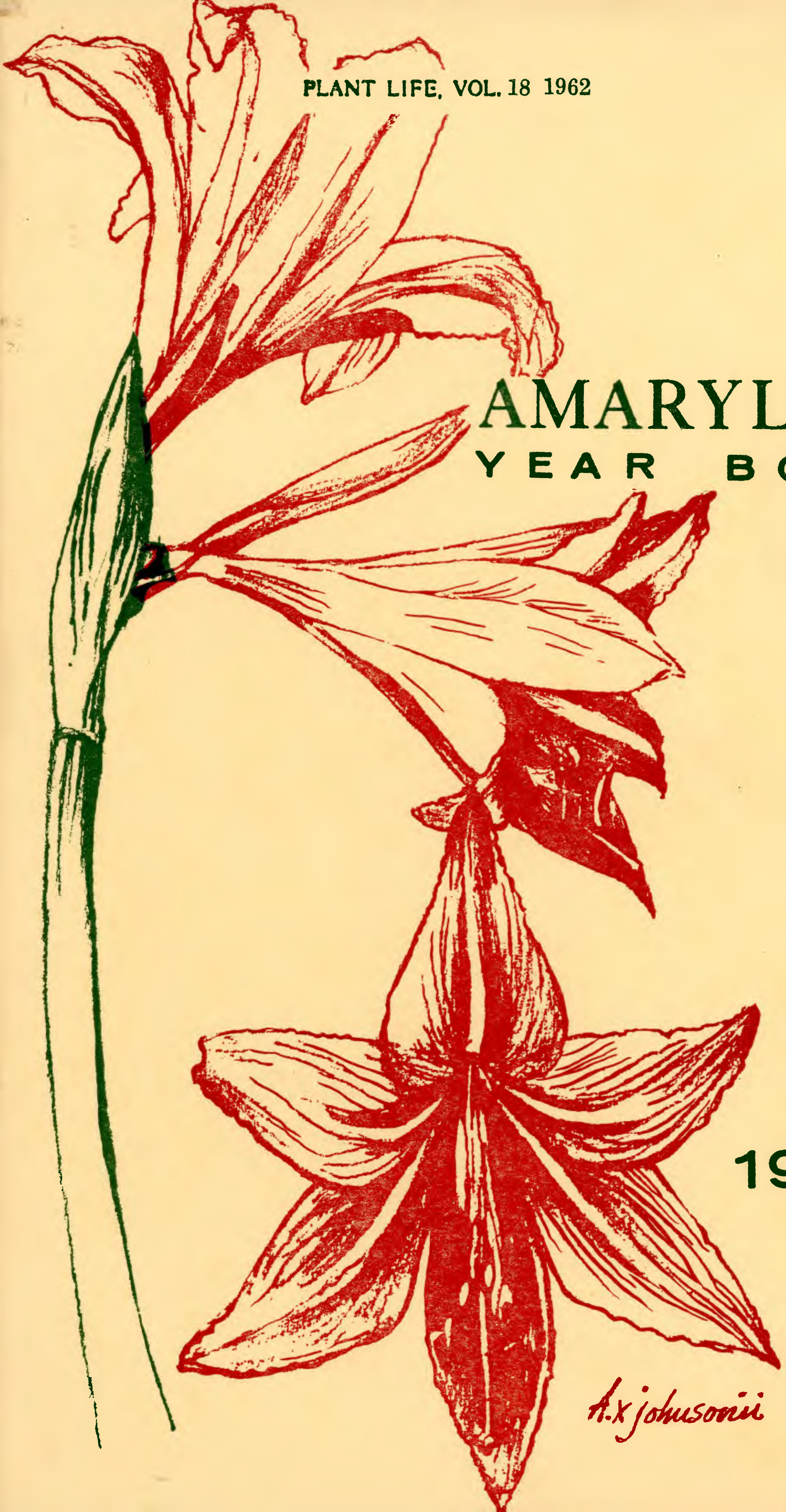
PLANT LIFE, VOL. 18 1962

AMARYLLIS
YEAR BOOK

1962



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[Nos. 1-4, Jan., Apr., Jul. & Oct.]

