by Consden, Gordon and Martin which promise to be of great applicability in the identification of minute quantities of plant products, like amino acids, alkaloids, simple sugars and their phosphorylation products, is being introduced in the Biochemical laboratory. The apparatus required for two dimensional analysis has been made in the workshop. A calibration curve has been prepared for fixing the position of 16 amino acids in a two dimensional filter paper analysis. Different combinations of solvents which give best separation are being tried taking into view their availability locally.

The mechanism of filter paper chromatography is being studied. R_F values of 16 amino acids with different concentrations of isopropyl alcohol and water have been investigated, and it is found that gradual increase of water content the R_F value increase and merge with that of pure water. The role of cellulose in filter paper chromatography has been investigated and a preliminary note on the subject has been published. Whether the application of an electric field will increase the chromatographic separation is being investigated.

Preliminary survey in the domain of alkaloids, isomeric compounds and amino acids is being undertaken.

2. *Organic Synthesis*—Synthesis of α - and β -Selenine—Further progress in the synthesis of these compounds have been achieved. Starting with Carvone, five of the seven steps necessary for the synthesis have been carried out, and the remaining two steps are under investigation.

Penicilline amine—The problem is being tackled in two different ways. Although no success can be claimed in achieving the main objective, a new

method has been worked out for adding benzyl mercaptan to the double bond.

3. *Applied Chemistry*—The herbicide 2, 4, D has been prepared by two different methods. The first method as reported previously consists in preparing 2,4 Dichloro phenol through the corresponding nitro and amino compounds and coupling the same with chloroacetic. The 2nd method consists in nuclear chlorination of phenoxy acetic acid with dichlorourea prepared in the laboratory.

At present attempts are being made to introduce fluorine in place of chlorine and to prepare 2, 4, D in large amounts with a view to incorporate it with activators and other substances, which are used commercially to enhance activity.

(i) Impregnation of bleached jute yarns with synthetic resins.

The object of the investigation is to restore wet strength of bleached jute yarns. Melamine formaldehyde resins prepared inside the fibre have given best result. Resins obtained from U.S.A. have been applied but the results are not equally satisfactory. Attempts are being made to correlate the results with various constituents of jute fibre.

(ii) Desulphurisation of coal.

Two methods—previously reported—have been developed; the sulphur content of Assam coal has been reduced by 87% and 92% by the ammonia process and sodium bicarbonate process respectively.

The scheme was financed by the C.S.I.R. and will be terminated with effect from 30th April 1950. It is understood that work on this scheme will be continued at the Fuel Research Institute, Digwadih.

C. 1. PLANT PHYSIOLOGY

The following papers have been submitted for publication in the *Transactions of the Bose Research Institute*:

(i) Utilisation of the freshly harvested potato tuber for cultivation purposes (as seed).

(ii) Periodicity of plant growth (with special reference to Cinchona).

The following investigations have been undertaken:

1. *Apical dominance of plants*—Different organs of a plant do not function independently but are interdependent on the activity of each other. When the apical bud of a plant grows vigorously the axillary and other lateral buds remain dormant; but as soon as the growth of the apical bud is inhibited by age, or the bud is cut off or injured, one of the lateral buds just below the apical bud resumes growth and finally takes the position of the apical bud and inhibits the growth of other lateral buds. This inhibition of growth of lateral buds by the apical bud is known as apical dominance.

Other factors such as, the food supply, the electrical pattern, or chemical regulators are also important. In recent years, the evidence in favour of some sort of chemical regulation has come to the forefront.

2. *Quantitative study of Photosynthesis in plants*—As a result of photosynthesis, plant leaf produces carbohydrate from carbon dioxide and water with the help of light energy. The usual method of studying photosynthesis consists of measurement of the volume of CO_2 consumed or the volume of O_2 liberated in the process. The weight of carbohydrate can be determined by the multiplication of the weight of either of the gases by their respective factors. Attempt is being made to determine directly the weight of carbohydrate produced by Bose's method of torsion balance. A sensitive torsion balance has been recently constructed with which a fraction of mg. in the order of .14 mg. can be detected. The experiment is being carried out with *Hydrilla verticillata*, a water plant. A small spring of hydrilla is suspended with silk thread from one arm of the torsion balance in a beaker of water with a sinker attached to the plant. On the other arm a small pan is suspended with a silk thread, and the weight of the plant in water is counterpoised with suitable weight placed on the pan. The position of the pointer which moves against the mirror scale is noted. Now the plant with the silk thread with it is placed in another beaker of water containing a definite quantity of CO_2 , covered with a glass funnel, a graduated eudiometer is placed over the stem of the funnel and placed in light for photosynthesis and collection of O_2 evolved in the eudiometer. After some time the volume of O_2 evolved is noted and the plant is again weighed in the balance; this time the shifting of the position of the lever in the scale gives the weight in mg. gained by the plant due to photosynthesis.

Various investigations on photosynthesis have been contemplated to be carried out with this method, one of which is the observation of quantitative difference in carbohydrate synthesis in CO_2 and Malic acid solutions. According to the calculation from the reaction given below, for equal volume of O_2 evolved, the weight increase with malic acid will be four times than that with CO_2 .

With CO_2 : $6\text{CO}_2 + 6\text{H}_2\text{O} = \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$; with malic acid: $6\text{C}_4\text{H}_6\text{O}_5 = 3\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{CO}_2 + 6\text{H}_2\text{O} = 4\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$.

At present control experiments are being carried out in order to study the conditions suitable for obtaining definite constant value of results.

3. *Observations on the growth of seedlings of Sinapis under continuous and intermittent illuminations of different frequencies*—The effect of application of light of a fixed amount either given in one exposure or intermittently, on the growth of the 4 day old seedlings of *Sinapis* germinated in the dark has been reported by Bunning *et al.*, using as source of light a 200 watt tungsten filament lamp at a distance of 1 foot from the seedlings. These investigators gave the seedlings a total exposure of duration 48

minutes, either continuously or of duration 2 minutes each separated by various dark intervals of 3, 13 and 28 minutes respectively. They found that the growth inhibiting effect of light was the more marked the greater the length of the intervening dark periods. It was explained that each light exposure of two minutes represented a stimulus to which the plant responded by retardation of growth. A refractory period followed, which depending on the duration of the dark period, absolute or relative. Application of further light stimuli during such periods of absolute or relatively refractory periods did not produce the same retarding effect as on a completely recovered seedling.

