

REPORT
OF
THE BOSE INSTITUTE
FOR
1954-55

REPORT OF THE BOSE INSTITUTE

1954-55

Governing Body. Two meetings of the Governing Body were held during the year. Besides the usual passing of audited accounts and the sanctioning of budget estimates, the Governing Body nominated the following to be members of the Council for 1954-57 : Messrs S. M. Bose, B. M. Sen, K. N. Chatterjee, S. K. Mondal, A. N. Mitter and Dr. S. K. Mitra.

Council. The Council for the year was constituted as noted in Appendix A. Dr. K. Ahmed Chowdhury was nominated as scientist nominee of the Government of India *vice* Dr. K. Krishnamurti. The Finance Committee and Building Committee were constituted as noted in Appendix A. The Council regrets the death of Dr. S.S. Bhatnagar representative of the Government of India on the Council.

Two meetings of the Council were held during the year. Besides the usual routine activities the following important decisions were taken :

The Council recommended the extension by six months of the period of service of the Director, Dr. D. M. Bose and recommended to the Government of India for amendment of By Law 9.

The Council created a new post of Reader in Microbiology and on the recommendation of the Director, appointed to this post Dr. P. Nandi, the Research Fellow in charge of the Department of Microbiology.

The Council approved of a five year scheme for non-recurring expenditure from 1954-55—1958-59, amounting to Rs. 10,17,800/- only.

The Council agreed to the proposal put forward by Dr. D. M. Bose 70th Birthday Celebration Committee to publish a special volume of the *Transactions of the Bose Research Institute*.

Grants. The following grants were received during the year :

a) (i) Non-recurring: Rs. 1,40,000/- (Government of India) which was allocated as follows :

- | | |
|--|--------------|
| i) Shamnagar building | Rs. 18,000/- |
| ii) Radiochemical laboratory | 5,400/- |
| iii) Laboratory remodelling | 15,000/- |
| iv) Electric wiring & internal telephone | 14,000/- |
| v) Library | 5,000/- |
| vi) Apparatus | 82,600/- |

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(2) Rs. 40,000/- (Government of West Bengal) for laboratory building at Shamnagar.

- (b) Recurring: i) Rs. 2,35,000/- (Government of India),
 ii) Rs. 10,141/12/- (Government of India for training in scientific research).
 iii) Rs. 45,894/1/- (Governing Body).

Grants-in-aid. The following grants-in-aid were received during the year :

Schemes	Sponsoring Body	Amount sanctioned		
		Rs.	as.	p.
X-ray irradiation on jute seeds	Indian Central Jute Committee.	9,738	0	0
X-ray irradiation on oilseeds	Indian Central Oilseeds Committee.	27,250	0	0
Weed control	Indian Council of Agricultural Research.	15,541	9	6
Antibiotic production	Council of Scientific & Industrial Research.	11,165	1	0
Cosmic ray investigation	Board of Research on Atomic Energy	75,000	0	0
Nuclear physics investigation	"			
Neutron generator investigation	"			
P ³² and C ¹⁴ tracers in photosynthetic and plant genetic investigations	"	6,000	0	0
For research scholarships, stipends etc.	Sir J. C. Bose Trust Fund No. I.			

Acharya Jagadish Chandra Bose Memorial Lecture. The sixteenth lecture of the series entitled 'Search for new sources of power' was delivered by Professor Satyendranath Bose on November 30, 1954. The lecture has been published along with the Director's Report presented to the 37th anniversary meeting of the Bose Institute.

Other lectures. Lectures were delivered in the Institute by Prof. J. D. Bernal F.R.S. (U.K.) on "International Co-operation in Science"; Prof. Tomonaga (Japan) on 'Collective vibration of particle assembly'; Prof. M. L. Oliphant (Australia) on "Science and Mankind"; Mr. Waldemar Kaempffert (U.S.A.), on "Social changes brought

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Visitors. The following visited the Institute during 1954-55 : Prof. J. B. S. Haldane, University College, London and Mrs. Haldane; Prof. L. Pauling, California Institute of Technology, and Mrs. Pauling; Prof. P. Auger, Head, Natural Science Section, UNESCO (Paris); Dr. G. P. Conger, University of Minnesota (U.S.A.); Dr. Henri Gestaut, Faculty of Medicine (France); Prof. P. A. M. Dirac, Cambridge University; Pandit Hridaynath Kunzru, M.P.; Mr. Baha Shubbar, Director General of Industry, Iraq; Prof. N. W. Pirie, F.R.S., Rothamsted Experimental Station, England; Mr. W. Kaempfert, Science Editor, New York Times, N.Y.; Prof. N. Nishimura, University of Kyoto, Japan; Mr. U. Takagi, Lawyer, Japan; Mr. Ai Kume, Tokyo; Mr. Chizuko Kaji, Tokyo; Mr. Hasegawa Masayasu, Asstt. Prof., Faculty of Law, Nagoya University; Mr. Toshitaka Ushiom, Asstt. Professor, Tokyo University; Mr. M. U. S. Jung, Dy. Agricultural Commissioner with Government of India; Academician N. V. Tsitsin (U.S.S.R.), Prof. J. D. Bernal (U.K.); Mr. Bernard Rollet, Forestry Research, Saigon (Vietnam); Mr. T. V. Hom, Mr. Ti Chaopa, Mr. Chon Kwanghsi, Mr. Pu-Chin Kin, of Academia Sinica, Peking (China); Mr. Lu Fu-Chien, Consul General for China, Calcutta; Prof. T. Z. Zahidov, Tashkent-U.S.S.R., Dr. M. S. Zaxudol, U.S.S.R.; Prof. D. S. Koiihiusky, Moscow, U.S.S.R.; Dr. V. D. Bolfin, Moscow, Dr. N. Parijsky, Moscow University, (Astronomy); Prof. A. A. Guber, Moscow University (Academy of Sciences); Prof. T. Orlov, Paleontologist, Academy of Sciences, U.S.S.R.; Prof. T. Smirnov, Moscow, U.S.S.R.; Prof. O. A. Oleinik, Moscow University, U.S.S.R.; Prof. A. Massewitch, Astrophysicist, Moscow University, Prof. W. Pardjisky, Astronomist and Geophysicist, Prof. M.L. Oliphant, National University, Canberra, Australia, Prof. Goroh Tomonaga, Institute of Industrial Science, University of Tokyo, Prof. Sin-itro Tominaga (China) and others.

STAFF CHANGES

Retirement : Sri B. K. Palit, one of the oldest scholars of the Institute associated with the Founder Director, retired on 31st March, 1955.

Dr. J. P. Sircar retired from the duties of Special Officer on 8th May, 1954.

Study abroad : Dr. D. P. Burma, Research Fellow in Chemistry was awarded a post-doctorate fellowship of the National Research Council of Canada and was granted study leave for one year.

Dr. C. R. Raha and Sri S. M. Bose Government of India Junior Scholars obtained post-doctorate Fellowships in the Universities of

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Sri S. B. Sarkar, Junior Scientific Assistant, (A.E.C.), was awarded an Indo-German Technical Co-operation Scholarship in West Germany.

New Appointments and Awards

The following were appointed Government of India Scholars during the year :

Senior Scholars : Sri Sachindra Kumar Chakraborti (Chemistry)
(*Vice* Sri R. K. Basu resigned)

Sri Jyotirmoy Datta (Chemistry)

Sri Upendra Kumar Rai (Botany)

Sri K. Venkateswara Rao (Chemistry)

Junior Scholars : Sm. Nilima Basu (Physics) (*vice* Sri S. M. Bose) resigned.

Sm. Mary Korah (Botany) (*vice* Sri C. R. Raha resigned).

Sri Chandra Chur Ghosh (Chemistry)

Sri Ajit Kumar Banerjee (Chemistry)

Sm. Mira Purakaystha (Microbiology) (*vice* Sri Ajoy Guha resigned).

Sri A. K. Das Gupta (Microbiology) was appointed Birla Scholar; Sri B. B. Biswas was appointed algologist in the A.E.C. Scheme (*vice* Sri S. B. Sarkar resigned).

Sri Ajoy Guha, Government of India Junior Scholar was appointed research assistant in the Indian Institute of Technology, Khargpur.

Sri R. K. Basu, Government of India Senior Scholar and Sri Anil Chandra Ghosh, research assistant in the I.C.J.C. scheme were appointed research assistants in the Jute Technological Research Institute, of the Indian Central Jute Committee.

The following were awarded the D. Phil. degree of the Calcutta University—Sri S. P. Sen, Mary & Richard Keating Student; Sri C. R. Raha, Government of India Junior Scholar; Sri N. N. Banerjee (Textile Institute, Serampore), an attached worker in this Institute.

Facilities Rendered

Various workers from other Institutes were given facilities and training for research in their special topics for short periods : Sri A. K. Pain, Central Sericultural Research Station, Berhampore, on 'Trace Elements'; Dr. D. C. Sircar, Sericulture Department, Govt. of West Bengal on X-ray irradiation of Silkworms; Dr. V. Chhadda, R. G. Kar Medical College on Paper chromatography; Sri A. R. Ghosh, College of Engineering & Technology on the measurement of absorp-

chromatography; Dr. B. K. Bakshi, Forest Research Institute, Dehradun, on soil micro-organisms, and others.

Seminar

Fortnightly seminar meetings were held during the year when members of the research staff reported on the results of their investigations and reviewed the progress of work on selected topics. Discussions followed the reading of papers. Seminar meetings were open to the members of research staff of other institutions. 13 meetings were held during the year. Average attendance at these meetings was 35. The Director presided at each of these meetings and at the inaugural meeting reviewed the aim, objects and scope of the investigations carried out at the Institute.

Laboratory re-arrangement and extension

(i) A radio chemical laboratory is in course of construction and equipment. It consists of (a) the preparation room with arrangement for disposal of radioactive waste products and for protection of workers against radiation damage, (b) a measurement room fitted with necessary electronic equipments.

(ii) With the removal of the Library from its old quarters on the first floor of the northern block, the latter has been fitted up as extension of the Botanical Laboratory. A room on the same floor previously used as a seminar room and which during the last two years was occupied by the Botany section has now been vacated by the latter. It is being again used as a seminar room.

(iii) As reported (A.3.1) a low energy neutron generator with a large yield of neutron per deuteron beam current and accelerating potential has been constructed. An apparatus whose yield of neutron beam will be about fifty times that of the present apparatus is under construction. Special shielding precaution is necessary for such a large neutron generator. The northern half of the glass house is being remodelled to house the neutron generator. About 200 hollow cement cubical blocks have been made to shield the latter. They will be filled with borax solution and an additional lead shield will be added. The neutron and gamma radiation shielding properties of the blocks are being tested.

(iv) Certain amount of progress has been made in the air conditioning and fitting up a pair of rooms on the ground floor of the southern

accommodation for low temperature biochemical and physicochemical work of the Institute. The low ceiling will reduce the cost of cooling.

The work is being hampered a little during the transition period, when arrangement is being made to convert the electric supply of the entire southern and eastern block from D.C. to A.C. supply.

A number of apparatus ordered for the laboratory like Refrigerating Centrifuge, Warburg's Manometer have already been received and others will be ordered when further non-recurring grants asked for is received.

(v) *Shamnagar*—Two assistant's quarters have been constructed and are in occupation. In March 1955 a grant of Rs. 40,000/- was received from the Government of West Bengal for the construction of the ground floor of a laboratory building at Shamnagar. The work will be taken up during the next financial year.

Further non-recurring grants will be necessary :

(a) for improving the supply of irrigation water to the Experiment Farm and (b) for the electrification of the laboratory and pumping machinery.

(vi) Cosmic ray investigations using both pressure ionisation chamber with counter telescope arrangement, as well with large rectangular cloud chamber are being carried out satisfactorily in the Mayapuri Research Station, Darjeeling.

The Institute's cosmic ray laboratory will participate in the programme of work connected with the International Geophysical Year in 1957. The nature of the participation and estimates of the cost involved are under consideration.

The question of establishing a plant virus station by the ICAR for the north eastern region at Darjeeling and locating the laboratory at Mayapuri is still under consideration.

RESEARCH ACTIVITIES

A non-technical account is given below of some of the notable results which have been obtained during the year under review. More detailed summaries are given in the following sections :

Ultrasonics.—Absorption of ultrasonic radiation in liquids has been studied with the help of new apparatus constructed after those devised by Cady, Gitting and others. When ultrasonic radiation is transmitted through a liquid, the propagation of radiation is accompanied by a bodily (hydrodynamic) flow of the liquid medium. By

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as well as the pressure due to the hydrodynamic flow. From results obtained by this method it is believed an explanation will be possible of the abnormally high coefficients of sound absorption shown in some organic liquids like CCl_4 , CS_2 , Benzene etc., as compared with those found in normal liquids; like water, alcohol etc. Such results are difficult of interpretation according to the existing relaxation theory of sound absorption.

Neutron generator.—The nuclei of the two isotopes of hydrogen, deuterium and tritium can, by using different methods, be made to fuse together resulting in the production of a helium nucleus and a neutron, and release of a large amount of energy. This is the principle of the hydrogen bomb. In the Bose Institute a low pressure glass discharge tube has been constructed, in which a beam of deuteron particles accelerated through 50 kv strikes a zirconium target on which tritium gas is adsorbed. One microampere of deuteron under such condition can produce a neutron beam nearly equivalent to that produced by one curie of Radium Beryllium source. The construction of a larger neutron generator is under way. Many applications of the neutrons so produced are envisaged. They include the production of radioactive isotopes used in biological investigations, as an agent for inducing mutation in plants, and for the study of interaction of neutrons of different energies with material bodies.

Physical Chemistry.—During the past decade or more, several physical methods have been developed (i) for rapid identification after separation of minute quantities of compounds present in small liquid volumes, (ii) purification and separation of small quantities of substance present in liquid extracts, (iii) optical resolution and separation of constituent large molecules present in biological fluid extracts.

The Institute is specializing in developing some of these methods, such as columnar and paper chromatography, electrophoresis, paper ionophoresis, and counter current distribution methods. Other methods are in course of development and will be reported later.

Radiochemistry.—For identification of very minute quantities of a chemical intermediates occurring in plant metabolic processes, radio isotope tracer technique is being employed along with paper chromatography. These include the study of photosynthesis, the dark fixation of CO_2 , the role of phosphorus and sulphur in plant metabolism, the glycolytic enzymes and the intermediates of glycolysis in *mung* seedlings and so on.

Algal studies.—During recent years, the theoretical

finding improved methods of utilisation of solar energy for food and fuel production.

In green algae (*Chlorophyceae*) solar energy is efficiently utilized for production of carbohydrates, oils and proteins, using atmospheric CO_2 , water, and some inorganic salts which include compounds of nitrogen. Blue green algae (*Cyanophyceae*) can fix not only atmospheric CO_2 but nitrogen as well. In the U.S.A., in many countries of western Europe, in Japan, semi large scale algal culture production methods are being tried, with a view to determining the economics of this method of utilisation of solar energy.

During the last year, the Bose Institute made some progress in the collection of both green and blue green algae, in maintaining cultures of pure strains and in studying their metabolism. The two efficient strains of the green algae *Chlorella*, *Scenedesmus*, are temperate climate plants which have to be maintained in air conditioned rooms. Attempt is being made to find green algae which are habitats of tropical countries and which have large photosynthetic efficiency. Collection of both green and blue green algae are being made from different localities in this country, including from the hot spring Bhimbandh near Monghyr. The micro-organisms collected from the last mentioned place is rich in blue green algae. So far no satisfactory strain of green alga has been discovered.

Plant physiology.—As has been reported before, an 'Active substance' stainable by many dyes like safrannin, (vital dyes like neutral red) etc., had been observed by J. C. Bose in 1928 in the pulvinar cells of motile plants, like different species of mimosa etc. At that time J. C. Bose had called attention to similar observation by an Austrian physiologist, of a highly stainable substance in the breast and wing muscles of birds like falcon and geese. J. C. Bose believed these two stainable substances found in the contractile organs of plants and animals to be of similar nature. Later investigations have shown that the stainable bodies present not only in the active muscles but also in actively metabolizing animal tissue like heart, liver, and kidney, are mitochondria bodies. In the pulvini of *Mimosa pudica*, several mitochondria like bodies revealed their presence in small numbers but they are not stainable with safranin and other dyes and therefore they cannot be J. C. Bose's 'active substance'. A number of investigations carried out in the Bose Institute and in other laboratories have established, that the active substance is nothing but the tannin bodies found in large vacuoles present in the contractile cells. Using Cresyl Blue stain, it has been possible to stain to different tints the tannin bodies as well as the fluid

of the containing cell. Further it has been possible by using certain chemicals to make the vacuole contract and then recover its previous size. Within the contracted vacuole the dye concentration increases showing there is a contractile membrane round the vacuole which is permeable to the liquid content of the vacuole but not to the dye nor to the tannin inclusion.

While our knowledge of the character of the contractile cell and its vacuole together with that of the probable mechanism of expulsion and reimpulsion of its sap has made steady progress, much yet remains to be understood, including the composition of the irritability substance which is believed to act a mediator in the transmission of excitation in the sensitive plants.

Studies on the mutagenic action of radiation.—The systematic action of radiation of different kinds in inducing mutation in plants, and selection out of such mutants strains with improved economic properties, have been engaging the attention of the Institute for more than ten years. The first investigation was commenced with x-ray irradiation of jute seeds. In 1946 the Institute received a grant from the Indian Central Jute Committee which has terminated this year. One of the important results obtained was, that of the different varieties of jute seeds like the *Capsularis* varieties, D158 and D386, and the *Olorius* varieties, *Chinsura Green* and R26 when irradiated, R26 was most susceptible to radiation. A new variety named the *Tall Mutant* has been obtained and stabilized by irradiation of R26 seeds. This variety is characterised by (i) enhanced vegetative activity leading to greater height and basal diameter, (ii) higher fibre yielding capacity and (iii) deep scarlet colour of leaves and stems when mature. The increase of fibre yielding capacity has been measured for two successive years, in 1953-54 with 250 plant, and in 1954-55 with 410 plants each of both controls and mutants; each year it was found that the average fibre yield per plant of the mutant was about 40 per cent greater than that for the control. Anatomical studies made in previous year showed that this increase in fibre yield was due to a larger number of fibre bundles present in the mutant plant, compared to that in the control.

Since 1953-54 the effect of B-rays from radioactive P32 and S35, two elements whose compounds are selectively absorbed in the plant nucleus, in producing mutation in jute plants is being investigated. As reported last year, from seeds of R26 treated with P32, progenies were obtained including besides the normal R26 plants, others with characteristic green and red colour similar to those of *Chinsura Green* and *Tall Mutant*.

C.G., and Tall Mutant have been obtained. Investigations are being continued, which will give information on the number of genes involved in mutation of R26 to *Chinsura Green* and *Tall Mutant*.

Fresh seeds of R26 treated this year both with P32 and S35 have given rise to plants with very varying morphological characters of leaf and stem but only one T.M. plant. Other *Capsularis* and *Olitorius* varieties subjected to isotope P32 treatment have revealed morphological peculiarities including plants with bifurcated stems.

Oilseeds.—X-ray irradiation of seeds of *Sesamum* and *Brassica* have given rise to plants with increased number of branches as compared to the control, resulting in increased production of seed pods and as well as higher yield of oil. For example in the X_5 generation of type No 16 of *Sesamum*, the mean oil content was found to be 53.5% as compared to 41.2% in the control.

In *Brassica*, favourable higher yield of seeds in progenies in some irradiated types as compared to that in the control has been maintained upto X_3 generation. It is too early to speak of stabilisation of these higher yielding plants.

The striking feature which has been observed in *Sesamum* and *Brassica* is that in both, more than one type has been found which are susceptible of improvement by X-ray irradiation, resulting in higher yielding progenies. In jute, only R26 has been found susceptible to improved mutation, resulting from treatment with X-rays and isotopic treatment.

Microbiology.—Irradiation with ultraviolet radiation of fungi with a view to obtaining improved mutants have been tried with *Aspergillus niger* and *P. notatum*. With *Aspergillus niger* the mutants were classified in five types according to the changed conidial colour and modified texture of the colony.

Out of 53 mutant strains tested, 20% produced more citric acid than the non-radiated parent strains, while 13% showed diminished activity.

In irradiated products of *P. notatum* out of 250 strains examined 122 proved to be mutant behaving differently from normal morphology, pigment production and antibiotic formation. None of them showed any improvement in antibiotic production compared to the parent strain.

An extensive study is being made of different antibiotic and anti-fungal production by micro-organisms belonging to the group *Streptomyces* sp. A CSIR scheme for the production, on a pilot plant scale, of an antibiotic substance isolated from a strain of *Streptomyces* sp. which has been found to possess remarkable antibiotic properties, against gram

current distribution apparatus. One 10 liter stainless steel fermentor for pilot plant production has been set up.

Microbial retting of jute fibre.—The Institute had during 1942–46 carried out some investigations on the retting of fibre plants like jute, flax, ramie, using retting micro-organisms cultured on suitable nutrients. This work was revived recently. Search for active retting micro-organisms resulted in the isolation of two strains of *A. niger*. The more active one was cultured on different substances. The retting activity of the cultured micro-organism was highest when the fungus had no supply of food materials other than that found in jute stems. Next to jute stem, wheat bran was found to be suitable; on the other hand rice bran was not suited for pectinose secretion by the fungus. The latter grew vigorously in the presence of sugar, but lost thereby its retting capacity. This is an example of enzymatic adaptability of micro-organisms.

The fungus cultured on wheat bran was used for stack retting of jute sticks. Over the wetted jute sticks arranged in stacks, cultured bran was strewn. The sticks were satisfactorily retted in 3–4 days. The experiment will be continued under field condition next year.

Delayed metamorphosis of tadpoles.—It has been reported previously (1953–54) that tadpoles of *Rana tigris*, which normally metamorphose into froglets in 4–5 weeks could be kept in the tadpole state by keeping the tadpole immersed for a short time in a very dilute penicillin solution. Some of the specimens could be kept in this condition for 15 months, after which one or two were observed to metamorphose themselves spontaneously into froglets, while the rest died. It has been also reported that five, six month old, tadpoles when treated with dilute solution of vitamin B₁₂ became all transformed into froglets within 10–14 days and survived in the froglet state for a few days.

During 1954–55 similar results were obtained by keeping two batches of retarded tadpoles in dilute B-12 solution (50 ug of B-12 in 3000 c.c. of water). All the tadpoles were transformed into froglets in 10–12 days. They survived in the froglet state only upto a fortnight. As a working hypothesis it was assumed that some of the intestinal flora of the larval tadpoles grown in the normal habitat could secrete vitamin B₁₂ which was then responsible for producing metamorphosis.

The intestinal flora of both untreated and treated (with dilute penicillin) tadpoles were cultured and tested for production of B₁₂. Some of the bacillus and coccus obtained from control tadpoles were found to produce B₁₂; the growth of such micro-organism was found to be inhibited by penicillin. In the cultured intestinal flora taken

A. PHYSICS

A. 1. New Apparatus

The following apparatus has been constructed during the year :—

The use of radiation pressure to determine the intensity in a sound beam is a well-known method, but the fact that both radiation and streaming forces act simultaneously on the disk has long troubled the investigators who were interested only in measuring the sound intensity. The apparatus described below is one with which the separation of the two forces can be effected efficiently.

An improved apparatus as designed by W. G. Cady and Gittings was made to measure the acoustic as well as the streaming forces. The acoustic and the streaming pressures were measured by measuring the excess pressure developed on a vane provided with an acoustic hohlraum.

The transducer with its baffle is mounted at one end of the tank containing the experimental liquid. At a distance that can be varied from 1 cm. to 25 cm., is the absorber attached to the vane. The vane is attached to a rod which is connected to a cross-bar. The cross-bar is supported at each end by a hardened steel pivot resting in a jewel groove. There are provisions for adjusting the sensitivity and the balance of the apparatus. A graduated scale having a rider of known mass, is attached to the cross-bar. By adjusting the position of the rider, the weight necessary to counter-balance the excess pressure developed on the vane can be ascertained. There is a provision also for a scale-pan to be placed at the end of the scale. By adding known mass on the pan, the excess pressure is directly determined. A mirror is fixed to the cross-bar. A lamp and scale device is used as an indicator. The acoustic hohlraum acts as the perfect absorber of acoustic energy. It consists of a glass tube of 13 cm. in length, the remote end being closed by a rubber stopper. It is attached to the vane. A baffle having the dimensions of the vane is fixed at a distance of 3 cm. from the vane and is placed in between the source of ultrasonic energy and the vane. The baffle has a central opening which can be closed by means of a cellophane paper. While measuring acoustic pressure, a cellophane paper is attached to the baffle to cut off the streaming. The pressure that is developed on the vane is due to ultrasonic energy only. To measure the streaming pressure, the cellophane is removed from

passes through the hohlraum, without producing any effect on it and so develops no pressure on the vane but the streaming liquid strikes the cellophane attached to the vane and develops pressure on the vane. The measure of this pressure gives the streaming pressure. Thus the acoustic and streaming forces can be measured separately.

The sensitivity of the apparatus is such that a force of 1 mgm. wt. can be measured easily.

A. 2. Microwave

To revive and extend the pioneer investigations on microwaves by Sir J. C. Bose, a microwave laboratory is going to be set up in this Institute. Sir J. C. Bose made a series of optical experiments with the help of his microwave apparatus. The details of the experiments are published in the volume, "Collected Physical Papers". A brief report on his apparatus was published in the last year's annual report of the Bose Institute.

The modern microwave technique will be used in the study of absorption in liquids and gases and also in the study of the para-magnetic resonance of the free-radicals present in some plants and some organic compounds. This will also be a useful extension of Dr. D. M. Bose's para-magnetic investigations.

For this purpose an order has been placed for a complete test-bench 3 cm. microwave equipment. This is expected to be received within a month or two. Electromagnets and other accessories are being procured. Works on remodelling the laboratory for this purpose are in progress.

A. 3. Ultrasonics

MEASUREMENT OF THE INTENSITY OF ULTRASONIC WAVES IN LIQUID BY RADIATION PRESSURE METHOD

The present report is the continuation of the work reported last year :

A.3.1. Measurements were made at constant energy density with a series of steel spheres having different radii—radii being 1.23 cm., 1.02 cm., 0.95 cm., 0.83 cm., 0.76 cm., 0.75 cm., 0.57 cm., and 0.43 cm. In each case a thin sheet of cellophane was placed between the ultrasonic source and the sphere. This device minimised the additional pressure due to mass flow, i.e., streaming. The excess pressure that was exerted on the sphere was taken with good approximation to be due to ultra-

did not appear to have any effect on the measurement of the energy density. The distance between the ball and the screen was 2 cm.

A.3.2. Measurements were made at constant energy density, using one sphere at different distances ranging from 3 cm. to 15 cm. from the face of the quartz crystal. Here the total pressure, *i.e.*, the sum of acoustic and streaming pressures was measured. The energy density was found to follow the exponential decay law with distances. This decay is the one to be expected generally. Here a part of the ultrasonic energy was converted into streaming which was converted into heat energy due to viscosity effect. In the investigation no effort was made to separate acoustic pressure from the pressure due to hydrodynamic flow. In a new experiment based upon Cady's method which is reported below, these two effects have been experimentally separated and studied.

A.3.3. *Experimental determinations of acoustic intensity, the streaming velocity and the second viscosity-coefficient.*

By means of the apparatus described in Section A.1. acoustic and streaming forces were measured separately. Measurements were taken in the interval ranging from 3 cm. to 18 cm. from the source of ultrasonic energy. Following are the findings of the experiment :—

The results of the investigation show that the intensity of the acoustic force decreases exponentially with distance and that of streaming force after increasing up to a distance of about 8 cm., then decreases exponentially. The sum of these two forces (acoustic and streaming) obtained by adding the magnitudes of the separate forces at the same place, is found to decrease at a very slow rate up to a distance of about 8 cm., and then decreases exponentially. Photographs of the stream-lines also show the irregularity in the stream-line pattern after about 8 cm. The analysis of these results reveals that up to a distance of 8 cm., most of the acoustic energy is converted into streaming, and only a very small fraction is lost due to viscosity; after this region most probably the reverse process takes place. According to Borgnis this sum should remain constant over a considerable distance from the source. Cady and Gittings experimentally showed that up to a distance of about 25 cm. (from graph) this sum remained constant. This is something unusual. According to this finding, viscosity of water (experimental liquid) has no effect at least up to 25 cm. Further work with highly absorbing liquids such as carbontetrachloride, benzene and also ethyl-alcohol are in good progress. The velocity of streaming

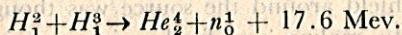
From the knowledge of acoustic and streaming pressures and the velocity of streaming, the co-efficient of second viscosity can be determined.

Detailed discussions and description of experimental arrangements will form the subject matter of a paper to be published soon.

A. 4.

A.4.1. *Setting up of a Neutron Generator :*

During the period under review an artificial source of fast neutrons was built up by using the following reaction :



Ions of deuterium generated in a radiofrequency type of ion source, were drawn out and focussed electrostatically to form a beam current equal to two microamperes (total). Of this roughly one microampere current constituted the atomic ions which alone were effective in causing the above reaction in an accelerator tube. The beam was accelerated to 52 kilovolts and made to strike against a target with a focal spot less than one cm. in diameter. A zirconium deposited copper disc which held tritium in absorption was used as the target.

An indirect method was adopted for determining the yield of neutrons under the conditions of experiment. A silver plate was irradiated for ten minutes under good geometry in the fast neutron flux. The stable silver nuclei Ag^{107} (51.9%) and Ag^{109} (48.1%) were transformed mainly into radioactive nuclei Ag^{106} (β^+ , 24.5 min.) and Ag^{108} (β^- , 2.3 min.) by $(n, 2n)$ reaction. $\sigma(n, 2n)$, the $(n, 2n)$ reaction cross section for Ag^{109} at 14.1 Mev is known to be equal to one barn. One minute after irradiation the activated plate was held in a fixed geometry around a thin walled G. M. counter and from the decay curve the relative initial activity (at $t=0$ after irradiation) for the 2.3 min. product was determined.

A similar experiment was performed with the same silver plate held around a Ra-Be source (100 millicurie strength) for ten minutes neutron irradiation and under the experimental condition Ag^{107} and Ag^{109} were transformed into Ag^{108} (β^- , 2.3 min.) and Ag^{110} (β^- , 22 sec.) by (n, γ) reaction. The 2.3 min. activity was measured one minute after irradiation and the extrapolated initial activity computed from the decay curve. The neutron number distribution curve over the energy range is fairly well known for a Ra-Be source. The

curve is necessary to cover the energy range of Ra-Be neutrons. From a comparison of the 2.3 min. activity in the two cases, the strength of the tritium-deuteron-neutron source was estimated to be equivalent to about 770 millicuries of Ra-Be. A note covering these results was published in the March 1955 issue of *Science and Culture*.

A further increase in yield can be effected on the following lines:

- (a) by increasing the beam current intensity,
- (b) by increasing the accelerating voltage, and
- (c) by using a thicker tritium target.

Even a partial fulfilment of the above procedure might result in producing a source several times stronger. The installation of an adequate neutron shield around the source was thought to be essential before attempting to realize any further increase in yield. For this purpose a single storied apartment in a remote corner of the Institute was selected and renovated. Hollow concrete blocks each one foot cube containing borated water are designed to be used as shield elements. The blocks will be placed in rows and columns and will admit of a flexible arrangement.

A new high vacuum installation with a pumping speed of 100 l/sec at 10^{-4} mm. Hg is under construction. Arrangements are being made for employing scintillation and enriched boron proportional counting techniques for high efficiency neutron counting.

A.4.2. A Radiofrequency Generator for D.C. High Voltages.

The radiofrequency voltage multiplier circuit which was briefly described in a previous report now consists of twenty four stages. Each stage consists of two condensers connected in series with a total rating of 0.025 μfd and 20 kv working voltage. The pair of condensers is placed within an aluminium casing as corona shield and each such unit is placed one above the other with perspex insulation between them. There are six condenser units arranged in a stack and there are four stacks arranged at the corners of a rectangular wooden platform. Each rectifier unit consists of three selenium rectifiers connected in series and is rated at 17 kv at 5mA. The rectifier chain is placed in a zigzag way in a vertical plane along the centre of the platform. The corresponding points along the condenser and rectifier chains are suitably connected by means of aluminium tubes. A resistance chain with a total value of about 600 megohms used in conjunction with a moving coil meter (400 microamperes full scale) measured the voltage developed by the source. The power to feed this multiplier is obtained from an R.F. oscillator (1 kv at 100 kilocycles/sec). A high Q coil is inductively

depending upon the operating characteristics of the oscillator. This variable voltage is then impressed at the input of the multiplier chain which multiplies the voltage as many times as the number of stages in the circuit.