1962

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Hamilton P. Traub

Harold N. Moldenke

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AMARYLLIS
YEAR BOOK
1962

Year Book of
The American Amaryllis Society
29th issue

GENERAL AMARYLLID EDITION

EDITED BY
HAMILTON P. TRAUB
HAROLD N. MOLDENKE

THE AMERICAN PLANT LIFE SOCIETY
Box 150, La Jolla, California

THE AMERICAN PLANT LIFE SOCIETY

For the roster of the general officers of the Society, the reader is referred to the inside front cover of this volume.

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[THE AMERICAN AMARYLLIS SOCIETY—continued on page 163.]

PREFACE

The cover design, featuring *Amaryllis* x *johnsonii,* is the work of Prof. Douglas D. Craft of THE DEPARTMENT OF DESIGN, ART INSTITUTE OF CHICAGO It is based on a plant grown by Prof. Craft. We are all grateful to him for this contribution.

The 29th edition of THE AMARYLLIS YEAR BOOK is dedicated to Dr. Floyd F. Smith, an outstanding scientist in the field of entomology, who received the 1962 HERBERT MEDAL for his contributions toward the description and control of the mite and insect pests of Amaryllis and the other amaryllids (see Plant Life 10: 91—95. 1954). Dr. Smith contributes an interesting autobiography in the present issue. His additional paper on the control of mite and insect pests was received too late for inclusion in this issue and will appear in a future edition. We are all grateful to Dr. Smith for the assistance that he has given to all of those interested in *Amaryllis* and the other amaryllids.

Mr. Percy-Lancaster writes on his South African travels in the present issue. He is now back at the National Botanical Gardens, Lucknow, India, as Technical Advisor in charge of a School of Plant Breeding and Genetics. He will write from there hereafter.

The articles on *Amaryllis* in the present issue are most interesting. Prof. Craft writes on *Amaryllis* x *johnsonii;* and Dr. Cardenas describes a new Bolivian *Amaryllis.* Mr. Stevens reports on the Blue Amaryllis as grown in New Zealand. Mr. Quinn Buck writes on the culture of *Amaryllis calyptrata;* and Mr. Cooper on the naturalized *Amaryllis striata* in Hawaii. Mr. Goedert reports on the *Amaryllis* hybrids and species of the 1960-61 season. Mr. Hill writes on bottom heat for *Amaryllis* and Mr. Turner on treating *Amaryllis* bulbs and soils. Mrs. Williams, Miss Stewart and Mrs. Harris report on their experiences in growing *Amaryllis.* Dr. Joseph C. Smith contributes notes on *Amaryllis* species. Mrs. Seale writes on *Amaryllis* arrangements for the home.

There are interesting articles on the other amaryllids. Mr. Wallace contributes articles on *Boophone disticha, Brunsvigia josephinae* and Nerines as grown in the San Francisco area. Mr. Morris writes on collecting *Crinum flaccidum* in Australia. Mr. Rokujo reports on *Crinum asiaticum japonicum,* and Mr. Hannibal on the breeding of Crinums. There is a report on the finding of a long lost *Crinum* within the City limits of Beaumont, Texas, by Mrs. Carl Shirley. Miss Dorman and Mr. Woelfle write about *Hymenocallis.* Mr. Hansberry reports on west coast *Vallota* culture; Mr. Woelfle on the miniature amaryllids; Mr. Brasol on breeding *Zephyranthes;* and Mr. McNeil on *Cyrtanthus* hybridizing. Mrs. Fred Flick contributes extracts from the Amaryllis Round Robin letters.

Dr. Ising contributes a valuable article on cromosome balance in *Cyrtanthus;* and Drs. Flagg and Flory write on the placement of *Sternbergia.* There are articles on the subfamilies and genera of the *Amaryllidaceae,* and the classification of *Hymenocallis.*

There are reports on the Official Amaryllis Shows for 1961; and

Mrs. Pickard writes on "The Amaryllis Parade". There are various other interesting items.