This experiment of Bunning *et al* was repeated in the Institute laboratory. The seedlings of *Sinapis* were grown in short glass tubes 1.25 cm. long and 0.8 cm. diameter, all sunk in holes made on the periphery of a wooden disc which fitted into a shallow galvanized iron trough with $1\frac{1}{2}$ inch rim and filled to $\frac{1}{2}$ " depth with tap water. The bottom of each glass was stopped with a porous plug of cotton wool which provided support for the germinating seedlings. A 200 watt tungsten lamp served as source of light at a distance of 25 cm. from the seedlings. By this arrangement it was provided that all the seedlings received approximately the same quantity of light.

For each experiment, 25 seedlings were used, and an equal number as control. Four groups of experiments were performed during both the warm and cold seasons. The growth of the plants for 48 hours after illumination was measured. The average growth during summer was about 3 cm. and during winter about 2 cm. There was no significant difference in the rates of growth in dark under continuous and intermittent illumination. The experiment is being repeated under altered conditions.

4. *Mechanism of transmission of excitation in M. pudica* — The investigations were continued from the previous year. The excitation is always found to be accompanied by a monophasic current of galvanometric negativity. Following are the results obtained by using a long period galvanometer :

(a) A small area of internodal portion of a branch of a plant of *Mimosa pudica* grown on soil was severely burnt by a flame. Galvanometric connections were made with the stem and the pulvinus on the basal portion of the branch. All the leaves dropped down due to shock. The leaves on the basal portion beyond the burnt place recovered from the shock after sometime. Thermal shock was then applied to the collapsed portion of the branch. Responsive movement with concomitant electric disturbance was the result of this shock.

(b) Constant application of iced water or chloroform to the intervening portion of a petiole and pulvinus or pulvinus and stem renders the motile

organ mechanically irresponsive. Still electrical response is obtained by stimulating any part of the plant.

(c) A certain length of hard wood was removed from the stem leaving the bark in tact and in another case the bark was peeled off the stem. In both of these cases excitatory impulse accompanied by electrical disturbance travelled along the stem.

(d) Ricea's experiments were conducted in a slightly modified manner. Stems of two different plants were connected together with a glass tube filled with water. In consequence of thermal shock, in some cases partial closure of leaflets beyond the water-gap was observed. But in each case electrical response of galvanometric negativity was obtained.

Stimulation gave similar results in leaf to leaf contact of separate plants or separate leaves connected with loosely spun cotton soaked in normal saline.

(e) Both electrical and mechanical response were obtained by introduction of staining agent or irritability substance mixed with staining agents to the cut ends of *Mimosa* plants. The colouring matter or stimulating substance is not bodily transported.

(f) Mechanical as well as electrical response is obtained by the introduction of pure distilled water to an incision made on the petiole, similar to those that are obtained by physical or chemical stimulation.

Even a drop of water applied to the petiole without any cut or scratch brings about responsive movement of the pulvinus as well as the monophasic electric response.

These investigations indicate that an act of stimulation can be of physical or chemical nature. A local electric disturbance is produced by the two modes of stimulation, which can travel as such from one living portion of a plant to another portion of the same or another plant between which there is only a physical connection. Such local excitation in the living protoplasm of the *Mimosa* plant is transmitted through the tissue by a series of local currents.

C. 2. PLANT BREEDING AND CYTOGENETICS

1. *Cotton Breeding investigations* — This is a scheme financed by the Government of West Bengal, for evolving long stapled disease resistant types of cotton suitable for cultivation in the deltaic areas of West Bengal and is in the fifth year of investigation, during the year under report.

The season was unfavourable for the growth of the cotton plants, due to the droughty conditions that prevailed during the earlier part of 1950. To overcome this, a few irrigations were given. This drought has resulted in a certain amount of boll shedding, lower yield, stunted growth and lateness in flowering.

During the year under report, 757 strains were being studied, comprising of 28 pure (parent) types, 4 wild types, the rest being reciprocal, cyclic and multiple crosses from the F 1 to F 7 generations. In addition, Sea Island Cotton is also being grown for the first time in the Experimental Station. In this connection it should be mentioned that this species gives a lint length of $2\frac{1}{2}$ inches in its original habitat, although the ginning percentage is rather low—25 to 28%. It was noticed that this species can thrive only under shady conditions. If this species can be successfully acclimatized, then it can be grown in other plantations under the shades of trees, where few other plants normally survive and will be of great benefit.

From the 757 strains, about 35 appear to be favourable, and it is proposed to carry forward mainly these strains during the next season. The following table (Table 1) gives the lint length, the ginning percentage, the number of days taken for flowering, of the parent types as against their hybrids, in the F 7, F 6, F 5 and F 4 generations in 25 types.

TABLE I

Serial No.	Name of types	No. of days reqd. for the first flush	Lint length in mm.	Ginning percentage
1.	CO4	104	33.0	35.7
2.	4F	114	33.8	36.0
3.	920	124	31.4	37.5
4.	LSS	109	33.0	36.0
5.	CO ₂	103	35.1	34.6
6.	7682	110	35.0	35.7
7.	7682 — 18B	79	34.4	35.7
8.	CO ₄ — B4O — 21	87	34.9	34.3
9.	CO ₃ — 41	88	34.8	37.0
10.	7682 — 21 × { CO ₄ × (SG × SI) × 4456 }	113	35.4	35.2
11.	7733D32e4 × (CO ₃ × CO ₄) × Rush. Ash. × SG. Ash.	111	35.5	34.9
12.	LSS — 4F (F ₇)	110	32.5	37.0
13.	920 — 4F (F ₇)	84	35.0	37.5
14.	920 — CO ₂ (F ₇)	79	33.0	35.1
15.	CO ₄ — LSS (F ₇)	76	34.0	35.8
16.	CO ₂ — 4F (F ₇)	64	34.8	37.5
17.	7625 — 1 — LSS (F ₆)	75	35.1	37.5
18.	7727G ₃ — 5286BVI	75	35.3	33.3

TABLE I (Contd.)