When operating in the 200 kilovolt region, the source is found to develop corona discharges which are manifest only through a hissing sound. Attempts to locate the affected points in a darkened room did not prove successful. This problem is being tackled through a process of gradual elimination and rounding off of sharp points and edges in the whole circuit. As a first step, the edges at the top shield plates are being covered with aluminium tubes bent into circles. Arrangements are also being made for determining the behaviour of the voltage source towards additional loading either by drawing current in a discharge tube or in a large chain of feeder resistances.

A. 5. Cosmic Ray Investigations

A.5.1. *Ionisation Chamber Method :*

Records of cosmic ray bursts in ion chambers have been analysed to investigate the phenomenon of nuclear interactions of cosmic rays with matter. Records of over thousand hours have been analysed.

The integral size frequency (sizes expressed in ion pairs per burst) distribution curves of bursts in an unshielded ion chamber when plotted on a log-log scale, show two different slopes with exponents $\nu = 2.9$ for larger bursts attributed to atmospheric cascades, and $\nu = 1.08$ for smaller bursts caused by nuclear interactions of N-rays within the chamber wall. Bursts caused by atmospheric cascades were separated out from nuclear interactions by noting coincidences between ion chamber pulses and discharges of shower counter sets. Burst pulses not coincident with any of the shower counter sets, were all attributed to nuclear interactions within the chamber wall. Such nuclear bursts show on subsequent analysis, that in addition to evaporation products of a nucleus (α -particles and protons), particles of higher energy capable of penetrating 10 cm. of lead are also liberated.

From a comparative analysis of the size frequency distribution curves of bursts (*i.e.*, bursts in the small size end of the curve) obtained in an unshielded ion chamber both at Calcutta and at Darjeeling, the average absorption length in air of the producing radiation has been found out to be $= 142 \pm 8.5$ g/cm². The value of air $= 150 \pm 7$ g/cm² for stars deduced from the observed variation of fre-

close correlation of absorption values suggests the same origin for the two processes.

A similar comparison of large bursts under thick shields (10 cm. of lead) shows that burst frequencies are attenuated by a factor of 5 between Darjeeling and Calcutta. Since μ -bursts, due to knock-on and bremsstrahlung processes of high energy μ -mesons, are not absorbed appreciably in the thickness of air in question, some other radiation more absorbable than the μ -radiation must also be responsible for such bursts under thick shields. The hypothesis of shower production by the decay of neutral mesons produced in high energy nuclear interactions induced by N-rays, has been found fruitful in accounting for the observed frequency and altitude dependence of large bursts.

A.5.2. Mean free path for nuclear interaction in lead :

The big square cloud chamber which was tested and mechanized in Calcutta, was taken to our high altitude research station at Darjeeling and set up there for the study of the mean free path of relativistic secondaries produced in a lead absorber placed above the chamber. Out of about 4,000 pictures taken with a penetrating shower arrangement 186 were selected which contained on an average more than four penetrating multiples per picture. Altogether 811 penetrating secondaries traversing about 36,000 gms. of Pb, were analysed and the number of interactions observed were 208. The mean free path in lead for these secondaries was found to be 169 ± 12 , which indicated almost a geometric cross section. The number of nuclear scatterings observed were 40, which gave a value for the m.f.p. for nuclear scattering alone, about five times the value obtained for all interactions. A number of specially interesting photographs of V-particles and also that of an S-event producing a θ° , have been obtained.

The chamber will be operated continuously with copper plates fitted inside so as to study the m.f.p. in copper. The following papers have been published during 1954-55:

1. Identification of particles from a probable V_0^0 -decay (*Transactions Bose Res. Inst.* XIX).
2. Production of θ° —from an S-event (*Ibid.*, XIX).
3. Determination of the mean free path of relativistic secondaries in lead. (in course of publication).

A.5.3. Differential momentum spectrum and scattering of low energy μ -mesons.

A completely mechanized cloud chamber (30 cm. diameter and 6 cm. illuminated depth) has been constructed and fitted with half-

by a threefold coincidence system placed above the chamber and is combined with an anticoincidence set placed just below the chamber so as to photograph tracks of particles stopped inside the chamber. The amount of lead absorber above the chamber will be varied by steps of 55 gms. and the spectrum of μ -mesons up to 700 Mev (range-equivalent 600 gms/cm² Pb) will be studied.

A.5.4. *Studies on the mean life and capture-probability of μ -mesons :*

The delayed coincidence experiment for studying the mean life of μ -mesons has been continued in water (*i.e.*, in oxygen, for hydrogen does not absorb mesons) and sodium fluoride absorbers. The mean life of a composite beam of mesons (both positive and negative combined) in water has been determined to be $1.95 \pm .09$ micro-seconds and that of negative mesons has been calculated by the subtraction method, reported previously. The mean life of negatives in water has been found to be 1.80 ± 0.19 micro-seconds. In the case of NaF ($Z_{\text{eff}}=10.1$), the experimental points have been found to represent a single decay curve up to the last point (4.0 μ -secs) and the composite decay curve gives a mean life equal to 1.82 ± 0.09 micro-seconds.

Theoretical predictions on the mean life of μ -mesons in absence of matter have also been attempted. The probability of a slow decrease of the mean life of the positive muons with the decrease of Z , as seen from some accurate experiments of recent times, has been utilized to put forward the hypothesis that the mean life for free decay of the negatives (in the absence of matter) is 2.35 micro-seconds, which is higher than that of the positives (2.22 micro-seconds), if the latter are assumed to undergo free decay in the presence of matter. If on the other hand an equality in the mean life for both positives and negatives in absence of matter is assumed, the slow decrease in the mean life of positive mesons in absorbers of increasing atomic number appears to be real.

A multichannel delayed coincidence apparatus has been constructed, which will enable a quicker determination of the mean lives of μ -meson, in light absorbers with a better statistics. Experiments with this apparatus and with some new absorbers are now in progress.

The following papers have been published:

1. Mean life of decay of muons in absence of matter (*Indian Jr. Phys.*, Vol. 128, 431, 1954).
2. The variation of the mean life of muons with the atomic number of absorbers. (*Trans. Bose Res. Institute*, XIX).

A. 6. Nuclear Physics

A.6.1. *Slow neutron cross section studies.*

(a) A spherical symmetry method for determining the absorption cross section of thermal neutrons has been developed in the laboratory. Theoretical formula for use in the experiment was developed after carefully considering various scattering and absorption effects. The detector used in the present set of experiments is an indium foil. The difference of activity of the foil when not enclosed within and when enclosed in a cadmium foil was taken as a measure of the thermal neutron flux. The β -activity induced in indium was measured by means of a scintillation beta counter, using anthracene phosphor. The method was utilised to determine the thermal neutron absorption cross section of NaCl. The value obtained (29 barns) agrees with the more elaborate methods using neutron radiation from atomic pile.

(b) A thermal neutron scintillator using methyl borate with usual counting liquid has been developed. Its response to Po-Be neutrons, cosmic rays and gamma rays has been studied.

A.6.2. *Instrumentation.*

(a) Several electronic equipments including (i) a feed back amplifier of gain 10,000 with rise time 2×10^{-7} sec., (ii) a push-pull amplifier of gain 2000 which eliminates the spurious counts from extraneous sources effectively, (iii) an electronically stabilized high voltage source, (iv) a 4-fold coincidence with anticoincidence circuit, and (v) a dekatron scalar of 1000 have been constructed in the laboratory.

(b) A large volume plastic scintillator to be used as ionisation chamber has been constructed.

A.6.3. *Absorption coefficients of gamma-rays.*

Absorption coefficients for various elements have been measured using both Geiger counter and RCA 5819 photomultiplier tube with NaI-Tl crystal. The two cobalt gamma lines 1.17 Mev and 1.33 Mev have been separated in a scintillation spectrometer arrangement and absorption coefficients have been measured separately. The stability of the preassigned pulse levels in the Differential Pulse Height Analyser used in the experiment are disturbed by the high humidity and the heating up of the apparatus. To overcome this the counting system is being housed in an air-conditioned chamber.

Measurements for the anomalous absorption cross-section as reported by Clay and others will be taken up at present, using a larger

B. CHEMISTRY

B. 1. Physical and Biochemistry

B.1.1. *Electrophoresis apparatus*.—The construction of the Tiselius' electrophoresis apparatus has been completed except for some minor mechanical attachments which are expected to be ready shortly. The preliminary standardization of the apparatus is in progress. It has been built mainly after the modified design of Langsworth and MacInnes with some changes in constructional details which would not affect the performance of the apparatus.

With the apparatus as it stands now, it is possible to obtain electrophoretic patterns by the cylindrical lens and diagonal slit method. It is hoped that the camera would be ready for the scanning procedure in the near future. The optical system comprising the illuminated horizontal slit, schlieren lens and the schlieren scanning camera has been brought to proper alignment and the focussing and other adjustments of the camera, the cylindrical lens, and the schlieren lens have been carried out. Aberrations due to the windows of the filled thermostat have been mostly eliminated. The thermostatic bath has been run at 3–4°C and has been found to maintain temperatures within $\pm 0.1^\circ\text{C}$. Difficulties, however, have arisen in maintaining the inside of the windows and their outside surfaces dry owing to high ambient humidity, in spite of continuous passage of dry air through the windows. Additional provisions are being made to obviate this difficulty.

B.1.2. *Paper ionophoresis*.—During the year under report, the technique itself has been brought to a fair degree of precision under controlled conditions. Both the 'horizontal box' and the 'paper in-between glass sheets' types of apparatus have been constructed and standardized with purified egg albumin. Results obtained from the studies on normal serum indicate close agreement with those already published. The apparatus is now suitable for quantitative work both by elution and spectrophotometry, and by densitometric measurements. Several such units are being built and appropriate power control units to work at different voltages are being designed.

B.1.3. *Studies on seed proteins*.—Work on the isolation, separation and purification of seed proteins and the study of their physico-chemical properties by paper electrophoresis have been commenced. The first materials chosen are the seeds of *Cajanus indicus* (arhar) and *Lens esculenta* (musur), two common Indian pulses. Preliminary determination of the total proteins has been completed.

have been separated from a mixture in 0.1 M caustic soda medium using a potential gradient of 5 volts/cm. These results await confirmation by further work which is in progress.

B.1.5. *Studies on pathological blood sera.*—This investigation, which has been undertaken in collaboration with Professor S. N. De, Pathology Department, Nilratan Sircar Medical College, Calcutta, covers the study, by paper electrophoresis and other methods, of the changes that are likely to occur in the total and relative concentrations of the protein constituents of blood sera (that is, globulins and albumin) of cholera patients at different stages of the disease. The paper ionophoretic patterns are being compared with those of normal serum. Quantitative measurements have been made with the help of a photoelectric densitometer. The results hitherto obtained indicate a general increase in globulin concentration. More cases are being studied.

B.1.6. *Measurements on oil-electrolyte interface potentials.*—Oil membranes consisting of a layer of oil or other immiscible liquid interposed between two electrolyte solutions have been considered to behave like natural membranes. The changes in the EMF of oil membrane cells (using a layer of nitrobenzene between two potassium chloride solutions of different concentrations) on the addition of pilocarpine hydrochloride have been studied. A Tinsley thermoelectric potentiometer was used for the measurements. Some interesting observations were made. It was found however that a more sensitive instrument of greater precision would be necessary for this type of measurements.

B.1.7. *Paper chromatography.*—The dependence of R_f values of two amino acids, serine and valine, on the shape and size of the filter-paper has been investigated with a view to studying the transition from linear to circular chromatography. The R_f values are affected very little by the width of the strip or the sector angle. It has been shown both experimentally and theoretically that the R_f values on strips are equal to the squares of those on sector or circular chromatography.

B.1.8. *Separation of indole derivatives and alkaloids.*—The following indole compounds have been separated by means of circular paper chromatography: indole acetamide, indole acetic acid, indole butyric acid, indole propionic acid, and *n*-acetyl indole. Satisfactory results have been obtained by using the solvent mixtures, (i) *t*-butanol-ammonia, (ii) isopropanol-ammonia, and (iii) isopropanol-ammonia-water. The circular technique has also been used to separate alkaloids such as quinine, cinchonine, cinchonidine, brucine, strychnine, morphine, thebaine, papaverine, narceine, narcotine etc.

(i) Standardization of a 24-tube counter-current distribution apparatus.

The apparatus set up in this laboratory was standardized by means of distribution of penicillin between ether and phosphate buffer. The distributed material was estimated by agar-cup method of assay using *Streptococcus aureus* as test organism. The pattern obtained was in close agreement with that reported by Craig. Results will be published in *J. Sci. Ind. Res.* (1955).

(ii) Physico-chemical aspects of the method of estimation of distributed antibiotic by agar-cup assay.

A simple equation has been derived governing the distribution of an antibiotic in a counter-current distribution apparatus and the zone of inhibition (mm.) produced by the antibiotic present in a tube when assayed against a standard test organism by the usual agar-cup method of assay. The proposed method of following up the pattern of distribution of an antibiotic gives results which are in fair agreement with those of other methods of estimation. The equation has been verified by studies on the distribution of *n*-benzyl penicillin and the antibiotic A₁₂ (see previous section). Results have been communicated to *J. Sci. Ind. Res.*

(iii) Effect of temperature on the distribution pattern in Craig's apparatus.

Studies were conducted to determine the effect of temperature on the distribution pattern of solute between immiscible solvent phases in Craig's apparatus. An equation based on van't Hoff's isochore has been derived governing temperature, number of transfer, and the number of tube where maximum concentration of the solute is attained. The systems taken up for study were (a) amyl alcohol-succinic acid-water and (b) ether-ferric thiocyanate-water.

Results calculated from the values obtained from Wark (*J. Proc. Soc. N.S.W.*, 63, 47, 1929) substantiated the validity of the equation derived. It is now intended to extend the temperature range in the case of the system amyl alcohol-succinic acid-water for further verification of the equation. Studies undertaken here suggest the possibility of effective utilization of optimum temperature at which distribution is to be carried out for better fractionation and on a preparative scale. A mathematical relation was deduced and experimentally verified showing that at $K=1$ the distribution curve became least sharp as compared with other values of K .

pattern has been studied at 18°C. The system taken up for investigation was benzene-picric acid-water. As expected, the maxima shifted as the amount of substance taken up for distribution became greater. It is intended to correlate the activity coefficient with the maximum tube number, incorporate the variability factor of temperature and derive a thermodynamic equation that will govern the distribution of a solute between two immiscible solvent phases in Craig's apparatus.

(v) Studies on the multiple extraction of a solute in Craig's apparatus.

A relation connecting the change of partition coefficient with concentration was theoretically deduced and experimentally verified in the case of Craig's single-tube multiple-extraction process. The systems studied were : (a) methylene blue between butanol and water, (b) acetic acid between water and *m*-xylene, (c) succinic acid between water and amyl alcohol, and (d) citric acid between water and amyl alcohol.

(vi) Effect of temperature on the R_f value of a solute with special reference to water as the developing solvent.

The variation of R_f has been noted in course of studies on the effect of temperature in paper partition chromatography (Burma, 1951) using water-miscible solvents. A thermodynamic equation was deduced using the data published by Burma, Underwood and co-workers. It was observed that when $\log R_f$ was plotted against $\log T$, a more or less linear relation was observed up to a particular temperature which varied according to the nature of the solution and the solvent systems. Above that temperature the variation was more or less marked. As the variation was more marked with the increase in percentage of water in the water-miscible solvent pair, and as it has now been fairly established that with water alone as the developing solvent, adsorptive forces other than partition alone play a dominating role, it was concluded that studies on the effect of temperature with water alone as the developing solvent may throw some light on the nature of the effects of temperature on R_f value. *dl*-Tryptophane was chromatographed on Whatman No. 1 filter paper with water as the developing solvent at 20°, 25°, 30°, 35° and 40°C. The plot of $\log R_f$ against $\log T$ produced a curve of sigmoid nature. The work at lower temperatures will be continued during coming winter.

The above work was undertaken for a proposed comparative study of the two related techniques of counter-current distribution and paper partition chromatography from physico-chemical standpoint.

APPLICATIONS

(vii) Studies on the homogeneity of rauwolscine, an alkaloid from *Rauwolfia canescens* Linn. and its separation from yohimbine by counter-current distribution.

Rauwolscine was studied by distribution between 2% HCl solution and ethyl acetate in a 16-tube Craig's apparatus. The maxima occurred at the fag-end (13 tube) of the series of tubes. So ether and acetic acid (0.1%) were selected as the solvents. The distribution was carried out as usual and following estimation, it was found that maximum-concentration was attained at the second tube. There was only one sharp inflexion in the pattern and this indicated the homogeneity of rauwolscine as studied in a 24-tube apparatus. The work was extended later on by distributing the material in a 48-tube distribution, the later 24 transfers being effected by means of single withdrawal technique. The distribution pattern demonstrated an inflexion at the 4th tube as also a second one at the 8th tube, as was expected from a 24-tube distribution. Equal amount of yohimbine hydrochloride when studied under identical conditions showed a peak at the 5th tube. A mixture of rauwolscine and yohimbine also showed identical distribution pattern when distributed under identical conditions. Unfortunately the work could not be extended further due to lack of authentic samples of the alkaloids. The gift of samples of rauwolscine and yohimbine by Dr. (Mrs.) A. Chatterjee, University College of Science of Technology, Calcutta and Dr. P. K. Bose of Bose Institute is gratefully acknowledged.

(viii) Studies on the separation of 2-4 DNP's of ketone bodies by means of counter-current distribution.

The counter-current distribution of the 2-4 DNP's of ketone bodies has not been attempted as yet. When distributed in a 24-tube apparatus it was observed that the keto glutaric derivative did not move at all, while other DNP's moved in accordance with their decreasing chain length, the derivative of acetone being at the furthest end of the series of tubes. The ketone bodies included acetone, sodium pyruvate and aceto-acetic acid. Benzene and formamide were selected as solvents. It was expected that with non-aqueous solvents distribution will behave thermodynamically to a greater extent and there will be less deviation from the ideal behaviour due to associative or dissociative effect. The above study forms the basis of an experiment to be undertaken with 100-tube apparatus shortly to arrive in this laboratory, for the effective separation of ketone bodies from natural sources.

Distribution of Be was effected in the system ethyl acetate (upper phase) and 2N-HCl (5 vol.)-liq. NH_3 (1 vol.), butyric acid (4 vol.) in order to provide a new method of obtaining very pure sample of Be directly from beryl. Estimation was carried out gravimetrically. Then a mixture of iron (one of the constituents of beryl) and Be were distributed and pH was adjusted at which iron was arrested in the first tube and Be distributed. The separation of Be from beryl in its ultimate purity is of considerable importance in view of the recent applicability of this light element in atomic science. Further investigation is in progress.

B. 2. Plant Chemistry

B.2.1. *Search for alkaloids.*—The leaves and stem bark of *Murraya koenigi*, the stem bark of *Taddalea aculeata*, and of *Enterolobium saman*, the herb, *Paederia foetida*, and the root bark of *Pavetta indica* have been examined for alkaloidal substances. The last two plant materials were found to be free from alkaloids. The first three materials contained varying amounts of water-soluble alkaloids, which gave characteristic precipitates with Dragendorff's and other reagents. But none of these plant bases could be isolated in crystalline or sufficiently pure condition although many attempts were made to that end.

B.2.2. *Paederia foetida.*—This medicinal herb, which is extensively used as a popular remedy against stomach disorders, has been chemically examined. The unpleasant smell of the plant has been traced to the presence of methyl mercaptan, which has been isolated as the mercury derivative. The details are being published in the *Transaction of the Bose Research Institute*, Vol. XIX.

B.2.3. *Pavetta indica.*—The somewhat bitter root bark of this plant, which is also used in indigenous medicine, has yielded, on extraction with alcohol, a crystalline non-bitter substance identical with *d*-mannitol. No crystalline product or alkaloid could be isolated from the leaves or stem bark.

B.2.4. *Constituents of wood.*—The chemical constituents of wood, specially of heart-wood, has received some attention of late. Some of the constituents have been found to possess antifungal and antibiotic properties. The durability of timbers is believed to be due in part to the presence of fungistatic substances. The heartwood of *Tectona grandis*, *Shorea robusta* and *Swietenia mahogany* have been investigated. The alcohol or acetone soluble matters have been fractioned into acidic and non-acidic portions. From the neutral fraction of *T. grandis*, the already known constituents, namely 2-methylantracene and 2-methyl anthraquinone were obtained. The other fractions of the plant

B.2.5. *Pistacia integerrima*.—The galls which are the results of insect bites on the leaves are used in Indian medicine. Ghosh (*Science & Culture*, 1945, 11, 46), had reported the presence of two crystalline acids in the galls. The structure determination of these compounds has commenced. Incidentally the best method of isolation of the products is being worked out.

B.2.6. *Indian spices*.—Although the aromatic principles or essential oils of many Indian spices have been extensively studied, not much attention seems to have been given to the chemistry of other constituents. Work has therefore been started on the basis of a systematic plan. *Cumin cyminium* has yielded a crystalline flavone glycoside, from which a high melting crystalline aglucone has been obtained on hydrolysis. Further work on this aglycone and on other spices are in progress.

B.2.7. *Other plant constituents*.—Preliminary experiments have shown that the unripe fruits of *Feronia elephantum* contain a lactone, m.p. 213°C., and the mature fruit of *Couropita guaianensis*, a crystalline substance of m.p. 130°–140°C. These are being purified. Microscopical examination indicates that oxidation of the fruit pulp of the latter leading to the formation of a green-blue pigment starts from the peripheral region. The shell oil of *Mesua ferrea* has properties different from those of the kernel oil. A detailed chemical study of mesuol has been taken up and the defatted kernel has been found to contain a colourless crystalline glycoside, m.p. 178–79°C.

B. 3. Chemical Investigations on the Irritability Substances Present in *Mimosa pudica*

B.3.1. *Irritant principle of Mimosa pudica*.—Further efforts have been made, in continuation of earlier work at this Institute, to isolate and purify the active substances responsible for the folding of leaves of *M. pudica*. Many workers have shown that the irritant substance is present in an aqueous extract of the plant. The active principle was precipitated as a mercury compound, the decomposition of which by sulphuretted hydrogen, gave an aqueous concentrate which showed pronounced mimosa or chemonastic activity. This solution gave positive ferric and ninhydrin reactions. It did not respond to the tests for alkaloids, but the presence of reducing substances was proved by alkaline *o*-dinitrobenzene.

When subjected to paper chromatographic analysis (both one and two dimensional), three ninhydrin-sensitive spots were obtained. These were identified as those of glycine, alanine, and glutamic acid.

position with H_2S in aqueous medium gave a solution which did not show any mimosa activity but gave the ferric chloride reaction. The soluble copper compound was freed from copper in the usual manner and the resulting solution showed comparatively more pronounced mimosa activity. By chromatographic technique again, the three amino acids, namely glycine, alanine and glutamic acid, were detected.

Fittig in 1928 tested a large number of water-soluble compounds commonly occurring in plants for their chemonastic properties towards *M. pudica*. He came to the conclusion that glycine, serine, alanine and glutamic acid are the most active, but he or later workers could not specifically demonstrate their presence in *Mimosa pudica* extracts. The findings reported above definitely prove that three amino acids, active towards Mimosa, are present in aqueous extract of the plant. Quantitatively however the three amino acids, in the concentration present in the purified samples, cannot account for the degree of activity. One is therefore tempted to the view that other active but less stable substances are also present in Mimosa. It seems certain that the mimosa activity cannot be attributed to a single chemical substance.

Incidentally ascorbic acid and some energy-rich phosphates such as ATP, ADP, PGA have been shown to be devoid of chemonastic activities. Although ascorbic acid is present in different organs of the plant, its concentration in the motile region (pulvinus) was not significantly higher than in other parts of the leaf system.

B. 3. Chemical investigations on the irritability substances present in *Mimosa pudica*

B.3.1. Irritant principle of *Mimosa pudica*. Further efforts have been made in continuation of earlier work at this Institute to isolate and purify the active substance responsible for the folding of leaves of *M. pudica*. Many workers have shown that the irritant substance is present in an aqueous extract of the plant. The active principle was precipitated as a mercury compound, the decomposition of which by sulphurated hydrogen gave an aqueous concentrate which showed pronounced mimosa or chemonastic activity. This solution gave positive ferric and molybdenum reactions. It did not respond to the test for alkaloids but the presence of reducing substances was proved by alkaline dithionite.

When subjected to paper chromatographic analysis, both one and two dimensional, three alpha-thin-sensitive spots were obtained. These were identified as those of glycine, alanine and glutamic acid.

C. BOTANY

C. 1. Plant Biochemistry

C. 11. CROWN GALL PROBLEM

C.11.1. *Host range for the causal organism : Agrobacterium tumefaciens*

In continuation of the work reported last year, further experiments were carried out with about 25 new plants belonging to various families to find out new hosts responsive to *Ag. tumefaciens* in producing crown gall. As usual, the young plants were inoculated at 3 or 4 different points along the main stem by single needle and multiple needle puncture method with a 72 hours agar plate culture of the causal organism. Out of these the following three plants as given below produced positive response.

No.	Common name.	Botanical name.	Plant family.	Reaction.	Apprx. time for visible gall formation.
1.	Balsam	<i>Impatiens balsamina</i>	Balsaminaceae	+++	15—20 days
2.	Jute	<i>Corchorus acutangularis</i>	Tiliaceae	++	20—30 days
3.	Flax	<i>Linum usitatissimum</i>	Linaceae	+	20—30 days

Plant species belonging to these three families have not yet been reported to be susceptible to crown gall organism.

Inoculation experiments were also carried out successfully to confirm the previous observation of positive reactions in cases of *Bryophyllum*, *Althaea*, *Tropaeolum*, *Antirrhinum*, *Lycopersicum*, *Petunea*, *Tagetes*, *Helianthus*, and *Verbena*.

C.11.2. *Effect of antibiotics on the causal organism and also the gall tumour (with special reference to a factor produced by Pseudomonas aeruginosa (Ps. pyocyanea)).*

A large number of antibiotics have so far been tested by several authors for controlling crown gall tumours. Of these 'Streptomycin' has been claimed to be the most effective as a controller of the crown gall, arresting the initiation of the gall and suppressing the growth of pre-formed galls, when applied locally on the surface. The effect of some of the known antibiotics on the *in vitro* growth of *Ag. tumefaciens*, and

tion it was observed that a strain of the bacterium *Ps. pyocyanea*, maintained in the microbiological laboratory of the Institute possessed fairly strong inhibitory action on *Ag. tumefaciens*. The results were confirmed by repeated experimentation. It was found that the inhibitory factor is an exogenous product of the bacterial metabolism and was obtained in the culture medium.

To find out the optimum conditions required by *Ps. pyocyanea* for the production of this antibacterial substance, experiments were carried out with three different nutrient media and different environmental conditions of growth. Antibacterial activity of the culture medium under these various conditions was examined by the usual Agar cup method of assay at intervals of 48 hours over a period of one month. It was observed that the medium, of the composition: peptone—10 gms, beef extract—3 gms, sodium chloride—5 gms, glycerol—10 gms, distilled water 1000 ml., pH 7.5 (Hays, E. E., 1955) at an incubation temperature of 37°C was the best in this respect and was used in subsequent experiments for the production of the antibacterial substance on a semilarge scale. It was further observed that the antibacterial substance appeared in the medium within 48 hours of incubation and reached the maximum concentration between the 10th and 12th days giving an inhibition zone of about 35 mm. in the assay and thereafter decreased in concentration. Autoclaving had very little effect on the activity of the substance. After the optimum conditions were determined, the substance was isolated on a semilarge scale in a partially purified form.

It is important to note that so far no report has appeared about the antibiotic action of an important bacteria like *Ps. pyocyanea* against an equally important plant pathogen *Ag. tumefaciens* causing crown gall tumour by a process presumed to be somewhat similar to that of tumour formation in animals. Hence it was feared that the present antagonism might have been due to some strain variation. To examine this possibility, a standard strain of *Ps. pyocyanea*—obtained through the courtesy of Dr. Dowson of the Department of Botany, Cambridge University—on comparative experiment was found to reveal positive antagonism towards *Ag. tumefaciens*. It may therefore be suggested that the antibacterial substance produced by the Bose Institute strain is 'pyocyanin' but this has yet to be confirmed.

It is worth noting here that streptomycin though an effective inhibitor of *Ag. tumefaciens*, also suppresses the growth of preformed gall tissue at a period when the presence of the bacteria is not required for gall proliferation. This would suggest a toxic action of strepto-

toxic to host tissue of animals. Considering the suggested similarity of our active factor with pyocyanin, it is worth examining the effect of this substance on the *in vivo* growth of *Ag. tumefaciens* and also on the proliferation of the gall tissue at different times of growth in comparable experiments. The antibacterial substance obtained in partially pure form will be tried in such experiments after further purification.

C.11.3. *Biochemical comparison of non-differentiated and differentiated plant tissue.*

In experiments with tomato tissue it was reported, that two days after inoculation with the bacteria, the protein and soluble nitrogen levels increased in the tumour tissue above that found in untreated controls. It was thought advisable to examine whether the same is true in case of *Bryophyllum*. With this in view experiments were undertaken in the first place to compare the free and bound amino acid contents of normal and infected *Bryophyllum* tissue. The technique of two dimensional paper chromatography using phenol and butanol solvents (phenol saturated with water, and butanol, acetic acid and water in the ratio 4 : 1 : 1) was employed for the identification of the amino acids. Considerable difficulty was experienced in the separation of the amino acids due to the presence of appreciable quantities of interfering material. Various methods, including the recently tried ion exchange column chromatography (Dowex-2) were used to eliminate this difficulty without much success. Modification of this technique using other grades of resin will be undertaken soon.

From the results obtained so far it may be inferred that about 16 amino acids are present in normal tissue besides at least two peptides (red colour with ninhydrin) having very low R_f values both in phenol solvent and butanol solvent in one dimensional chromatograms. The two peptides, however, separate on a two dimensional chromatogram only when the butanol solvent is used after the phenol solvent and not *vice versa*, giving two distinct spots, having identical R_f values in the phenol direction but different R_f values (0.03 & 0.07) in the butanol direction. Further identification of the peptides would involve their more efficient separation and recently experiments are on the way with this purpose in view. The following different solvent compositions are being used for this purpose:

- i) Ethylacetate, acetic acid, water, in various proportions *viz.*, 4 : 3 : 3, 5 : 2 : 5, 3 : 3 : 1.
- ii) 70% Ethanol.
- iii) *n*-Butanol saturated with water.

- v) Acetic acid, water; 7 : 3 and 1 : 1.
- vi) Isopropyl alcohol, water; 7 : 3.
- vii) Butanol, acetic acid, phenol saturated with water; 4 : 1 : 1.

The mixed peptides were separated on a semilarge scale by band development in butanol solvent using a modified technique to reduce the normal running time of 20–22 hrs. to only 10 to 12 hrs. and isolated by elution in water. The isolated peptide mixture was hydrolysed to the constituent amino acids by treatment with 11N HCl for 24 hours, and the amino acids identified by two dimensional paper chromatography. Preliminary experiments suggest the presence of 4 to 5 amino acids in the substance, but final picture will be obtained only when the two peptides could be separated satisfactorily.

C.12. BIOCHEMICAL INVESTIGATIONS IN ALGAE

C.12.1. *Collection and cultivation of algae.*

The collection of different species of algae belonging to *Chlorophyceae* and *Cyanophyceae* and their isolation in pure form were undertaken during the course of the year under review. So far, of the *Chlorophyceae*, four species of *Chlorella* and 2 species of *Scenedesmus* have been isolated in pure bacteria free unialgal state and are being so maintained. Among them two species of *Chlorella*—*C. pyrenoidosa*, and *C. vulgaris* and two species of *Scenedesmus*—*S. obliquus* and *S. species* are maintained in Beijerinck's nutrient solution supplemented with micronutrients. The other two species of *Chlorella*, *C. variegata* and *C. ellipsoidea* are not yielding satisfactory growth in the above mentioned medium at room temperature and the present condition of lighting. Allen's modified solution, and Benson *et al.* solution have been tried as alternative culture medium for these species but no promising result has yet been achieved. Some of these cultures are being used for biochemical studies.