Contributors for the 1963 issue of THE AMARYLLIS YEAR BOOK are requested to send in their articles by August 1, 1962, in order to insure earlier publication of this edition. Unless articles are received on time, publication will again be delayed to June or July or even later as with some issues in the past several years. Your cooperation toward earlier publication will be greatly appreciated.

December 12, 1961,
5804 Camino de la Costa,
La Jolla, California.

Hamilton P. Traub
Harold N. Moldenke

CORRIGENDA

PLANT LIFE, Vol. 17. 1961

Page 43, 12 lines from top, for the first "flowers" read "leaves".
Under *Calostemma purpureum* var. *purpureum,* 14th line, for "1-seeded" read "1-, rarely 2, seeded,"
Page 50, delete 9th line from top beginning "Allium saxicola etc."
Page 160, under "GLORIOSA L.", end of 1st line, for "Abyssinica" read "Abyssinia".

[PLANT LIFE LIBRARY, continued from page 162.]

MAKERS OF NORTH AMERICAN BOTANY, by H. B. Humphrey. Ronald Press Co., 15 E. 26th St., New York 10, N. Y. 1961. Illus. pp. i-ix + 265. $6.00. This interesting book includes brief biographies of 122 North American botanists, from colonial to the present times. Those included were selected for their important contributions toward the advancement of plant science, particularly for outstanding research, teaching, or effectiveness in administration. There are some omissions—W. W. Garner (photoperiodism), R. B. Harvey (plant physiology), etc., but these can be added in a future edition. This is a reference book which all plant scientists will want to have in easy reach. Highly recommended.

ADVANCES IN AGRONOMY, Vol. 13. Edited by A. G. Norman. Academic Press, 111 5th Av., New York 3, N. Y. 1961. Illus. pp. 386. $12.00. This is volume 13 in a series designed to review research progress in soil and crop sciences and development in agronomic crop practice. The present volume includes contributious by outstanding authorities on podzol and podzolic soils; subterranean clover; stubble mulch farming; contamination of soils by petroleum hydrocarbons; the barley yellow dwarf virus disease of small grains; the abundance of earthworms and their possible significance in agriculture; physical chemistry of clay-water interaction; and iron chlorosis in plants. This attractive book is highly recommended to all who are interested in crop production.

BIOLOGY: AN INTRODUCTION TO THE SCIENCE OF LIFE, by C. J. & Marie L. Goodnight, and R. R. Armacost. John Wiley & Sons, 440 Park Av., S., New York 16, N. Y. 1961. Illus. pp. 460. $6.95. This course in biology offers a clear and concise survey of the major features of the plant and animal kingdoms. Following the introductory section, the subject is presentel in four parts—human anatomy and physiology with the principle of homeostasis as an integrating concept; structure and functioning of higher plants, and a survey of the plant kingdom; the principal types of animals, with particular reference to adaptation and anatomy; and reviews of material previously presented from the viewpoint of genetics, evolution, ecology and conservation. This stimulating text is highly recommended.

[PLANT LIFE LIBRARY, continued on page 5.]

DEDICATED TO

FLOYD FRANKLIN SMITH, PH.D.