Serial No.	Name of types	No. of days reqd. for the first flush	Lint length in mm.	Ginning percentage
19.	CO ₂ — 4F (F ₅)	77	32.1	34.4
20.	(CO ₂ × 4463) — (CO ₄ — LSS) (M5)	75	32.1	32.1
21.	7733 — 8 — 7727G ₃ (F ₄)	63	35.0	33.3
22.	7733 — 8 — 5286BVI (F ₄)	64	32.0	31.6
23.	7733 — 8 — 289F ₁ (F ₄) 124	66	33.0	35.7
24.	7733 — 8 — 7625 — 1 (F ₄)	66	31.5	32.8
25.	6113F ₂ — LSS (F ₄)	62	35.3	31.5

Irradiation experiments were conducted on 12 pure (parent) types and 3 hybrids in the F 7 generation, which appeared to be promising. The exposures given were 4 m.a.H and 8 m.a.H in each of the parents and the hybrids. Unlike the previous year, the results of this season appear to be promising. The plants grown from the irradiated seeds were healthier, more vigorous and had a greater number of bolls than the controls. At the time of sending in this report, it has not been possible to analyse fully, the differences in the treatments and the control, but the following table (Table II) gives the lint length and ginning percentage in 9 control types (7 parents and 2 hybrids) and the plants grown from the seeds which had the lowest dose (4 m.a.H).

TABLE II

Type	No.	Name	Treat-ment	Lint length in mm.	Length Difference with control	Ginning Percentage	% of Difference with control
Parent :	1.	7682 — 14 — E ₂	control	35.3	—	36.7	—
	2.	7682	„	35.0	—	35.7	—
	3.	7682 — 18B	„	34.4	—	35.7	—
	4.	CO ₄ — B40 — 21	„	34.9	—	34.3	—

TABLE II (Contd.)

Type	No.	Name	Treat- ment	Lint length		Ginning Percentage	
				Length in mm.	Difference with control	% of Difference with control	
	5.	LSS	„	33.0	—	36.0	—
	6.	CO ₂	„	35.1	—	34.6	—
	7.	7733D32e4 _x (CO _{3x} CO ₄) x.R.A. × S.G.A.		35.5	—	34.9	—
F 7	1.	920.4F	„	35.0	—	37.5	—
	2.	CO ₂ .4F	„	34.8	—	37.5	—
Parent :	1.	7682 — 14 — 4. m.a.H. E ₂		35.2	— 0.1	40.0	+ 3.3
	2.	7682	„	35.0	+ 0	35.7	— 1.0
	3.	7682 — 18B	„	34.6	+ 0.2	38.5	+ 2.8
	4.	CO ₄ — B40 — 21	„	35.0	+ 0.1	40.6	+ 6.3
	5.	LSS	„	32.9	— 0.1	36.3	+ 0.3
	6.	CO ₂	„	34.9	— 0.2	42.4	+ 7.8
	7.	7733D32e4 _x (Co _{3x} CO ₄) x.R.A. × x.SG.A.	„	35.6	+ 0.1	36.4	+ 1.5
F 7	1.	920.4F	„	34.9	— 0.1	40.8	+ 3.3
	2.	CO ₂ .4F	„	35.1	+ 0.3	39.6	+ 2.1

It will be seen from the above table, that although there is not much difference in the lint lengths there are considerable differences in the ginning percentages. For example, CO₂ gives a ginning percentage of 7.8 greater than the control, and CO₄ — B40 — 21 gives a value 6.3 per cent higher. If these behave equally well in the X₂ generation, it is a great achievement.

Progenies of a fuzzless mutant from a cross between CO₂ and 4F obtained during the season 1946-47, were studied with regard to the grades of fuzziness. Two other fuzzless mutants, one in a cross between 920 and 4F and the other between 920 and L.S.S., have also been studied with regard to this character, in the offsprings. 44 plants were studied in each type and the following table (Table III) gives the results.

TABLE III

No. Type	Nature of seed coats.							
	Totally fuzzless No. of seeds	% age	$\frac{3}{4}$ of the seed coat fuzzless No. of seeds	% age	$\frac{1}{2}$ of the seed coat fuzzless No. of seeds	% age	Less than $\frac{1}{2}$ seed coat fuzzless No. of seeds	% age
1. CO ₂ — 4F (F ₆)	109	40.37	43	15.93	80	29.63	38	14.07
2. 920 — 4F (F ₆)	137	33.22	68	17.48	89	22.88	95	24.42
3. 920 — (L. S. S.) (F ₆)	85	38.99	46	21.1	53	24.31	34	15.60

It should be mentioned that all the seeds were linted, the differences in the gradations being in the quantity of fuzz hairs found on the seed coats. It is proposed to work out the factors involved, by suitable crossings.

2. *Jute-irradiation experiments* — This is a scheme financed by the Indian Central Jute Committee, for inducing mutations by irradiations and is in the 5th year of investigation, during the year under report.

During this year, the following species and varieties of Jute were irradiated for 26, 36, 42 and 48 m.a.H., which includes one very high dose, not attempted last year.

<i>Corchorus capsularis</i> var D.	154
„ „ D.	386
„ <i>olitorius</i> „ C.G.	
„ „ „ R.	26

(a) HEIGHTS AND BASAL DIAMETERS

The maximum heights and max. basal diameters attained by the individual plants in the various treatments and varieties are included in the following table :

TABLE IV

Variety	Max. Height	Max. Basal diameter
D154 → Control	13' 7"	1.0"
„ 28 m.a.H.	13' 6"	1.1"
„ 36 „	13' 9"	1.0"
„ 42 „	14' 9"	1.1"
„ 48 „	14' 5"	1.3"

TABLE IV (Contd.)

Variety	Max. Height	Max. Basal diameter
D386—Control	13'	1.1"
„ 28 m.a.H.	13' 7"	1.3"
„ 36 „	14' 5"	1.2"
„ 42 „	14' 8"	1.3"
„ 48 „	13' 5"	1.3"
C. G.—Control	17' 8"	1.2"
„ 28 m.a.H.	19' 0"	1.3"
„ 36 „	17' 11"	1.1"
„ 42 „	17' 8"	1.2"
„ 48 „	17' 11"	1.2"
R26—Control	17' 5"	0.9"
„ 28 m.a.H.	18' 10"	1.2"
„ 36 „	18' 5"	1.2"
„ 42 „	17' 10"	1.3"
„ 48 „	19' 3"	1.3"
Tall Mutant	21' 10"	1.5"

It must be mentioned that the same plant does not always combine the maximum height and maximum basal diameter, except in the case of the progenies of the tall mutant (given at the end of the table). In general, it will be noticed that their heights and basal diameters are greater in the treatments than in the controls, the most marked difference being in R26. In C.G., there is not much increase, except in the lowest dose. But the tall mutant is strikingly different from the controls.

Table V gives the average heights and basal diameters of 40 plants from the control and treatments, selected at random, from 4 replications and under different soil conditions.

TABLE V

Average measurements of 40 plants from the 4 replications taken at random.