Among the *Cyanophyceae*, *Nostoc muscorum* and *Hapalosiphon* species have been obtained in pure form and are so maintained. Different culture media were tried in this laboratory to ascertain the conditions for the maximum growth of these forms. Of these Chu No. 10 and Beneck's solution, supplemented with micronutrients (Cu, Mn, Zn, B, Mo) are found suitable. *Nostoc muscorum* is being used for the investigations on the chemical nature of the central body in *Cyanophyceae*, (reported later).

Mass culture of green algae as a possible source of nutritional protein and fat is under contemplation and with this in view, isolation of suitable strains of algae for open air culture under tropical conditions is in progress. As a matter of fact algae in general prefers a compara-

worthwhile to find out high temperature tolerant strains for this purpose, which obviously would eliminate the cost and difficulties of maintaining the culture at 25°C. At the same time it may be presumed that a thermophillic strain will work more efficiently in the conservation of solar energy. It was brought to our notice that wide varieties of algae grew profusely, some of them even at as high a temperature as 60°C., in the hot spring of Bhimbandh area near Monghyr in Bihar. A survey was made of these hot springs and a number of collections were made during last February on the basis of the different temperatures of the source springs. Examinations in the laboratory reveal the presence of the following species in the hot springs at different temperature ranges as mentioned against the species:

Cyanophyceae.	Temp.
1. <i>Phormidium lamilosum</i>	50°C—60°C.
2. <i>Mastigocladus lamilosus</i>	60°C
3. <i>Calothrix sp.</i>	52°C
4. <i>An unicellular form (unidentified)</i>	50°—64°C.
Chlorophyceae.	
5. <i>Cladophora sp.</i>	40°—45°C.
Bacillariophyceae.	
6. Some species of <i>Diatoms</i>	

The unicellular form which has not yet been identified though blue green in colour, does not correspond with the detailed characteristics of any unicellular species belonging to Cyanophyceae, and may possibly turn out to be a pigmented bacteria on further examination.

Experiments are on the way to obtain these species of algae in pure form. As soon as that has been achieved studies of the conditions for the optimal growth of these forms will be taken up.

In the meantime a rocking tray table with arrangements for illumination and aeration has been designed to be used for the semilarge-scale culture of the algae. One of the serious handicap in the work with algae has been the want of a suitable temperature controlled room with facilities for adequate illumination and aeration of the cultures. The proposed room of the desirable type as being now set up on the demifloor of the eastern wing of the main buildings, will provide a standard condition for the growth of the algae round the year and will be of immense value in the progress of these studies.

C.12.2. Studies on the nutrition of algae.

the algae is grown in the basal nutrient medium, the pigment does not develop and gradually the culture becomes colourless, even in presence of light. Yeast extract added to the medium restores the pigmentation within 6-7 days of growth, but the green coloured cells when transferred to the basal medium, give rise to colourless cells again. Thiamin, riboflavin, adenine, or caseinhydrolysate used separately is not capable of replacing yeast extract in reviving pigmentation. The five micro-nutrients Cu, B, Mn, Zn & Mo, were added separately each in a higher concentration to the medium, and it was interesting to observe that Mo in a higher concentration (0.4 mg/lit. compared to 0.1 mg/lit. in the basal medium) had the desired effect of restoring the colour in the colourless form; the pigment developing within 3 to 4 days of inoculation in this enriched medium. This experiment shows that molybdenum plays an important part in the development of the pigment in this form and under present experimental conditions, 0.4 mg/lit. is found to be the optimal concentration of the element.

Deficiency of molybdenum is known to reduce the activity of nitrate reductase, the enzyme fundamentally responsible for the synthesis of all organic nitrogenous substances in systems where the only source of nitrogen is inorganic nitrogen. The possible difference in nitrate reductase activity in the green and colourless cells and if so a correlation of the enhancement of nitrate reductase activity with the revival of pigmentation in presence of a higher dose of Mo should be examined carefully to explain the role of molybdenum and possibly of nitrate reductase in the synthesis of the green pigment in this form. Experiments are now in progress on these points.

C.12.3. *Biochemical studies on the central body in Cyanophyceae.*

The central body in Cyanophyceae is a point of interest and its biochemical nature is yet to be established. The overall nature of the central body, however, is a matter of lively debate as it differs from the conventional type of nucleus, in having no nuclear membrane and also in its mode of division. The cyto and histochemical nature of the central body and its protein moiety has been shown to be parallel with the characteristic of chromosomes of higher plants. A detailed study of the nucleic acid in this form is likely to throw interesting light on this problem and has been taken up recently.

The nucleic acids are isolated from *Nostoc muscorum* using the conventional methods of Schmidt and Thaunhouser and of Schneider.

Desoxyribonucleic acid (DNA) has been precipitated from the alkali solution of the cells with 10% trichloroacetic acid solution and

test in diphenylamine reaction (Dische reagent). The purified acid is hydrolysed with IN HCl, and the constituent products thus obtained were analysed by paper chromatography. The chromatogram showed only two spots of bases corresponding to guanine and adenine, but the pyrimidine bases are lacking. Further investigations are now in progress to elucidate this point.

Ribonucleic acid (RNA) has been precipitated from the DNA filtrate with the help of alcohol, after removal of lipoids and polysaccharides, and further purified from nucleoproteins by extraction with chloroform amyl alcohol mixture. RNA thus purified has been tested for ribose sugar and gives positive reaction in Orcinol test (Mejbaum test). The purified product was hydrolysed with IN HCl and analysed by paper chromatography. The chromatogram reveals four spots corresponding to guanine, adenine, cytidylic acid, and uridylic acid. Molybdcic acid reagent for nucleotides was used for the identification of the latter two compounds on the chromatogram.

Radioactive isotopes of carbon C^{14} , and of phosphorus P^{32} are being used in the study of the constitution of the central body nucleic acids. The missing spots corresponding to the pyrimidine bases in the DNA may be due to the amount of the base being much too small to be detected on the chromatogram and, if so, application of C^{14} as a tracer might help its detection. At the same time, the use of P^{32} is likely to throw light on the exact nature and turnover of nucleic acids in Cyano-phyceae.

C. 13. APPLICATIONS OF TRACER TECHNIQUE

C.13.1. *Applications of C^{14} and S^{35} in studies on photosynthesis and dark fixation of CO_2 .*

It has been postulated that the sulphur containing compound thioctic acid plays an important role in the fixation of CO_2 by green plants, in diverting it into two different pathways according to the presence or absence of light. Experiments are being undertaken in collaboration with Dr. S. P. Sen of the Department of Microbiology to examine this hypothesis in detail; the green algae, *C. pyrenoidosa* is allowed to fix CO_2 in presence of radioactive S^{35} both in dark and in light. The resulting metabolic products, under the two different conditions, are analysed for the compounds containing radioactive S^{35} ; for detailed report, C.14.1 may be referred to.

C.13.2. *Studies in the phosphorus metabolism in higher plants using radioactive isotope of phosphorus P^{32}*

C.13.2.1. *Glycolytic enzymes and intermediates of glycolysis in mung bean*

to study the sequence of incorporation of radioactive P^{32} into the different phospho-intermediates of glycolysis and phospho-adenine nucleotides in mung bean and gram. The technique of steeping was the same as reported last year and the phospho-compounds were extracted in 10% trichloroacetic acid and fractionated into 'Ba-insoluble' and 'Ba-soluble' fractions and analysed by paper chromatography and radio-autography.

The experiments confirmed the earlier observations that in the steady state the glycolytic intermediates like G-1-P, G-6-P, FDP, PGA become labelled earlier than the nucleotides. A few other spots, as yet unidentified, appear at an early stage. Whether these spots are due to other phospho-intermediates, or phosphopyridine nucleotides, or phytic acid is yet to be studied. Lack of authentic known compounds prevented us from clarifying this point.

From the results it may be presumed that the pattern of glycolytic breakdown of carbohydrate in mung bean, if not wholly, at least upto the triose-phosphate stage, is essentially the same as that found in animal muscle and yeast and also as reported in pea. The comparative ease with which inorganic P^{32} finds its way into the glycolytic intermediates suggest the presence of the chain of glycolytic enzymes in pea seedlings in a fairly active stage. Considering that the enzymes phosphorylase, phosphoglucomutase and hexokinase are yet to be isolated in a pure form from plants, it appears that mung bean may serve as a suitable source material. During the present year work on the isolation of these enzymes is to be taken up when the contemplated enzyme laboratory is completed with the requisite apparatus which has started arriving from abroad.

Considering the sequence of appearance of label P^{32} in ATP, ADP and AMP, the presence of the enzyme myokinase in mung seedling is suspected. Myokinase has been found in kidney, liver and mitochondria in animals and also in yeast. Recently its presence has been suggested in plants. Experiments are being undertaken to throw more light on this point.

C.13.22. *Paper chromatographic separation of sugars*

A method for satisfactory separation of sugars on paper chromatogram is essential for further studies on the glycolytic enzymes, as a combination of identification of the phospho-esters and the hydrolysis of the esters, can serve as the requisite experimental method in following the activity of the enzymes.

Several methods for the paper chromatographic separation of

therefore thought advisable to standardise the method of separation of the sugars.

Different solvent mixtures were tried out, using circular and unidimensional methods of development. The picric acid, tertiary-butanol, water solvent combination (2 gm, 80 ml 20 ml. respectively) as recommended by Buchanan was found to be satisfactory but not entirely. To improve the resolution, the composition of the solvent was changed by varying the concentrations of the components. It was observed that the alcohol and water could not be varied beyond a limited range to produce any improvement, whereas the picric acid concentration could be reduced substantially to 0.25%. The descending technique of unidimensional method produced the most satisfactory resolution of the sugars studied. Thus with a solvent composition picric acid, 0.25%; tertiary butanol, 80 ml.; water 20 ml., a satisfactory resolution of galactose, glucose, arabinose, xylose, maltose and sucrose has been achieved in unidimensional descending chromatography.

One of the peculiarities of the Picric acid solvent appears to be that the acid tends to move slower than the alcohol water mixture, or in other words two solvent fronts, one of the acid containing component and the other without the acid is obtained. However, the R_f values of the sugars remain constant with respect to the picric acid containing front. The movement of the solvent is somewhat slow but a satisfactory separation of the sugars is obtained when the picric acid containing front moves a distance of about 22 cm, from the point of application of the sugars (about 25 cm for the other front) and this would require a running time of about 12 to 15 hours. A smaller run is unsatisfactory and a larger run is of no extra benefit.

This solvent composition however does not separate arabinose and laevulose satisfactorily. It has been reported that solvent combinations comprising ethylacetate, pyridine, water or ethylacetate, acetic acid, water can resolve these sugars. Theoretically it appears that in a two dimensional system, using picric acid, tertiary-butanol, water, and one of the latter two solvents, a satisfactory separation of the sugars is possible. At the time of writing, experiments are being conducted with this in view.

C. 14. RADIOCHEMISTRY

C.14.1. *Mechanism of photosynthesis and sulphur metabolism in plants :*

According to Melvin Calvin's latest hypothesis, the distribution of CO_2 into photosynthetic and darkfixation products is controlled by the disul-

actually takes place in light and in darkness has not been demonstrated experimentally. If this hypothesis is correct it may be expected that when photosynthesising green cells are allowed to metabolise $\text{Na}_2\text{S}^{35}\text{O}_4$, S^{35} will find its way into the dithiol form of 6, 8-dithiooctanoic acid molecule; when light is turned off, this dithiol form will be converted to the disulphide form to facilitate the entrance of CO_2 into the Krebs cycle acids *via* acetyl Coenzyme A, which is also a sulphur containing compound and be thus detectable on paper chromatograms.

Growing cells of *Chlorella pyrenoidosa* were allowed to metabolise $\text{Na}_2\text{S}^{35}\text{O}_4$ at pH 6.5–7.0 for $\frac{1}{2}$ hour in light. At the end of $\frac{1}{2}$ hour, half of the suspension was poured into hot 80% ethanol and the remaining half subjected to darkness for another $\frac{1}{2}$ hour. The extracts were then chromatographed two dimensionally on Whatman's No. 1 filter paper with phenol-water and butanol-acetic acid-water as the developing solvents, followed by radioautography with Ilford X-ray films. Activity of individual compounds was obtained directly from the paper chromatograms with a large end-window scintillation-counter.

It was found that in $\frac{1}{2}$ hour as many as 20 compounds were labelled with S^{35} . There was however no marked difference between the chromatograms of the photosynthetic and dark metabolism of S-containing compounds. Since $\frac{1}{2}$ hour may not be enough for S^{35} to appear in the lipoic acid molecule the period of light and dark treatment was extended to 4 hours each. Some 40 compounds were tagged with tracer sulphur. The most interesting change was observed in a compound which produced an unusual large spot having high R_f values in both the solvents used and possessing high radioactivity.

The large number of S^{35} labelled compounds detected in only 4 hours indicates that S-containing compounds in plants are more abundant than is usually believed. Identification of the compounds, delayed largely due to the non-availability of the authentic samples of the suspected compounds, is expected to be completed in the near future. Probably a large number of them belongs to derivatives of coenzyme A, lipoic acid, glutathione etc., and their biogenetic intermediates, apart from the well known sulphur containing amino acids.

C.14.2. *Path of sulphur in sulphate reduction*: The experiments described above prompted an investigation on the path of sulphur in sulphate reduction in green plants. For this one set of pea seeds was germinated on filter paper with distilled water and the other set was grown on soil. When the seedlings grown on soil were 2–3" high their roots were removed and immersed in phosphate-buffer containing $200\mu\text{c}$ of $\text{Na}_2\text{S}^{35}\text{O}_4$ in darkness. These were extracted with hot 80%

15 minutes. Chromatography and radioautography followed as described above.

Five minutes were enough for the incorporation of S into as many as 6 compounds. Label appeared in other compounds as the experimental period was increased. The most interesting observation is the very early appearance of label in taurine (2-aminoethanesulphonic acid). It has been shown very recently (*J. Biol. Chem.*, 212: 469, 477, 1955, published during the progress of this work) that same is the case with developing chick-embryo supplied with S^{35} as sulphate. It is also interesting to note that large amount of 2-hydroxyethanesulphonic acid occurs in squid giant nerve fibres (*Proc. Nat. Acad. Sci. U.S.*, 40: 60, 1955); taurine has not been unequivocally demonstrated to occur in plants. The significance of taurine in plant metabolism is obscure.

The similarity of products of sulphate reduction in the roots and leaves indicates that sulphate reduction probably follows the same pathway in both tissues.

C. 2. Plant Physiology

C.2.1. Quantitative determination of the sap expelled from the pulvinus of *Mimosa* due to excitatory contraction.

In previous reports it had been shown that the sap expelled out of the pulvinus due to excitatory contraction partially flows through the cut end into a potometer and the rest escapes through the pores on the surface of the plant material. The total quantity of sap expelled out of the pulvinus is determined from the excess quantity absorbed over normal suction of the plant material from the potometer during recovery. The quantity of sap escaping through the pores is determined by subtracting the quantity of expelled sap through the potometer from the excess quantity absorbed during recovery. It has also been reported that the quantity of outflow of sap through the cut end depends upon the resistance of the path-way. It has been previously mentioned that the specimen specially prepared for the experiment has three cut surfaces; one is at the lower end of the stem, the other at the upper end, and the third at the petiole attached to the stem piece. When one cut end is introduced into the potometer the remaining two are sealed with collodion flexile. It had been shown that when the petiolar end is introduced into the potometer the quantity of outflow through the potometer is the greatest, indicating that the petiolar pathway offers the least resistance to the movement of sap. The sap encounters greatest resistance in outflowing through the upper cut end of the stem, and

outflow through the lower cut end is much higher than through the upper. Later it has been found that when the stem portion is young and tender the outflow of sap through the lower cut end is quantitatively much less than that obtained with mature stems. This shows that in the tender portion of the stem, passage of water through the surface pores receives less resistance in comparison to the mature stem. It was observed in preliminary experiments that specimens selected from the mature portion of the stem was most suitable for observing the outflow of sap through the potometer. Hence in studying the preferred path of the exuded sap through the different cut ends, the 4th or the 5th leaf was generally selected.

C.2.2. *Study of the diurnal variation of moto-excitability of Mimosa pulvinus.*

It has been previously reported that the study of the diurnal variation of moto-excitability of *Mimosa* has been undertaken with the help of an automatic device for giving a measured electric stimulus at intervals of one hour. A series of records have already been taken both during the winter and summer months.

A difference in the responsive behaviour of the contract pulvinules has been observed between young and mature leaves. In young leaves the amplitude of response considerably diminishes or totally disappears at night, the difference being more marked in winter. In mature leaves such variation is not conspicuous. In excised condition the diurnal variation of response sometimes disappears on application of glucose.

The leaf exhibits different nyctinastic movements in winter and summer. In winter there is a rapid down movement in the evening, followed by a sharp rise after a few hours. When the leaflets are totally discarded the movement of the petiole stump is not in any way different from the movement of the whole leaf. This indicates that the movement is only dependent on the activities of the pulvinus and it is not influenced by the presence of the leaves. In complete darkness the peculiar evening movement disappears. By covering the pulvinar portion with black paper also, the evening movement has been found to disappear in most cases.

In summer when the temperature is high, the leaf does not exhibit any fall in the evening; instead there is slight gradual rise after the onset of darkness. It has been found in some cases that when the plant is enclosed in a blotting paper chamber, whether moist or dry, the evening fall of the leaf reappears even in summer. Here mention may be made that inside the blotting paper chamber the intensity of light is below 50 foot candle (F.C.) whereas, in open condition it is 175 F.C.

the nyctinastic movement. But the turgidity condition of the pulvinus which is directly associated with the movement, must be influenced by temperature and humidity. Therefore, in arriving at a definite conclusion regarding the movement, the individual effects of these two environmental factors also requires to be separately elucidated. Temperature records have been taken all through. A suitable device for recording the humidity is also under construction. It is expected that a complete explanation of different nyctinastic behaviours can be obtained when all the factors have been critically assayed.

During the above experiment it has further been observed that the young leaf of *Mimosa* occasionally executes autogenic responses. From results of some experiments it appears that sudden changes in environmental factors, such as light and temperature or any change of internal hydrostatic pressure, may induce a stimulatory effect in causing the responsive movement.

From the study of records it appears that on many occasions with the application of stimulus the negative response is preceded by a quick positive response. This has been found to occur mostly at night.

C.2.3. *Relation between applied electric potential and growth of Avena coleoptile.*

In measuring the electric potential of plants different workers have observed that the apex of the shoot is negative in relation to the base. The significance of electrical potential differences has been considered in accounting for the growth substance transport. In explaining the cause of geotropism Cholodny suggested that the transverse translocation of auxin is produced by an E.M.F. which is itself caused by the action of gravity. Such E.M.F. was first observed by Bose. It has been observed by others in studying the tropic movements of plants that a suitable electric potential is first initiated before the commencement of tropic curvature. That the applied E.M.F. can also bring about a redistribution of hormone in the plant organ with the consequent curvature in suitable direction, has been shown by some workers. The object of the present investigation is to observe whether the direction of the applied E.M.F. can influence the natural flow of auxin from tip towards base and thereby inducing change in growth rate as well.

The new device of recording the growth of coleoptile has been described in a previous report. For application of electric current of definite strength a suitable potentiometer has been constructed. Current strength from .8 to 1.2 micro amp. when applied in the descending direction through the coleoptile, has been found to accelerate growth. Whereas, in ascending direction the same current has been found to retard growth. It is to be noted that the normal electrical polarity of coleoptile, when observed through a galvanometer is negative

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the plant however, though there is a difference of potential at the two ends, no current flows within the tissue. It has therefore to be determined how the growth is effected when the current produced by plant's own E.M.F. is allowed to flow into the tissue through a galvanometer.

C.2.4. *Effect of contractile response of the pulvinus of Mimosa on its respiration.*

This experiment was further continued with some modification. In order to minimise the inclusion of respiration of other tissues attached to the pulvinus, the stem portion was totally discarded leaving only a portion of the petiole attached to the pulvinus. The pulvinus, even in such condition, was found to respond to stimulus. The petiolar end was dipped in water inside the micro-respirometer, the pulvinus being free to move. But no definite change in the rate of respiration was recorded by the responsive movement. The experiment was also performed with a more sensitive respirometer; still no change could be observed.

C. 3. Cytology

C.3.1. *Active substance present in contractile pulvini*

From staining of sections with safranin and other dyes, the pulvini of different plants with motor pulvini, whose contractility can be classified from very active to inactive, J. C. Bose had found that their stainability was proportional to the degree of contractility of the pulvini. Molisch had also observed that by using his stain II, these pulvini section took a deep stain, due to the presence of what he calls phloroglucotannoid compounds. The presence of tannin vacuoles in such pulvinar cells had also been observed in investigations, by Guillermond, Weintraub, and others.

From investigations which were carried out during the year, it was found that the same kind of cells are present in the active pulvini of different plants; these react similarly to the different staining techniques which are enumerated below

The plants experimented with belonged to two groups:— (a) which show nastic movement on stimulation, like *M. pudica*, *M. spegazzinii*, *Biophytum sensitivum*, *Averrhoa carambola* and, (b) which show autonomous movements like *Desmodium gyrans* and *Oxalis repens*.

(a) From the different tests employed the following conclusions may be deduced—

(i) the tannin bodies present in the contractile cells exhibit

(ii) the vacuoles contain tannin compounds, as determined by the following tests : Molisch's reagent II, reduction of osmic acid, blue coloration with HCl and osmic acid.

(iii) the vacuole is separated from the cell protoplasm by a semi-permeable membrane, which has selective permeability to safranin, neutral red and other staining dyes. The membrane is destroyed by extreme heat as well as by cold treatment; when its semipermeable nature is destroyed, the dye materials and tannin entrapped in it can diffuse out into the cell protoplasm.

(iv) on stimulation the pulvinus cells of the lower side contract, leading to the expulsion of sap as observed by Dutt and Guhathakurta (C 2.1). This sap comes primarily from the contractile vacuole. With the recovery of the cell after stimulation, the contractile vacuole resumes its previous dimension *i.e.*, during expulsion from the cell, the membrane bounding the cell as well as the vacuole lose their selective permeability for certain electrolytes, but so far as observation goes not to the tannin material enclosed inside the vacuole.

There seems to be a great deal of similarity between these contractile vacuole and those found in other contractile cells of animal origin like amoeba, which also possess a contractile vacuole.

(b) The pulvini with autonomous movement like *D. gyrans* and *O. repens* have also similar stainable vacuoles enclosing tannin materials. In some respects their behaviours are different. These are being investigated.

C.3.2. *Studies on mitochondria present in active, semiactive, and inactive plant tissues.*

This is a continuation of the previous year's work, on the study of mitochondria in the pulvini of *Mimosa pudica* L. For the purposes of comparison secondary pulvini of *Averhoa*, *Sesbania*, Bean etc. have also been studied. Mitochondria have been found to be abundant in the primary, secondary and tertiary pulvini of the *M. pudica*. Longitudinal section of the tertiary pulvinus of this plant shows some variation in the density of mitochondria; they appear more dense in the upper and less dense in the lower half of the pulvinus. In the secondary pulvinus, mitochondria appear more dense towards the inner side of the section in relation to the primary axis taken as centre. Mitochondria appear more dense on the lower side of the primary pulvinus. Movement of cytoplasm has often been noted in some cells of the pulvini. Here the mitochondria show two types of movements (i) a transposition of the mitochondrion from one part of the cell to the other part along

quick or the movement may stop abruptly, forming a colony of small granules which later begin to move again. A few spindle-shaped, very few rod-shaped and mostly granular mitochondria are seen in sections of living specimens examined in dilute solution of Janus green B. Here, the mitochondria on the superficial layer, appear mostly hypertrophied, wider and vesiculated but the smaller, non-vesiculated granular mitochondria are seen in the deeper layer of the section. In some cells, Brownian movement is often noted. There are some fat and oil bodies and a few small chloroplast inside the active cells. Two types of vacuoles have been observed in the sections of the pulvini: (a) There are some voluminous, higher refractive yellowish coloured vacuoles, rich in tannin. They are vitally stained by dyes like neutral red, methylene blue etc., and they turn black in dilute osmic acid. (b) The second type of vacuoles are the smaller ones, not shining like the first and they show no reaction with osmic acid, but are stained by dilute solution of neutral red. In the semiactive secondary pulvinus of *Averrhoa*, the mitochondria appear to be fewer than in the secondary pulvinus of *M. pudica* and in the inactive secondary pulvinus of Bean, the number of mitochondria were least, when compared to the first two. In the secondary pulvinus of *Averrhoa* the big, refractive vacuoles with tannin are found mostly on the upper surface, but no such vacuoles have been noted in the secondary pulvinus of Bean. Following several mitochondrial techniques, mitochondria have been observed in permanent preparations. Both the living and fixed preparations give the same mitochondrial picture in form and structure.

C. 4. Cytogenetics and Plant Breeding

C. 4. 1. COTTON.

C.4.11. Cotton breeding investigations.

Detailed studies were made of 411 strains, which included 5 crosses in the F_1 generation between Sea Island and other economic types, the rest being reciprocal, cyclic and multiple crosses up to the F_{11} generation.

Among the parent types, CO₄-B40-21 and 7682 may be considered to be the best yielders under the environmental conditions at Falta with 42 and 40 bolls in their best plants and with an average yield of 16.4 and 15, respectively. Moreover, the lint length and ginning percentage were also favourable, viz., 34.5 and 35 mm. and 35.3 and 36.9 respectively. Among the hybrid strains in the F_{11} generation, the best plant in CO XI 4F had 36 bolls with an average yield of 21.3

good strain, combining a fairly good yield, lint length, ginning percentage and earliness.

In F_{10} generation, $4463 \times \frac{289F}{124}$ and $\frac{289F}{43} \times CO_2$ were good yielding types, both with respect to the maximum number of bolls and the average yield per plant, which were 39 and 16.9 in the former type and 39 and 16.3 in the latter. But as regards earliness in flowering in 1954-55 season, $6097C_6 \times CO_2$ was the best, taking only 63 days. It yielded 34 bolls from its best plant, the average being 16, and the lint length was 34 mm. with ginning of 36.4%.

In F_9 generation, $7727G_3 \times IX \times CO_2$ was found to be one of the best types. It was early flowering taking only 62 days for the first flush in the 1954-55 season. Its lint length and ginning percentage were 33 mm. and 35.7 respectively and had 38 bolls in the best plant with average of 21.6 per plant.

Among the multiple crosses in the F_9 generation ($CO_3 \times 5286BVI$) $IX \times 920$ had 44 bolls in its best plant with an average of 22.6. It was also an early flowering type requiring 66 days for the first flush and its lint length and ginning percentage were 32.5 mm. and 38.9 respectively.

In F_8 generation, $\frac{289F}{43} \times VIII \times 7733-8$ had 38 bolls in its best plant with an average yield of 23 bolls per plant. The types $7733-8 \times VIII \times \frac{289F}{124}$, $CO_4 \times VIII \times \frac{289F}{124}$, $[7733D32e4 \times (CO_3 \times CO_4) \times R.A. \times SG.A.] \times VIII \times \frac{289F}{43}$, $7733-8 \times VIII \times \frac{289F}{43}$ and $6097C_6 \times VIII \times 4F$ with 39, 34, 34, 34 and 38 in their best plants and with average yields 22.9, 20.5, 22.0, 28.8 and 27.0 bolls were fairly good and their lint lengths and ginning percentages were also satisfactory.

In the F_6 generation, types $CO_4 \times VI \times (CO_2 \equiv 4F)$, $(CO_4 - CO_2) \times VI \times (CO_2 \equiv 4F) \left[\frac{289F}{43} - \frac{(289F - CO_2)}{43} \right] \times VI \times (CO_2 \equiv 4F)$ had 32, 39 and 41 bolls in their best plants with average yields of 24.2, 20.0 and 28.9 respectively, and with the ginning percentages of 38.6, 33.3 and 33.3.

In F_5 generation, type $(CO_2 \equiv 4F) \times V \times 7682-14-E_2$ had 51 bolls in its best plant and the average number of bolls per plants was 28.8. Its lint length was 31.5 mm. and ginning percentage was 38.5. Next to it was $7682-18B \times V \times 5286B \times VI$, with 49 as the maximum number of bolls and 28.8 as the average figure per plant.

In the reciprocal types, $(5286BVI-6097C_6) \times VIII \times 6097C_6$, had

diated types. The average yield per plant, lint length and the ginning percentage for this type were 22.7 bolls, 32.5 mm. and 35%.

C.4.12. *Irradiation experiments in cotton.*

During the year, due to some technical difficulties, X-ray irradiation of the seeds could not be done in time. These were available only in December and thus the sowing of the irradiated types was unusually late. Nine types, including four parent types, one hybrid in F_9 generation and four in F_{10} generation were irradiated and sown.

The treatments given were 25 m.a.H., 50 m.a.H., and 75 m.a.H. on the dry seeds. All these were sown with their respective controls in four replications. Due to late sowing, and the droughty conditions some of the plants did not survive up to the fruiting stages. The results with regard to the yield and ginning percentages in the surviving plants in treatments were however favourable when compared to their respective controls. But the lengths of the lint did not increase by the treatments, as in the previous years.

With 25 m.a.H., the increase in ginning percentages in 7682, was about 10%, in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$, about 10%, in $7727G_3$ IX 5286BVI about 6.5%, in CO_4XLSS about 7%, and $920 \times CO_2$ about 10%, while in $7682-14-E_2$ there was a decrease of about 7%. The increase in the number of bolls in the best plants of these types over their respective controls were, 9 bolls in 7682, 85 bolls (about $9\frac{1}{2}$ times more than control) in $7682-14-E_2$, 18 bolls in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$, and 2 bolls in CO_4XLSS , but in $7727G_3$ IX 5286BVI and $920 \times CO_2$ these were lower by 1 and 2 bolls respectively than the control.

With the 50 m.a.H. treatment, increase in ginning percentages were found to be about 12% in $7682-14-E_2$, about 7% in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$, about 8.5% in $920X4F$, about 7% in CO_4XLSS and about 7% in $920 \times CO_2$. It is lower in 7682 by about 5.5% and in $CO_2 \times 4F$ by about 5.5%. Increase in the number of bolls in the best plant of each type over the controls, were observed in 7682 by 8 bolls, in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$ by 17 bolls, in CO_4XLSS by 1 boll, in $CO_2 \times 4F$ by 14 bolls, and in $920 \times CO_2$ by 16 bolls, while it is lower in $7682-14-E_2$ and $920 \times 4F$ by 2 and 1 bolls respectively.

In the treatment with 75 m.a.H. the increase in ginning percentages were about 14% in 920, about 10% in $920 \times 4F$, about 3% in $CO_2 \times 4F$ and 10% in $920 \times CO_2$, while it was lower by about 1.5% in 7682, about 4.5% in $7682-14-E_2$, and about 10% in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$. The increase in the number of bolls in the best plants of each type over the controls were, 5 bolls in 7682, 4 bolls in $7682-14-E_2$, 17 bolls in $7682-21 \times \{CO_4 \times (SG \times S1)\} \times 4456$, 1 boll in CO_4XLSS , 14 bolls in $CO_2 \times 4F$, and 16 bolls in $920 \times CO_2$.

S1)} $\times$ 4456, 3 bolls in 920, 10 bolls in 920 X 4F, 10 bolls in CO₂ X 4F and 2 bolls in 920 X CO₂. It was thus observed that the best plant in this treatment had greater number of bolls in all the types. But the behaviour of these higher yielding plants in the subsequent generations will have to be studied, before their economic importance can be assessed.

During the year, some crosses could be successfully made between Sea Island and CO₃ and Sea Island and some hybrids which were in the F₁₀ generation. The data for ginning percentage and the number of bolls produced per plant were not available at the time of reporting. The period for the first flush in all cases excepting one was 86 days or less and the lint lengths in three of the crosses were more than 1 $\frac{3}{4}$ ". But their behaviour in the subsequent generations will have to be studied.

G.4.13. Cytogenetical investigations.

Karyotype analysis of five types of Asiatic Cotton, belonging to *Gossypium arboreum*, viz., KI, C-II-2, 7036, 7070 and 7067 has been done.

During the course of this investigation, it has been found that there were a fairly large number of satellites and secondary constrictions, including a pair of chromosome with supernumerary constrictions, as seen in the varieties C-II-2, 7067 and 7070, which have not so far been reported.