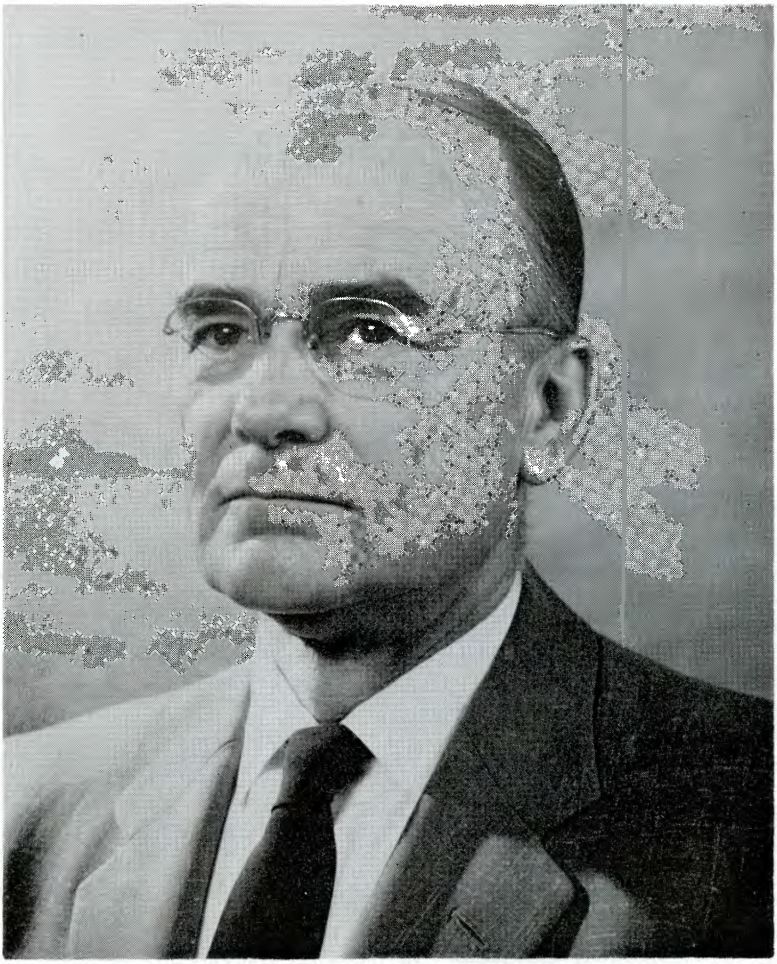
[PLANT LIFE LIBRARY, continued from page 4.]

AN OUTLINE OF CHEMICAL GENETICS, by B. S. Strauss. W. B. Saunders Co., W. Washington Sq., Philadelphia 5, Pa. 1960. Illus. pp. 188. $5.00. The purpose of this excellent book is to emphasize the effect of recent advances in genetics, particularly those pertaining to nucleic acids, on genetic theory as a whole. Chapters are devoted to the genetic control of protein synthesis, the chemical nature of the hereditary material, the molecular meaning of genetic recombination, mutation as a chemical process, nucleo-cytoplasmic relationships and the problem of protein synthesis, and the biochemical genetics of man. Highly recommended.

GARDENING IN BRITAIN, by Miles Hadfield. Chas. T. Branford Co., Newton Centre 59, Mass. 1960. Illus. pp. 483. $12.00. This is the book on British gardening that we have all been waiting for. How often in the past has one sought for a single source on this subject! Now this need has at long last been met in Mr. Hadfield's handsome volume. The subject is presented in a charming style and a wealth of detail, and the sixteen illustrations are outstanding. Chapter one discusses British gardening from ancient times to 1529, and in the next seven chapters the subject is carried by historical stages to 1939. This book is highly recommended and the reader should not hesitate to acquire it at the first opportunity. Britain is the mother of gardening and this book will illuminate the beginnings of our own gardening tradition.

A HISTORY OF BIOLOGY, by Charles Singer. 3rd revised ed. Abelard-Schuman, 6 West 57th St., New York 19, N. Y. 1959. Illus. pp. i—xxxvi + 580. $6.00 The purpose of this attractive book is to give in simple language a critical survey of the historical development of biological concepts to about 1900 which is to serve as an introduction to living things. Following the opening section, the book is divided into three parts—the rise of ancient science, the historical foundation of modern biology, and the emergence of main themes of modern biology. There is one important omission—Michel Adanson who first enunciated the multivariate principle in systematic biology. Dr. Singer, an outstanding authority in biological history, who died in 1960, approached the subject from a dynamic point of view—biology as a developing science—and thus produced a sound critical survey. This revised edition of a stimulating book is highly recommended.

[PLANT LIFE LIBRARY, continued on page 13.]



Herbert Medalist — Floyd Franklin Smith, Ph.D.

FLOYD FRANKLIN SMITH, Ph.D.