Variety and Treatment	Height	Basal diameter
D154—Control	9' 8.9"	0.66"
„ 28 m.a.H.	10' 10.6"	0.82"
„ 36 „	9' 5.8"	0.64"
„ 42 „	9' 11.3"	0.67"
„ 48 „	10' 1.9"	0.73"

TABLE V (Contd.)

Variety and Treatment	Height	Basal diameter
D386—Control	9' 5.6"	0.65"
„ 28 m.a.H.	11' 5.4"	0.89"
„ 36 „	12' 1.6"	0.83"
„ 42 „	11' 4.9"	0.84"
„ 48 „	10' 4.5"	0.79"
C.G.—Control	12' 10"	0.69"
„ 28 m.a.H.	13' 7.9"	0.84"
„ 36 „	14' 0.5"	0.8"
„ 42 „	14' 1.5"	0.9"
„ 48 „	12' 2"	0.7"
R26—Control	13' 1.5"	0.75"
„ 28 m.a.H.	14' 1.5"	0.86"
„ 36 „	12' 11"	0.75"
„ 42 „	13' 9.5"	0.8"
„ 48 „	15' 6"	0.9"
Tall mutant	17' 2"	0.9"

In general, the treated plants had greater heights and basal diameters. In D. 154, the lowest dose (28 m.a.H.); in D. 386, the 2nd dose (36 m.a.H.); in C.G., the 3rd dose (42 m.a.H.) and in R. 26, the final dose (48 m.a.H.), gave the best results. Here again, the progenies of the tall mutants were the best.

During the season under report, an attempt was made to compare the sizes of the pollen grains in the different varieties and treatments and Table VI gives the average lengths and breadths of 1,000 pollen grains, selected at random.

TABLE VI

Variety and Treatment	Average measurements of about 1,000 pollen grains	
	Length in μ	Breadth in μ
D154—Control	36.41	32.97
„ 28 m.a.H.	39.30	34.12
„ 36 „	40.10	36.57
„ 42 „	37.80	34.76
„ 48 „	39.51	35.45

TABLE VI (Contd.)

Variety and Treatment	Average measurements of about 1,000 pollen grains	
	Length in μ	Breadth in μ
D386—Control	32.22	29.12
„ 28 m.a.H.	27.50	25.71
„ 36 „	34.79	31.42
„ 42 „	36.33	33.48
„ 48 „	35.16	32.81
C.G.—Control	35.96	33.74
„ 28 m.a.H.	36.39	32.30
„ 36 „	38.71	36.12
„ 42 „	37.11	34.38
„ 48 „	37.0	34.49
R26—Control	37.48	32.84
„ 28 m.a.H.	40.37	34.65
„ 36 „	40.21	33.24
„ 42 „	46.45	37.38
„ 48 „	42.21	35.96
Tall mutant	42.58	37.13

In every variety and treatment, except in the 1st dose of D. 386, the readings are greater in the treatments than in the controls, and in R. 26, it increases with the increase in dosage to a certain extent, except in the highest dose (48 m.a.H.). The pollen grains of the tall mutant also gave a value far greater than the control.

It was also found desirable to find out if there was any relationship between the percentages of sterility or fertility in the pollen grains, with the dosage, in the different varieties, and Table VII gives the data.

TABLE VII

Variety and Treatment	Pollen Counts			Percentage	
	Total	Fertile	Sterile	Fertile	Sterile
D154—Control	1060	1038	22	97.925%	2.075%
„ 28 m.a.H.	991	932	59	94.047%	5.953%
„ 36 „	1191	1095	96	91.93%	8.07%
„ 42 „	2592	2383	209	91.94%	8.06%
„ 48 „	1714	1581	133	92.241%	7.759%

TABLE VII (Contd.)

Variety and Treatment	Pollen Counts			Percentage	
	Total	Fertile	Sterile	Fertile	Sterile
D386—Control	1059	1019	40	96.22%	3.78%
„ 28 m.a.H.	1292	1191	101	92.18%	7.82%
„ 36 „	1117	1053	64	94.27%	5.73%
„ 42 „	1179	1041	138	88.29%	11.71%
„ 48 „	1119	1036	83	92.47%	7.53%
C.G.—Control	812	790	22	97.291%	2.709%
„ 28 m.a.H.	1110	1024	86	92.253%	7.747%
„ 36 „	985	898	87	91.371%	8.629%
„ 42 „	933	883	50	94.64%	5.36%
„ 48 „	972	863	109	88.786%	11.214%
R26—Control	1052	1023	29	97.244%	2.756%
„ 28 m.a.H.	741	681	60	91.903%	8.097%
„ 36 „	1141	1035	106	90.70%	9.30%
„ 42 „	1284	1071	213	83.42%	16.588%
„ 48 „	1354	1146	208	84.63%	15.37%
Tall mutant	2446	2266	180	92.466%	7.534%

It will be noticed from the above table that in the controls of all the varieties, the percentage of sterility is the lowest,—between 2 and 4%. But in the treatments, it is much higher. In D. 154, the percentage of sterility is highest in the 2nd, in D. 386 in the 3rd, in C.G. in the final and in R. 26 in the 3rd treatments. The tall mutant gives a value much less than any of the treatments, but greater than the control. This may mean that the type is getting more and more stabilized.

The earliness noticed during the previous seasons, was not appreciable in R. 26, as shown in the following table (Table VIII) :

TABLE VIII

Variety & treatment	Date of Sowing	Date of flowering	Number of days taken for flowering
R26—Control	28.4.49	23.8.49	117 days
„ 28 m.a.H.	„	17.8.49	111 „
„ 36 „	„	17.8.49	111 „
„ 42 „	„	14.8.49	108 „
„ 48 „	„	10.8.49	104 „
R26—Control	28.4.49	23.8.49	117 „
Tall Mutant	„	26.8.49	120 „

But selections from the early types of R. 26 of the previous seasons, were sown without any further treatment, when it was observed that this character was being maintained, as shown in Table IX. This also shows that the results of X-radiation with regard to this character are not predictable, but selections could be made for this character, when once such types are obtained.

TABLE IX

Variety & Treatment	Date of Sowing	Date of flowering	Age of the plant at the time of flowering
R26—Control	30.4.49	14.8.49	106 days
„ Treatment—1 (4 hours)	„	8.7.49	69 „
„	„	6.7.49	67 „
„ Treatment—2 (6 hours)	„	6.7.49	67 „
„	„	2.7.49	62 „
„	„	7.7.49	68 „

During the year under report as in the previous year, the bifurcations are mainly seen in the variety C.G.