The chromosome complement has been classified into nine types:

Type A—Chromosome with a primary constriction and two secondary constrictions (supernumerary)—one as a typical satellite and the other with a secondary constriction.

Type B—Similar to type A, but differing in the lengths of the arms of the chromosomes.

Type C—Chromosome with nearly median primary constriction and a satellite on the shorter arm.

Type D—Chromosome with submedian primary constriction and a satellite on the shorter arm.

Type E—Similar to type D but with a thick satellite knob.

Type F—Chromosome with nearly submedian primary constriction and a secondary constriction on the longer arm.

Type G—Chromosome with submedian primary constriction and a secondary constriction on the longer arm.

Type H—Chromosome with submedian primary constriction only.

Karyotypes of different types.

G. arboreum var. *typicum* KI—One pair of D, one pair of E, three pairs of H and eight pairs of I form the somatic complement of this type.

G. arboreum race *indicum* var. 7036—One pair of E, one pair of F, three pairs of H and eight pairs of I, form the somatic complement of this type.

G. arboreum race *indicum* var. C-II-2—One pair of D, one pair of G, five pairs of H and five pairs of I, form the somatic complement of this type.

G. arboreum race *indicum* var. 7067—One pair of A, one pair of B, one pair of G, three pairs of H and seven pairs of I, form the somatic complement of this type.

G. arboreum race *indicum* var. 7070—One pair of B, one pair of C, two pairs of E, two pairs of G, one pair of H and six pairs of I, form the somatic complement of this type.

An attempt has also been made to trace the phylogenetic relationships of the types studied. In this series, KI and 7036 have been considered to be more primitive, for it has been pointed out already that both these types are without any typical secondary constriction. C-II-2 has a karyotype intermediate between 7067 and 7070 on one hand and 7036 and KI on the other, in having a pair of G type chromosome, which is secondarily constricted. Among the types 7070 and 7067, the former has been placed higher in the grade, as it has altogether 14 secondary constrictions, both as satellites and typical secondary constrictions, including one pair of chromosomes (B type) with supernumerary constrictions. But the type 7067 has only 10 secondary constrictions, including two pairs of chromosomes with supernumerary constrictions. The absence of the A type chromosome in 7070 followed by increase in the number of chromosomes with secondary constrictions may be explained on the basis of simple translocations between chromosomes with secondary constrictions including type A and those without them.

The behaviour of the chromosomes during meiosis is, however, expected to throw more light on this, which has been undertaken.

Important results obtained during the year.

1. Among the parent types selections from CO₄-B40-21 and 7682 gave a good yield, lint length and ginning percentage.

2. Among the hybrids from the F₅ to the F₁₁ generation, selections were made combining good yield, lint length and ginning percentage. A selection from a reciprocal cross in the F₉ generation gave the maximum

3. Increase in the number of bolls as a result of X-ray irradiation has been noticed in some of the types. These will have to be studied in the subsequent generations, before their economic importance can be assessed.

C.4.2. JUTE

C.4.2.1. Irradiation experiments.

RANGE IN THE HEIGHTS OF PLANTS.

It was noticed that both in the control and in all the treated population, there was difference in heights of plants. All the plants, at the time of harvesting were classified in five groups according to their heights attained. Tables 1-4 show the range of plant heights of X_1 , X_2 , X_3 and X_4 population along with their respective controls of all the varieties of jute under investigations.

TABLE 1
RANGE IN PLANT HEIGHTS OF X_1 POPULATION

Variety & Treatments		No. of plants studied	Plant Heights				
			1'-5'	5'1"-10'	10'1"-15'	15'1"-20'	Over 20'
Tall Mutant	Control	244	4	38	123	78	1
	20 m.a.hrs.	243	7	29	121	86	0
	200 "	243	2	51	116	74	0
R26	Control	242	4	75	130	33	0
	20 m.a.hrs.	241	9	66	126	40	0
	200 "	244	7	56	117	64	0
Chinsura Green	Control	243	9	57	94	83	0
	20 m.a.hrs.	241	7	66	99	69	0
	200 "	241	5	56	118	62	0
D154	Control	294	5	185	104	0	0
	20 m.a.hrs.	294	6	170	118	0	0
	200 "	294	1	156	137	0	0
D386	Control	293	1	199	93	0	0
	20 m.a.hrs.	292	9	225	58	0	0
	200 "	293	10	189	94	0	0

In the X_1 population of Tall Mutant and R. 26, as seen from Table 1, the number of plants where the heights range between 15'1" and 20' ft. are more than in the control, e.g., in Tall Mutant the number

64 in the 200 m.a.hrs. treatment. In D 154 the figure for the control was 104 against 118 and 137 in 20 and 200 m.a.hrs. respectively, in the range 10'1"—15'.

TABLE 2
RANGE IN PLANT HEIGHTS OF X₂ POPULATION

Variety & Treatments		No. of plants studied	Plant Heights			
			1'-5'	5'1"-10'	10'1"-15'	15'1"-20'
Tall Mutant	Control	159	4	25	73	57
"	100 m.a.hrs.	159	1	24	87	47
"	150 "	159	1	19	84	55
"	300 "	158	0	20	81	57
"	10,000 r	157	5	12	83	57
"	12,500 r	157	0	22	74	61
R26	Control	158	2	25	69	56
"	100 m.a.hrs.	155	4	52	54	45
"	150 "	159	4	19	68	68
"	300 "	156	4	30	69	53
"	10,000 r	158	6	12	79	61
"	12,500 r	156	9	21	62	64
Cinsura Green	Control	158	2	29	56	71
"	100 m.a.hrs.	159	3	41	67	48
"	150 "	157	8	25	73	51
"	300 "	158	3	19	75	61
"	10,000 r	159	4	22	75	58
"	12,500 r	158	5	30	60	63
D154	Control	294	5	185	104	0
"	100 m.a.hrs.	294	3	163	128	0
"	150 "	294	2	160	132	0
"	300 "	293	1	160	132	0
"	10,000 r	294	0	170	124	0
"	12,500 r	294	0	173	121	0
D386	Control	293	1	199	93	0
"	100 m.a.hrs.	291	2	180	109	0
"	150 "	293	3	206	84	0
"	300 "	294	0	175	119	0
"	10,000 r	293	2	213	78	0
"	12,500 r	293	2	193	98	0

In Table 2, where the same data for X₂ population are recorded, it can be seen that the behaviour of *capsularis* varieties, especially that of D154 were very promising. Here all the treated population had many more tall plants in the 10'1"—15' ft. range, than in the control; the highest number of such plants recorded being 132 in 150 and 300 m.a.hrs. treatment against 104 in the control. The same holds good

in the control as against 109 in the 100 m.a.hrs. and 119 in the 300 m.a.hrs. treatments. In Tall Mutant, the 12,500 r treatments and in R 26, the 150 m.a.hrs., 10,000 r and 12,500 r treatments had more tall plants than in the control.

TABLE 3

Variety & Treatments		No. of plants studied	Plant Heights			
			1'-5'	5'1"-10'	10'1"-15'	15'1"-20'
Tall Mutant	Control	207	2	40	128	37
	80 m.a.hrs.	207	2	41	117	47
	125 "	207	3	39	113	52
R26	Control	204	7	53	102	42
	80 m.a.hrs.	206	4	54	106	42
	125 "	204	5	37	107	55
Chinsura Green	Control	203	10	59	91	43
	80 m.a.hrs.	207	5	61	98	43
	125 "	205	8	52	114	31
D154	Control	196	2	131	63	0
	80 m.a.hrs.	196	2	125	69	0
	125 "	196	3	116	77	0
D386	Control	195	0	153	42	0
	80 m.a.hrs.	196	3	160	33	0
	125 "	196	2	111	83	0

Again from Table 3, which shows the behaviour of X_3 population, it appears that 125 m.a.hrs. in all the types here investigated, excepting in Chinsura Green, gave rise to larger number of tall plants, having heights between 15'1" to 20' ft. in the case of *olitorius* varieties and between 10'1" to 15' ft. in case of *capsularis* varieties. In D 386 the same treatment gave rise to nearly double the number of tall plants than in the control.

Like the X_3 population, X_4 population of Chinsura Green as seen from Table 4, did not show any increase in the number of taller plants. In Tall Mutant, all the treatments had many taller plants than in the control, the maximum number being in 48 m.a.hrs. treatment where there were 46 plants in the range between 15'1" to 20' ft. out of 168, as against 25 in the control. In R 26 there is however not any marked

TABLE 4
RANGE IN PLANT HEIGHTS OF X_4 POPULATION

Variety & Treatments	No. of plants studied	Plant Heights			
		1'-5'	5'1"-10'	10'1"-15'	15'1"-20'
Tall Mutant Control	168	1	43	99	25
" 28 m.a.hrs.	169	2	44	83	40
" 36 "	169	2	51	78	38
" 42 "	165	1	42	85	37
" 48 "	168	4	28	90	46
" 60 "	168	4	26	109	29
R26 Control	166	7	51	85	23
" 28 m.a.hrs.	168	4	39	97	28
" 36 "	162	3	39	95	25
" 42 "	169	1	56	97	15
" 48 "	168	3	43	95	27
" 60 "	168	2	42	98	26
Chinsura Green Control	165	9	53	73	30
" 28 m.a.hrs.	167	24	77	62	4
" 36 "	167	13	66	77	11
" 42 "	166	10	50	92	14
" 48 "	165	11	52	87	15
" 60 "	167	9	59	82	17
D154 Control	98	2	64	32	0
" 28 m.a.hrs.	98	3	68	27	0
" 36 "	98	0	65	33	0
" 42 "	98	1	39	58	0
" 48 "	98	1	57	40	0
" 60 "	98	1	25	72	0
D386 Control	98	1	46	51	0
" 28 m.a.hrs.	98	1	19	78	0
" 36 "	98	1	40	57	0
" 42 "	98	0	10	88	0
" 48 "	98	1	41	56	0
" 60 "	98	0	43	55	0

In some of the varieties, the tallest plant was in the controls, but the treatments had a larger number of plants which were quite tall and hence giving a better average height.

FLOWERING BEHAVIOUR

C.4.22. Early flowering types.

During the year under report, all the selections of early flowering

with regard to time taken for first flowering were studied. Table 5 gives the data for the same as well as the maximum heights attained by these plants.

TABLE 5
FLOWERING BEHAVIOUR OF EARLY FLOWERING TYPES—1954

Variety	Selection No.	Date of sowing	Date of first flowering	Time taken for 1st flowering	Earliness Lateness	Plant Height	Basal Diameter
Tall Mutant	Control	26.4.54	13.8.54	109 days		15'9"	0.9"
	32/69 (50)	"	7.6.54	42 "	67 days early	15'4"	0.8"
	21/21 (48)	"	7.6.54	42 "	67 " "	16'2"	0.8"
	29/30 (50)	"	8.6.54	43 "	66 " "	15'11"	0.8"
	32/37 (50)	"	30.7.54	95 "	14 " "	18'1"	1.0"
R26	Control	26.4.54	10.6.54	45 days		12'10"	0.7"
	8/31 (53)	"	8.6.54	43 "	2 days early	11'10"	0.6"
	24/6 (47)	"	10.7.54	75 "	30 " late	13'8"	0.6"
Chinsura Green	Control	26.4.54	7.8.54	103 days		15'8"	0.9"
	26/93 (47)	"	14.7.54	79 "	24 days early	14'3"	0.9"
	29/97 (47)	"	14.7.54	79 "	24 " "	15'7"	0.9"
	8/30 (51)	"	15.7.54	80 "	23 " "	14'7"	0.8"
	34/38 (48)	"	16.7.54	81 "	22 " "	16'7"	1.0"
	28/4 (47)	"	18.7.54	83 "	20 " "	13'8"	0.7"
	30/4 (51)	"	29.7.54	94 "	9 " "	16'4"	0.8"
	34/73 (48)	"	30.7.54	95 "	8 " "	17'9"	1.0"
	23/58 (48)	"	30.7.54	95 "	8 " "	15'6"	0.8"
	25/17 (47)	"	1.8.54	97 "	6 " "	16'9"	0.9"
	19/38 (48)	"	2.8.54	98 "	5 " "	14'6"	0.7"
	23/66 (49)	"	6.8.54	102 "	1 day "	15'10"	0.9"
	61/1 (49)	"	8.8.54	104 "	1 day late	15'8"	0.8"
	17/31 (49)	"	8.8.54	104 "	1 " "	12'3"	0.6"
	55/10-1(49)	"	9.8.54	105 "	2 days late	17'4"	1.0"
	21/23 (49)	"	20.8.54	116 "	13 days late	15'2"	0.8"

From Table 5, it appears that all the selections of Tall Mutant for early flowering, were promising. The first three, namely, 32/69(50),

although flowered later than the other early strains, was earlier than the control by 14 days, and at the same time attained a height of 18'1" as against 15'9" in the control. The selections of R 26 did not show any earliness during the year under report. Excepting the last four selections from Chinsura Green, viz., 17/31(49), 55/10-1(49) and 21/23(49), all the rest flowered early, the maximum earliness in this variety recorded this year being 24 days over the control, in the selection Nos. 26/93(47) and 29/97(47).

C.4.23. *Other irradiated populations : X_1 , X_2 , X_3 and X_4 .*

Tables 6, 7, 8 and 9 show the flowering behaviour of X_1 , X_2 , X_3 and X_4 population of all the varieties of jute, studied, with regard to time taken for first flowering.

TABLE 6

FLOWERING BEHAVIOUR : TIME TAKEN FOR FIRST FLOWERING IN X_1 POPULATION

Variety & Treatment		Date of sowing	Date of 1st flower-ing	Time taken for 1st flowering	Earliness Lateness	Plant Height
Tall Mutant	Control	28.4.54	1.9.54	126 days		16'8"
"	20 m.a.hrs.	"	31.8.54	125 "	1 day early	19'5"
"	200 "	"	1.9.54	126 "	nil	14'4"
R26	Control	29.4.54	11.6.54	43 days		12'9"
"	20 m.a.hrs.	"	9.6.54	41 "	2 days early	15'7"
"	200 "	"	10.6.54	42 "	1 day early	14'2"
Chinsura Green	Control	28.4.54	7.8.54	101 days		18'10"
"	20 m.a.hrs.	"	1.8.54	95 "	6 days early	17'10"
"	200 "	"	7.8.54	101 "	nil	17'3"
D154	Control	5.5.54	21.8.54	108 days		12'2"
"	20 m.a.hrs.	"	20.8.54	107 "	1 day early	13'0"
"	200 "	"	21.8.54	108 "	nil	12'9"
D386	Control	5.5.54	20.8.54	107 days		12'10"
"	20 m.a.hrs.	"	20.8.54	107 "	nil	12'7"

TABLE 7

FLOWERING BEHAVIOUR: TIME TAKEN FOR FIRST FLOWERING IN X_2 POPULATION

Variety & Treatment	Date of sowing	Date of first flowering	Time taken for first flowering	Earliness — Lateness	Plant Height
Tall Mutant Control	27.4.54	11.9.54	137 days		18'6"
" 100 m.a.hrs.	"	6.9.54	132 "	5 days early	15'9"
" 150 "	"	12.9.54	138 "	1 day late	15'8"
" 300 "	"	14.9.54	140 "	3 days late	15'8"
" 10,000 r	"	11.9.54	137 "	nil	17'11"
" 12,500 r	"	8.9.54	134 "	3 days early	16'5"
R26 Control	27.4.54	16.7.54	80 days		13'7"
" 100 m.a.hrs.	"	16.7.54	80 "	nil	14'9"
" 150 "	"	28.8.54	123 "	43 days late	16'10"
" 300 "	"	9.8.54	104 "	24 days late	17'11"
" 10,000 r	"	24.8.54	119 "	39 days late	16'5"
" 12,500 r	"	23.8.54	118 "	38 days late	14'9"
Chinsura Green Control	27.4.54	8.8.54	103 days		16'4"
" 100 m.a.hrs.	"	10.8.54	105 "	2 days late	18'2"
" 150 "	"	7.8.54	102 "	1 day early	16'6"
" 300 "	"	11.8.54	106 "	3 days late	15'8"
" 10,000 r	"	12.8.54	107 "	4 days late	17'10"
" 12,500 r	"	11.8.54	106 "	3 days late	13'9"
D154 Control	5.5.54	21.8.54	108 days		12'2"
" 100 m.a.hrs.	"	20.8.54	107 days	1 day early	12'3"
" 150 "	"	21.8.54	108 "	nil	12'3"
" 300 "	"	21.8.54	108 "	nil	11'10"
" 10,000 r	"	21.8.54	108 "	nil	12'8"
" 12,500 r	"	21.8.54	108 "	nil	10'3"
D385 Control	5.5.54	20.8.54	107 days		12'10"
" 100 m.a.hrs.	"	21.8.54	108 "	1 day late	13'5"
" 150 "	"	20.8.54	107 "	nil	12'3"
" 300 "	"	20.8.54	107 "	nil	12'7"
" 10,000 r	"	20.8.54	107 "	nil	12'10"
" 12,500 r	"	21.8.54	108 "	1 day late	12'6"

From Tables 6 and 7, it is found that there is no marked difference in the time taken for first flowering in X_1 and X_2 generations, when compared to their respective controls. In Table 6, it may however be seen, that 20 m.a.hrs. treatment of the X_1 plants in the varieties Tall Mutant, R 26, Chinsura Green and D 154 flowered 1, 2, 3 and 1, day earlier than the control, which is not significant.

TABLE 8

FLOWERING BEHAVIOUR : TIME TAKEN FOR FIRST FLOWERING IN X_3 POPULATION

Variety & Treatment		Date of sowing	Date of first flowering	Time taken for first flowering	Earliness Lateness	Plant Height
Tall Mutant	Control	27-4-54	31-8-54	126 days		14'10"
	80 m.a.hrs.	"	8-9-54	123 "	8 days late	14'8"
	125 "	"	14-9-54	140 "	14 "	16'2"
R26	Control	27-4-54	25-8-54	120 days		14'3"
	80 m.a.hrs.	"	12-7-54	76 "	44 days early	11'10"
	125 "	"	8-8-54	103 "	17 "	14'10"
Chinsura Green	Control	27-4-54	18-8-54	107 days		14'2"
	80 m.a.hrs.	"	7-8-54	102 "	4 days early	11'4"
	125 "	"	9-8-54	104 "	3 "	13'2"
D154	Control	5-5-54	21-8-54	108 days		12'2"
	80 m.a.hrs.	"	20-8-54	107 "	1 day early	13'9"
	125 "	"	21-8-54	108 "	nil	12'4"
D386	Control	5-5-54	20-8-54	107 days		12'10"
	80 m.a.hrs.	"	20-8-54	107 "	nil	11'10"
	125 "	"	21-8-54	108 "	1 day late	12'2"

In Table 8, special mention may be made of 80 and 125 m.a.hrs. treatment on R 26. Both are in the X_3 generation and flowered 44 and 17 days earlier than the control.

TABLE 9

FLOWERING BEHAVIOUR : TIME TAKEN FOR FIRST FLOWERING IN X_4 POPULATION

Variety & Treatment	Date of sowing	Date of first flowering	Time taken for first flowering	Earliness		Plant Height
				Lateness		
Tall Mutant	Control	27-4-54	31-8-54	126 days		14'10"
"	28 m.a.hrs.	"	30-8-54	125 "	1 day early	14'10"
"	36 "	"	31-8-54	126 "	nil	15'10"
"	42 "	"	22-8-54	117 "	9 days early	15'3"
"	48 "	"	1-9-54	127 "	1 day late	15'8"
"	60 "	"	9-9-54	135 "	9 days late	15'7"
R26	Control	27-4-54	25-8-54	120 days		14'3"
"	28 m.a.hrs.	"	26-8-54	121 "	1 day late	13'0"
"	36 "	"	6-8-54	101 "	19 days early	14'9"
"	42 "	"	16-7-54	80 "	40 days early	14'5"
"	48 "	"	25-8-54	120 "	nil	14'1"
"	60 "	"	24-8-54	119 "	1 day early	12'9"
Chinsura Green	Control	27-4-54	12-8-54	107 days		14'2"
"	28 m.a.hrs.	"	12-8-54	107 "	nil	14'2"
"	36 "	"	9-8-54	104 "	3 days early	13'8"
"	42 "	"	5-8-54	100 "	7 days early	12'2"
"	48 "	"	11-8-54	106 "	1 day early	15'3"
"	60 "	"	7-8-54	102 "	5 days early	13'7"
DI54	Control	5-5-54	21-8-54	108 days		12'2"
"	28 m.a.hrs.	"	21-8-54	108 "	nil	12'10"
"	36 "	"	21-8-54	108 "	nil	12'2"
"	42 "	"	21-8-54	108 "	nil	10'11"
"	48 "	"	21-8-54	108 "	nil	10'8"
"	60 "	"	21-8-54	108 "	nil	13'4"
D386	Control	5-5-54	20-8-54	107 days		12'10"
"	28 m.a.hrs.	"	21-8-54	108 "	1 day late	12'10"
"	36 "	"	21-8-54	108 "	1 day late	12'8"
"	42 "	"	20-8-54	107 "	nil	12'10"
"	48 "	"	20-8-54	107 "	nil	13'2"
"	60 "	"	21-8-54	108 "	1 day late	12'3"

Again in Table 9, 36 and 42 m.a.hrs. treatments of R 26 in the X_4 generation flowered 19 and 40 days earlier than the control, when the other varieties did not show any marked difference during the year under report.

C.4.24. Dry Weight of fibres :

Dry weight of fibres of 410 plants were taken at random in bundles

TABLE 10

Control R26			Tall Mutant		
Bundle No. (10 plants in each bundle)	Dry Weight		Bundle No. (10 plants in each bundle)	Dry Weight	
R 26 1/54 (F)	=	287.8 gms.	T. M. 1/54 (F)	=	260.7 gms.
R 26 2/54 (F)	=	282.9 "	T. M. 2/54 (F)	=	281.5 "
R 26 3/54 (F)	=	313.8 "	T. M. 3/54 (F)	=	304.5 "
R 26 4/54 (F)	=	301.0 "	T. M. 4/54 (F)	=	281.4 "
R 26 5/54 (F)	=	295.1 "	T. M. 5/54 (F)	=	215.2 "
R 26 6/54 (F)	=	296.8 "	T. M. 6/54 (F)	=	435.4 "
R 26 7/54 (F)	=	344.3 "	T. M. 7/54 (F)	=	316.1 "
R 26 8/54 (F)	=	282.9 "	T. M. 8/54 (F)	=	339.7 "
R 26 9/54 (F)	=	211.9 "	T. M. 9/54 (F)	=	401.1 "
R 26 10/54 (F)	=	140.9 "	T. M. 10/54 (F)	=	411.4 "
R 26 11/54 (F)	=	196.5 "	T. M. 11/54 (F)	=	325.7 "
R 26 12/54 (F)	=	221.0 "	T. M. 12/54 (F)	=	467.8 "
R 26 13/54 (F)	=	191.9 "	T. M. 13/54 (F)	=	369.0 "
R 26 14/54 (F)	=	177.6 "	T. M. 14/54 (F)	=	365.0 "
R 26 15/54 (F)	=	170.3 "	T. M. 15/54 (F)	=	404.5 "
R 26 16/54 (F)	=	173.1 "	T. M. 16/54 (F)	=	293.8 "
R 26 17/54 (F)	=	161.4 "	T. M. 17/54 (F)	=	352.0 "
R 26 18/54 (F)	=	141.8 "	T. M. 18/54 (F)	=	415.6 "
R 26 19/54 (F)	=	216.0 "	T. M. 19/54 (F)	=	396.2 "
R 26 20/54 (F)	=	257.7 "	T. M. 20/54 (F)	=	429.7 "
R 26 21/54 (F)	=	155.2 "	T. M. 21/54 (F)	=	403.6 "
R 26 22/54 (F)	=	164.1 "	T. M. 22/54 (F)	=	281.7 "
R 26 23/54 (F)	=	179.1 "	T. M. 23/54 (F)	=	321.7 "
R 26 24/54 (F)	=	206.1 "	T. M. 24/54 (F)	=	286.4 "
R 26 25/54 (F)	=	174.2 "	T. M. 25/54 (F)	=	178.8 "
R 26 26/54 (F)	=	316.5 "	T. M. 26/54 (F)	=	227.1 "
R 26 27/54 (F)	=	225.3 "	T. M. 27/54 (F)	=	278.1 "
R 26 28/54 (F)	=	173.7 "	T. M. 28/54 (F)	=	267.4 "
R 26 29/54 (F)	=	156.2 "	T. M. 29/54 (F)	=	232.0 "
R 26 30/54 (F)	=	176.8 "	T. M. 30/54 (F)	=	212.4 "
R 26 31/54 (F)	=	174.0 "	T. M. 31/54 (F)	=	250.5 "
R 26 32/54 (F)	=	165.1 "	T. M. 32/54 (F)	=	173.6 "
R 26 33/54 (F)	=	166.1 "	T. M. 33/54 (F)	=	179.6 "
R 26 34/54 (F)	=	168.0 "	T. M. 34/54 (F)	=	185.8 "
R 26 35/54 (F)	=	190.2 "	T. M. 35/54 (F)	=	152.9 "
R 26 36/54 (F)	=	151.8 "	T. M. 36/54 (F)	=	184.0 "
R 26 37/54 (F)	=	138.2 "	T. M. 37/54 (F)	=	128.4 "
R 26 38/54 (F)	=	164.5 "	T. M. 38/54 (F)	=	139.4 "
R 26 39/54 (F)	=	170.3 "	T. M. 39/54 (F)	=	142.0 "
R 26 40/54 (F)	=	159.0 "	T. M. 40/54 (F)	=	180.7 "
R 26 41/54 (F)	=	131.3 "	T. M. 41/54 (F)	=	149.7 "

Control R26

Tall Mutant

Average dry weight of fibres of ten

plants..... 204.1 gms.

284.9 gms.

It may be seen from Table 10, that there is increase in the dry weight of fibres in Tall Mutant and the test of significance has been found to be 4.95.

C.4.25. *Important results obtained during the year under report*

(1) Increase in the maximum heights and basal diameters of the plants have been recorded in X_2 and X_4 generations of both the species of *Corchorus* studied.

(2) Increase in the number of plants having greater heights, in X_1 , X_2 , X_3 and X_4 generations, have been recorded in all the five varieties of jute investigated, which is sometimes nearly double in some of the varieties.

(3) Early flowering types showed improved performances during the year under report. Here special mention may be made of the selections from the progenies of Tall Mutant. The four promising strains 32/69(50), 21/21(48), 29/30(50) and 32/37(50), so far selected during the years 1948 and 1950, started flowering 67, 67, 66 and 14 days respectively earlier than the control; their plant heights however were not affected due to early flowering, on the other hand three of them were taller than the control.

(4) Although the X_1 and X_2 progenies did not yield any early flowering types during the year under report, the X_3 and X_4 generations of R 26 were very favourable with regard to earliness in flowering.

(5) Dry weight of fibres of over 400 plants taken at random from Tall Mutant and R 26 shows significant difference between the two, the former having yielded more.

C. 4. 3. INDUCING MUTATIONS IN TIL (*Sesamum*) AND RAPE AND MUSTARD (*Brassica*).

C.4.31. *Til (Sesamum) :*

The season was fairly favourable in the initial stages for the *Sesamum* plants, but towards the flowering and fruiting periods, a large number of plants were affected due to the heavy rains. Many of the plants were attacked with the Sesam gall fly, *Asphondyla sesami*, which affected the ovaries and hence the yield. But as in the previous year, the X-radiated progenies exhibited varying degrees of resistance, which was taken into consideration in making the selections.

During the year, fresh irradiations were given to the dry seeds of Berhampur (West Bengal), type nos. 10, 12, 16 and 20 and T.M.V. I and T.M.V. 2 (Madras) with doses ranging from 20 m.a.H., (equivalent to 8,000 r units) to 250 m.a.H. (equivalent to 100,000 r units) and were sown in the field in replicated plots, and with control in each

the year, although a very high dose *viz.*, 1,00,000 r was given to some of the types, the germination was very satisfactory and there were not very many aberrant types, showing thereby that still bigger doses are necessary for inducing wider variations, which will be taken up during the next year. Recently this Institute has bought a contact and cavity therapy X-ray apparatus, capable of giving 12,500 r units per minute and with this, very high doses for inducing sufficient variability can be given.

TABLE 11

Type	Control & Treatment	Selection No.	Maximum No. of fruits	Total weight of seeds in gms.
No. 10 (West Bengal)	Control	8/2/51	96	4.93 gm.
	20 m.a.H.	8/3/50	137	13.04 "
	40 "	8/4/10	100	6.37 "
	60 "	8/5/25	124	7.44 "
	100 "	8/6/6	74	3.5 "
	200 "	8/7/51	190	12.8 "
No. 12 (West Bengal)	Control	8/9/24	108	11.15 gm.
	20 m.a.H.	8/10/52	100	11.93 "
	40 "	8/11/14	85	6.04 "
	60 "	8/12/40	65	3.82 "
	100 "	8/13/7	100	10.35 "
	200 "	8/14/39	106	9.0 "
	250 "	8/15/59	145	13.1 "
No. 16 (West Bengal)	Control	8/16/12	106	7.5 gm.
	20 m.a.H.	8/17/51	105	5.94 "
	40 "	8/18/46	100	4.97 "
	60 "	8/19/43	124	10.62 "
	100 "	8/20/32	85	4.2 "
	200 "	8/21/34	109	7.25 "
No. 20 (West Bengal)	Control	8/22/32	60	4.46 gm.
	20 m.a.H.	8/23/30	81	5.72 "
	40 "	8/24/23	99	6.72 "
	60 "	8/25/6	110	8.0 "
	100 "	8/26/15	110	9.6 "
	200 "	8/27/41	72	3.6 "
T.M.V. 1 (Madras)	Control	8/28/11	80	5.45 gm.
	20 m.a.H.	8/29/20	112	5.68 "
	40 "	8/30/11	50	3.77 "
	60 "	8/31/14	130	6.19 "
	100 "	8/32/23	177	10.4 "
	200 "	8/33/13	65	5.75 "
T.M.V. 2 (Madras)	Control	8/34/81	45	2.02 gm.
	20 m.a.H.	8/35/50	54	3.0 "
	40 "	8/36/86	57	3.02 "
	60 "	8/37/22	33	1.02 "
	100 "	8/38/47	100	5.0 "
	200 "	8/39/74	46	2.5 "

Table 11 gives the results of the behaviour of the above types in the X_1 generation during the current year.

From this table it will be seen that in type no. 10 from West Bengal, the best plant in the control had 96 fruits with a seed weight of 4.93 gms. while one plant from the 200 m.a.H. treatment had 190 fruits with a seed weight of 12.8 gms. In the same type, selection no. 8/3/50 with 137 fruits only, gave a seed weight of 13.04 gms., the latter being the maximum. In type no. 12, also from West Bengal, while the control had 108 fruits with a seed weight of 11.15 gms., one plant in the 250 m.a.H. treatment had 145 fruits with a seed weight of 13.1 gms. Again, in type no. 16, while the control had 106 fruits with a seed weight of 7.5 gms., selection no. 8/19/43, from the 60 m.a.H. treatment had 124 fruits with a seed weight of 10.62 gms, which combines the maximum number of seeds with the highest seed weight, as in the previous case. In type no. 20, also from West Bengal, the relative figures are, 60 fruits with a seed weight of 4.46 gms, in the control, as against 110 fruits giving 9.6 gms. of seeds in selection no. 8/26/15, from the 100 m.a.H. treatment. In T.M.V. 1 from Madras, while the control had 80 fruits giving 5.45 gms. of seeds, one plant in the 100 m.a.H. treatment had 177 fruits with a seed weight of 10.4 gms. Again, in T.M.V. 2, also from Madras, while the control had only 45 fruits with a seed weight of 2.02 gms., selection no. 8/38/47, also from the 100 m.a.H. treatment, had 100 fruits, with a seed weight of 5.0 gms. *Thus it will be seen that in all the X_1 plants of the current year, selections from the treated plants had a much larger number of fruits over the control giving a higher seed weight also. The behaviour of these will have to be studied in the subsequent generations without further treatments.*

Table 12, gives comparative figures regarding the maximum number of fruits obtained in the X_1 generation during the previous year of some of the selections, together with their behaviour in the X_2 generation of the current years.