An autobiography

I was born July 27, 1900, on a farm in Hinckley Township of Medina County, Ohio, and was the oldest of six children. School grades one through eight were spent in a one room district school. During the first two years I was one of the total of six children enrolled in the school. On two blizzardy days during the first school year I was the only pupil in attendance (no closing of schools in those days). As a small boy I had an intense interest in wild plants and trees and for several years maintained a wild flower garden and a garden of lichens and mosses collected from the woods. Graduating from Hinckley High School in 1918, I enrolled in the Students Army Training Corps at Wooster College which disbanded after the close of World War I. The following year I enrolled in the College of Agriculture at Ohio State University majoring in entomology with a minor in horticulture. During the summer vacation periods I worked as field assistant in the study of insect transmission of raspberry viruses at a USDA laboratory in northern Ohio. In 1923 I graduated with a B.Sc. degree and also married the prettiest black haired gal, Dorothy Louise Kuder, whom I first saw getting a drink at the town pump on my first day of high school 9 years previously. I continued graduate studies and served as graduate instructor in zoology at Ohio State. After receiving a Master of Science degree in 1924, I accepted an appointment with the Pennsylvania Bureau of Plant Industry and we moved to Willow Grove, near Philadelphia. One third of my time was devoted to nursery inspection and the remainder to research on greenhouse and nursery pests. Insects of chief interest were the boxwood leaf miner, the black vine weevil, and pine shoot moths. But a number of insects new to science or new to America were discovered, including the bulb scale mite in imported narcissus bulbs. Through association with a fellow worker, Arthur B. Wells, who was an excellent botanist, I learned to recognize a vast number of ornamental plants and trees grown in commercial nurseries and greenhouses, and also in conservatories and grounds of the numerous great private estates in the Philadelphia area. During this period I pursued post graduate studies *in absentia* and in 1928 I was awarded a University Fellowship in Entomology at Ohio State University. After spending the following year in graduate studies in chemistry, plant physiology, plant ecology, and insect parasitism, I was awarded in 1929 the Ph.D. degree.

In the same year I was appointed an associate entomologist in the United States Department of Agriculture laboratory of Dr. F. W. Poos at Arlington Farms across the Potomac River from Washington, D. C. With Dr. Poos I investigated the nature of the injury produced on various crops by feeding activities of the potato leafhopper and related species.

In 1931 I was appointed entomologist in the Division of Truck Crop and Garden Insect Investigations, a unit of the Bureau of Entomology and Plant Quarantine of the U.S.D.A. There, in Washington, under the direction of Dr. C. A. Weigel, I investigated many pests of ornamentals and devoted particular attention to the life history and control of the cyclamen mite. For several years after the arrival of the gladiolus thrips in this country I devoted considerable time along with other entomologists in our group to studies and life history and control of this insect both in the field and under storage conditions. The tartar emetic-sugar sprays, the standard treatment for several prewar II years was later replaced by DDT or one of the other new organic compounds. In recognition of the research contribution that helped save the gladiolus flower for the average gardener, the New England Gladiolus Society awarded me its Gold Medal in 1949.

In 1935 the project on greenhouse and ornamental insects was transferred to the Agricultural Research Center at Beltsville, Maryland, where more greenhouse and laboratory space was provided and investigations on greenhouse pests was expanded. I cooperated with chemists on the aerosol method of insect control in both the field and the greenhouse. With the advent of newer insecticides such as DDT, hexaethyl tetraphosphate, parathion, and many others, and their use in aerosols, smokes and sprays, higher and higher levels of pest control were achieved. Because of these accomplishments I was given the Award of the Society of American Florists for the Outstanding Research Contribution to Floriculture in 1947.

Interest in insect transmission of plant diseases began in 1922 as a temporary employee of USDA on raspberry diseases. In experiments we discovered that the mysterious dying of blackcap raspberries was due to aphids infecting them with a mosaic from red raspberries growing nearby. In 1932 I first became associated with Dr. Philip Brierley, a plant virus disease specialist, in a pooling of talents against several virus diseases of ornamentals. Included in our joint studies, which have continued to the present time; were the virus diseases of iris, lilies, tulip, chrysanthemum and gladiolus. Through our combined efforts the necessary knowledge of several diseases was developed so that commercial growers could successfully combat them and maintain or increase their production.

Current problems under investigation are the viruses of gladiolus and chrysanthemum.