In this connection it is interesting to note that in this type (C.G.) the chief effect of X-radiation is to produce bifurcations, and not many of the other changes detailed earlier, unlike the other varieties under investigation.

OTHER MORPHOLOGICAL PECULIARITIES

In D. 154, two plants of the population, irradiated for 36 m.a.H. and 42 m.a.H. had irregular, deeply serrated leaves.

One plant of D. 154, which grew from a seed irradiated for 36 m.a.H., was dwarfish (maximum height being $3\frac{1}{2}$ ft.) with narrow, deeply serrated leaves.

The flowers of these have been fixed for cytological studies, to find out the nature of chromosome aberrations, which gave rise to the above morphological changes. These plants were also found to be highly sterile.

A few of these irradiated plants of R. 26 had pigmentation different from the controls; the flowers of some of these have also been fixed for cytological studies.

CYTOLOGICAL OBSERVATIONS

Cytological studies of the flower buds of selected plants grown from irradiated seeds and those showing morphological peculiarities were continued. The abnormalities noticed were :

(a) *Cytomixis* — This is a phenomenon in which either the whole or part of the chromatin of a cell pass into the next one. There have been several views regarding this and many cytologists contended that this is an artefact, brought about by the effects of fixation. That it is not so, is seen from the fact that this phenomenon is not usually met with in the controls, but generally in the irradiated plants and increases with increase in dosage. That means that X-radiation can also bring about this phenomenon. If this happens in the pollen mother cells (as seen in Jute), it may result in unequal numbers of chromosomes at the poles leading to different numbers of chromosomes in the pollen grains. If such pollen grains fertilize the ovum, the resultant plant may have different chromosome numbers. But generally such pollen grains lag behind in the divisional stages and may be lost.

(b) *Unequal numbers of chromosomes at the different poles* — This may be the result of cytomixis or failure of pairing or disjunction of the chromosomes at meiosis. The pollen grains developed from these will also behave as in the previous case.

(c) *Lagging bivalents and univalents at anaphase I & II* — This may be the result of failure of pairing or failure of congression and orientation at the metaphase plate.

(d) *Restitution nucleus* — Occurrence of such nuclei may be the result of the failure of the formation of the spindle, giving rise to pollen grains with different numbers of chromosomes.

(e) *Meiotic bridges* involving chromosomes or chromatids, due to inverted pairing.

In general, these irregularities increase with increase in dosage.

3. *Saline water experiments* — As in the previous year, the seeds of *Corchorus capsularis* — D. 154 and D. 386, and *C. olitorius* — C. G. and R. 26, were used in the experiments. These seeds were collected from the previous years treated plots, and were further treated, as per details given below.

Treatment I — The seeds of the above 4 varieties (from the same treatment of the previous season) were soaked in 5% common salt solution for 3 hours and sown in plots irrigated with saline water from the Ganges. A second irrigation with saline water was given on the 30th day after sowing.

Treatment II — The seeds were soaked in pond water for 3 hours and sown in the ground. The plots were irrigated with saline water from the Ganges on the 30th day.

Treatment III — Control

The germination percentage, the rates of growth and the final heights and basal diameters attained by the plants were recorded and the following is a short summary of the results :

In Treatment I, D. 154 and D. 386 had nearly 60% germination, out of which about 50% of the plants survived. The heights of the better plants were from 4 to 5 ft., against 9 to 10 ft. in the control. The flowering was delayed, but the seeds formed were healthy. In C. G. and R. 26, about 40% of the plants germinated, but only 10% of those survived after the second saline irrigation. These flowered very late and the seeds formed were scanty.

In treatment II, all the four types of jute gave good germination, (about 90%), but after irrigation with saline water, the mortality in *capsularis* was about 15%, while in *olitorius* it was about 40%. Many of the survivals of the latter type deteriorated rapidly, leaving only about 30% in the field. The fruit and seed formations in the *capsularis* were better than in the *olitorius*.

Thus it was observed that the *capsularis* types can stand salinity better than the *olitorius* types, confirming the results obtained during the previous season. It should also be mentioned that the surviving plants appeared to be slightly better than those of the previous season. It is therefore proposed to carry out the same experiment during the next season, with the seeds collected from this year's control and treatments.

4. *Paddy — manurial experiments* — The year under report was favourable to the growth of paddy. During this year, the effects of chemical fertilizer, compost and cowdung on the growth and yield of a variety of aman paddy — "Bhasamanik" were investigated, under field conditions, in 5 replications, and the results are given in the following table (Table X). The chemical fertilizer used, consisted of a mixture of $(\text{NH}_4)_2\text{SO}_4$, K_2SO_4 and superphosphate, each at the rate of 40 lbs. per acre.

TABLE X

Serial No.	Treatment	Yield per acre			Increase of yield			% of increase over the control
		Md.	Sr.	Ch.	Md.	Sr.	Ch.	
1	No manure (control)	36	23	3				
2	Fertilizer	38	15	7	1	32	4	+ 4.92
3	Compost	42	28	8	6	5	5	+ 11.56
4	Cowdung	40	17	9	3	34	6	+ 10.53
5	$\frac{1}{2}$ Compost + $\frac{1}{2}$ fertilizer	44	4	15	7	21	12	+ 20.54
6	$\frac{1}{2}$ Cowdung + $\frac{1}{2}$ fertilizer	37	30	6	1	7	3	+ 3.18

It will be noticed from the above Table that a mixture of $\frac{1}{2}$ compost and $\frac{1}{2}$ chemical fertilizer gave an increased yield of 20.54% over the control, while compost alone registered an increase of 11.56%.

The greatest vegetative activity was recorded in the mixed dose of cowdung and fertilizer, which incidentally gave the lowest increase in yield over the control. The plants in the plots manured with chemical fertilizer alone, were more vigorous in the early stages, but gave an increase of only 4.92% in the yield of grains. Treatment of cowdung alone gave good straw height while the yield of grains was 10.53% over the control.

5. *X-ray studies in Oil-seeds* — This is a scheme financed by the Indian Central Oil-seeds Committee for a period of 3 years in the first instance, at a cost of Rs. 60,000/-, to find out the effects of irradiation on Sesamum and Brassica and to see if any favourable mutations could be induced in them. This scheme was put into operation on the 1st January, 1950.

The first task was to collect the improved types of Sesamum and Brassica from the Agricultural Departments of the Indian Union and the different States. Practically every State Department of Agriculture, complied with our request and sent us their improved strains. 15 strains of Sesamum and 6 of Brassica have been received so far. Of the Sesamum types received, 8 gave good germination percentage and it is proposed to experiment with these types only, during the coming season. In each type, 2 exposures were given and they will be sown in the field in May, along with the controls, in replicated plots.

