

From the Arboretum plantings 552 packets of seeds, and from the cooperative Arnold Arboretum - Fan Memorial Institution Yunnan expedition collections, 824 packets, a total of 1376 packets were distributed to institutions and individuals in the United States and nine foreign countries. At the same time 4115 living plants and 946 lots of cuttings and scions went to various institutions and individuals in the United States and four foreign countries. Among the plants distributed were 3000 hybrid ornamental crabapple seedlings to 337 institutions and individuals. These were grown in connection with Dr. Sax's hybridization work and were distributed with the understanding that the Arboretum has the right to take propagating material from any plant that may prove to be of exceptional horticultural value. In eliminating unwanted duplicate material from the general plantings, several truck loads of plants were presented to Boston University, Tufts College, the University of New Hampshire, and the Boston Park Department. Many other public institutions received living plants in the ordinary course of plant distribution.

Accessions to the Arboretum include 2114 living plants, 140 packets of seeds (including only those actually planted in the propagating houses), 721 packets of Yunnan seeds from the Fan Memorial Institute of Biology, these mostly redistributed because the species represented are not adapted to New England climatic conditions, and 19 lots of cuttings and scions.

Having encountered various difficulties in the past in our attempts to disseminate recently introduced plants or those of outstanding horticultural value through the medium of scions and cuttings, we have now adopted a policy of actually growing rare items for distribution as established plants. The recipients are thus placed in a position so that they can do their own propagating from established stock. It is believed that this policy will expedite the establishment in other centers of important horticultural forms introduced by the Arboretum.

In connection with the horticultural activities of the institution, many popular lectures have been given, the rapidly increasing correspondence regarding plants and plant problems has been taken care of, and the Bulletin distribution has been increased, the mailing list now exceeding 2000 names. An interesting development has been the rapidly increasing use that is being made of our source list of desirable horticultural plants.

Cytogenetic Laboratory.—The work in experimental cytology under Dr. Sax has included an extensive analysis of differential sensitivity of cells to X-rays. X-ray sensitivity during the nuclear cycle in

the *Tradescantia* microspore, as measured by chromosome aberrations, is at a minimum early in the resting stage and the period of greatest sensitivity is slightly before mid-prophase. Of the various cells the sporocyte is most sensitive with decreasing sensitivity found in microspores, root-tip cells and generative nuclei in *Tradescantia*. *Tradescantia* microspores are twice as sensitive to X-rays as are those of *Allium*. Differential sensitivity appears to be determined by factors involving the capacity for chromosome movement. The production of chromosome aberrations is only one of several effects of X-radiation which may cause the death of the cell.

The behavior of aberrant chromosomes in successive cell generations has been studied in onion root-tips. Apparently, the cells with aberrant chromosomes cannot compete effectively with normal cells and in later cell generations few aberrations are found. This conclusion is also supported by the behavior of X-rayed seedlings of numerous ornamental trees and shrubs. Doses of X-rays ($\pm 40,000r$), sufficient to inhibit growth for several weeks or longer, produced no apparent effect on the plants at a later period in their development. Abnormal plants resulting from gross chromosome aberrations can best be produced by X-raying pollen to produce zygotes with unbalanced genomes, which are not subject to competition with normal cells. This method has been used successfully with *Petunia* by Dr. Rick.

The exponential increase of chromosome aberrations with X-ray dosage has been difficult to reconcile with the linear relation between dosage and mutation frequency since it is known that many mutations are caused by chromosome rearrangements. The discrepancy is still greater since Dr. Rick found that the small interstitial deletions also show an exponential increase with increased dosage.

On the other hand, Dr. Rick has found that chlorophyll deficiencies in barley are produced in greater frequency when the seeds are X-rayed at low temperatures. Radiation of cells at low temperatures is more effective than radiation at high temperature, as measured by chromosome aberrations.

The radiation work has been extended considerably by Mr. Swanson and Dr. Giles. Mr. Swanson has found that ultra-violet radiation produces breaks in only one of the two sister chromatids at prophase. X-rays may break one or both chromatids at a given locus, but a single "hit" cannot break chromatids of different chromosomes. Dr. Giles has found that a single "hit" resulting from neutron radiation can break one or both sister chromatids or chromatids of different chromosomes. This

greater effectiveness of neutrons is attributed to greater ionization density in the proton path than in the electron path produced by X-rays.