While continuing in the service of the U.S.D.A. at Beltsville I was promoted to Senior Entomologist in 1944, Principal Entomologist in 1954, and in 1960 to Investigations Leader in the section on insects affecting ornamentals and vegetable crops. These advancements have brought their administrative responsibilities but have left considerable opportunity for continuing with research activities. Especially satisfying, however, is the opportunity to work with younger research entomologists in our group who are energetically attacking new insect problems. During this period I have been author or co-author of about 230 bulletins and papers.

In 1935 we built our home in Woodside Park, a community in Silver Spring, Maryland, where on our half acre of fine soil, I have raised many kinds of flowers, bulbs and shrubs which incidentally enable my wife to follow her hobby of flower arranging, an art in which she has earned a considerable reputation as exhibitor, teacher and judge. Our son, Dwight Raymond, who graduated in medicine from the University of Chicago, has established his practice in surgery in the Washington area. Our daughter, Margaret Isabel, the wife of an architect, is an accomplished pianist.

This briefly outlines my research and related activities for the past 38 short years. I can only briefly refer to the most pleasant personal experiences from association with other entomologists and with scientists in related fields of plant pathology, chemistry and physiology, while exploring together the ways of insects and the possibilities of control. In the early years the challenges were great because we had few tools (insecticides) to work with. Then, for a short while, the powerful new insecticides resulted in such spectacular slaughter of the insect hordes that great ingenuity was not required. Today, however, with the development of resistance to insecticides in many of our important insect
I had heard of the beauties of South African flora time and time
species we are faced with new challenges to maintain our high standards of control. But new approaches to insect control now on the horizon, such as irradiation and chemosterilants that effect the reproduction of insects are opening up new possibilities in research. The future looks exciting and makes one wish to be starting over again.

SOUTH AFRICAN TRAVELS, 1960

SYDNEY PERCY-LANCASTER, *Southern Rhodesia*

again but it was only in September-October, 1960, that I had the opportunity of seeing for myself some of the gems of that country. On the 23rd September I left Salisbury, by Comet, for Johannesburg on the first lap of the journey that would take me to Cape Town. I spent the next two days in seeing the sights of this City and visiting gardens and parks, as well as nurseries. What gave me most pleasure was the collection of tropical plants in the glasshouses of the Public Park, many I had not met before. My Doctor son drove up from East London and, before going south, we spent a day in Pretoria.

The main Highway in South Africa is very good; awkward curves, and very few exist, are being straightened out so that one can drive at 50 miles per hour; we often touched 70, but had to conform to the rules of 35 m.p.h. near towns. Stopping for a night en route we easily did the 627 miles in two days, though it gave us little time to admire the flora. *Arctotis* and *Gazania* in variety were weeds of the roadside. In the drier parts we met with clumps of *Aloe* and small forests of tall *Euphorbia*, while hardy shrubs, most noticeable being *Acacia Karroo*, with 2½ to 3 inch thorns, grew in stony land. *Argemone* of a pale creamy shade has apparently invaded Africa while *Opuntia*, in two or three species, was also met with near coastal towns. One of the amenities provided by a thoughtful Government is the provision of cement seats and tables, placed in the shade of trees, for the benefit of travelers. We passed many picnic parties on our way to the Cape, in fact we had a lunch at one of these convenient spots. Among the trees used for avenues were *Grevillea robusta,* leafless & therefore a wonderful sight with masses of orange yellow flowers, a scarlet *Brachychiton* was also very noticeable, as were the flowering *Eucalyptus* in shades ranging from red to a creamy white. *Jacaranda* was in bud and *Erythrina caffra* just over. One of the bushes that attracted our attention was *Erythrina acanthocarpa,* three feet high and carrying large sprays of scarlet tipped greenish-yellow flowers.