C. 3. PALAEOBOTANY

MICROFLORA FROM CAMBRIAN STRATA OF THE SALT RANGE ETC., AND ITS BEARING ON THE AGE OF THE SALINE SERIES, SALT RANGE, PUNJAB

The age of the Punjab Saline Series has created a vexed but interesting problem in Indian Geology. A strata of 1,500 ft. in thickness, is not in its normal Cambrian or pre-Cambrian position throughout and at places it overlies the Cambrian beds and manifests itself on or between rocks of post-Cambrian ages — Carboniferous to Tertiary. It is this complexity that has caused the raising of the age controversy of the Series; Gee and other geologists take the Series as an originally deposited sedimentary sequence of undisputed Cambrian (or possibly pre-Cambrian) origin; while Pascoe and others interpret the infra-Cambrian position of the Saline Series due to various earth movements specially the Himalayan phase of orogenesis to which the Series had been a mute subject. This latter view has been supported by the occurrence of Tertiary microflora, in different beds of the Series, recorded by the late Prof. B. Sahni and his collaborators at Lucknow. All geologists who have actually visited the Salt Range area are, however, against this view as the field evidence does not support it. When such was the position Dr. Gee and others suggested that micropalaeontological

being discarded in every case. The moisture content of these soils is reduced to a level of about 20% before plating and each lot is stored in tin cases for future reference. Altogether 196 samples are collected from 28 different places of which 145 are investigated during the period under review.

Differential culture media were used to facilitate isolation of the three groups of micro-organisms, *e.g.*, fungi, actinomycetes and bacteria. The isolates were grown in subculture, their antibiotic activities were tested and those showing positive inhibitory effects were screened out for a preliminary examination of their cultural and morphological characteristics. Of 540 isolated fungi, 139 were found to be capable of producing antibiotic substances. These are mostly species of *Penicillium* and *Aspergillus*. However 20 strains of Fungi Imperfecti were found mostly to produce inhibitory substances effective against *Staph. aureus*.

Comparing the zones of inhibition produced by filtrates of positive cultures, a selection was made to reject the less effective strains. The number of active cultures was thus reduced to 35 and a detailed study of their biochemical activities will now be taken up. Amongst the active cultures a strain of *Penicillium* (No. 136) was found to be effective equally against gram-positive and gram-negative bacteria. Here the zone of inhibition was 40 mm. (equivalent to 10 units of penicillin per ml.), against both test organisms which is maximum so far obtained.

206 actinomycetes strains were isolated from soils of which 30 could be successfully grown in culture media. Only 24 of these actinomycetes were pigment-producing and 16 of them possessed antibacterial properties both against gram-positive and gram-negative bacteria. The medium for the growth of actinomycetes contained glucose, tryptone, straw extract and salts. It was experienced, however, that these organisms grow well at a narrow limit of optimum temperature. Further studies on the growth of actinomycetes in culture media is progressing. Among 57 bacterial isolates only 20 possessed inhibitory properties against gram-positive bacteria (*Staph. aureus*) and not against gram-negative forms. The bacterial growth in meat ext.-peptone-glucose broth was excellent but difficulty was experienced in separating the bacterial cells from the culture media before assaying. The cultures examined for preliminary identification, are mostly found to be sporeformers. It is now planned to study the metabolism of these bacterial isolates by the alteration of the composition of the nutritive substances with a view to increasing their antibacterial activity.

2. Investigations have been undertaken in this laboratory to study the nitrogen metabolism in soil with special reference to nitrifying and nitrogen-fixing micro-organisms and their sensitivity towards soil antibiotics. A course of preliminary experiments were done to determine the nitrifying capacities of different soil samples of West Bengal. By the method of enrichment purified cultures of *Nitrobacter* and *Nitrosomonas* are obtained for detailed physiological studies. Six such strains are now continued in culture.

Nine strains of *Azotobacter* have been isolated from cultivated soil and studies on their growth and nitrogen-fixing capacities are now in progress.

Root-nodules from the following legume crops are collected from the districts of Burdwan, Hooghly and 24 Parganas.

1. Gram (*Cicer*)
2. Pigeon pea (*Cajanus*)
3. Lentil (*Lens*)
4. Soybean (*Glycine*)
5. Lucerne (*Medicago*)
6. Khesari (*Lathyrus*)
7. Horse bean (*Phaseolus*)
8. *Antka*

The bacteria were isolated from nodules by crushing in sterile water and plating in crystal violet (1 : 200,000) agar medium. The colonies developed were subcultured in mannitol agar and studies on the cultural characteristics are now in progress. There are 17 strains of *Rhizobium* so far isolated from nodules of leguminous plants.

2. EFFECT OF ULTRASONICS ON THE BACTERIAL CELL IN TAP WATER AND NUTRIENT BROTH

The biological effects of ultrasonics have been studied and it was reported that in sea water the transmitted waves caused death of small fishes and other marine life. The reduction of the microbial cell count in milk has been demonstrated in certain cases. Generally high frequency sound waves of 200,000 to 1,500,000 cycles per second have been shown to exert a destructive effect on bacteria and other organisms. *Spirogyra*, *Paramecium* and yeast were found to be killed by the application of supersonic radiation of the above frequency but small bacterial cells (cocci) remained unaffected at that frequency. It was also said that the presence of protein or other organic matter in the media through which the waves are transmitted definitely interfered with the action of sonic energy on micro-organisms.

A pyrex glass tubing (1" dia., 4" ht.) capped with cellophane paper at one end, sterilized in a hot air oven at 150°C for 2 hours and filled to one-third its height with the liquid medium. The tube is clamped and immersed in the oil bath just over the surface of the vibrating crystal. An arrangement has been made to keep down the temperature of the medium by introducing a glass spiral through which cold water was circulated.

(1) A preliminary experiment was at first, conducted to study the effect of ultrasonics on the bacterial number of tap water. The frequency applied

was 1,000 K.C.S. and 25 c.c. of tap water was treated for 25 minutes the results being taken at intervals of 5 minutes. The difference of temperature of the oil bath and the tap water inside the glass tube were recorded. It would be seen from Table I that the initial temperature of the tap water which was lower than that of the bath, went up gradually as exposure continued.

(2) An experiment was next done with the cooling device in operation and the above experiment was repeated. Samples of 0.1 c.c. quantities of tap water were taken and plated out with nutrient agar. Colonies were counted after incubating the plates at 37°C for 24 hours. It will be seen from Table II that the killing-effect of the high frequency waves was a gradual operation in which the number of organisms killed in unit time was rather greater at the beginning and less and less as the exposure period was increased.