It will be seen from this table that in type no. 10, in the X_1 of 1953, the best plant in the 10,000 r units treatment had 289 fruits as against 140 in the control. But in the X_2 generation of 1954, this high yielding plant gave only 135 fruits, as against 124 in the control. In this generation, one plant selected from the 200 m.a.H. treatment of the previous year, yielded 270 fruits as against 141 in the control and with a seed weight of 17.58 gms. and average yield of 114 fruits per plant. This plant had only 91 fruits in the previous generation. But the best seed weight and average yield were from another selection, which were 20.85 gms.

In T.M.V. 1, in the X_1 of the treatments from 36 to 200 m.a.H. the best plant of the control had 88 fruits as against 160 in the X_2 generation. The best plant in the treatments of the X_1 generation was from the 50 m.a.H. treatment having 172 fruits, which had 214 fruits in the X_2 generation, with a seed weight of 24.82 gms, which was the highest recorded in this type for the above treatments and an average of 92.6 fruits per plant. But the maximum number of fruits in the X_2 viz., 220 was obtained from another selection, which also gave the highest average number of fruits viz., 125. But its seed weight was only 20.0 gms. being lower than the previous one. In the 10,000 r and 12,500 r units treatments, the highest yielder was in the former in the X_2 generation with 350 fruits as against 200 in the control and an average of 178.3, with a seed weight of 28.2 gms. This had only 107 fruits in the X_1 generation.

TABLE 12

Type	Control & Treatment	Selec- tion No.	X_1 —1953		X_2 —1954		Average No. of fruits of 10 plants
			Maxi- mum No. of fruits	Selec- tion No.	Maxi- mum No. of fruits	Total seed weight in gms.	
No. 10 (West Bengal)	Control		260		141	9.14	77.1
	140 m.a.H.	8/24/17	228	9/69/40	108	16.6	74.4
	200 "	8/28/6	248	9/71/42	132	15.14	90.2
	200 "	8/27/24	91	9/75/36	270	17.58	114.0
	200 "	8/27/10	73	9/79/30	205	20.85	128.8
	Control		140		124		
	10,000 r	6/63/21	289	9/81/18	135	15.175	81.7
	10,000 r	6/63/28	97	9/86/30	187	16.73	106.1
	12,500 r	6/64/93	228	8/91/65	180	16.51	103.4
	Control		88		160	20.5	104.5
T.M.V. 1 (Madras)	36 m.a.H.	2/56/18	57	9/5/5	176	16.3	96.9
	50 "	1/57/8	172	9/10/10	214	24.82	92.6
	140 "	1/3/31	48	9/14/27	136	13.2	66.6
	200 "	1/6/22	143	9/16/20	220	20.0	125.0
	200 "	1/6/9	10	9/21/13	215	22.85	114.2
	Control		343		200	17.32	139.2
	10,000 r	3/27/42	404	9/30/36	198	19.60	115.4
	10,000 r	3/28/14	107	9/24/55	350	28.2	178.3
	10,000 r	2/60/3	17	9/28/11	300	27.25	114.9
	12,500 r	3/26/35	324	9/36/19	310	26.80	154.3
	12,500 r	3/59/1	84	9/41/42	308	24.34	161.4
	Control		112		89	5.36	38.2
	10,000 r	3/34/33	74	9/47/13	53	2.90	28.2
	10,000 r	3/34/31	32	9/56/48	112	10.80	37.2
	12,500 r	3/59/1	84	9/41/42	308	24.34	161.4
T.M.V. 2 (Madras)	Control		112		89	5.36	38.2
	10,000 r	3/34/33	74	9/47/13	53	2.90	28.2
	10,000 r	3/34/31	32	9/56/48	112	10.80	37.2

In T.M.V. 2, one plant from the 12,500 r units treatment gave the highest yield in the X_1 generation—*viz.*, 200 fruits, as against 112 in the control. The X_2 progeny of this was the best yielder in this generation, with 152 fruits as against 89 in the control and with an average of 70.4 fruits. Also, the seed weight in this was the highest—*viz.*, 11.8 gms.

Table 13, gives the behaviour of the X_2 generation of 1953 and the X_2 generation of 1954, in types no. 10, 12, 16 and 20 from West Bengal.

TABLE 13

Type	X_2 —1953				X_3 —1954		Average No. of fruits of 10 plants
	Control & Treatment	Selection No.	Maximum No. of fruits	Selection No.	Maximum No. of fruits	Total seed weight in gms.	
No. 10 (West Bengal)	Control		374		52	1.80	42.2
	36 m.a.H.	8A/16/20	289	6/3/40	71	2.20	44.5
	50 "	8A/17/17	265	6/4/6	62	2.31	41.3
	100 "	8A/18/12	470	6/5/54	64	2.65	40.8
	Control		238		336	23.83	186.2
	100 m.a.H.	6/43/70	456	3/58/1	316	30.68	176.8
	140 "	6/44/64	488	3/63/4	275	17.84	157.4
	140 "	6/44/60	432	3/69/16	372	20.70	198.6
	140 "	6/44/14	400	3/71/2	334	23.03	181.2
	Control		168		277	27.70	122.9
No. 12 (West Bengal)	100 m.a.H.	6/49/25	166	3/78/5	342	19.29	190.8
	100 "	6/49/39	154	3/80/88	316	35.01	174.0
	100 "	6/49/23	150	3/82/23	330	19.95	200.5
	140 "	6/50/39	116	3/88/6	331	20.88	186.7
No. 16 (West Bengal)	Control		232		68	2.50	33.0
	36 m.a.H.	8A/21/18	248	6/9/44	56	1.88	27.8
	50 "	8A/22/13	320	6/10/57	70	2.69	35.2
	100 "	8A/23/35	260	6/11/20	76	2.9	44.1
	Control		177		198	17.62	138.9
	100 m.a.H.	6/52/52	254	1/4/34	246	25.02	168.1
	100 "	6/53/53	243	1/9/53	310	25.02	187.6
	140 "	6/56/16	236	1/1/63	142	22.46	109.4
	140 "	6/56/7	196	1/16/21	220	24.97	153.2
	100 "	6/52/33	200	1/7/8	280	31.49	—
No. 20 (West Bengal)	Control		331		100	5.94	46.1
	36 m.a.H.	8A/11/3	137	6/15/1	100	7.06	40.9
	50 "	8A/12/3	192	6/16/38	75	2.91	43.0
	100 "	8A/13/33	264	6/17/1	100	5.90	37.0
	Control		215		368	31.54	202.9
	100 m.a.H.	6/59/17	252	1/21/31	208	17.25	167.9

It will be seen that in the first replication of type no. 10, the control of the X_3 had 52 fruits, with a seed weight of 1.8 gms. and an average yield of 42.2, as against the control of the X_2 generation with 374 fruits. The best plant in the X_3 of the treatments was a selection from the 100 m.a.H. with 64 fruits and an average yield of 40.8 and with a seed weight of 2.65 gms. This was the best yielder of the X_2 generation, with 470 fruits. In the second replication, the best plant in the X_3 had 372 fruits as against 336 in the control, with an average of 198.6 and having a seed weight of 20.7 gms.

In type no. 12, the best plant in the control of the X_3 had 277 fruits as against 342 in a selection from the 100 m.a.H. treatment. But this had only 166 fruits in the X_3 as against 168 in the control. The best seed weight in the X_3 was 35.01 gms. also from the 100 m.a.H. treatment, as against 27.7 gms. in the control. But the best average yield of the X_3 was from another selection of the 100 m.a.H. treatment, viz., 200.5, as against 122.9, in the control.

In the first replication of type no. 16, the control of the X_3 had 68 fruits with an average yield of 33 and with a seed weight of 2.5 gms. But a selection from the 100 m.a.H. treatment had 76 fruits with an average of 44.1 and a seed weight of 2.9 gms. In the second replication, the best plant from the treatments in the X_3 had 310 fruits as against 198 in the control, with a seed weight of 25.02 gms. as against 17.62 in the control and an average yield of 187.6 fruits, as against 138.9 in the control.

In type no. 20, in the X_3 generation, both in the first and second replication, the control was equal to or better than the treatments. But the seed weight in one of the treated selection was higher than in the control in the first replication and the average yield of another selection from the treatment of the second replication was better than the control.

Table 14, gives the comparative behaviour of the two T.M.V. types in the X_3 generation of 1953 and the X_4 of 1954.

Here, it will be noticed that in T. M. V. 1, the best plant in the X_4 generation had 400 fruits, as against 240 in the control. This also gave the best average yield of 222.6 fruits as against 150.8 in the control. But this was not the best plant in the previous X_3 generation when it had 206 fruits as against 150 in the control. The highest seed weight in the X_4 generation was 28.86 gms., selected from the 36 m.a.H. treatment. In T.M.V. 2, the best plant in the X_4 had 227 fruits as against 79 in the control. But this was not the highest yielder of the X_3 generation. The maximum seed weight and the best average yield in the

TABLE 14

		X ₃ —1953			X ₄ —1954		
Type	Control & Treatment	Selection No.	Maximum No. of fruits	Selection No.	Maximum No. of fruits	Total seed weight in gms.	Average No. of fruits of 10 plants
T.M.V. 1 (Madras)	Control		150		240	19.64	140.8
	36 m.a.H.	6/24/12	262	3/27/69	218	23.64	174.0
	36 "	6/24/3	245	3/29/43	290	28.86	156.2
	50 "	6/27/3	261	3/32/61	315	26.21	205.2
	50 "	6/26/5	172	3/33/15	320	22.99	171.9
	100 "	6/29/36	206	3/36/3	400	25.39	222.6
	100 "	6/29/2	196	3/38/39	352	24.68	199.0
T.M.V. 2 (Madras)	Control		100		79	8.67	50.4
	50 m.a.H.	6/35/2	45	3/44/18	112	10.09	67.8
	50 "	6/35/10	44	3/46/4	227	10.45	132.5
	100 "	6/37/5	219	3/49/28	224	16.22	173.9

TABLE 15

		X ₄ —1953			X ₅ —1954		
Type	Control & Treatment	Selection No.	Maximum No. of fruits	Selection No.	Maximum No. of fruits	Total seed weight in gms.	Average No. of fruits of 10 plants
No. 12 (West Bengal)	Control		241		212	34.10	133.9
	36 m.a.H.	6/6/80	139	3/3/41	252	34.84	165.0
No. 16 (West Bengal)	Control		168		170	23.60	115.1
	36 m.a.H.	6/13/31	303	3/12/42	330	38.10	117.6
	36 "	6/16/41	292	3/14/51	542	38.34	255.3
	36 "	6/16/53	234	3/17/46	460	40.23	117.8
	50 "	6/19/21	280	3/18/38	280	24.40	157.6
	50 "	6/18/43	228	3/21/45	465	31.05	205.8

Table 15, gives the behaviour of the X₄ generation of 1953 and the X₅ of 1954, in type nos. 12 and 16 from West Bengal. In the former, the single X₄ selection, although gave a lower yield than the control, behaved better in the X₅ with 252 fruits, with a seed weight of 34.84 gms. and an average yield of 165 fruits as against 212 fruits in the best control plant, giving an average of 133.9.

In type no. 16, the best plant in the X₅ generation had 560 fruits with a seed weight of 40.23 gms, as against 170 fruits weighing 23.6 gms. in the control. The second best yielder of the X₄ generation had the best average in the X₅ generation—viz., 255.3 fruits, as against

Table 16, gives the behaviour of the early selections of 1950, in type no. 16, which were sown in the subsequent years without further treatments and are in the X_5 generation, during the year under report.

TABLE 16

Type	Control & Treatment	Sele- ction No. of 1953	Sele- ction No. of 1954	Date of sowing	Date of flower- ing	Age	Earliness or Lateness
No. 16	Control		5/47/44	12.4.54	21.5.54	39	
(West Bengal)	36 m.a.H.	5/12/14	5/43/8	"	26.5.54	44	5 days late
	36 "	5/21/3	5/46/4	"	18.5.54	36	3 days early
	50 "	5/14/5	5/49/6	"	19.5.54	37	2 days early
	50 "	5/15/4	5/50/6	"	18.5.54	36	3 days early
	50 "	5/24/7	5/52/4	"	17.5.54	35	4 days early

It will be seen from the table that one selection is later than the control by 5 days, the rest being earlier, the maximum being 4 days.

Table 17, gives the further performances of the early selections of 1951, which are in the X_4 generation during the current year, in type nos. 10, 12, and 16 from West Bengal.

TABLE 17

Type	Control & Treatment	Sele- ction No. of 1953	Sele- ction No. of 1954	Date of sowing	Date of flower- ing	Age	Earliness or Lateness
No. 10	Control		5/2/30	12.4.54	24.5.54	42	
(West Bengal)	36 m.a.H.	5/25/14	5/5/8	"	18.5.54	36	6 days early
	50 "	5/27/3	5/8/29	"	17.5.54	35	7 days early
No. 12	Control		5/9/5	12.4.54	21.5.54	39	
(West Bengal)	100 m.a.H.	3/6/25	5/11/16	"	18.5.54	36	3 days early
	100 "	3/7/17	5/14/37	"	16.5.54	34	5 days early
No. 16	Control		5/17/18	12.4.54	19.5.54	37	
(West Bengal)	36 m.a.H.	3/13/41	5/19/8	"	11.5.54	29	8 days early
	36 "	3/20/9	5/25/22	"	12.5.54	30	7 days early
	36 "	3/20/7	5/27/3	"	11.5.54	29	8 days early
	50 "	3/16/1	5/22/4	"	16.5.54	34	3 days early
	50 "	3/22/11	5/29/36	"	16.5.54	34	3 days early
	100 "	3/17/1	5/23/10	"	17.5.54	35	2 days early

It will be seen that *all the selections continued to be early in all the types*, the maximum being 7 days in type no. 10, 5 days in type no. 12 and 8 days in type no. 16.

Table 18, gives the flowering dates in the controls and the various treatments during the current year, in the West Bengal type nos. 10,

TABLE 18

Type and Locality	Control & Treatment	Date of sowing	Date of flowering	Age	Earliness or Lateness
No. 10 (West Bengal)	Control	25-5-54	12-7-54	48 days	
	20 m.a.H.	"	10-7-54	46 "	2 days early
	40 "	"	10-7-54	46 "	2 " "
	60 "	"	10-7-54	46 "	2 " "
	100 "	"	13-7-54	49 "	1 day late
	200 "	"	13-7-54	49 "	1 " "
	250 "	"	29-6-54	35 "	13 days early
No. 12 (West Bengal)	Control	25-5-54	1-7-54	37 days	
	20 m.a.H.	"	28-6-54	34 "	3 days early
	40 "	"	1-7-54	37 "	
	60 "	"	10-7-54	46 "	9 days late
	100 "	"	10-7-54	46 "	9 " "
	200 "	"	10-7-54	46 "	9 " "
	250 "	"	10-7-54	46 "	9 " "
No. 16 (West Bengal)	Control	25-5-54	10-7-54	46 days	
	20 m.a.H.	"	10-7-54	46 "	
	40 "	"	10-7-54	46 "	
	60 "	"	8-7-54	44 "	2 days early
	100 "	"	10-7-54	46 "	
	200 "	"	13-7-54	49 "	3 days late
No. 20 (West Bengal)	Control	25-5-54	2-7-54	38 days	
	20 m.a.H.	"	10-7-54	46 days	8 days late
	40 "	"	11-7-54	47 "	9 " "
	60 "	"	11-7-54	47 "	9 " "
	100 "	"	15-7-54	51 "	13 " "
	200 "	"	15-7-54	51 "	13 " "
T.M.V. 1 (Madras)	Control	25-5-54	14-7-54	50 days	
	20 m.a.H.	"	16-7-54	52 "	2 days late
	40 "	"	13-7-54	49 "	1 day early
	60 "	"	15-7-54	51 "	1 day late
	100 "	"	11-7-54	47 "	3 days early
	200 "	"	12-7-54	48 "	2 " "
T.M.V. 2 (Madras)	Control	25-5-54	20-7-54	56 days	
	20 m.a.H.	"	20-7-54	56 "	
	40 "	"	18-7-54	54 "	2 days early
	60 "	"	13-7-54	49 "	7 " "
	100 "	"	17-7-54	53 "	3 " "
	200 "	"	19-7-54	55 "	1 day early
	250 "	"	19-7-54	55 "	1 " "

It will be seen that in type no. 10, one plant selected from the 250 m.a.H. treatment was *earlier than the control* by 13 days. In type no. 12, the maximum earliness is by 3 days, in type 16, by 2 days, in T.M.V. 1, by 3 days and in T.M.V. 2, by 7 days. There were a number of plants which flowered later than the controls.

plant and the last plant to flower in the population. This is an important aspect, as, if all the plants in any population flower more or less at the same time, the fruits will ripen also at the same time and will have uniform maturity and harvesting will be easier and cheaper. But in actual practice, all the plants in any population do not or cannot flower on the same day, hence the minimum number of days taken for flowering is taken into account.

TABLE 19

Type & Locality	Control & Treatment	Date of sowing	Date on which 1st plant flowered	Date on which last plant flowered	No. of days covered
No. 10 (West Bengal)	Control	25-5-54	12-7-54	22-7-54	11 days
	20 m.a.H.	"	10-7-54	22-7-54	13 "
	40 "	"	10-7-54	22-7-54	13 "
	60 "	"	10-7-54	20-7-54	11 "
	100 "	"	12-7-54	21-7-54	9 "
	200 "	"	19-7-54	21-7-54	9 "
No. 12 (West Bengal)	Control	5-5-54	15-6-54	30-6-54	16 days
	20 m.a.H.	"	10-6-54	1-7-54	21 "
	40 "	"	12-6-54	1-7-54	20 "
	60 "	"	12-6-54	30-6-54	19 "
	100 "	"	15-6-54	1-7-54	17 "
	200 "	"	12-6-54	1-7-54	20 "
No. 16 (West Bengal)	Control	5-5-54	12-6-54	30-6-54	19 days
	20 m.a.H.	"	16-6-54	30-6-54	15 "
	40 "	"	11-6-54	2-7-54	22 "
	60 "	"	12-6-54	1-7-54	20 "
	100 "	"	14-6-54	30-6-54	17 "
	200 "	"	11-6-54	1-7-54	21 "
No. 20 (West Bengal)	Control	25-5-54	2-7-54	18-7-54	17 days
	20 m.a.H.	"	10-7-54	18-7-54	9 "
	40 "	"	11-7-54	19-7-54	9 "
	60 "	"	11-7-54	18-7-54	8 "
	100 "	"	15-7-54	19-7-54	5 "
	200 "	"	15-7-54	19-7-54	5 "
T.M.V. 1 (Madras)	Control	25-5-54	14-7-54	23-7-54	10 days
	20 m.a.H.	"	16-7-54	23-7-54	3 "
	40 "	"	13-7-54	23-7-54	11 "
	60 "	"	15-7-54	23-7-54	9 "
	100 "	"	11-7-54	23-7-54	13 "
	200 "	"	12-7-54	23-7-54	12 "
T.M.V. 2 (Madras)	Control	5-5-54	28-6-54	1-7-54	4 days
	20 m.a.H.	"	28-6-54	1-7-54	4 "
	40 "	"	29-6-54	2-7-54	4 "
	60 "	"	28-6-54	2-7-54	5 "
	100 "	"	29-6-54	2-7-54	4 "
	200 "	"	29-6-54	2-7-54	4 "

It will be seen from the above table that in type no. 10, while the control took 11 days it is as high as 21 days in the 250 m.a.H. and as low as 9 days, both in the 100 and 200 m.a.H. treatments. In type no. 12, while the control took 16 days, the treatments vary from 16 to 21 days. In type no. 16, the respective figures are 19 days in the control as against 15-21 days in the treatments. In type no. 20, there is a marked difference between the control and the treatments. While in former it takes 17 days, the 100 and 200 m.a.H. treatments took only 5 days. This is true in the case of T.M.V. 1, where it is as low as 3 days in the 200 m.a.H. as against 10 days in the control. But in T.M.V. 2, there is very little differences.

Table 20, gives the number of days taken by the population, both the control and the treatments to flower, in the X_4 and X_5 generations, in some of the types under study.

TABLE 20

Type & Locality	Generation	Control & Treatment	Date of sowing	Date on which 1st plant flowered	Date on which last plant flowered	No. of days covered
No. 10 (West Bengal)	X_5	Control	12-4-54	18-5-54	31-5-54	14 days
		50 m.a.H.	"	20-5-54	31-5-54	12 "
No. 16 (West Bengal)	X_5	Control	12-4-54	21-5-54	31-5-54	11 days
		36 m.a.H.	"	26-5-54	31-5-54	12 "
		36 "	"	18-5-54	30-5-54	13 "
		50 "	"	19-5-54	30-5-54	12 "
		50 "	"	18-5-54	29-5-54	12 "
No. 10 (West Bengal)	X_4	Control	12-4-54	24-5-54	2-6-54	10 days
		36 m.a.H.	"	18-5-54	2-6-54	16 "
		50 "	"	17-5-54	31-5-54	15 "
		100 m.a.H.	"	18-5-54	31-5-54	14 "
No. 16 (West Bengal)	X_5	Control	12-4-54	19-5-54	3-6-54	16 days
		Control (S)	"	15-5-54	30-5-54	16 "
		36 m.a.H.	"	11-5-54	1-6-54	22 "
		36 "	"	12-5-54	27-5-54	16 "
		36 "	"	11-5-54	27-5-54	17 "
		50 "	"	16-5-54	31-5-54	16 "
		50 "	"	16-5-54	30-5-54	15 "
		100 "	"	17-5-54	1-6-54	15 "

It will be noticed that there are little differences in the controls

Table 21, gives the percentage of sterile pollen grains in the controls and the various treatments in the four types from West Bengal and the two types from Madras.

TABLE 21

Type	Control & Treatment	% of sterile pollen grains
No. 10 (West Bengal)	Control	4.40
	20 m.a.H.	7.36
	40 "	21.28
	60 "	12.91
	100 "	14.30
	200 "	23.11
No. 12 (West Bengal)	Control	6.44
	20 m.a.H.	17.29
	40 "	18.06
	60 "	12.02
	100 "	16.46
	200 "	19.35
No. 16 (West Bengal)	Control	8.72
	20 m.a.H.	20.27
	40 "	11.20
	60 "	17.83
	100 "	19.63
	200 "	16.41
No. 20 (West Bengal)	Control	6.88
	20 m.a.H.	9.34
	40 "	9.79
	60 "	22.94
	100 "	12.59
	200 "	25.43
T.M.V. 1 (Madras)	Control	6.76
	20 m.a.H.	19.52
	40 "	11.79
	60 "	14.80
	100 "	17.35
	200 "	11.69
T.M.V. 2 (Madras)	Control	6.31
	20 m.a.H.	10.23
	40 "	9.20
	60 "	10.77
	100 "	15.31
	200 "	12.36
	250 "	20.98

It will be seen that in all the types, the percentage of sterility is lowest in the controls, while it is higher in the treatments. In type nos. 10 and 20, the maximum sterility were found in the 200; in type

Table 22, gives the average diameter of 100 pollen grains in the controls and the various treatments in all the types under investigation.

TABLE 22

Type	Control & Treatment	Pollen diameter (in μ average of 100)
No. 10 (West Bengal)	Control	61.07
	20 m.a.H.	65.02
	40 "	65.44
	60 "	66.11
	100 "	65.69
	200 "	63.43
No. 12 (West Bengal)	Control	62.24
	20 m.a.H.	65.86
	40 "	63.43
	60 "	63.25
	100 "	62.66
	200 "	65.94
No. 16 (West Bengal)	Control	62.92
	20 m.a.H.	65.86
	40 "	64.85
	60 "	65.35
	100 "	67.37
	200 "	66.44
No. 20 (West Bengal)	Control	63.08
	20 m.a.H.	64.34
	40 "	63.67
	60 "	65.35
	100 "	65.02
	200 "	65.52
T.M.V. 1 (Madras)	Control	66.28
	20 m.a.H.	65.52
	40 "	64.76
	60 "	65.60
	100 "	73.25
	200 "	75.85
T.M.V. 2 (Madras)	Control	70.56
	20 m.a.H.	78.88
	40 "	76.69
	60 "	74.68
	100 "	77.36
	200 "	76.10
	250 "	75.01

It will be seen that in all the types, except in T.M.V. 1, the dia-

the control as against 73.25μ in the 100 and 75.85μ in the 200 m.a.H. treatments. This increase in pollen diameter may also account for the greater weight of the seeds observed during the current year and in the previous years.

Further irradiations on the higher yielding mutants.

The higher yielding mutants of the Bengal types 12 and 16 in the X_4 generations were further irradiated with X-rays, the exposures given being 36 and 50 m.a.H., to find out if still higher yielding mutants could be obtained. But due to the late sowing, many of the plants were affected by the rains and the attack of the Sesam gall fly, mentioned earlier, and hence comparative data could not be obtained. It is proposed to repeat these, in the subsequent years.

Other Mutants.

1) A white flowered mutant was isolated in the X_3 generation from type no. 16 and its progenies were grown in the subsequent generation. Their yield and flowering behaviour are being investigated.

2) Plants showing variations in the colour and the shape of the seeds were also isolated and are being investigated.

C.4.32. Rape and Mustard (Brassica)

The season was fairly favourable for the mustard crop. But during the flowering and fruiting stages, many of the plants were attacked by aphids. As in the case of *Sesamum*, here also, it was observed that some of the irradiated progenies were not affected, which was taken into consideration in making the selections. The aphids could be controlled to a great extent by the application of "Folidol" on the plants. The dilution used was 1 c.c. of "Folidol" in 2 gallons of water.

During the year, Tori 7 and Rai 5 from West Bengal, Brown Sarson and R. L. 9 from East Punjab T 71, T 88, T 164 and T 185, from the Indian Agricultural Research Institute, Delhi, were irradiated for 100 and 300 m.a.H., and were sown in replications in the field, with a control in each plot. Table 23, gives the behaviour of the X_1 generation of some of these types with regard to the number of fruits harvested.

It will be seen from the above table that in Tori 7, while the control had 229 fruits, the selection from the 100 m.a.H. treatment had 318 fruits. In Rai 5, the relative figures are 903 fruits in the control as against 2627 fruits in a selection from the 300 m.a.H., treatment; *an increase of 3 times over the control.* In Brown Sarson, while the control had only 524 fruits, a selection also from the 300 m.a.H., treatment had 1163 fruits i.e. *double the number of fruits over the control.* In R. L. 9, while

TABLE 23

Type & Locality	Control & Treatment	Selection No.	Maximum No. of fruits
Tori 7 (West Bengal)	Control	3-F7/1/6	229
	100 m.a.H.	3-F8/3/3	318
	300 "	3-B9/3/4	309
Rai 5 (West Bengal)	Control	3-G4/1/5	903
	100 m.a.H.	3-F5/2/5	1090
	300 "	3-J6/5/5	2627
Brown Sarson (E. Punjab)	Control	3-N4/4/2	524
	100 m.a.H.	3-O5/1/8	804
	300 "	3-N6/3/6	1168
R. L. 9 (E. Punjab)	Control	3-L1/3/9	703
	100 m.a.H.	3-L2/2/2	3594
	300 "	3-M3/1/1	3248
T. 185 (New Delhi)	Control	3-V1/5/9	484
	100 m.a.H.	3-S2/1/4	379
	300 "	3-R3/3/1	717

had 3594 fruits; an increase of 5 times. In T 185, the relative figures are 484 fruits in the control as against 717 fruits in a selection from the 300 m.a.H. treatment. Thus it will be seen that in all the above cases, selections from the irradiated progenies had a much larger number of fruits.

Table 24, gives the comparative yield of the X_1 of 1953 and X_2 of 1954 in the types of mustard under investigation.

It will be seen from the above table that in the X_2 generation, of Tori 7, one plant selected from the 140 m.a.H. treatment had 456 fruits, as against 312 in the control. This particular plant had only 450 fruits as against 460 in the control of the X_1 generation. The highest average number of fruits, viz., 223.0 as against 188.7 was obtained in the X_2 from a 65 m.a.H. treatment. It will be noted that the best yielders of the X_1 generation also gave a high yield in the X_2 ; but its average number was low, even lower than in the control.

In Rai 5, although the control was the best yielder in the X_1 , in the X_2 , one plant selected from the 175 m.a.H. treatment had 1900 fruits, as against 1022 in the control. The best average yield in the X_2 was from the 65 m.a.H. treatment, viz., 739.8 fruits, as against 333.7, in the control i.e., more than double the yield of the control.

In Brown Sarson, the best plant in the X_2 had 993 fruits, with an average of 354.1, as against 841 fruits in the best plant of the control.

TABLE 24

Type & Locality	X ₁ —1953			X ₂ —1954		Average fruits of 10 plants
	Control & Treatment	Selection No.	No. of fruits	Selection No.	No. of fruits	
Tori 7 (West Bengal)	Control	2/2/18	460	3-B5/3/1	312	188.7
	65 m.a.H.	2/4/13	460	3-E1/6/12	395	223.0
	100 "	2/7/93	380	3-E2/6/13	375	205.8
	140 "	2/8/2	450	3-D3/6/7	456	157.0
	200 "	2/11/109	508	3-D4/6/11	430	180.4
Rai 5 (West Bengal)	Control	2/12/73	1900	10-A5/5/18	1022	333.7
	65 m.a.H.	2/15/36	1200	10-A1/10/11	1047	739.8
	100 "	2/18/3	1450	10-D2/4/2	728	532.5
	175 "	2/25/2	1220	10-F3/1/11	1900	379.1
	250 "	2/32/24	1834	10-D4/8/7	1300	283.8
Brown Sarson (E. Punjab)	Control	1/35/86	394	1-I4/1/5	841	286.7
	65 m.a.H.	1/38/26	198	1-J1/1/6	993	354.1
	100 "	2/38/78	662	1-F2/6/20	870	271.1
	200 "	1/46/72	321	1-G3/3/7	708	291.9
T. 88 (New Delhi)	Control	2/3/1	210	5-B1/5/25	162	168.9
	100 m.a.H.	2/4/19	200	5-C2/7/11	490	244.3
T. 185 (New Delhi)	Control	2/5/5	1620	5-C3/1/21	1452	547.3
	100 m.a.H.	2/6/1	600	5-C4/10/6	880	383.8
T. 164 (New Delhi)	Control	2/1/19	1250	3-C2/1/22	445	359.4
	100 m.a.H.	2/2/13	1200	3-A2/1/24	840	375.9

in the X₁, viz., 198 fruits as against 394 in the control. The best plant in the X₁ also gave a good yield in the X₂ and the average yield was also satisfactory.

In T 88, although the treatment in the X₁ had a lower yield than the control, in the X₂, it gave 490 fruits, as against 162 in the control with an average of 244.3, as against 168.9 in the control.

In T 185, the controls gave higher yields than both the X₁ and X₂ generation.

In T 164, while the control was better than the treatment in the X₁, in the X₂, it had 840 fruits with an average of 375.9, as against 445 fruits in the control with an average of 359.4.

Table 25, gives the behaviour of the X₁ of 1951, the X₂ of 1953 and the X₃ of 1954 in Rai 5.

Here it will be seen that the best plant in the X₁ generation was

TABLE 25

Type & Locality	Control & Treat-ments	Selec- tion No.	X ₁ —1951		X ₂ —1953		X ₃ —1954	
			Fruits No.	Selec- tion No.	Fruits No.	No. average of 10 plants	Selec- tion No.	Fruits No. average of 10 plants
Rai 5 (West Bengal)	Control	8/23/12	456	1/4/16	1250	455.0	1-D5/1/9	890 515.2
	50 m.a.H.	8/22/34	665	1/6/18	2300	850.0	1-C1/6/2	1268 723.1
	65 "	8/28/20	437	1/5/22	1050	577.7	1-E2/1/11	898 606.7
	100 "	8/30/42	552	1/3/14	725	375.9	1-A3/1/5	1120 501.5
	140 "	8/26/36	547	1/2/12	1050	352.0	1-A4/1/19	1030 405.8

Table 26, gives the number of days taken by the first plant to flower, in the control and the various treatments of the X₁ generation in the types under study.