The mechanics of mitosis has been studied in divisions of generative nuclei in pollen tubes of several genera. Where spatial relations permit, the chromosomes form an equatorial plate and divide regularly, but large chromosomes in a narrow pollen tube may divide without congregating on an equatorial plate and are distributed irregularly to the poles.

Chromosome behavior in an induced autopolyploid of *Tradescantia* resembles that to be expected in an allopolyploid. Mr. Skirm attributes this behavior to structural hybridity. This conclusion is supported by the work of Mr. Swanson who finds that both pure species of *Tradescantia*, as well as the hybrids, are heterozygous for numerous inversions.

A considerable number of ornamental shrubs have been treated with colchicine to produce polyploidy. A few polyploid plants have been obtained. Other techniques for inducing polyploidy are being tried.

The breeding work has been carried on extensively. Several thousand natural hybrid crabapple seedlings were grown in 1939. Several hundred were saved for testing and the others were distributed to persons interested in such work. In the spring of 1940 several thousand apple and an equal number of cherry seedlings were set out in the nursery to be selected or distributed next spring. Seeds from hybrids in the Arboretum have also been grown to get recombinations of favorable characters. The controlled pollinations in species hybridization has been continued with apples, cherries, lilacs, azaleas, and magnolias. Numerous hybrids are in the cold frames or nurseries. This work has been facilitated by the assistance of the graduate students, their wives, and of a volunteer worker, Mr. John Minns.

Wood Anatomy.—Extensive investigations of a wide range of representative dicotyledons have demonstrated that there are clearly defined trends of structural specialization in the cambium and xylem of the higher plants. Certain of these trends of evolutionary modification are irreversible and are significant not only in the identification of living and fossil woods but also in the investigation of the phylogeny and relationships of the various families and orders of the dicotyledons. Their significance in the study of lesser taxonomic units, viz., species, genera, tribes and sub-families, can be determined only by intensive investigations of specific families. During the last two years, we have initiated such an investigation of the pan-tropical family, *Icacinaceae*, and have assembled material for detailed comparative studies of the stem, node, leaf, floral organs and pollen. It has been essential in this connection to

devote considerable attention to the task of developing improved techniques for the microscopic analysis of herbarium material.

Various individuals are collaborating with Dr. I. W. Bailey in different phases of these investigations. Dr. Dahl is providing expert knowledge in the study of pollen. Mr. Howard is undertaking a critical taxonomic revision of the Icacinaceae under the direction of Professor Johnston. Mr. Hyland has developed a much improved paraffin technique for the rapid sectioning of stems from herbarium specimens. Mr. Barghoorn's studies of ray ontogeny, although not confined specifically to the Icacinaceae, are providing a more reliable basis for interpreting the ray structures in this family. Dr. Watson, Commonwealth Fellow in Botany, has devoted his attention to the Euphorbiaceae, certain genera of which must be considered in any general discussion of the Icacinaceae. Working in association with Professor Bailey and Professor Wetmore, Mr. Heimsch has continued his survey of the wood structure of the Geraniales and Sapindales in an endeavor to correlate histological data with current taxonomic concepts. Dr. Charlotte Nast has initiated a study of parenchyma patterns with view to understanding their ontogenetic and phylogenetic implications. Dr. Carlos O'Donnel, visiting professor from Tucuman University, has given special attention to the significance of wood structure in the Convolvulaceae as well as the Santalaceae, Olacaceae, Styraceae and presumed related families.

During the year 3,374 microscopic slides have been added to the collection of wood sections, the total now being 23,593. An attempt has been made to secure a representation of various small families in this basic collection, eighteen families having been added. This material was received from various herbaria, and through the cooperation of Dean S. J. Record and Professor R. W. Hess of the Yale School of Forestry. Special attention has been given to sectioning representatives of the Anacardiaceae, Meliaceae, Burseraceae, Rutaceae, Sapindaceae, Euphorbiaceae, Icacinaceae, Styraceae, Santalaceae, Polygalaceae and Alangiaceae.

Plant Pathology. — There has been an undiminished number of inquiries seeking advice on tree and shrub diseases. During the course of a year these naturally cover a wide range of subjects. But proper attention to them is important, for it fulfills one of the functions of the Arboretum and in addition sometimes helps to indicate needed research.

Much time has been expended on bringing into more readily workable order an accumulated collection of Polypores. An herbarium especially rich in species found in northeastern America results; but there is also

a considerable representation from other parts of America and some from other parts of the world. This collection will be deposited in the Farlow Herbarium.

Research has been actively carried on by Dr. Faull and four graduate students under his sponsorship, namely, Messrs. E. V. Seeler, A. E. Prince, C. J. Gilgut, and R. Gosselin.