(3) In another experiment *B. coli* cells were suspended in sterile broth from a freshly-grown culture and the exposure was given for 30 minutes, the results being recorded at intervals of 5 minutes as before. Here the death rate of the bacterial cells was more or less similar as in the previous case.

(4) This experiment was repeated with *Staph. aureus* as the test organism but the destructive effect of ultrasonic radiations in this case was not significant.

To study whether high frequency sound waves can be utilised for reducing the bacterial content of the small-pox vaccine, an experiment was conducted with calf lymph in glycerine. No distinct bactericidal action was noticed in this case which was probably due to the presence of high percentage of organic matter.

TABLE I

1000 K.C.S.		The effect of ultrasonics on the bacterial content of tap water.	
Time in mins.	Temp. of the oil bath	Temp. of the tap water	No. of viable cells per c.c.
0	30.0 C	28.0 C	460
5	30.9 „	32.0 „	100
10	31.4 „	34.1 „	85
15	32.0 „	34.7 „	90
20	32.7 „	35.0 „	90
25	33.0 „	35.2 „	80

TABLE II

65 Volts 15 amp. (Input power to the valve) R.F. 150 milliamp. (crystal) (Cooling spiral used)

The effect of ultrasonics on the bacterial content of tap water.

Time in mins.	Temp. of the oil bath	Temp. of the tap water	No. of viable cells per c.c.
0	29.5 C	28.0 C	472
5	30.9 „	29.0 „	99
10	31.0 „	31.0 „	61
15	32.0 „	31.5 „	60
20	33.0 „	31.5 „	14
30	33.5 „	32.0 „	13

E. ZOOLOGY

Polymorphism in Ants—Previously some investigations were carried out in this laboratory regarding polymorphism in some species of ants. Nutritional experiments are being started again for the elucidation of the problem of determination of different castes in aggressive red ants *Oecophylla smaragdina* Fabr. It has been observed that workers or the so called neuters are present in nests throughout the year. Males and queens appear in the nest only for a short period of time, i.e., from February to April. It has also been noticed that fertilised eggs of the queen give rise to neuters, and unfertilised eggs produce males only. Polymorphism, regarding external appendages like tallness or shortness and general contour of the body, is prevalent not only in workers above, but also in queens and perhaps in the males. Workers lay parthenogenetic eggs throughout the year and as a rule workers come out of them. During summer months nursing workers collect nectarine secretions from flower-buddings, mealy-bugs, aphids etc. and regurgitate them to some of the young larvae. Queens, though few in number, were obtained in artificial nest by supplying them with flower-buddings etc. Diet without these secretions brings forth normal workers. From these results it seems probable that polymorphism is dependent on the nutritional difference, i.e., quality or quantity of food administered. Chemical analysis show that these nectarine secretions are rich in vitamin B. This factor alone when present in the food has been proved to be incapable of producing anatomical and physiological changes resulting in production of true male and female. Probably this and other factors conjointly bring about the anatomical and physiological changes during the growth of larvae. No positive result has yet been obtained by administering synthetic vitamin B to the larvae. So the presence of other factors in food require to be found out.

From the chromosomal aspect of the question, the gigantism of the queen might be regarded as a sort of polyploidy induced by active agencies like vitamin etc. Similar to the parthenogenetic males, the queen-mother must be regarded as heterozygote like birds, butterflies and some other organisms.

LIBRARY

The Library contains of 2,836 volumes (1,435 books and 1,401 periodicals). During the year under report 127 volumes (55 books and 72 bound periodicals) were added to the stock as against 134 during the previous year. The total number of periodicals received was 61, out of which 39 were purchased and the remaining 22 were received in exchange of the Institute publication—"Transactions of the Bose Research Institute".

The total number of volumes issued out of the Library was over 700 and the volumes consulted in the Reading Room was more than 1,200.

Though the Library is primarily meant for use of the staff of the Bose Institute, yet because of its efficient service and well arranged selected acquisitions, a great number of outside scholars were attracted to visit the Library for reference work. The average number of such visitors was 40 to 50 a month during the year under report, and the number is gradually increasing.

Due to restriction of funds it has not always been possible to meet the demands of the research staff; it is felt that further additions of important books and journals are necessary to meet the requirements of the staff as well to build up an up-to-date Research Library.

Due to the devaluation of the Indian currency against dollar it has been found necessary to discontinue subscription to nine American journals.

AUDITED ACCOUNTS

An analysis of the income/expenditure accounts of the Institute for the last three years is given below :

<i>Income</i>	1947-48			1948-49			1949-50		
	Rs.	As.	P.	Rs.	As.	P.	Rs.	As.	P.
Trust Fund contribution	48,287	5	0	50,000	0	0	47,733	0	0
Central Government Grant	65,027	0	0	1,00,000	0	0	1,00,000	0	0
D.A.	22,335	9	0						
Special Grant for reorganisation							25,000	0	0
Grants-in-aid	62,118	8	9	1,06,203	14	9	98,147	10	9
<i>Expenditure</i> (total)	2,14,901	3	0	2,50,825	1	0	2,66,274	4	8
Deficit	11,267	0	6	2,659	5	9	6,054	15	1
				(surplus)					

Capital Grant — The Institute has received during 1949-50 capital grants from different sources, of the following amounts :

	Rs.	As.	P.
Sir J. C. Bose Trust Fund No. I	50,000	0	0
Non-recurring grant for equipment and laboratory	96,250	0	0
Special non-recurring grant for implementing the recommendation of the Scientific Man Power Committee	30,000	0	0
Total	1,76,250	0	0

The non-recurring grants are being utilized for the erection and equipment of the new laboratory as well as for the equipment of the existing laboratories and workshop.

APPENDIX

I. MEMBERS OF THE GOVERNING BODY:

LADY ABALA BOSE
 DR. DEBENDRA MOHAN BOSE
 MR. SUDHANSUMOHAN BOSE
 MR. KEDARNATH CHATTERJEE
 MR. SUDHIRKUMAR MONDAL
 MR. ABANINATH MITTER
 MR. SATISH CHANDRA MUKHERJEE, I.C.S. (Retd.)
 PROF. NAGENDRA CHANDRA NAG
 MR. KSHITISH CHANDRA NEOGY, M.L.A.
 MR. BHUPATIMOHAN SEN, I.E.S. (Retd.)