TABLE 26

Type & Locality	Control & Treatment	Selection No.	Date of sowing	Date of Ist flower- ing	Age of the plant at the time of flower- ing	Earliness or Lateness in days
Tori 7 (West Bengal)	Control	J1-3/3/5	7-10-54	1-11-54	25	
	100 m.a.H.	F2-3/1/9	"	28-10-54	22	3 days early
	300 "	G3-3/4/4	"	27-10-54	21	4 " "
Rai 5 (West Bengal)	Control	G4-3/3/6	7-10-54	16-11-54	40	
	100 m.a.H.	J5-3/2/2	"	14-11-54	38	2 days early
	300 "	H6-3/3/7	"	11-11-54	35	5 " "
Brown Sarson (E. Punjab)	Control	N4-3/1/7	7-10-54	4-12-54	58	
	100 m.a.H.	P5-3/4/6	"	20-11-54	44	14 days early
	300 "	O6-3/1/1	"	30-11-54	54	4 " "
R. L. 9 (E. Punjab)	Control	A1-1/2/3	4-11-54	1-1-55	58	
	100 m.a.H.	C2-1/4/10	"	5-1-55	62	4 days late
	300 "	C3-1/1/8	"	3-1-55	60	2 " "
T. 185 (New Delhi)	Control	U1/1/2	22-10-54	15-12-54	54	
	100 m.a.H.	S2/5/2	"	15-12-54	54	
	300 "	S3/3/3	"	18-12-54	57	3 days late
T. 88 (New Delhi)	Control	U4/4/4	22-10-54	16-12-54	55	
	100 m.a.H.	V5/1/8	"	16-12-54	55	
	300 "	V6/1/1	"	18-12-54	57	2 days late
T. 164 (New Delhi)	Control	G1-3/3/7	31-10-54	21-12-54	51	
	100 m.a.H.	G2-3/5/10	"	20-12-54	50	1 day early
	300 "	G3-3/3/4	"	23-12-54	53	2 days late
T. 71 (New Delhi)	Control	I4-3/4/8	31-10-54	1-1-55	62	
	100 m.a.H.	I5-3/2/10	"	31-12-54	61	1 day early

It will be seen from the above table that the maximum earliness was found in the 100 m.a.H. treatment of Brown Sarson, which flowered 14 days earlier than the control. Many of the treatments in the other types were also early, ranging from 1-5 days. But a few were later than their respective controls.

Table 27, gives the number of days in between the first and the last plant to flower in the population, both in the controls and the treatments in the X_1 , in the types of *Brassica* under investigation.

TABLE 27

Type & Locality	Control & Treatment	Date of sowing	Date on which the first plant flowered	Date on which the last plant flowered	No. of days covered	Earliness or Lateness in days
Tori 7 (West Bengal)	Control	7-10-54	1-11-54	12-11-54	12	
	100 m.a.H.	"	28-10-54	16-11-54	20	8 days late
	300 "	"	27-10-54	13-11-54	18	6 " "
Rai 5 (West Bengal)	Control	7-10-54	16-11-54	2-12-54	17	
	100 m.a.H.	"	14-11-54	2-12-54	19	2 days late
	300 "	"	11-11-54	2-12-54	22	5 " "
Brown Sarson (E. Punjab)	Control	7-10-54	4-12-54	14-12-54	11	
	100 m.a.H.	"	20-11-54	11-12-54	22	11 days late
	300 "	"	30-11-54	11-12-54	12	1 day late
R. L. 9 (E. Punjab)	Control	4-11-54	1-1-55	16-1-55	16	
	100 m.a.H.	"	5-1-55	16-1-55	12	4 days early
	300 "	"	3-1-55	16-1-55	14	2 " "
T. 185 (New Delhi)	Control	22-10-54	15-12-54	2-1-55	19	
	100 m.a.H.	"	15-12-55	4-1-55	21	2 days late
	300 "	"	18-12-55	4-1-55	18	1 day early
T. 88 (New Delhi)	Control	22-10-54	16-12-54	23-12-54	8	
	100 m.a.H.	"	16-12-54	29-12-54	14	6 days late
	300 "	"	18-12-54	29-12-54	12	4 " "
T. 164 (New Delhi)	Control	31-10-54	21-12-54	9-1-55	20	
	100 m.a.H.	"	20-12-54	9-1-55	21	1 day late
	300 "	"	23-12-54	23-1-55	32	12 days late
T. 71 (New Delhi)	Control	31-10-54	1-1-55	10-1-55	10	
	100 m.a.H.	"	31-12-54	11-1-55	12	2 days late
	300 "	"	28-12-54	11-1-55	15	5 " "

It will be seen that in Tori 7, Rai 5, Brown Sarson, T 88, T 164 and T 71, the controls are better than the treatment as regards the duration of flowering. But in R. L. 9, the 100 m.a.H. treatment is

Table 28, gives the average of 100 readings of the diameter of the pollen grains in microns, in the control and the treatments in the X_1 generation.

TABLE 28

Type & Locality	Control & Treatment	Pollen diameter in μ (average of 100)
Tori 7 (West Bengal)	Control	46.37
	100 m.a.H.	48.05
	300 "	48.38
Rai 5 (West Bengal)	Control	48.38
	100 m.a.H.	49.73
	300 "	48.72
R. L. 9 (E. Punjab)	Control	48.22
	100 m.a.H.	51.24
	300 "	51.41
Brown Sarson (E. Punjab)	Control	42.00
	100 m.a.H.	44.52
	300 "	46.54
T. 71 (New Delhi)	Control	43.68
	100 m.a.H.	44.86
	300 "	46.87
T. 88 (New Delhi)	Control	46.20
	100 m.a.H.	45.36
	300 "	46.20
T. 164 (New Delhi)	Control	43.51
	100 m.a.H.	46.70
	300 "	46.70
T. 185 (New Delhi)	Control	46.70
	100 m.a.H.	45.70
	300 "	48.89

It will be seen that in Tori 7, R. L. 9, Brown Sarson and T 71, the diameter of the pollen grains is least in the control and increases with increase in dosage. In T 164, the control has the smallest pollen grains, while it is equal to the two treatments. In Rai 5, the control has the smallest pollen grains, while the lower dosage gave the biggest pollen grain. In T 88, the pollen diameter is the same both in the

Table 29, gives the percentage of pollen sterility in the X_1 generation in the controls and the treatments in the types of *Brassica* under investigation.

TABLE 29

Type & Locality	Control & Treatment	% of pollen sterility
Tori 7 (West Bengal)	Control	3.29
	100 m.a.H.	6.12
	300 "	9.30
Rai 5 (West Bengal)	Control	2.31
	100 m.a.H.	3.59
	300 "	3.85
R. L. 9 (E. Punjab)	Control	2.10
	100 m.a.H.	4.25
	300 "	4.43
Brown Sarson (E. Punjab)	Control	7.81
	100 m.a.H.	10.00
	300 "	17.13
T. 71 (New Delhi)	Control	7.63
	100 m.a.H.	5.38
	300 "	5.34
T. 88 (New Delhi)	Control	3.09
	100 m.a.H.	4.87
	300 "	13.01
T. 164 (New Delhi)	Control	1.97
	100 m.a.H.	3.83
	300 "	4.38
T. 185 (New Delhi)	Control	3.44
	100 m.a.H.	3.42
	300 "	9.09

It will be noticed that in Tori 7, Rai 5, R. L. 9, Brown Sarson, T 88 and T 164, the sterility is least in the control and increases with increase in dosage. In T 185, the 300 m.a.H. has the maximum sterility, while it is slightly lower in the 100 m.a.H. treatment than in the control. In T 71, the control has the maximum sterility, while it decreases with increase in dosage.

C.4.4. Important results obtained during the year 1954-55.

1. *Sesamum*

a) Yield (number of fruits).

(ii) In the X_2 generations, many of the selections from the previous year's treatments produced higher yielding plants, when compared to the controls.

(iii) Most of the X_3 and X_4 populations also gave higher yields than their respective controls.

(iv) The X_5 populations of the West Bengal types *viz.*, Type Nos. 12 and 16 continued to give higher yields.

b) *Earliness.*

(i) In the X_1 population in type no. 10, a selection from 250 m.a.H. treatment was earlier than its control by 13 days.

(ii) The early X_2 selections of type nos. 10, 12 and 16 from West Bengal continued to be early. The maximum earliness of 7 days has been observed in a selection from the 50 m.a.H. population of type no. 10 and 8 days from a selection of the 36 m.a.H. population of type no. 16.

(iii) Early selections from the X-rayed populations of 1950 continued to exhibit this character in the X_5 generation also.

c) *Other features.*

(i) The duration of flowering has been found to be shortened in many of the treated populations of X_1 , X_4 and X_5 .

(ii) A white flowered mutant of type no. 16 isolated previously is being investigated in the subsequent generations with reference to its yield and quality of the oil.

d) *Oil content and quality of the oil.*

(i) The oil content in a mutant selection of type no. 16 in the X_5 generation was found to be 53.53% as against 41.24 (mean percentage) in the control.

(ii) In the white flowered mutant of type no. 16 in the X_5 , the maximum oil content was 46.38%.

II. *Brassica.*

a) *Yield (number of fruits).*

(i) In the X_1 generation some selections have been found to be much better than their respective controls.

(ii) Most of the selections of X_1 gave higher yields in the X_2 over their respective controls.

(iii) The yield selections of Rai 5 proved to be better than the control in the X_3 generation.

b) *Earliness.*

(i) The maximum earliness of 14 days was observed in a selection of the 100 m.a.H., X_1 population of Brown Sarson.

c) *Other features.*

G.4.5. Cytological, cytogenetical and anatomical investigations in other plant genera and species.

a) Cytogenetics of *Solanum* sp.

Single plant selections were made from the heterogenous population of *S. melongena* L. (Brinjal or Egg plant) varieties obtained from Indian Agricultural Research Institute, New Delhi; Bihar Agricultural Research Institute, Sobour; Allahabad, Lucknow and Bulsar, and used in these investigations.

Genetical studies.—Data were collected mainly on fruit shape, size and colour; flower size and colour, nature of inflorescence, thorny nature of the plants, their height and spread; flowering and fruiting period; yield and weight of the fruits.

Typical varieties, based on above characters, such as Green long (Lucknow); S. M. 5 and S.M. 1 (Sabour); T. 17 and *S. melongena* var. *insanum* (Delhi); Bulsar long purple (Bulsar); Long Purple (Sutton's); "Ram Nagar giant" and "All the year" (Globe Nursery); together with *S. nigrum* (Allahabad); *S. xanthocarpum* (Allahabad); *S. macranthum* (Sabour) and various intervarietal crosses were selected for the present study.

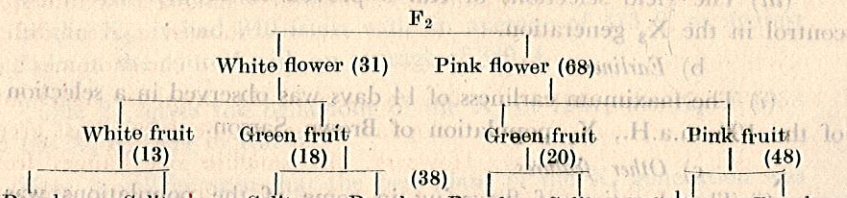
Occurrence of tricotyledonous seedlings, carpel polymorphism and fusion of two buds leading to twin fruits have been recorded and will be studied later.

Crossing experiments —

Intervarietal crosses, employing Kakizaki method of bagging the flowers and simple budtying method, were made.

Cross No. 1.

	Green Long Parent	T. 17 Parent	F ₁
Habit	Tall and erect	Spreading	Medium height and spreading, more than average.
Branches	7	7	7
Leaves	Thick and large	Medium and small	Medium.
Inflorescence	Solitary	Cluster	Cluster.
Flowers	Large and pink	Small and white	Pink and medium.
Fruits	Pink and long but few in number.	White and small in bunch.	Pink and medium in bunch.



Heterosis was noted in F_1 . Pink colour of the fruit as well as flower and cluster inflorescence was found to be dominant over white colour and solitary inflorescence, respectively.

Some plants with erect habit and thin papery leaves have been observed and will be studied later.

Cross No. 2

S.M. 5

S. melongena var *insanum*

Habit	Tall and erect	Spreading and thorny
Leaves	Thick and large	Small
Inflorescence	Cluster	Cluster to solitary
Flowers	Pink and large	Pink and small
Fruits	White round	Small dull green with streaks

Though the F_1 of this cross is under study, observation of plants having white flowers with pink streaks on the back of the petals, is of special interest both genetically and cytologically.

Cytological Investigations.

Mitosis. Detailed studies on the chromosome morphology were undertaken, which has not been done previously. The somatic number ($2n=24$) is constant in all the *S. melongena* varieties, except *S. melongena* var *insanum*, where a fragment was observed. The lengths of the chromosomes in varieties already mentioned varied from 2.8 microns to 1.4 microns and form a graded series without any wide gap. They have been classified as large, large medium, medium, medium small and small chromosomes. Mostly, chromosome complements show median and submedian primary constrictions but a pair of chromosome in S.M. 5, "Ram Nagar giant", Sutton's "Long purple", a progeny of S.M. 5 × S.M. 1 and hybrids of Green long × T. 17 and S.M. 5 × var. *insanum*, showing terminal and subterminal primary constrictions, have been recorded. A hexaploid *S. nigrum* ($2n=72$) has its chromosome ranging between 1 micron to 1.9 microns in length. Due to the smallness of the chromosomes, the position of primary constriction was difficult to be traced, but 6 pairs of chromosomes having very thin split satellites have been observed. Brinjal varieties showed a great difference in number of satellited and secondary constricted chromosomes and as such, their attachment to the nucleolus in the prophase stages and the number of nucleoli in the telophase stages by Feulgen—Fast green technique is under study. However, the satellite size ranges from 0.5 micron with a knob to 1 micron thread. This study, together

bivalent associations in prometaphase and metaphase stages, have been undertaken to throw light on the basic number of the genus *Solanum* and to see if it is a secondarily balanced diploid. This aspect is important in view of Wanscher's assumption that the basic chromosome number of solanaceous plants is 4, but Muntzing thinks it to be 6.

Some metaphase plates showing somatic pairing have also been observed. Achromatic distal ends of the chromosomes and its relation if any, with the end to end fusion of two pairs of chromosomes in the hybrid of S.M. 5 var. *insannum* is under investigation.

A thorough study of prochromosomes, quite prominent in resting nuclei, tracing all the stages from round and oval to complete formation of prophase chromosomes, have been made.

Meiosis. Smear preparations, acetocarmine squash and microtomed sections of anthers were made to study meiosis in pollen mother cells. Since acetocarmine preparations of the material fixed in Aceto-Alcohol (1 : 3), gave good spreading and staining, it was largely employed for the present studies. Regular division of bivalents ($n=12$) was observed except in *S. macranthum*, where bridge formation, laggards and extrusion were frequent, leading to the highest degree of sterility, confirmed by its inability to set any fruits. Chiasma frequency from the pachytene to the diakinesis stages of meiosis in the above materials has been studied. One to three chiasmata per bivalent, depending on the size of the chromosomes have been observed in these varieties. Terminalisation of chiasmata appeared to be complete at diplotene in the short chromosomes. Most of the medium and long chromosomes showed interstitial chiasmata at metaphase. Further studies are in progress.

C.4.6. *Cytogenetical studies in Tomato.*

For these investigations, the following species and varieties of tomato (*Lycopersicon esculentum*) were collected.

1. *L. esculentum* var Early Market, from Sutton's
2. *L. esculentum* var Golden queen, from Sutton's
3. *L. esculentum* var Best of all, from Sutton's
4. *L. esculentum* var Harbinger, from Sutton's
5. *L. esculentum* var Perfection, from Sutton's
6. *L. esculentum* var Abundance, from Sutton's
7. *L. esculentum* var San-Margano, from U.S.A.
8. *L. esculentum* var Male sterile Pearson, from U.S.A.
9. *L. peruvianum*, from Rio Supe, Peru, collected in 1949
10. *L. peruvianum* var hirsutifolium, from San Juan
11. *L. hirsutum*, from Canta, Peru, collected in 1949

Among the plants grown from Sutton's seeds, the following aberrant types were isolated for further studies.

- (1) With bicompond leaves, isolated from Golden queen.
- (2) Dwarf plants, isolated from Abundance.
- (3) With accidial cup like structure instead of the first leaf succeeding the cotyledons, isolated from Early market.
- (4) Tricotyledonary and tetracotyledonary plants, isolated from early market. These did not survive.

Detailed observations were made on the nature of the inflorescence, size of flowers, colour, shape, size and weight of the fruits. The duration of flowering and fruiting and the order of the ripening of the fruits were also recorded. It has been found that in the fruits, characters such as colour, skin and flesh, size, shape and number of chambers and a green cap in the unripe ones, are specific, helping in the identification of the varieties.

The number, weight and morphology of seeds, were also noted. Seeds of each variety were collected for raising pure line cultures. One fruit in the variety of "Best of all" was found to contain tan coloured seeds, while a fruit in "Abundance" variety had a few of its seeds with a single tan spot and the rest with the normal colour. These were separated for further studies.

$2n$ was found to be 24 in six of the Sutton's varieties studied, with a pair of secondary constricted chromosomes in their complements. The number of nucleoli in somatic cells so far observed was 4. Comparative studies of mitotic plants of different varieties are being continued.

Meiotic studies in relation to secondary association and multivalent formation are being undertaken. Lagging chromosomes and extrusion of chromatin were observed frequently.

c) Cytological aspects of sex-differentiation and evolution in plants.

For this study, some monoecious genera of *Cucurbitaceae* such as *Cucumis sativus*, *Cucurbita maxima*, *Citrullus vulgaris* and *Trichosanthes anguina* were selected.

Primary and secondary root tips of the above species, grown in the soil or sand and saw dust in pots and from seedlings germinated in petridishes were fixed in different types of fixatives like chromic-formalin, platinum chloride-formalin and acetic-alcohol in various pro-

formalin in the proportion 1 : 3 : 6. Staining was done by crystal violet and Feulgen-Fast green techniques.

The morphology of the chromosomes, the number of nucleoli and their relation to secondary constrictions in *Cucumis sativus*, *Cucurbita maxima* and *Citrullus vulgaris* are being investigated, with a view to find out the heteromorphic chromosomes, if any.

In *Cucumis sativus*, the somatic chromosome number of $2n=14$ has been confirmed, but few cells having $2n=15$, 16 and 17 chromosomes have been recorded. One pair of the chromosomes appear to be heteromorphic, which is being thoroughly studied. Secondary constrictions were clearly seen. The number of satellited and secondary constriction chromosomes and their attachment to the nucleolus in the prophase stages and the number of nucleoli formed in telophase are being investigated. Tetraploid cells were occasionally observed in the cells of the root tips.

The reported somatic number of $2n=24$ in *Cucurbita maxima* has been confirmed, and the details of chromosome morphology are being studied. The chromosomes being comparatively small, are difficult for critical studies. Flower buds were also fixed in Navashin's fluid for detailed meiotic investigations.

Root tips of *Citrullus vulgaris* showed the somatic number to be $2n=22$ as reported earlier. The morphology of the chromosomes are being studied.

C. 5. Control of weeds by the use of hormone type of selective weed killers.

This is a co-ordinated scheme financed by the Indian Council of Agricultural Research and is in the second year of investigation, during the year under report.

The weeds selected for detailed studies had been mentioned in the previous years report, but are listed again for the sake of continuity. They are (1) *Cyperus rotundus* L., (2) *Vicia sativa* L., (3) *Imperata arundinacea* Cyrill., (4) *Ludwigia parviflora* Roxb. (5) *Rottboelia compressa* L.

TABLE 31

Name of the weeds

Chemicals	Eichornia crassipes			Ludwigia parviflora			Rottboellia compressa			Cyperus rotundus			Imperata arundinacea			Vicia sativa			Remarks
	% Used in Laboratory	% Used in Field	No. of days	% Used in Laboratory	% Used in Field	No. of days	% Used in Laboratory	% Used in Field	No. of days	% Used in Laboratory	% Used in Field	No. of days	% Used in Laboratory	% Used in Field	No. of days	% Used in Laboratory	% Used in Field	No. of days.	
+Carbowax	0.05	0.07	14	0.07	0.1	12	5.0	7.0	30	2.0	3.0	10	5.0	7.0	25*	0.1	0.15	4	
water	0.5	0.7	15	0.5	0.7	15	6.5	7.0	30*	4.5	6.0	7	5.0	8.0	15*	1.0	1.5	5	
water	0.4	0.75	16	1.5	2.0	12	10.5	15.0	28*	5.0	7.0	15	10.0	12.0	20*	1.0	1.5	5	
water	1.0	1.25	15	2.0	2.5	15	10.0	15.0	30*	5.0	8.0	23	10.0	15.0	30*	1.0	1.25	4	
de I in water	0.1	×	24	0.2	×	3	0.2	×	3	1.0	×	6	×	×	×	0.75	×	4	× Expts. were conducted in the seedling stage except for in <i>Eichornia</i> sp. as this chemical usually does not have any effect on established plants.
water	0.3	0.5	17	0.75	1.0	15	7.5	10.0	28*	5.0	7.0	20	7.0	10.0	22*	0.5	1.0	5	
water	0.2	0.5	16	0.15	0.25	15	5.0	7.0	27*	2.0	3.0	10	5.0	8.0	15*	0.5	1.0	6	
water	0.4	0.75	16	1.5	1.75	14	12.0	15.0	30*	2.5	4.0	10	6.0	9.0	15*	0.5	1.0	7	
water	0.3	0.5	13	1.0	1.5	12	10.0	12.0	30*	2.5	4.0	12	5.0	9.0	15*	0.5	0.75	6	* Occasional revival from undestroyed parts.
C.A. in water	3.5	3.0	14	2.5	3.0	14	5.0	7.5	22*	2.5	5.0	12*	5.0	7.5	10	1.0	2.0	10	

The chemicals used, together with the names of the firms or organisations who supplied them are given in the following table.

TABLE 30

Chemicals :	Supplied by
1. 2,4-D (D.C.P.A.)	1) National Chemical Laboratory of India, Poona. 2) M/s. Boots Pure Drug Co. (India), Ltd. 3) M/s. Bengal Chemicals.
2. Fernoxone (Na-salt of 2,4-D)	M/s. Imperical Chemical Industries Ltd.
3. Cornox D. (Amine Salt of 2,4-D)	M/s. Boots Pure Drug Co.
4. Dicotox (Ester of 2,4-D)	M/s. May & Baker Ltd.
5. Crag Herbicide I. (2,4-Dichloro-phenoxy ethyl sulphate)	M/s. National Carbon Co.
6. 2,4-5 T. (2,4-5 Trichloro phenoxy acetic acid)	M/s. Imperical Chemical Industries Ltd.
7. 2, Methyl Chlorophenoxy acetic acid (M. C. P. A.)	National Chemical Laboratory of India.
8. Cornox M. (M. C. P. A.)	M/s. Boots Pure Drug Co. (India), Ltd.
9. Agroxone 3 (M. C. P. A.)	M/s. Imperical Chemical Industries Ltd.
10. Na-Trichloro-acetate (Na-salt of T. C. A.)	1) National Chemical Laboratory of India 2) M/s. Imperical Chemical Industries.

During the year, the following lines of investigations were undertaken.

C. 5.1. *The doses of chemicals necessary to eradicate the weeds in the laboratory, or small plots of fields, without the economic plants.*

Detailed experiments in pots at the Bose Research Institute Laboratory and in small plots of fields at the Bose Research Institute Farms both at Falta and Shyamnagar and at the State Agricultural Farms at Tullygunj and Chinsurah had been carried out. Most of the experiments had been done on the selected weeds growing alone i.e., without economic plants, as per the programme.

The concentrations of the chemicals used, to find out the doses

G. 5.2. *The survey of the principal economic crops and weeds associated with them.* The economic crops of West Bengal studied in this connection are :—

- (1) Paddy
- (2) Jute
- (3) Sugar cane
- (4) Wheat
- (5) Banana
- (6) Cotton
- (7) Mustard

and the weeds associated with them are :

(1) *Paddy.*

Rottboelia compressa, *Ludwigia parviflora*, *Ammania baccifera*, *Echinochloa crusgalli*, *Hydrolea zeylanica*, *Vicia sativa*, *Cyperus difformis*, *Eleocharis plaustris*, *Scirpus supinus*, *Aeschynomene indica*, *Trianthema* sp., *Astercantha longifolia*.

(2) *Jute.*

Trianthema portulacastrum, *Echinochloa crusgalli*, *Echinochloa colona*, *Cyperus pallilus*, *Cyperus rotundus*, *Croton sparsiflorus*, *Cassia tora*, *Eragrostis pseudointerrupta*, *Euphorbia hirta*, *Phyllanthus niruri*.

(3) *Sugarcane.*

Imperata arundinacea, *Panicum colona*, *Cyperus rotundus*, *Cyperus cephalotes*, *Euphorbia hirta*, *Phyllanthus simplex*, *Sida cordifolia*, *Digitaria digitata*, *Cynodon dactylon*.

(4) *Wheat.*

Trianthema sp., *Melilotus alba*, *Melilotus indica*, *Boerhaavia diffusa*, *Anagallis arvensis*, *Panicum* sp., *Cyperus rotundus*, *Digera arvensis*, *Achyranthes aspera*, *Physalis minima*, *Leucas aspera*, *Gomphrena indica*, *G. celocioides*.

(5) *Banana.*

Echinochloa colona, *Eragrostis interrupta*, *Alternanthera phylloxeroides*, *Alternanthera triandra*, *A. sessilis*, *Croton sparsiflorus*, *Rottboelia compressa*, *Cyperus rotundus*, *Imperata arundinacea*, *Cynodon dactylon*, *Eragrostis pseudointerrupta*.

(6) *Cotton.*

Cyperus rotundus, *Imperata arundinacea*, *Cyperus cephalotes*, *Rottboelia compressa*, *Trianthema portulacastrum*, *Digitaria digitata*.

Kyllingia monocephala, Lippia sp., Justicia simplex, Sida cordifolia, Euphorbia hirta, E. thymifolia, Leucas aspera, Amarantus spinosus, Celosia argentea, Croton sparsiflorus, Tridax procumbens, Scoparia dulcis, Boerhaavia diffusa.

(7) *Mustard.*

Cynodon dactylon, Eragrostis pseudointerrupta, Oplismenus compositus, Anagallis arvensis, Cassia tora, Croton sparsiflorus, Cyperus rotundus, Argemone mexicana and Chenopodium album.

C.5.3. *The action of the chemicals on the various tissues of the weeds, methods and order of decay and death, under laboratory conditions and small plots in the fields.*

Almost all the selective herbicides so far used, with the exception of Crag Herbicide I, have more or less the same mode of action regarding the order of decay of the tissues of the plants. When sprayed on the leaves they are readily absorbed, stomata not being the only portals entry. The diffusion of the chemicals largely depends on the thickness of the cuticle and the presence of other epidermal outgrowths. They are absorbed and translocated mostly through the phloem downwards, but when applied to roots, it is transported upwards through the xylem, resulting in the wilting and death of the leaves first, which are away from the points of application.

C.5.3.1. *Order of the decay of tissues in the individual weeds.*

1) *Eichornia crassipes* : When sprayed with herbicidal concentrations of 2,4-D, M. C. P. A., and 2,4-5 T. formulations, the outer leaves show epinasty, curling and contortion within 24 hours. Dry patches appear on the leaf blades on the following day. Drying and curling in of the outer half blade continues along with chlorosis. After two days, these leaves turn completely pale. As stated earlier, the outer leaves are first to be affected. By about the third day, the effect of the chemical is noticed on many other parts of the plant and there is complete inhibition of the growth. Then the roots get decayed, first at their joints with the stem and these come out easily when pulled. Thus the whole root system and the outer leaves are killed by the tenth day. The decay continues to the younger leaves and stem which are also killed within a period of twelve days. In general, in about two weeks the plant as a whole is killed by the herbicide.

With Crag Herbicide I, the action of the chemical when sprayed on the leaf, is slower and they exhibit epinasty as in the above cases, but the dry patches on the leaf blades could not be noticed. Chlorosis of the leaf was apparent within five days. Tissue gradually decayed.

about twentyfour days. As in the previous case, the outer leaves are affected first.

With Na-salt of T. C. A., there was more burning effect on the leaves after spraying but the order of decay was similar to the earlier cases. The plants died in about fourteen days.

2) *Ludwigia parviflora* : When sprayed with herbicidal concentration of 2,4-D, M. C. P. A., and 2,4-5-T., the younger parts are affected first. The tender leaves on the growing apex with the stem tip bend downwards the day following the application. This is followed by twisting of stem and drying of the upper leaves. Chlorosis of the leaves is visible by third or fourth day. This, along with decay of the portion mentioned above, continues downwards till the whole plant is killed, which takes place within a period of twelve to fifteen days.

When sprayed with Crag Herbicide I, the initial responses are similar as in the above case, viz., epinasty of leaves, contortion and bending of stem and chlorosis of the older leaves. But the plant showed signs of revival after seven or eight days. Germinating seedlings have been killed within three days.

Na-Salt of T.C.A., has a slower effect even when concentration is high, symptoms of burning are conspicuous. Plants die in about fourteen days.

3) *Rottboelia compressa*. The plants are not killed completely as in the above cases, especially at concentrations below 10%. At higher concentrations, the effect of these selective herbicides is more or less like that of contact herbicides i.e., the drying of plant parts where the chemical has come in contact. The absorption and translocation appear to be difficult in this case, with the result that those parts of the plant where the chemical has not reached, remain un-affected for a long time, although the growth of the plants is inhibited throughout this period. With the higher concentrations, most parts of the plants have been killed in about thirty days. Revival of underground portions of the sprayed plants has been noticed, even after two months.

Crag Herbicide I, had no action on this plant after it was established. Germinating seedlings have been killed in about three days.

Na-salt of T.C.A. kills the aerial parts of the plant in a shorter period of about twenty two days and in this sense appears to be effective. But the plants may revive after that period.

4) *Cyperus rotundus*. When sprayed over the plants so as to cover the leaves at the herbicidal concentrations with 2,4-D (and its formulations), M.C.P.A. and 2,4-5 T, the plants show the symptoms associated with their effects in about twenty four hours. There is a marked wilting

develop a greyish colour. Death, however, starts from the tip and the edges of the leaves. Older leaves are the first to die. Besides, there is also the death of the leaf tissue at its base. Aerial parts die completely within 15-23 days.

When applied in similar concentration into the soil, the rhizomes stop their further activity.

The effects of Crag Herbicide I, are not very pronounced on a established *Cyperus* plant. Sprouting rhizomes, however when sprayed at the early stage, were killed in about six days.

Application of Na-Salt of T.C.A., brings about a characteristic yellowing of the older leaves. There is no complete killing and most of the plants gradually recover. In very high concentrations, however, it acts as a contact herbicide and kills the plant in about 12-13 days.

5) *Imperata arundinacea*. Being a comparatively resistant plant, it is not affected by the chemical unless applied in higher concentrations, more so with 2,4-D., its formulations, M.C.P.A. and 2,4-5 T. However, the general effect when leaves are sprayed with 2,4-D and others mentioned above in herbicidal concentrations are, that the leaves wilt at first, followed by chlorosis of the leaves. Ultimately, the death of the tissues of leaves starts both from the leaf tip and in scattered patches. The older leaves are first to be affected and these mostly die in about 30 days. There is generally no complete killing of plants and some plants revive even though their aerial portions had dried.

Crag Herbicide I, has even lesser effect on the established plants.

T. C. A., however, has been found to kill the plant with an average concentration of 5.0%. The leaves become chlorotic within 48 hours and in another 3-4 days, the aerial parts dry completely, but the whole plant takes about 10 days to be killed. However, no patches etc., are found on the lamina as in previous cases.

6) *Vicia sativa*. When sprayed with herbicidal concentration of 2,4-D (and its formulations) M.C.P.A., and 2,4-5 T. the plants collapse in about 2 days. The younger leaves and the stem apex are first to be affected. This is followed by chlorosis and gradually the plant succumbs in about 7-10 days. When applied to soil in similar concentrations, the seeds do not germinate at all and the young seedlings cease to grow at that stage, ultimately dying in about two days.

Application of Crag Herbicide I brings about similar though delayed effect when applied on the leaves of a relatively young plant.

Na-Salt of T.C.A. does not have much effect until sprayed in relatively high concentrations, when it acts as a contact herbicide and kills the plant in about 10 days.

C.5.4. Besides the above observations with regard to the effect of these herbicides on the mode of decay and death of the weeds, certain observations on the anatomical and physiological changes in the plants due to these chemicals were also made. They are :—

1. The application of all the formulations of 2,4-D, particularly the Amine salts, had a marked effect on the storage tissues of the plant. Within 48 hours of spraying of the aerial portions in *Cyperus rotundus* with a herbicidal concentration of these chemicals, depletion of the starch content in the rhizome was noticed. The hydrolysis and the consequent depletion of the starch continued and by the time the plant was killed, almost all the starch had disappeared from the rhizome tissues.