Dr. Seeler has completed an investigation of two hitherto unknown diseases of *Gleditsia*. Both prove to be caused by a fungus native to America, *Thyronectria austro-americana* (Speg.) Seeler. This subject was undertaken primarily to determine the cause of a wilt that suddenly destroyed some *Gleditsia japonica* trees in the Arboretum that had been doing well from the time the species had been introduced in 1904. The project was enlarged when it was discovered that the same fungus causes a canker of the American *G. triacanthos*. The latter is rather slow-acting, but can be fatal. Fortunately, from its nature, it should be readily controllable. Control of the wilt disease in *G. japonica*, however, is another matter. Evidently choice of this species for planting in America calls for discretion, and should the causal fungus find its way into the home regions of *G. japonica*, severe losses would probably result. As part of his final program Dr. Seeler revised the genus *Thyronectria* and has prepared two papers which have been published in this Journal.

Mr. Prince, who had studied the species of *Gymnosporangium* occurring in Maine, elected to investigate *G. nidus-avis*, a broom-forming rust on *Juniperus* and a parasite on certain of the Pomaceae. The wealth of experimental plants available at the Arboretum has enabled him to complete important biological studies on that subject. His results, when published, will form a continuation of the earlier studies made by Drs. Crowell and MacLachlan at the Arboretum on certain other economically significant species of *Gymnosporangium*. As a result of the work of these men, we now have a much extended knowledge of the hosts subject to attack from species of *Gymnosporangium* and of their relative susceptibilities. This is of practical aid in choosing and arranging planting stock. It may also be added that Crowell and MacLachlan worked out a method of control of *Gymnosporangium* rusts that obviates control by eradication of the alternate host.

Mr. Gilgut is continuing his investigation of a serious basal trunk canker of the flowering dogwood and has confirmed Creager's findings that it is caused by a species of *Phytophthora*. Our first attention to it was in connection with our work in a field laboratory on the estate of Mrs. Harold I. Pratt on Long Island. We now know that it occurs in other localities one of which is in western Massachusetts. In addition

to etiological studies, efforts are being made to devise satisfactory control measures.

Mr. Gosselin is concentrating on the study of a butt heart rot of conifers caused by a widely spread virulent polypore. This topic seems to have a bearing on forestry practice and on estimates of the future history of some stands of timber.

Dr. Faull's own work is still largely concerned with biological and taxonomic studies of certain rust genera. *Hyalopsora* rusts are the immediate subjects under investigation. Pertinent to this research, various parts of Mexico were visited last November and December ranging from the State of Chihuahua in the north to Chiapas in the south. Of special interest was the discovery in Chiapas of forests in which there is an intermixture of firs and tropical ferns. As firs and ferns are the alternate hosts of various rust fungi and as these rusts may be perpetuated in mild climates on the fern hosts alone, an explanation is suggested for the unexpectedly rich development of these rusts on tropical ferns far beyond the range of *Abies*. A second subject now engaging his attention is a widely spread wilt disease of certain hardwoods. Heretofore, this topic has received meager study because of failures to transmit the disease artificially. This difficulty has been overcome and the disease can now be studied from its inception.

The Herbarium.—The number of mounted specimens actually inserted into the Herbarium was rather small, only 9525 sheets, but supplementing this number approximately 40,000 specimens were mounted, but being identified only in part are hence not yet ready for distribution into the herbarium. The total number of specimens now filed in the herbarium amounts to 494,467 sheets.

The number of specimens (including duplicates) received during the year amounts to 67,212 of which 42,497 are from America, 13,701 from China, 793 from Eastern Asia exclusive of China, 4032 from Indo-China, 4936 from Malaysia, Papuasias and Polynesias, and 1253 from Europe, Central Asia and Africa. Among the more important Asiatic collections received is one of 7911 specimens from Yunnan by T. T. Yü, two sendings of about 4400 specimens (including duplicates) from southeastern China by W. T. Tsang, one of 997 specimens from Indo-China by Dr. A. Pételot, and one of about 3000 specimens (including duplicates) by W. T. Tsang also from Indo-China. Important American collections received were about 5000 specimens from British Guiana made by A. C. Smith on the Terry-Holden Expedition, 2875 specimens of Bolivian plants of the Steinbach Herbarium, 3452 specimens from

Argentina and Chile, received by Dr. Johnston for identification and 1540 specimens collected in Mexico by him, 3331 specimens collected by Woodson, mostly from Panama, 1312 specimens from Mexico and Central America received from the University of Michigan, 1171 specimens collected by J. W. Thompson in British Columbia, and 14,300 specimens collected by H. M. Raup in the MacKenzie Mountains in northwestern Canada.