II. MEMBERS OF THE COUNCIL:

LADY ABALA BOSE
 MR. SUDHANSUMOHAN BOSE
 MR. KEDARNATH CHATTERJEE
 MR. S. K. MONDAL
 MR. S. C. MUKHERJEE, I.C.S. (Retd.)
 PROF. N. C. NAG
 MR. B. M. SEN, M.A., I.E.S. (Retd.), F.N.I.
 DR. D. M. BOSE, Director (*Ex-officio*)
 MR. K. C. NEOGY, M.L.A. (Representative of the Central Legislature)
 DR. P. PARIJA, D.Sc., O.B.E., F.N.I., Pro Vice-Chancellor, Banaras
 Hindu University.
 DR. K. KRISHNAMURTI, D.Sc. (Lond.), Principal, Science College,
 Nagpur.
 DR. SIR S. S. BHATNAGAR, K.T., D.Sc., F.R.S., F.N.I., Secretary,
 Department of Scientific Research, Government of India.

III. FINANCE COMMITTEE:

MR. B. M. SEN, Chairman,
 Accountant General, West Bengal.
 DR. D. M. BOSE (*Ex-officio*)

IV. BUILDING COMMITTEE:

DR. D. M. BOSE
 MR. KEDARNATH CHATTERJEE (Representative of the Council)
 MR. A. N. MITTER (Representative of the Governing Body)

APPENDIX

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V. STAFF:

Director—DR. D. M. BOSE, M.A., Ph.D., F.N.I.
 Registrar—A. K. GHOSH, M.Sc., M.M.G.I., F.G.S.

DEPARTMENT OF PHYSICS:

Head of the Department—Director.
 Research Fellow—S. R. DAS, M.Sc. (resigned from 26-10-49)
 DR. H. K. ACHARYA, D.Sc. (Cal.), Ph.D. (Lond.)
 (up to 31-7-49)
 DR. AMITABHA SEN, Ph.D. (Leeds) from 1-8-49
 to 1-12-49.
 Research Scholar—N. K. GANGULY, M.Sc. (up to 30-4-49)
 T. C. BHADRA, M.Sc. (from 1-4-49)
 Attached Workers—PROF. H. P. DEY, M.Sc., P.R.S.
 (Vidyasagar College, Cal.)
 DR. M. S. SINHA, D.Sc.
 I. L. CHAKRAVERTY, M.Sc.
 A. M. GHOSH, M.Sc.
 N. K. GANGULY, M.Sc. (from 1-5-49)
 A. N. BANERJEE, M.Sc.
 S. P. DUTT, M.Sc.

DEPARTMENT OF CHEMISTRY:

Head of the Department—DR. J. K. CHOWDHURY, M.Sc., Ph.D.,
 F.N.I.
 Research Fellow—DR. B. BANERJEE, Ph.D. (Munich)
 Research Scholar—A. C. GHOSH, M.Sc.
 Birla Scholar—D. P. BARMAN, M.Sc.
 SIR J. C. BOSE Scholar—R. P. CHATTERJEE, M.Sc.
 Attached Workers—B. SARMA, M.Sc.
 N. N. BANDYOPADHAYE, M.Sc.
 (Textile Institute, Srirampur)
 S. K. DUTT, M.Sc.
 (Gokhale Memorial Girls' College)

DEPARTMENT OF BOTANY:

Head of the Department—DR. K. T. JACOB, M.A., Ph.D. (London)
 Research Fellow—DR. B. K. KAR, Ph.D. (Leipzig) up to 15-12-49.
 Special Scholars—B. K. PALIT, B.Sc.
 B. K. DUTT, B.Sc.
 A. T. GUHA THAKURTA
 SIR J. C. BOSE Scholar—SUNANDA BOSE, M.Sc. (up to 30-6-49)

DEPARTMENT OF MICROBIOLOGY :

SIR J. C. BOSE Scholar—S. P. SEN, M.Sc.

Attached Workers—DR. P. NANDI, M.Sc., Ph.D. (Lond.)

(Scottish Church College, Cal.)

S. K. MUKHERJEE, M.Sc.,

(Surendranath College, Cal.) (from 1-1-50)

Guest Worker—DR. P. K. DE, M.Sc., Ph.D. (Lond.)

(Directorate of Agriculture, Govt. of West Bengal)

DEPARTMENT OF PHYSIOLOGY AND ZOOLOGY:

Research Fellow—DR. J. P. SIRCAR, M.B., Ch.B. (Edin.)

(also in charge of the workshop)

Special Scholar—G. C. BHATTACHARYA

Staff appointed under grant-in-aid Schemes :

1. COUNCIL OF SCIENTIFIC AND INDUSTRIAL RESEARCH--

Desulphurisation of Coal—

P. B. DATTA, M.Sc. (up to 14-7-49)

S. P. SEN, M.Sc. (from 1-4-49)

S. R. GHOSH, M.Sc. (from 15-10-49)

2. INDIAN CENTRAL JUTE COMMITTEE—

(a) Production of suitable mutants in Jute by X-ray irradiation—

K. L. CHOWDHURY, M.Sc. (Cytologist) (up to 28-2-50)

D. P. DUTT, M.Sc. (Radiologist)

R. K. BASU, M.Sc. (Cytologist from 3-3-50)

(b) Impregnation of bleached jute yarns with suitable synthetic resins—

J. M. SIRCAR, M.Sc.

H. C. NANDI, M.Sc. (up to 9-3-50)

3. COTTON SCHEME (Government of West Bengal)—

A. K. ADHIKARY, M.Sc. (in charge of plant breeding)

4. BURMA OIL COMPANY (INDIA CONCESSIONS) LTD.—

Micropaleobotanical Investigations with special reference to the age of the Saline Series, Salt Range, Punjab—

ATINDRIYA BOSE, M.Sc.

5. NATIONAL INSTITUTE OF SCIENCES OF INDIA—

Senior Research Fellow (Physics)—DR. S. D. CHATTERJEE,
D.Sc. (up to 31-8-49)

Imperial Chemical Industries Fellow (Physics)—

DR. P. K. SEN CHOWDHURY, D.Phil. (from 10-8-49)

6 SIR J. C. BOSE RESEARCH FELLOW—Calcutta University—

A. M. NAHA, M.Sc. (up to 31-12-49)

7. INDIAN CENTRAL OILSEEDS COMMITTEE—

Scheme for inducing mutations with economic characters in Til (*Sesamum*), Rape and Mustard (*Brassica*) by X-ray.

K. L. CHOWDHURY, M.Sc. (from 1-3-50)