2. The same treatments in most of the weeds were found to produce a blocking of the lumen of the xylem vessels by the precipitation of a dark brown semi-gelatinous substance about 3 days after application. The number of such blocked lumen and the density of the precipitate went on increasing on succeeding days. However, even when the plant was completely killed, all the vessels were not blocked. This blocking may also be seen in some of the adjacent cells of the vascular tissue. The blocking of the vessels may impair the ascent of sap in the plants and is probably the cause of the reduced rate of transpiration exhibited by the treated plants.

3. These chemicals were observed to have a pronounced effect in the lignification of the xylem walls, with the result, that the walls become thicker.

4. When applied to very young seedlings of the weeds e.g., *Vicia sativa*, it produced a characteristic swelling of the root tips. The root stops growth, unless the treatment was made with a non-herbicidal concentration, and ultimately the seedlings dies.

d) Most suitable methods of application of the chemicals for various weeds in relation to the economic crops.

Spraying experiments for eradication of weeds has been carried out on a small scale during the year under report. Hand sprayers and high volume sprayers have been employed for this purpose. But in cases where the sprays had to be sent to longer distances, "Indian Fire Pump" (Knap sack type) had been used.

Eichornia crassipes : In tanks covered with this weed, spraying

Ludwigia parviflora : Spraying on the leaves of the weed growing along with the crop and/or alone had been carried out both with hand sprayers and high volume spraying equipments. The sprayer used was of the 'Smith Lightning type', with a long nozzle so that the spray could be directed to the weeds growing in between the crops. When the weed is young and the crop established, this method of application was the most affective.

Rottboelia compressa : As the weed requires a very high concentration of all the chemicals mentioned for its killing, it is most economic to eradicate weeds from the field before the crop is sown. This can be done either by selective or by contact herbicides.

Cyperus rotundus : For spraying the weed under the field conditions with and without economic plants, 'continuous hand-sprayers' as well as 'Smith Lightning type' of sprayers were used. For a better coverage and for spraying in between and under the economic plants, 'Smith Lightning type' of sprayer was found to be more satisfactory. Application of the chemical before the sowing of the economic plants or at an early stage of the growth of the weed is more effective.

Imperata arundinacea : Spraying the aerial portions with 'Lightning type' of sprayer with short range, multi-hole-nozzle is more successful, as it gives a better coverages. The plant itself, however, is very resistant and very high concentrations of these chemicals are needed to kill the plants. It is therefore, more effective and successful to spray before the crop is sown.

Vicia sativa : For spraying the weeds in the crop fields with the herbicides, 'Smith Lightning type' of sprayer was again found to be more useful. With the help of its long nozzle, the spray can be directed as desired; besides it also gives a better coverage. This plant being quite susceptible to most of the herbicides even in low concentrations, the herbicides can be applied with the economic plants without harmful effects on the latter.

However, for weeds out side crop fields, 'continuous hand sprayer' may also be employed with advantage, but it is not good for large scale operations.

C. 6. Paleobotany

Microflora from the Cambrians of India and Pakistan.

During the year under review five rock-specimens from the Vindhyan, one Neobolus shale from Kusak Fort, Punjab Salt Range obtained through the courtesy of the Geological Survey of India and six samples

of vascular microflora. This investigation has three fold bearings *viz.*, (1) it has led to a systematic micropalaeobotanical examination of the Vindhya's whose age it is now possible to surmise; (2) it has led to correlate the Dharliala Well samples with similar other formations; and (3) it has given scope to make a review of the vegetable zone-fossils.

This work is being carried out with the help of a grant-in-aid (third instalment) received from the Burmah Oil Company (India Concessions) Limited.

The following table gives the description of the rocks examined:

	S. No.	Registered No.	Description	Locality	Horizon
A. Vindhya's	1.	58/899B	Rohtas Lime-stone.	Patwadh Hill	Rohtas Stage
	2.	58/907B	Rohtas Shales	Do.	Do.
	3.	58/919B	Olive Shale	Nala east of Patwadh.	Kheinjua Stage.
	4.	58/921B	Porcellanites	West of Chohan Village.	Porcellanites Stage.
	5.	58/923B	Do.	South of Chohan Village.	Do.
B. Salt Range	6.	K33/591	Shale	Kusak Fort	Neobolus shale.
C. Dharliala Well	7.	Serial No.	1 Chocolate Sillstone	Depth 1550 ft.	
	8.	"	2 Impure Dolomite	"	1960 ft.
	9.	"	3 Oil shale	"	1987 ft.
	10.	"	4 Red Marl	"	2350 ft.
	11.	"	5 Rock Salt with some inclusions of Marl	"	3965 ft.
	12.	"	6 Impure anhydrite	"	3965 ft.

Besides carbonized woods, (a) Two winged spores along with several other simpler types occur in abundance in samples 1, 2, 7 and 8 only, (b) One winged spores with or without slit have been found only in the sample 6; (c) while simpler types of spores (? sporites) are recorded only in 12. Fragments of structureless carbonized woods and fibres occur in samples 3 and 11 respectively. Samples 4, 5, 9 and 10 have yielded negative results.

and siltstones and this leads one to compare them with the different stages of the Punjab Saline Series which (a) is composed of similar types of rocks and massive gypsum and variegated gypseous clays in addition and (b) is rich in microflora most of which are identical to those found in the Dharliala well No. 1 rocks and other rocks of undisputed Cambrian age. Therefore on lithological and palaeobotanical evidences it seems quite reasonable to conclude that both Dharliala well No. 1 rocks and the Punjab Saline Series are Cambrian in age and to suggest that either the Dharliala well No. 1 rocks represent a Saline Series homologous to the Punjab one or that the former is but an extension of the latter.

Two-winged and One-winged spores have all along been recorded in the Cambrian Neobolus Shales, Magnesian and Salt Pseudomorph stages of the Punjab Salt Range, and also in the mid-Cambrians of Kashmir. Since their existence has been displayed in the Dharliala Well rocks, serial Nos. 1 and 2, Rohtas limestones and shales and also in the Kheinjua rocks (see Annual Report 1953-54), it is possible to correlate these beds with the above-mentioned known Cambrian beds.

D. MICROBIOLOGY

The following items of investigation were undertaken during the year under review.

D. 1. Studies on soil micro-organisms in relation to antibiotic production and decomposition of herbicide.

1. Studies on the occurrence and isolation of antibiotic producing micro-organisms from the soils of India.
2. Antibiotic activity of the fungi from W. Bengal soil.
3. Identification of *Streptomyces* spp. from W. Bengal soil.
4. Studies on the production of antibiotics in soil.
5. Control of *H. sativum* by antibiotic-producing organisms.
6. Studies on the decomposition of Crag Herbicide and its effect on the soil microflora.

D. 2. Production of antibiotics by soil micro-organisms.

1. Further studies on the production of an anti-gram positive pigment by a *Streptomyces* sp. (A₁₂).
2. Further studies on the production of an antifungal antibiotic by a *Streptomyces* sp. (AC₄ 248).

and siltstones and this leads one to compare them with the different stages of the Punjab Saline Series which (a) is composed of similar types of rocks and massive gypsum and variegated gypseous clays in addition and (b) is rich in microflora most of which are identical to those found in the Dharliala well No. 1 rocks and other rocks of undisputed Cambrian age. Therefore on lithological and palaeobotanical evidences it seems quite reasonable to conclude that both Dharliala well No. 1 rocks and the Punjab Saline Series are Cambrian in age and to suggest that either the Dharliala well No. 1 rocks represent a Saline Series homologous to the Punjab one or that the former is but an extension of the latter.

Two-winged and One-winged spores have all along been recorded in the Cambrian Neobolus Shales, Magnesian and Salt Pseudomorph stages of the Punjab Salt Range, and also in the mid-Cambrians of Kashmir. Since their existence has been displayed in the Dharliala Well rocks, serial Nos. 1 and 2, Rohtas limestones and shales and also in the Kheinjua rocks (see Annual Report 1953-54), it is possible to correlate these beds with the above-mentioned known Cambrian beds.

D. MICROBIOLOGY

The following items of investigation were undertaken during the year under review.

D. 1. Studies on soil micro-organisms in relation to antibiotic production and decomposition of herbicide.

1. Studies on the occurrence and isolation of antibiotic producing micro-organisms from the soils of India.
2. Antibiotic activity of the fungi from W. Bengal soil.
3. Identification of *Streptomyces* spp. from W. Bengal soil.
4. Studies on the production of antibiotics in soil.
5. Control of *H. sativum* by antibiotic-producing organisms.
6. Studies on the decomposition of Crag Herbicide and its effect on the soil microflora.

D. 2. Production of antibiotics by soil micro-organisms.

1. Further studies on the production of an anti-gram positive pigment by a *Streptomyces* sp. (A₁₂).
2. Further studies on the production of an antifungal antibiotic by a *Streptomyces* sp. (AC₄ 248).
3. Further studies on the production of antibiotic substance by a *Streptomyces* sp. (AC 202).

4. Studies on the antibiotic activity of a *Streptomyces* sp. related to *S. flaveolus* and its possible identity with Actinomycin (s).
5. Production of a Streptothricin-like antibiotic by a pigmented strain of *Streptomyces* sp.

D. 3. Studies on the Biochemistry of fungi and actinomycetes

1. Studies on the amino acid content of mycelia and fructification of some higher fungi.
2. Studies on the formation of perithecia by *P. vermiculatum* Danegard.
3. Studies on the biochemistry of micro-organisms (I) *P. vermiculatum*.
4. Studies on the enzymatic activity of actinomycetes (I) Phosphatase.

D. 4. Studies on the mutation of fungi.

1. Studies on the mutation of *Aspergillus niger* induced by irradiation with ultraviolet rays.
2. Studies on the change in the morphological and antibiotic activity in *P. notatum* produced by ultraviolet induced mutations.

D. 5. Studies on the fermentation techniques.

Set-up of a ten-litre stainless steel fermenter.

D.1.1. Studies on the occurrence and isolation of antibiotic producing actinomycetes from Indian soils.

As a part of routine work in the survey of antibiotic producing micro-organisms from Indian soils altogether 257 strains were screened in the year 1954-1955 against bacteria, both gram-positive and gram-negative, as well as fungi. Among the fungi were included *Aspergillus niger*, *Curvularia* sp. and *Alternaria solani*. *Staph. aureus*, *E. coli* and *Eb. typhosa* were used as the test bacteria. The nature of distribution of antagonistic activity among the actinomycetes strains will be revealed from Table I.

TABLE I

DISTRIBUTION OF ANTIBIOTIC PROPERTY AMONG THE ISOLATES

No. of soil samples analysed	No. of strains tested by cross-streak method	No. of strains showing positive action against at least one of the		
		gram-positive bacteria	gram-negative bacteria	Test fungi
8	35	15	7	15
	116	23	8	
	106			46

The potent strains were tested further by agar-cup method of assay. Part of the results has been published in *Science & Culture*, 20, 141, (1954) and *Proc. Ind. Sci. Cong., Part III*, 220, (1955).

D.1.2. Antibiotic activity of fungi from W. Bengal soil.

50 strains of fungi possessing antibiotic activity were identified according to Gilman, Thom and Raper. The survey demonstrated peculiarities of antibiotic activity amongst *P. variable*, *P. vermiculatum* and *P. steckii*. It was further shown that *Curvularia lunata* possessed activity against gram-positive bacteria. A strain of *A. candidus* isolated from W. Bengal soil was found to possess antagonistic action against gram-positive bacteria. The antibiotic activity possessed by *Curvularia* sp. as recorded here suggests vigorous search for antagonistic action among this species. Results were communicated to *Proc. Ind. Sci. Cong., Part III*, 220 (1955).

D.1.3. Identification of *Streptomyces* spp. from W. Bengal soil.

A detailed systematic study of 70 antibiotic-producing strains of actinomycetes isolated from the soils of W. Bengal was completed in the year under review. The most frequently occurring strains from this soil were found to be *Streptomyces fradiae*, *Streptomyces halstedii*, *Streptomyces rutgersensis*, *Streptomyces erythrochromogenes* and *Streptomyces californicus*. Streptomycin-producing strains belonging to '*Streptomyces griseus* group' were rare though actidione-producing strains of the above-mentioned group were quite common. Aureomycin or terramycin-producing strains of *S. aureo-faciens* and *S. rimosus*, respectively had not been isolated from W. Bengal soil. Strains producing neomycin were quite common. Two strains possessing strong antifungal properties differed to certain extent in their cultural characteristics as compared with those of *Streptomyces albus*. They were described as species related to *S. albus*. Among other isolates, the antagonistic strains of *S. albosporus*, *S. alboflavus*, and *S. viridochromogenes* were also found. The following species *S. flacovireus*, *S. erythreus*, *S. cellulosa*, *S. albidoflavus*, *S. griseolus* and *S. purpeochromogenes* had also been found to occur. An anthocyanine-like pigment producing strain possibly related to *S. coelicolor* had recently been obtained from a forest soil, while another strain which closely resembled *S. lavendulae* in its major characters, but lacked in lavender coloured mycelium—a prominent character of *S. lavendulae*, was also found. Among other strains, species related to *S. antibioticus*, *S. scabies*, and *S. laveolus* had also been identified while a few remained unidentified so far. Part of the results has been communicated to the *Indian Phytopathology* (In press).

D.1.4. *Production of antibiotics in soil.*

Investigation was also undertaken to determine whether the isolate $Ac_8(185)$ could produce antibiotics in soil. Spore suspensions of $Ac_8(185)$, were thoroughly mixed with definite amounts of semi-sterilised soil aliquots in conical flasks and kept at room temperature for 3 weeks. Three sets of experiments were conducted simultaneously. In one set, glucose—1.5%, and straw dust—3.5% were added to the soil while the other set was supplemented by the same amount of the abovementioned organic nutrients but straw-dust was replaced by de-fatted soybean meal. 3rd set acted as control where no nutrient was added to soil. Production of antibiotics was also studied both by soil solution technique as well as by solvent extraction method. Soil solution obtained from each set of these experiments by the perfusion technique when assayed against *S. aureus* and *E. coli* failed to produce any inhibitory zone, while the residual matters obtained by solvent extraction method from each of the above-mentioned soils showed inhibitory zone when assayed against *S. aureus*. It was also found that no appreciable difference in the production of antibiotics in soils supplemented by soybean or straw dust was obtained. Control soil, however, showed little action when tested for antagonistic property. The failure of the detection of antibiotics in soil solution was probably due to very low solubility of the same in water.

Further investigations in the effect of this antibiotic on soil microflora are under progress.

D.1.5. *Control of Helminthosporium sativum by antibiotic-producing organisms—*

$Ac_8(125)$ and $Ac_8(185)$.

$Ac_6(125)$, a strain of *Streptomyces* sp. related to *S. griseus* and $Ac_8(185)$, a strain related to *S. flaveolus*, were found to possess antifungal properties. Both the strains showed inhibitory action when assayed against *Helminthosporium sativum*,—a pathogen on wheat and barley plant. The inhibitory action of $Ac_6(125)$ was much greater when compared with that of $Ac_8(185)$. It was also found that both the strains could produce detectable amounts of antibiotics in soil supplemented with organic nutrients like glucose, soybean or straw. Some 2–3 days old wheat seedlings were transferred to glass tubes, $9" \times 1\frac{1}{4}"$ in dimension, each containing about 30 gms. of sterile soil. The seeds, prior to germination, were sterilised with mercuric chloride for $\frac{1}{2}$ –1 minute and transferred to sterile petridishes containing moist filter papers for germination. 5 ml. of conidial suspension of *H. sativum* in water was added to each of 8 tubes containing the germinated wheat seedlings. 4 of them were simultaneously inoculated with spore suspension of $Ac_8(125)$. Two tubes were kept as control. The plants were allowed

to grow at room temperature in diffused daylight and sterile tap water was added from time to time to make up loss due to transpiration and evaporation.

It was found after 2 weeks that almost normal growth occurred in all cases except in the case of those inoculated with *H. sativum*. Some spots or streaks appeared on leaves as well as on stems. The growth of the plant was gradually checked.

D.1.6. *Studies on the decomposition of Crag Herbicide and its effect on the soil microflora.*

It has been observed that 'Crag' herbicide, Sod. 2-(2,4-dichlorophenoxy) ethyl sulphate, normally an inactive compound, requires soil contact before its activity is manifested. It was further reported that the compound would be rapidly hydrolysed in acid pH (upto 5.4) in sterile and non-sterile soil. Activity was never shown to occur in sterile soils if the pH was above 5.5 whereas conversion of the herbicide occurred in a pH range of 4.0—7.0.

The substance Sod. 2-(2,4-dichlorophenoxy) ethyl sulphate is rapidly converted by enzymatic hydrolysis into (1) 2-(2,4-dichlorophenoxy) ethanol and Sod. sulphate. The substance is further broken down into (2) 2,4-D. The former (1) is an active suppressor of the growth of plant roots while the latter (2) may account for the increased activity of the plant growth in soil.

The enzymatic conversion of 'Crag' herbicide into an active form was shown (Viltos A. J. 1952, *Cont. Boyce Th. Inst.* Vol. 16, No. 9) to be due to the activity *B. cereus* var. *mycoides* in soil while the second phase of break down although not definitely established is probably a microbiological reaction. However, the possibility of other micro-organisms playing a role in converting 'Crag' herbicide into its active form was considered feasible and there were indications that the fungi and actinomycetes may also elaborate similar hydrolytic enzymes.

Experiments were therefore, conducted to study the role of other soil microorganisms (fungi, actinomycetes and bacteria) in converting Sod. 2-(2,4-dichlorophenoxy) ethyl sulphate into 2-(2,4-dichlorophenoxy) ethanol which possesses root suppressing effect.

Soil samples were treated with 100 ppm 'Crag' herbicide and allowed to stand at the room temperature for one week or more. At the end of the incubation soil dilution plates were prepared with 10 gm. quantities of soil from each lot. Serial dilution plates were prepared in differential media to isolate fungi, actinomycetes and bacteria. The colonies appearing on dilution plates were isolated and subcultures were made. A preliminary microscopical examination of the cultures were made and maintained in subculture for further use.

To study whether the herbicide affects the growth, beneficial soil organisms counts of Azotobacter, Nitrobacter, Nitrosomonas and cellulose-decomposing bacteria were also made. It was interesting to note that there was a general stimulation of growth of all the microorganisms noted in the soils under investigation.

Fungi, actinomycetes and bacteria were isolated from soil plates on the basis of their predominant growth on dilution plates. The bacteria were transferred to nutrient agar slants and fungi and actinomycetes to C-D agar medium and Straw infusion agar medium respectively.

Experiments were set up to determine the conversion of the inactive herbicide into its active form in soil. Some of the bacterial isolates were inoculated into soils to test their capacity for hydrolysing Sod. 2-(2,4-dichlorophenoxy) ethyl sulphate into 2,4-dichlorophenoxy ethanol. The estimation of the above substance was done according to the method developed by the chemists of the Carbide and Carbon Chemicals Co. (U.S.A.) It was found that rate of conversion of the herbicide increased significantly when the isolated bacteria were added to the soil.

The work is now in progress with other microorganisms.

D.2.1. *Further studies on the production of the antigram-positive pigment by a Streptomyces sp. (A₁₂).*

The isolation of an acid-base indicator pigment having antigram-positive activity has been reported last year. A review of the literature revealed that similar pigments from microorganisms had attracted attention of workers of such eminence as Robinson, Waksman and Brockman.

The anthocyanine-like nature of the pigment of A₁₂ has already been mentioned in last year's report. Further qualitative tests showed that the pigment on acid hydrolysis gave Fehling's test even after purification. The pigment was extracted almost completely from 1% HCl into a mixture of cyclohexanol and toluene (1 : 5). It was relatively unstable in 2N NaOH and the blue colour gradually disappeared on standing. It also gave positive, FeCl₃ test in alcoholic solution. It was soluble in methanol, ethanol, amyl-alcohol, ether, chloroform, acetone, benzene and water and insoluble in petrol ether. The red form was less soluble in water than the blue form. Qualitative test for nitrogen was negative. The result was confirmed by the micro analytical results. The absence of nitrogen in the compound immediately precludes its relation with azo dyes and the interest in the pigment is renewed.

was therefore, distributed in a Craig's 24-tube counter-current apparatus between hydrochloric acid water (pH 4.0) and ether and estimations were made by Klett-Summerson photo-electric colorimeter (Filter-54) as well as by standard antibiotic assay using *Staph. aureus* as test organism. The distribution curve showed a single peak in the 19th tube. The pigment was extracted with ether from the 18th, 19th and 20th tubes and the solvent phase was evaporated to obtain the pure product. Spectrophotometric studies were made with this sample. Elemental analysis by Weilar and Strauss (Oxford) showed C—51.9%, H—5.56%, O—42.54%.

A study of the absorption spectra in the visible range of the pigment in 0.1 *N*. HCl and 0.1 *N*. NaOH with a Beckman's spectrophotometer (DU model) indicated maxima at 500 and 530 $m\mu$ in acid solution and 400 and 520 $m\mu$ in alkali.

Infra red study showed the presence of carbonyl group and bonded hydroxy group in the compound.

The pH tolerance test with the crude product confirmed that the antibiotic was unstable at pH levels higher than 8 at room temperature. At pH 10 the activity was rapidly destroyed within 24 hours. The activity remained unaltered between pH 1 and pH 7.

The antibiotic showed activity against gram-positive bacteria only. Fungi were insensitive to its action. Table II shows the antibacterial spectrum.

TABLE II

ANTIBIOTIC SPECTRUM OF THE ANTIBIOTIC A₁₂

	Inhibition zone in mm.
<i>Staph. aureus</i>	40
<i>E. coli</i>	12
<i>E. coli</i> R.	12
<i>Klebsiella pneumoniae</i>	4
<i>Eberthella typhosa</i>	17
<i>Vibrio cholerae</i>	27
<i>Proteus vulgaris</i>	40
<i>Strept. faecalis</i>	23
<i>Pseudomonas aeruginosa</i>	

A study of the nitrogen metabolism of the organism made in some detail pointed out that nitrate was the most favourable nitrogen source. From a basal medium consisting of KH_2PO_4 , MgSO_4 , FeSO_4 , KCl and glucose, the organism could not utilize NH_4NO_3 and NaNO_2 . Both KNO_3 and NaNO_3 were equally good as nitrogen sources. Of the amino acids tried aspartic acid gave highest yield of antibiotic. Antibiotic potency was measured by the agar-cup method using *Staph. aureus* as the test organism as well as by measuring the optical density of the culture filtrate in a Klett-Summerson photo-electric colorimeter using filter-54 (540 mu).

D.2.2. *Further Studies on the production of an antifungal antibiotic by Streptomyces sp. Ac₄(248).*

The isolation and preliminary observations on the strain Ac (248) have already been reported (*Science and Culture*, 20, 141, 1954). Partial purification of the active principle was effected by precipitation from the culture fluid by adjusting its pH to 4.0 with 2*N.* HCl. The precipitate containing the major portion of the antibiotic was centrifuged, washed with acidulated distilled water and dissolved in M/15 phosphate buffer at pH 7.0. The antibiotic principle was next adsorbed from the buffered solution on to an alumina column (pH 5.2) and eluted with 50% acetone. The eluate on evaporation *in vacuo* gave a brownish residue with activity.

The crude principle thus obtained was stable at room temperature. The pH-tolerance experiment showed that the activity was best retained at pH 4 at room temperature and it decreased gradually at pH levels below 2 and above 9. The crude substance gave negative FeCl_3 -test, Fehling's test and ninhydrin test. Nitrogen was found to be absent on qualitative test, 2,4-dinitrophenyl hydrazine test, however, was positive.

With a view to finding out a good medium for fermentation a variety of culture media were tried. The organism was grown on the following media; casein-hydrolysate, nutrient broth, wheat-bran-glycerol, broth, straw infusion, neomycin broth, potato-starch-tryptone broth, molasses-peptone broth, tryptone-commercial sucrose broth, tryptone-yeast extract broth and molasses-peptone broth. Both growth (determined by the mycelial dry weight) and antibiotic production were considered. The results (Table III) show that molasses medium sustained a greater growth and antibiotic production than any other medium. Growth and antibiotic activity were next highest in straw-infusion medium. Both media were used in later studies.

set was grown under stationary conditions and the other was shaken mechanically on a horizontal reciprocal shaker (r.p.m.—120; length of stroke—5 cm.). Results indicated that shaking improved antibiotic production in both media and growth was adversely affected (Table IV).

TABLE III
GROWTH AND ANTIBIOTIC PRODUCTION OF *Ac.* (248) IN DIFFERENT MEDIA.

Medium	Dry wt. of mycelium/ 100 ml. of medium in mg.	Inhibition zone against <i>Curvularia</i> in mm.
Casein-hydrolysate broth	400.0	19
Nutrient broth	75.0	18
Wheat bran-glycerol-broth	210.0	19
Straw infusion-dextrose broth	295.0	21
Neomycin broth	45.0	15
Potato-starch-peptone broth	185.0	17
Molasses-peptone broth	520.0	24
Tryptone-commercial Sugar broth	150.0	16
Tryptone-yeast extract-glucose Whey-peptone broth	115.0	23

TABLE IV
GROWTH AND ANTIBIOTIC PRODUCTION OF *Ac.* (248) IN MOLASSES BROTH AND STRAW INFUSION MEDIA IN SHAKE AND STILL CULTURES.

Medium		Age of culture in days							
		2		4		6		8	
		I	II	I	II	I	II	I	II
Molasses-peptone	Shake	74.0	25.0	87.4	27.0	62.0	21.0	64.0	17.0
	Stationary	14.0	22.0	49.0	21.0	82.0	17.0	128.0	17.0
Straw infusion broth	Shake	39.0	23.0	49.1	25.0	54.0	19.0	39.0	19.0
	Stationary	9.5	22.0	31.4	23.0	41.0	19.5	68.0	19.5

I. Dry weight of mycelium/flasks in mg.

II. Diameter of inhibition zone against *Curvularia* in mm.

The presence of "Tween 80" did not appreciably alter the antibiotic titre in either media in shake cultures.

In order to find out a suitable nitrogen source which might effectively increase the antibiotic potency of the culture broth the following compounds were tried individually: $(\text{NH}_4)_2\text{SO}_4$, NaNO_3 , NaNO_2 .

asparagine, acetamide, urea, glycine, d-alanine, glutamic acid, phenylalanine, aspartic acid, tryptophane and leucine. The above compounds were used as sole nitrogen sources only and carbon was supplied in all cases in the form of glucose. Pridham and Gottlieb's medium was used as the basal medium. It was observed that the organism could utilize only $(\text{NH}_4)_2\text{SO}_4$ among the inorganic salts. All the amino acids were utilized. Among the organic nitrogen sources tried only acetamide and urea were not utilized by the organism, d-alanine, leucine and phenylalanine supported a higher antibiotic production than $(\text{NH}_4)_2\text{SO}_4$ and growth was best in glutamic acid among all the sources tried.

A similar experiment with the same basal medium with different carbon-sources and a constant nitrogen source $(\text{NH}_4)_2\text{SO}_4$ was undertaken to study the variation in growth and antibiotic production in a synthetic medium with different C-sources. The following compounds were tested at 1% concentration. Starch, dextrin, maltose, sucrose, glycerol, levulose, dextrose, d-arabinose, d-xylose, galactose and 3 (+) mannose. It was observed that only d-xylose gave a higher yield of antibiotic than glucose.

A study of the chemical changes in the fermentation medium during the progress of fermentation by the strain has recently been undertaken. The results so far obtained indicated that the total amount of reducing substances in the medium as determined by Somogyi's method gradually decreased to a minimum on the 3rd day of fermentation in a shake culture and then gradually increased. Such a change pointed out that autolysis started after the 3rd day releasing the contents of the cells into the bulk of medium. Experiments concerning the changes in the total nitrogen and ammonia-N contents are in progress.

The importance of the role played by some metallic ions in minute quantities on growth and antibiotic production by micro-organisms has been emphasized by several workers. A study was therefore undertaken to investigate into the relationship of growth and antibiotic synthesis in *Ac4* (248) with the trace elements Zn, Cu, Fe and Mn. The results so far obtained with Zn and Cu indicated that complete absence of the two elements affected growth adversely. The optimum concentrations, however, appeared to be quite low and were in the order of 0.1–0.2 μ g. ml. of the medium. The effect on antibiotic productions was inconclusive.

Biosynthesis of proteins has become a centre of considerable interest in recent years. With a view to gaining some knowledge of the protein constitution of the strain, a study of the amino acid metabolism of the organism was undertaken. The amino acids were detected by paper-chromatography. On growing the strain in a beef-extract-peptone medium, the mycelium was found to contain the following free amino

acids: aspartic acid, glutamic acid, serine, glycine (?), l-alanine, valine and/or phenylalanine, arginine and leucine. On hydrolysis of the dried mycelium with equal volume of glacial acetic acid and conc. HCl the presence of the following amino acids were detected on the chromatogram: aspartic acid, glutamic acid, serine, glycine (?), l-alanine, valine and/or phenyl alanine, leucins, proline, lysine, ornithine, arginine, asparagine and an unknown ninhydrin positive compound (U). The medium used for this study was found to contain the following amino acids aspartic acid, glutamic acid, glycine (?), serine, valine and/or phenylalanine, arginine, leucine and the same compound (U₁). During the progress of fermentation aspartic acid and glutamic acids were the first to disappear from the medium. They could not be detected after 24 hours in the shake culture medium. After 96 hours of growth all the amino acids but alanine disappeared.

The effect of individual amino acids were also studied in a synthetic basal medium with the amino acid as the sole nitrogen source. The results presented in Table V show that glutamic acid alone had a remarkable effect on growth and is by far the best nitrogen source for growth. The study of effect of groups and pairs of amino acids with variable C-source is in progress. Part of the results published in *Proc. Ind. Sci. Cong., Part III*, 221, 1955.

TABLE V

EFFECT OF AMINO ACIDS ON GROWTH AND ANTIBIOTIC PRODUCTION OF *Ac*₄ (248)

N-source (0.106 mg. of N/L)	Dry wt. of mycelium per 100 ml. of medium in mg.	Inhibition zone against <i>Curv.</i> <i>laria</i> in mm.	Final pH* of the medium
(NH ₄) ₂ SO ₄	126.5	19.0	6.00
Glycine	10.0	19.0	7.00
Alanine	177.5	23.0	6.70
dl-Alanine	130.0	20.5	7.00
Glutamic acid	480.0	17.5	9.25
Phenylalanine	125.0	21.0	6.85
Aspartic acid	130.0	15.0	6.75
Tryptophane	67.5	16.0	6.85
Leucine	147.5	24.0	6.70
Asparagine	110.0	20.0	6.40

* Initial pH of medium—7.0.

D.2.3. *Further studies on the production of antibiotic substance by a Streptomyces sp. AC₃ (203).*

The effect of zinc, copper and iron on growth and antibiotic production by AC₃ (203) was studied. None of the elements were found to be indispensable for antibiotic production, provided they were present in concentrations sufficient for growth. The optimum concentration of the above elements for antibiotic production was found to lie between 2-5 parts/million. The effect of Zn was more pronounced than the rest. The medium selected was that due to Gottlieb and Pridham. The antibiotic titre was considerably lowered thereby but results obtained were more confirmatory than with straw-extract broth as the basal medium.

The nitrogen metabolism of AC₃(203) was studied by means of paper chromatography. It was observed that amino-acids supplied in the form of nutrients disappeared in the culture filtrate at the end of growth for 96 hours in stationary culture. The acid-hydrolysate of the mycelium showed the presence of twelve ninhydrin sensitive spots on the paper-chromatogram using phenol-water and benzyl alcohol-acetic acid-water as the developing solvents. The homogeneity of the antibiotic 203 was tested by distributing the material with borate buffer-stearic acid-amyl alcohol (pH 7.6) as solvent system. Estimation of the distributed product was done gravimetrically after the transfer of all the distributed material into the aqueous phase with two drops of conc. HCl and 5 cc. of chloroform.