In continuation of exchanges 2996 duplicate specimens were distributed, mostly to American institutions and 1298 duplicates were sent to various specialists for identification. To the Gray Herbarium were transferred 14,440 specimens, 1743 illustrations and their accompanying descriptions, while 569 specimens and 240 illustrations and descriptions of orchids were sent to the Ames Orchid Herbarium at the Botanical Museum, and 162 specimens of cellular cryptogams to the Farlow Herbarium. The total distribution of specimens amounted to 19,465, and of illustrations 1983.

Twenty-six loans approximating 2300 specimens were sent to 13 institutions, mostly American. For study by members of the staff, 36 loans involving over 2100 specimens were received from institutions in the United States, Venezuela, England, and China.

The collection of negatives representing types and critical specimens now amounts to 4026 negatives, 75 having been added during the fiscal year. The current card catalogue of references to new species and other important literature and illustrations of woody plants was increased by 4642 items, the total now amounting to 125,819 cards.

Routine herbarium work has involved a further breaking down of the material in large genera into geographic sequences, at least a maintenance of the normal amount of mounting, although we are now far in arrears in this field, and the incorporation of many thousands of additional typed or clipped descriptions and illustrations into the herbarium. The crowded condition of the available herbarium cases, mentioned in previous reports, becomes more and more critical.

In connection with the general herbarium work various staff members have devoted much time to their special activities, with gratifying results. Professor Alfred Rehder completed his time-consuming task of seeing the second and thoroughly revised edition of his *Manual of Cultivated Trees and Shrubs* through the press. Dr. Johnston continued work on the very extensive Goodspeed collections of Chile, Peru and Argentine plants, identified the White and Shreve collections of Mexican plants, his own collection made in Mexico in the summer of 1938, and at the same time has reported on extensive collections submitted for identifi-

cation by his South American correspondents. He reported on nearly 600 specimens of Boraginaceae sent to him by numerous collectors for identification. Dr. H. M. Raup has made excellent progress on the study of his MacKenzie Mountains expedition plants collected in the past summer, and at the same time has identified and reported on important collections of Arctic and Saskatchewan plants submitted to him by various correspondents. He has also practically completed his report, in association with Mr. R. E. Carlson, on the land use history of the several tracts of land forming the Harvard Forest, the field work having been accomplished in the summer of 1938. This investigation was financed in part by the Arnold Arboretum, but mostly by a grant from the Harvard committee on research in the social sciences. Dr. Kobuski has continued his work on the Theaceae and on the genus *Jasminum*, while Dr. Allen has devoted much time to her studies on various large collections of Old World Lauraceae. Dr. Perry has continued her work on the identification of the extensive Richard Archbold Expedition collections of New Guinea plants. Dr. Croizat has devoted most of his time to a study of various genera of the Euphorbiaceae. Working under my general supervision, Miss Chen has completed a study of the eastern Asiatic species of *Ormosia*, and has initiated work on the peculiarly difficult genus *Sabia*. Such time as I have had available for herbarium work has been devoted to the study of various collections from China, the Philippines, Malaysia, Indo-China, and the 1938-39 collections of Captain F. Kingdon Ward on the Vernay-Cutting Expedition to Upper Burma. During the entire year Professor F. P. Metcalf of Lingnan University has occupied space in the herbarium working on the manuscript of his Flora of Fukien Province, and is the recipient of a Guggenheim Fellowship that enables him to remain a second year with the objective of completing this task.

Field Work.—The MacKenzie Mountains expedition of Dr. H. M. Raup during the summer of 1939 was eminently successful. On June 8, headquarters were established on Brintnell Lake, in the headwaters of the South Nahanni River, about 200 miles west of Fort Simpson. To reach their base involved several hundred miles of travel by airplane. The party remained at this base until August 20, when they returned to Fort Simpson, field work being continued there for about three weeks. Leaving Boston on May 20, 1939, Dr. Raup reached home on September 28. A total of 1665 numbers, about 14,340 specimens, were collected from this hitherto botanically unexplored area. The expedition was financed by grants from the Milton Fund of Harvard University, the

American Academy of Arts and Sciences, the National Academy of Sciences, the Arnold Arboretum, and generous donations from several individuals for this specific project.