D.2.4. *Studies on the production of antibiotic substance by a Streptomyces sp. AC₈ (185).*

A strain of *Streptomyces* sp. isolated from the soils of West Bengal was found to possess antagonistic action against certain gram-positive and gram-negative bacteria and plant pathogenic fungi. A detailed morphological study of the strain was made in order to identify it. Differential test for growth was also conducted on the basis of utilisation of different carbon sources. It was found that the isolate failed to utilize raffinose and dulcitol while in cases of sucrose, inulin and d-mannitol doubtful results were obtained. The formation of numerous open and close spirals, production of soluble golden yellow pigment in organic media, liquefaction of gelatin, coagulation and peptonisation of milk suggested its strong affinity with *Streptomyces flaveolus*. It differed, on the other hand, from the above species in growth characteristics on potato and starch agar. It also failed to produce nitrites from nitrates.

The culture was grown in Czapek-Dox medium (pH 6.8-7.0)

was produced in the medium which gradually turned dark brown with age. The culture filtrate retained its activity on prolonged incubation for more than a month at room temperature. The active principle was isolated by extraction with ethyl acetate and chromatography through Alumina. Two fractions, one yellow with reduced antibiotic activity and the other rose-red with greater activity, were recorded. Qualitative tests showed the resemblance of the active substances with actinomycins. Interest in the compounds isolated has been revived due to recent report of Waksman and Brockmann about new actinomycins. Further work on the characterisation of the compounds is in progress.

D.2.5. *Production of Streptomycin-like antibiotic from a pigmented strain of Streptomyces sp.*

In course of the survey of antibiotic-producing strains of *Streptomyces* spp., a strain designated Ac₃ 298 was isolated with red pigment in the aerial mycelia. The strain was found to possess antibiotic activity both against gram-positive and gram-negative bacteria and against fungi when assayed both by agar-streak and agar-cup method.

The strain was grown on Dey's modified straw infusion broth for 6-7 days when good aerial growth was obtained with the characteristic red pigment. The filtrate was acidified with 2N H₂SO₄ to bring its pH down to 2-3, absorbed in 2% Norit charcoal (SBX 30), eluted with 20% acetone, the elute, evaporated to remove acetone and to it was added 4-5 vol. acetone. On keeping overnight at 4°C. heavy precipitate was obtained which was found to contain the active principle.

The precipitate failed to respond to the maltol and furfural tests though it gave positive ninhydrin reaction. When hydrolysed in a sealed Pyrex glass tube for 24 hours and chromatographed on Whatman No. I filter paper, it gave 5 ninhydrin-positive spots. The active principle was then assayed against *E. coli* R, *E. coli* made resistant to Streptomycin sulphate (Glaxo Lab.) and *E. coli* W, *E. coli* made resistant to Streptothricin sulphate (Upjohn Company). The substance was found to be active against *E. coli* R but not against *E. coli* W. Further studies as to the properties and identity of the antibiotic and of the strain that produces this active principle are in progress.

D.3.1. *Studies on amino acid contents of mycelia and fructifications of some higher fungi.*

Little work has been done on the protein contents of fungal mycelia and fruit bodies. In order to have some idea as to what free and bound amino acids are usually present in the vegetative mycelia of higher fungi and what changes, if there be any, take place in the constituent

purpose of investigation. Fresh fruit bodies were collected and pure cultures of the respective fungi were obtained from spore-fall.

In order to study the amino acid content of vegetative mycelia, the fungi were grown in 2% malt soln. (pH 6.5) at room temperature (28–30°C.) for 10–15 days when thick mats of mycelia appeared. They were filtered, washed with distilled water several times, and crushed with 80% alcohol in a blender. The mixture was filtered and evaporated till a small concentrated amount was left. This was centrifuged and the supernatant liquid was taken for further study.

In the case of fruit bodies, they were cut into small pieces, crushed in a blender with 80% alcohol. Subsequent treatments were same as in the previous case.

For study of bound amino acids the alcoholic extract of mycelia or of fruit bodies which was left after filtration was dried by keeping overnight at 60°C. Then a few mg. of the dry substance was hydrolysed in a sealed pyrex glass tube with 6*N* HCl at 110°C. for 36 hours. The contents of the tube were evaporated on a water-bath to remove the last trace of HCl, and the substance left was treated with 80% alcohol. Centrifugation and concentration were effected in the usual way.

Indication of the amino acids present was obtained by two-dimensional paper chromatography using phenol-water and n-butanol-acetic acid-water (4:1:1) as the developing solvents. The spots were made visible by spraying the papers with 0.1% ninhydrin solution in n-butanol.

The following table shows the amino acids that were indicated on the chromatograms in the case of different materials examined:

TABLE VI

Materials examined	Aspartic acid	Glutamic acid	Serine	Ornithine	Threonine	Arginine	Alanine	Valine and/or Methionine	Leucine
<i>Polyporus osteriformis</i>									
a) Vegetative mycelia	+	+	+	—	—	—	+	+	—
b) Do. (hydrolysed)	+	+	+	—	+	—	+	+	+
c) Fruit body	+	+	+	—	+	—	+	+	+
d) Do. (hydrolysed)	+	+	+	—	+	—	+	+	+
<i>Daedalea flavidula</i>									
a) Vegetative mycelia	+	+	+	—	+	+	+	+	+
b) Do. (hydrolysed)	+	+	+	—(?)	+	+	+	+	+
c) Fruit body	+	+	+	+	—	—	+	+	+
d) Fruit body (hydrolysed)	+	+	+	—	+	+	+	+	+
<i>Polystictus hirsutus</i>									
a) Vegetative mycelia	+	+	+	—	—	—	+	+	+
b) Do. (hydrolysed)	+	+	+	—	+	+	+	+	+
c) Fruit body	+	+	+	—	+	+	+	+	+
d) Fruit body (hydrolysed)	+	+	+	—(?)	+	+	+	+	+

D.3.2. Studies on formation of perithecia in *Penicillium vermiculatum*.

Penicillium vermiculatum produces perithecia, asci and ascospores when grown on malt-agar medium. When grown on Czpek-Dox agar (C.D.A.) and Potato-dextrose agar (P.D.A.), the strain produces no perithecia though good growth takes place in either case. It is rather interesting that there is present in malt some factor which induces perithecia formation and which is absent in C.D.A. and P.D.A.

In order to find out if it was some vitamin factor which was responsible for perithecia formation, yeast extract was added to C.D.A. in proportions of 1% and 2% and the fungus was grown on both these media. There appeared no signs of formation of perithecia till one-and half month after inoculation. On 2% malt agar medium perithecia appear in 18-20 days. For the same purpose *Aspergillus niger* culture filtrate (the fungus was grown on C.D. soln. for 10 days) was brought to pH 6 and 2% agar was added. In another set equal volumes of the same *A. niger* culture filtrate and C.D. soln. were added, pH adjusted to 6 and solidified with agar. When grown on these two media the fungus produced no perithecia till 45 days after inoculation. In both these media growth was not poor.

Biotin (in concentrations of 0.5, 1.0, 5.0 and 10.0 $\mu\text{g.}$ per litre) and thiamin (100 $\mu\text{g.}$ per litre) when added individually or together to C.D.A. did not also favour perithecia formation.

Various carbohydrate sources were tried, replacing glucose in C.D.A. by the following sugars—Lactose 5%, Sucrose 5%, Dextrin 1%, Starch 1%, Laevulose 0.5%, Galactose 1%, D (+), Mannose 1%, Glucose -1-phosphate 1%, 1-arabinose 1%, and D-xylose 1%. The fungus grew well on all these media, but perithecia were produced in none of them.

Preliminary attempts were made to find out the active principle in malt which induces sexual reproduction in this fungus leading to the formation of perithecia, asci and ascospores. 2% malt soln. was adsorbed in activated charcoal (SBX 30) at pH 2, 7 and 9 and filtered. In all the three cases, the soln. became colourless. They were adjusted at pH 6 and solidified in slants with 2% agar agar. In all of them *P. vermiculatum* produced abundant perithecia with asci and ascospores. From this it appears that the active factor is not coloured. Further attempts at isolation of the active principle are being made by extraction with different organic solvents and by chromatography.

D.3.3. Studies on the biochemistry of micro-organisms.

(I) the colouring matters of *P. vermiculatum*.

mat was filtered, dried at 80°C. and then powdered. The dried mass was extracted with petroleum ether (40–60°C) to free it from fat and then extracted with 70% alcohol. The rose-red extract thus obtained was concentrated to 1/8th of its volume when solid mass separated out. This was further purified by chromatography through Alumina IV (pH 2.8). Preliminary tests carried out so far indicated anthraquinone nature of the compound. This was corroborated by spectrophotometric analysis. Further investigation is in progress.

II. Isolation of antibiotic principle from *P. vermiculatum*.

In continuation of the work reported earlier attempt was made to isolate the active principle of this potent strain. The highly thermolabile nature of the compound makes it difficult under the available facilities for the isolation of the active substances. Further purification has been attained by evaporation of the culture filtrate under vacuo at 30°C, precipitation of inert material with dry absolute alcohol, concentration of the alcoholic filtrate under vacuo followed by chromatography through cellulose and subsequent elution with pyridine-water. No crystalline compound has been obtained as yet.

D.3.4. Studies on the enzymatic activity of *Streptomyces* spp. (I) Phosphatase.

Four strains, A₁₂, AC₄(248), Ac₃ (203) and *S. griseus*, were selected for investigation with regard to their phosphatase activity. It was observed that all the strains produced phosphatase with Na-Phenolphthalein phosphate as substrate and glucose as carbon-source. It was further observed that with Na-acetate, Na-citrate and Na-succinate as carbon source, phosphatase was produced by all the strains though their activity was much diminished. When glycine was incorporated, none of the strains were able to produce phosphatase.

As expected, the strains varied in their capacity of producing phosphatase. A₁₂ was found to be least active among all the strains tested. *Nocardia madurae* was also found to produce phosphatase with Na-phenolphthalein phosphate as substrate. Further investigation on the effect of different carbon sources, when used alone or in combination, on the phosphatase activity of *Streptomyces* spp. is in progress.

D.4.1. Studies on the mutation of *Aspergillus niger* induced by irradiation with ultraviolet rays.

A great deal of information has accumulated on the subject of ultraviolet induced mutations in micro-organisms. Mutants may differ from the normal in growth rate, form and texture of the colony.

functions leading to an increase or decrease of the chemicals formed as by-products or waste or intermediate products.

In our experiments a strain of *Aspergillus niger* which was capable of producing citric acid was selected as a material for study.

The stock culture of *A. niger* (BI-V) was grown on Czapek-Dox-agar slants and sporulation was obtained in 6 days' time. The spores were suspended in sterile calsolene solution (1 : 10,000) which served as a detergent. 4 cc. of the spore suspension was distributed in 5 sterile 9 cm. petridishes, the lids were kept off and the suspension continuously stirred by means of a sterile glass rod, during the exposure to ultraviolet rays of 2537Å from a Phillips Germicidal lamp which was about 26 cm. from the petri dishes. The irradiated spore suspension was diluted, plated out in Czapek-Dox agar and incubated at 28°C. for 4-6 days. In most cases colonies appeared during this period. The mutants were isolated on agar slants. Experiments were conducted in series and each set of irradiation was reported at least thrice. It will be seen from Table VII that survival percentage decreased with the increase in the time of exposure. The maximum number of probable mutants were, however, obtained on exposure of 32 minute while at 40 minutes the figure falls down considerably.

TABLE VII

PERCENTAGES OF SURVIVAL AND MUTATION OF *A. niger* ON EXPOSURE TO ULTRAVIOLET 2537A°

Time of exposure in minutes	Percent survival	Percent mutation
0	100	0
8	15.5	1.5
16	2.2	7
24	1.3	11
32	1.2	25
40	0.4	4.2

The mutants thus obtained were classified into 5 types according to the changed conidial colour and modified texture of the colony.

Mutant type I—Conidial colour chocolate to cinnamon.

„ „ II—Formation of orange red to brown pigment in the medium.

III—Close textured leathery colonies, with conidial heads less abundant.

VI—Dark floccose colonies, with abundant sporulation.

V—Colonies yellowish brown with less sporulation and plenty of sclerotia :

For testing the citrogenous activity of the mutants the strains were grown in sucrose-broth medium (pH 1.6—2.0), having sucrose as the chief source of carbon. 50 c.c. of the medium was distributed in 250 c.c. Erlenmeyer flasks and incubated at 28°–30°C. for a period of 10 days, after which total titrable acidity was determined using N/10 NaOH with phenolphthalein as an indicator. Oxalic and citric acids were estimated by means of precipitation with CaCl_2 depending upon the varying solubilities of the calcium salts of oxalic and citric acids.

Out of 35 mutant strains thus tested only 7(20%) produced more citric acid than non-irradiated parent strain & 5(13.5%) showed diminished activity while the rest resembled the parent one in citric acid production, though with a change in the morphological appearance.

D.4.2. *Studies on the change in the morphological and antibiotic activity in P. notatum produced by ultraviolet induced mutations.*

For studies on ultraviolet induced mutation in *Penicillium notatum* (BI.P1) a strain which had been obtained from the Indian Institute of Science, Bangalore was selected. This strain produced a fair amount of Penicillin.

Irradiation technique was the same as that with *A. niger* except that here irradiation was done in a 9 cm. petri dish containing 10 cc. of the spore suspension and at intervals of 0, 2, 4, 6, 8 and 10 minutes. 1 cc. of the sample was taken out from the petri-dish, diluted, plated in Czapek-Dox agar, and incubated at room temperature (28°–30°C). Counts for viability were made after 4–5 days, colonies picked up on Czapek-Dox agar slants, and incubated for a fortnight. Then they were grown on 50 cc. of Higuchi's medium contained in 250 cc. Erlenmeyer flasks and incubated at 28°C. The antibiotic property was tested on the 6th day using *Staph. aureus* as the test organism.

Out of the 250 strains examined 122 proved to be mutants behaving differently from the normal in morphology, pigment production and antibiotic formation. Table VIII shows the antibiotic titre of the strains.

TABLE VIII
ANTIBIOTIC TITRE OF MUTANTS OF *P. notatum*

Groups	Total no. of strains = 122.	
	No. of strains	Inhibition Zone in mm.
1	13	No inhibition.
2	3	14 or less
3	3	15–19
4	11	20–24
5	7	25–29
6	48	30–34
7	37	35–36

Morphologically the following changes were observed in the mutant strains.

- Type. (1) White to yellow basal felt, light sporing. (T_1)
„ (2) Change in the pigment colour from yellow to brownish pink. (T_2)
„ (3) Disappearance of pigment. (T_3)
„ (4) Crumpled and wrinkled growth with dark green to white conidial areas. (T_4)

Non-irradiated parent strain :—Close textured basal felt, conidial areas bluish green, reverse yellowish, pigment golden yellow.

The following points emerge from the experiments on *P. notatum*.

- (1) No correlation could be drawn between pigment production, morphological character and antibiotic formation.
- (2) Strains of the type (T_1) had changed totally in the morphological appearance; still most of them retained the ability of normal antibiotic production and pigment formation.
- (3) Strains of the type (T_2) with brownish pink pigment usually showed diminished antibiotic activity.
- (4) Two pigmentless strains were encountered—one morphologically similar to the parent and the other with greenish to white conidial areas. The former was normal in antibiotic production while the latter did not produce any antibiotic substance.
- (5) Colonies with wrinkled growth with dark or white conidial areas showed normal antibiotic production. Among them such colonies which were leathery in appearance did not produce any antibiotic substance.

D.5.1. *Studies on the fermentation techniques.*

A stainless-steel fermenter (capacity 10 litre) made up of 18 : 8 plantinised steel is on the way of being set up in this laboratory. The fermenter, consisting of two propellers is provided with an automatic foam-detecting electronic device. It contains an air-inlet provided with glass-window which is filled with inert material for the sterilisation of air to be introduced. Details of the design have been submitted to the Council of Scientific and Industrial Research in the report of 1954.

E. ZOOLOGY

E. 1. *Effect of some antibiotics and vitamin B₁₂ on the metamorphosis of tadpoles.*

Experiments on the retardation of metamorphosis in tadpoles reported last year, were continued throughout this year. During the rainy season (from June to August, 1954) a large number of tadpoles were collected from different localities outside Calcutta. Out of them 150 specimens were selected for penicillin treatment. The specimens were divided into five groups, each one of which was treated with penicillin solution of different concentration. 45 specimens were kept as control. Except for a few death all the tadpoles in the control, transformed into froglets on different dates within a month and a half. But metamorphosis in the penicillin treated tadpoles was delayed for a considerable length of time, varying from 5 to 10 months. In spite of increased death rate, some of the specimens treated with 60, 70 and 80 units of penicillin are still retaining their larval forms. Tadpoles treated with 100 units of penicillin died within a month. Other antibiotics, such as 0.2 gm. of Dihydro-streptomycin Base diluted in 200 to 300 c.c. of water were also used for the tadpoles. Some of them survived in the larval stage for over two months.

Different treatments were tried to hasten the metamorphosis of penicillin treated tadpoles out of which the following one has only been successful. Early in 1954, some experiments were conducted to find the effect of vitamin B₁₂ (1 μ g per 50 cc. of water) on the tadpoles with retarded metamorphosis. The result was satisfactory. All the tadpoles were transformed into froglets within a week or more. But the four kept in higher concentration of vitamin B₁₂, showed no sign of metamorphosis upto the middle of March, 1954, when they died one after another within a very short time.

This experiment was repeated twice—one in early November and the other in December, 1954. In each of these experiments tadpoles whose metamorphosis had been retarded for 5 and 6 months, were used. They were kept in a vessel containing 3000 cc. of water to which 50 μ g of vitamin B₁₂ was added. The result was the same as before. All the tadpoles were transformed into froglets within 10 to 12 days. But they did not survive for more than a fortnight.

In view of the fact that two widely different chemical substances Penicillin and Streptomycin have similar retarding effect it appears probable that antibiotics act indirectly on retardation of metamorphosis through the intermediary of some micro-organisms. The effect of

on metamorphosis of tadpoles. For verification of this assumption, intestinal flora collected from normal and penicillin treated tadpoles were cultured in proper medium. Bacteria isolated by plate culture from the intestinal flora of normal tadpoles were found to contain gram-positive bacillus and gram-positive coccus, which formed different types of red, yellow and white colonies. The white colony of bacillus and red colony of coccus produced vitamin B_{12} . Vitamin B_{12} assay was done by the agar-cup method using the mutant *E. Coli* as the test organism. It has been subsequently found by agar-cup method that these bacteria are penicillin susceptible, i.e., their growth is inhibited by penicillin.

Intestinal flora of penicillin treated tadpoles were isolated and cultured. In the case of freshly treated tadpoles there were no growth of bacteria within 48 hours; but in the case of tadpoles in which metamorphosis had been arrested for a considerable length of time, gram-positive and gram-negative bacilli and gram-positive cocci developed but none of them produced vitamin B_{12} . Further work is being continued on the physiology and chemistry of vitamin producing bacteria and on their identification.

E. 2. *Effect of penicilin on the metamorphosis of silkworm.*

Silkworm experiments are being continued. Effect of penicillin on the metamorphosis and cocoon formation of silk worm is being studied. A number of larvae emerged on 12-1-55 from two layings of eggs of multi-voltine moth. Fresh mulberry leaves were supplied to them until the second moult was complete. After the second moult 15 larvae were separated from the lot and penicillin treated mulberry leaves were given to them as food. Young leaves dipped in penicillin solution for some time were cut into pieces and supplied to the larvae. Cocoon formation started in the specimens fed on fresh leaves after 32 days, counting from the date of emergence. But in the specimens fed by penicillin treated, cocooning was much delayed. Cocooning started after 48 days from the date of hatching. Besides that penicillin treated worms looked much shorter in length than the normal ones. Mature moths, however, emerged from the cocoons of the treated larvae. The moths laid a large number of eggs after mating. Hatching eggs started after about 14 days. A large number of larvae emerged, but all of them died within a week, probably due to high temperature. However, five layings of eggs of Nistari moth (an indigenous race) have been obtained recently from the Central Sericultural Research Station, Berhampore, West Bengal. A large number of larvae emerged from those eggs on 13-4-55. They are being reared for further investigations.

E. 3. *Comparative Study of brain of some Indian Fishes in relation to their feeding habits.*

Comparative morphology of the brain of *Scatophagus argus*, *Hilsea ilisa*, *Mugil persia*, *Mugil tade*, and *Mugil corsula* has been studied. Histological study of the different lobes of the brains with particular attention of the medulla oblongata has also been investigated. With the help of the examination of the stomach and post-intestinal contents the nature of the food of the fishes has been determined. It is possible to correlate the structural modifications of the medulla oblongata of the fishes with their feedings habits. The olfactory region of the brain shows also some indication of such correlation.

Morphological and histological studies of the brains of *Callichurous pabda*, *Cillago domina*, and two species of *Engraulidae* are now in progress.

LIBRARY

The Library consists of 3,587 volumes (1,766 books and 1,821 periodicals). During the year under report 200 volumes (95 books and 105 bound periodicals) were added to the stock as against 159 during the previous year. The total number of periodicals received was 97 (inland 15 and foreign 82), out of which 49 were purchased and the remaining 48 were received in exchange of Institute publications. The Library also received a large number of technical pamphlets, bulletins, circulars, reprints, annual reports, etc., from various Research Institutes and Government Departments, both inland and foreign.

The total number of volumes issued out of the Library was about 3,000 and the volumes consulted in the Reading Room was well over 7,000.

In spite of the fact that the Library is primarily meant for use of its research staff only, it is very frequently consulted by research workers and scientists from other institutions. The number of such outside workers are increasing from year to year.

The Library was shifted to the first floor of the new two storied building erected to the south-west corner of the Institute quadrangle. The eastern room was fitted up as Stack Room and the western room as Reading Room which has been fitted up with up-to-date electric fittings and furniture—chairs, reading tables and cabinets for displaying current periodicals.

into two types of catalogues *viz.*, "Classified Catalogue" with subject index and "Author & Title Catalogue" combined on cards. The existing "Dewey Classification" system is also being changed and in its place the "Universal Decimal Classification" system is being adopted.

With the increase of research staff in the Institute and the growing number of outside research workers, there has been a pressing demands for more books and journals in the Library. It could be partially removed by purchasing some very important and valuable back number of periodicals out of a non-recurring grant received during the year under report. Efforts are also being made in a planned way to provide more money in addition to recurring grant for the purchase of a good number of important books and periodicals to meet the requirements of the research staff as well as to build up an up-to-date Research Library.

PUBLICATIONS

During the year under report demand for publication of "Transactions" (mostly on exchange basis) increased considerably. Vol. 19 of the *Transactions* is now in press and is expected to be published shortly. A special volume of *Transactions* being Vol. 20 of the series—"Dr. D. M. Bose Seventieth Birthday Commemoration Volume"—containing valuable articles from eminent scientists of India and abroad has already been published. For the contents of this volume see Appendix C.

The reprinting of "Plant Autographs and their Revelations" by Sir J. C. Bose is now complete and will shortly be published. Efforts are also being made to reprint other out of print volumes of Sir J. C. Bose *viz.*, "Response in the Living and Non-Living", "Plant Response", "Researches on the Irritability of Plants", etc., in the near future. Other publications during the year under report include (1) Annual Report 1953-54 and (2) The Sixteenth Acharya Jagadish Chandra Bose Memorial Lecture on "Search for new Sources of Power by Prof. S. N. Bose with the Director's Report".

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APPENDIX A.

I. The Governing Body :

Dr. Debendramohan Bose
Mr. Sudhansumohan Bose
Mr. Kedarnath Chatterjee
Mr. Sudhir Kumar Mandal
Dr. Sisir Kumar Mitra
Mr. Abani Nath Mitter
Mr. Kshitish Chandra Neogi
Mr. Bhupatimohan Sen, I.E.S. (Retd.)

II. The Council :

Mr. S. M. Bose
Mr. K. N. Chatterjee
Mr. S. K. Mandal
Dr. S. K. Mitra, D.Sc., F.N.I.
Mr. A. N. Mitter
Mr. B. M. Sen, I.E.S. (Retd.)

} Nominees of the Governing Body

Dr. D. M. Bose, M.A., Ph.D., F.N.I. (*Ex-officio*)

*Dr. S. S. Bhatnagar, D.Sc., F.R.S., F.N.I., Secretary to the Government of India, Ministry of Natural Resources and Scientific Research (Nominee of the Central Government)

Dr. S. R. Chatterjee, M.P. (Representative of the Loka Sabha)

Dr. P. Parija, D.Sc., F.N.I., I.E.S. (Retd.) } Scientists nominated by
Pro-chancellor, Utkal University, Cuttack. } the Central
Dr. K. Ahmed Chowdhury, D.Sc., F.N.I., } Government.
Forest Research Institute, Dehra Dun. }

Mr. Nandadulal Sreemany (Representative of the Calcutta Corporation)

III. Finance Committee :

Mr. B. M. Sen (*Chairman*) (representative of the Council)
Mr. K. C. Chaudhuri, Accountant General, West Bengal (up to 3.1.55) (representative of the Central Government)
Sri S. Natarajan, Accountant General, W. Bengal (from 4.1.55)
Dr. D. M. Bose (*Ex-officio*)
Sri A. K. Ghosh (*Secretary*)

IV. Building Committee :

Dr. D. M. Bose (*Ex-officio*)
Mr. K. N. Chatterjee (representative of the Council)
Mr. A. N. Mitter (representative of the Governing Body)
Sri A. K. Ghosh (*Secretary*)

APPENDIX B.

Staff :

Director : Dr. D. M. Bose, M.A., Ph.D., F.N.I.

Registrar : Mr. A. K. Ghosh, M.Sc.

Special Officer : Dr. J. P. Sircar, B.Sc., M.B., Ch.B. (Edin.)
(Retired from 8-5-54)

Department of Physics :

Head of the Department : Director

Research Assistant : Mr. T. C. Bhadra, M.Sc.

Government of India Junior Scholar : Miss Nilima Basu, M.Sc.
(from 6-9-54) (Honorary Scholar up to 5.9.54)

Attached workers : Prof. H. P. Dey, M.Sc., P.R.S.
(Vidyasagar College, Calcutta)

Mr. S. P. Datta, M.Sc. (Vidyasagar
College, Calcutta)

Mr. Quazi Md. Hassan, M.Sc.

Department of Chemistry :

Head of the Department : Dr. P. K. Bose, D.Sc., F.N.I.

Research Fellows : Dr. A. Sen, M.Sc., Ph.D. (Leeds)

Dr. D. P. Burma, M.Sc., D.Phil.

(on study leave from September, 1954)

Research Scholar : Mr. D. P. Chakraborty, M.Sc.

Government of India Senior Scholars :

Mr. R. K. Bose, M.Sc. (upto 31-7-54)

Mr. J. Datta, M.Sc. (from 1-9-54)

Mr. K. Venkateswara Rao, M.Sc., (from 15-9-54)

Mr. S. K. Chakraborty, M.Sc. (from 4-1-55)

Government of India Junior Scholars :

Dr. C. R. Raha, M.Sc. D.Phil. (upto 8-5-54)

Mr. A. K. Guha, M.Sc. (upto 30-4-54)

Mr. C. C. Ghosh, M.Sc. (from 2-8-54)

Mr. A. K. Banerjee (from 2-8-54)

Attached workers : Dr. S. N. De, M.B., D.T.M., Ph.D. (Lond.)

Department of Botany :

Head of the Department : Dr. K. T. Jacob, M.A., Ph.D.
(Lond.)

Research Fellow : Dr. S. K. Roy, M.Sc., Ph.D.(Lond), D.I.C.

Research Assistants : Mr. B. K. Palit, B.Sc.
Mr. B. K. Datta, B.Sc.
Mr. A. T. Guha Thakurta
Mr. A. K. Adhikari, M.Sc. (also *Farm Superintendent*)

Research Scholar : Mr. V. N. Gadgil, M.Sc.

Government of India Senior Scholar : Mr. U. K. Rai, M.Sc.

Government of India Junior Scholars :

Mr. S. M. Bose, M.Sc. (upto 6-9-54)
Miss Mary Korah, M.Sc. (from 15-11-54)

Research stipendiary : Mr. V. S. Sarma, M.Sc.

Attached workers : Mr. D. K. Chakraborty, M.Sc. (R. G. Kar
Medical College)

Miss Madhuri Datta, M.Sc. (Lady
Brabourne College)

Mr. Samir Rakshit, M.Sc.

Department of Microbiology :

Head of the Department : Dr. P. N. Nandi, M.Sc., Ph.D.
(Lond.), D.I.C.

Mary & Richard Keating Student : Dr. S. P. Sen, M.Sc.,
D.Phil.

Sir J. C. Bose Scholar : Mr. A. K. Banerjee, M.Sc.

Birla Scholar : Mr. A. K. Das Gupta, M.Sc.

Government of India Junior Scholars :

Mr. Ajit Kumar Mishra, M.Sc.
Miss Mira Purakayastha, M.Sc. (from 1-6-54)

Attached worker : Mr. S. K. Mukherjee, M.Sc. (Surendranath
College)

Department of Zoology :

Research Assistant : Mr. G. C. Bhattacharjee

Research Scholar : Mr. A. K. Medda, M.Sc.

STAFF APPOINTED UNDER GRANT-IN-AID SCHEMES**A. Board of Research on Atomic Energy***(Investigator-in-Charge : Dr. D. M. Bose)***(i) Cosmic Ray Investigation :**Dr. S. D. Chatterjee, D.Sc. (*Honorary*)Dr. M. S. Sinha, D.Sc. (*Research Officer*)Mr. I. L. Chakraborty, M.Sc. (*Junior Research Asst.*)

Mr. N. C. Das, M.Sc. „

Mr. N. N. Biswas, M.Sc. „

(ii) Nuclear Physics Investigation :Mr. A. M. Ghosh, M.Sc. (*Junior Research Asst.*)

Mr. N. K. Ganguly, M.Sc. „

(iii) Neutron Generator :

Mr. A. N. Banerjee, M.Sc. „

Mr. H. N. Raha, (*Assistant*)**(iv) Use of C^{14} and P^{32} as tracers in photosynthetic and Plant Genetic Investigation :**Mr. S. B. Sarkar, M.Sc. (upto 1.10.54) } (*Junior*
Mr. B. B. Biswas, M.Sc. (from 7.6.54) } *Research Asst.*)**B. Indian Central Jute Committee**Production of suitable mutants in Jute by X-ray irradiation (*Investigators-in-Charge : Dr. D. M. Bose and Dr. K. T. Jacob*)Mr. R. K. Basu, M.Sc. (*Cytologist*)Mr. B. C. Mukherjee, M.Sc. (*Radiologist*)**C. Indian Central Oilseeds Committee**Inducing Mutants with economic characters in til, rape and mustard by X-ray—(*Investigator-in-Charge : Dr. K. T. Jacob*)Mr. K. L. Chowdhury, M.Sc. (*Botanist*)Mr. Ashoke Das, M.Sc. (*Asst. Botanist*)Mr. Samir Sarkar, M.Sc. (*Chemical Asst.*)**D. Calcutta University***(Investigator-in-Charge : Dr. D. M. Bose)*

E. Indian Council of Agricultural Research

Control of weeds (*Investigator-in-Charge* : Dr. K. T. Jacob)
 Mr. K. George, M.Sc. (*Asst. Botanist*)
 Mr. M. G. Srivastava, M.Sc. „

F. Council of Scientific and Industrial Research

Studies on the Production of antibiotic substances by *Streptomyces* spp. (*Investigator-in-Charge* : Dr. P. N. Nandi)
 Mr. G. P. Sen, M.Sc. (*Senior Research Asst.*)
 Mr. S. B. Ghosh, M.Sc. (*Junior* „ „)

G. Burma Oil Company

(*Investigator-in-Charge* : Mr. A. K. Ghosh)
 Paleobotanical Research: Mr. A. Bose, M.A. (*Research Asst.*)

APPENDIX C.**A. LIST OF PAPERS PUBLISHED DURING 1954-55**

- Banerjee, A. K., Sen, G. P. and Nandi, P. Action of isoniazid and antibiotics on *Nocardia Maduræ*. *The Lancet*, June 19, 1954 pp. 1299-1300.
- Banerjee, A. K., Mukherjee, S. K. and Nandi, P. Production of antifungal substances by *Streptomyces* Spp. isolated from Indian Soil. *Science & Culture*, 20, pp. 141-143, 1954.
- Banerjee, A. K. and Nandi, P. Biological studies on a strain of *Streptomyces* producing an antifungal antibiotic. *Proc. Ind. Sc. Cong.*, Part III, 221, 1955.
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