Otherwise actual field work on behalf of the Arboretum has been done through the granting of modest subsidies to resident collectors and botanists, particularly in China. These include grants to the Fan Memorial Institute of Biology, Peiping, Sun Yatsen University, Hong-kong, Lu Shan Arboretum, Likang, Yunnan, Nanking University, Lingnan University, National Szechuan University, and to Dr. A. Pételot, Hanoi, Indo-China. This cooperative work has been outstandingly successful in spite of continued and increasingly adverse unsettled conditions in China.

The Library.—At the end of the fiscal year the library comprised 44,506 bound volumes, several hundred unbound volumes, 12,726 pamphlets, 18,644 photographs, 3200 slides, and several thousand nursery catalogues. During the year there were added 383 volumes, 257 pamphlets, and 200 photographs. The A. B. Morse Company of Michigan made a generous gift of over 200 negatives and prints taken by the late Herbert W. Gleason mostly in the Arboretum, and 150 of them were selected and added to the collection of photographs. A fine series of photographs of New Guinea vegetation was presented by Mr. Richard Archbold of New York, to supplement the extensive botanical collections received from him last year. The cards added to the periodical and author catalogue numbered 1,200, among which were 300 containing bibliographical information, and 1406 slips were incorporated in the file which supplement the printed author and subject catalogues of the library. Nineteen new periodicals were acquired, most of them to continue as exchanges with our own publications. About 200 volumes have been loaned to other libraries, and some have been borrowed for use here. The demand for photostats continues and many books have been sent to the Harvard College Library for that work to be done. The holdings of the library have been checked up to the letter L for inclusion in the new edition of the Union List of Serials. A collection of about 300 books, left to the Plymouth Public Library some years ago by Benjamin M. Watson, Jr., formerly of the Bussey Institution, was purchased from that library, and was found to contain some rare and desirable items.

Atkins Institution of the Arnold Arboretum, Soledad, Cienfuegos, Cuba. — The plantings have been greatly extended, approximately thirty

acres of the tract transferred last year to the garden, having been developed through the replanting of the living material in the genera *Acacia*, *Bauhinia*, *Erythrina*, and *Ficus*. During the rainy period, July and August, many palms were transferred to the palm section, while the vine section has been re-arranged. To increase efficiency in handling young plants a nursery area has been developed, to which material is transferred from the propagating house. Further interplantings of desirable native trees have been made in the naturally wooded section, the entire area now being under easy control through the elimination of undesirable undergrowth. To help decrease the cost of maintaining the areas planted to trees and shrubs, a flock of forty sheep was acquired, and this innovation promises well in reducing the cost of controlling the growth of grass. The unusually cold winter season caused some damage to a few of the more tender species, but all of the damaged plants are recovering. The removal of the houses from Colonia Limones has proved to be a very excellent move from the standpoint of the garden, resulting in a cessation of damage by domestic animals and a great reduction in petty pilfering. As the cane fields surrounding the garden are turned into pasture, the fire hazards are correspondingly reduced. During the year, 516 packages of seeds, 369 living plants, and 54 lots of cuttings were received, and 404 packets of seeds and 94 lots of cuttings were distributed. About thirty individuals enjoyed the hospitality of Harvard House for shorter or longer periods of time. Graduate students at Harvard University working at the garden on various problems were Mr. C. T. Parson and G. E. Folk, Jr., while Dr. E. V. Watson, Commonwealth Fellow at Harvard, included the institution in his travels in connection with his ecological observations. The number of students listed for the next year is largely in excess of those in previous years. This increased attendance at the Atkins Institution is a reflex associated with the additional housing facilities now available in Casa Catalina, and greater ease of access due to the improved roads leading to Cienfuegos.

Publications. — The usual numbers of the Journal and of the Bulletin of Popular Information were issued. These official publications, however, reflect only in part the activities of the staff. A bibliography of the published writings of the staff and students working under the supervision of staff members is appended.

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E. D. MERRILL, Director

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CORRECTIONS

- Page 53, line 4 from below, for **dauricum** read **dauricus**
- “ 62, line 14 from below for *minutus* read *minutum*.
- “ 194, line 3 for *E. papuanum* read *P. papuanum*.
- “ 285, line 6 for *striata* read *striatum*.
- “ 385, line 14, for **numulariifolia** (G. Don) read **nummulariifolia** (D. Don).
- “ 385, line 16 for G. Don read D. Don

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Synonyms are printed in *italics*; new names in **bold-face** type.

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