I spent a very happy eleven days in East London with my son and family, enjoying the wonderful sea beaches and the gardens, and then, on the 10th October, my son and I left for Cape Town where he had to attend a Medical Congress. We drove the 995 miles by car and it was a most pleasant journey which took us two days to accomplish. The Highway leads along the east coast of S. Africa, more or less parallel to the sea; and the frequent sea views, the picturesque towns, and the flowers, were all interesting. One of the noted bridges is over the Storm River, this is an arched concrete structure, 630 feet long spanning a 330 foot deep chasm. The scenery in the vicinity of two Passes, Blaukras Pass and Grootriver Pass, reminded me of the lush tropical growth one meets on the way to Darjeeling, or to Kalimpong. It was in a deep damp gully that I saw what looked like thin stemmed *Ravenala madagascariensis* but proved to be a *Strelitzia, S. nicolai,* twenty to thirty feet high, with flowers of no floral beauty. *S. reginae* was not seen wild but, in many of the towns we passed through, it had been used as a boundary hedge and the Municipal Corporation had planted long rows to form a demarcating fence between "up and down" traffic lanes. Traffic islands were invariably decorated with *Pelargonium, Mesembriathemum,* and many other free flowering plants. Stops by the wayside had to be limited as we were pressed for time and we got to Constantia, a suburb of Cape Town, late in the evening of the second day. Pelargoniums and geraniums were everywhere en route, the ivy-leafed types rambled over tall bushes, the zonal were in drifts, or solitary bushes; the dwarf, growing only six inches or so above ground, were very deeply rooted. *Pelargoniums* spread in dense carpets close to the Highway and one with mauve flowers, the size of a shilling, was especially attractive. *Plumbago capensis* was a ragged bush seen everywhere and *Tecomaria capensis* looked very bright in full bloom. I missed, however. *Bauhinia galpinii,* which is one of the attractive rambling bushes seen from the Railway all the way up from Beira, in Mozambique, to Salisbury.

At Tzitzikama, the Government has a huge Forest Experimental Reserve with indigenous and introduced species useful for timber purposes. South Africa has a very ambitious scheme for planting trees of economic value and you meet with forests of *Eucalyptus, Podocarpus* and *Pinus* every here and there. We spent three days with a friend in Cape Town and I was shown the sights of this great city. One day we visited Protea Gardens, enjoyed the various plants in bloom and here I saw a *Fatsia papyrifera,* 12-15 feet high, and a large specimen of *Paulownia imperialis* in full flower. I also took the opportunity of seeing the National Botanic Garden at Kirstenbosch but, unfortunately, we picked on the lunch hour for our visit and missed the chance of obtaining a guide to show us round the extensive grounds. I also spent an hour in their Herbarium noting the specimens of *Gloriosa* in their collection. Our return trip from Cape Town was on Saturday the 15th of October, and we reached East London late on Sunday night. We had spent the night at Riversdale and made frequent stops to examine interesting flora. I spent the next two days with my son and family intending to leave on the 18th but, owing to high winds, the plane could not touch down that afternoon and I left the following day. The first call was Durban, then we landed at Johannesburg airport about 7 p.m. Three days were spent in seeing gardens and the suburbs that I had failed to visit on my first trip. I caught the plane to Salisbury on the 23rd and a couple of hours later was in Southern Rhodesia, just a month from the date I left. I had travelled 2700 miles by road and some 1025 by plane.

A motor trip, unfortunately, takes you down only a corridor from East London to Cape Town, more or less parallel to the sea, and all the plants one sees are those growing close to the Highway, or in gardens. The wet weather in Cape Province had been the worst for forty years and many plants were not in flower. The Calla Lily, *Zantedischia,* was seen in drifts in swampy land, and *Kniphofia* too in small clumps. Any amount of *Plumbago* was met with, but ragged and an apology for itself. The Compositeae were well represented, many I failed to recognise, but specimens of the following were identified:—*Arctotis, Dimorphotheca, Gazania, Helichrysum, Ursinia* and *Venidium.* Others met with were *Cotula, Chaeris, Felicia, Heliophila, Matricaria, Osteospermum, Senecio* and *Vernonia. Agapanthus* was seen in clumps and the variety of Irideae was large and interesting. Except for two dwarf species of *Gladiolus,* the great majority had finished flowering. *Moraea* in white and blue, *Aristea* in blue, and *Watsonia* in a great range of colours was in bloom. White *Ornithogalum,* a tall, as well as, a dwarf species, was met with in drifts and sometimes among the white species *O. aureum,* with orange flowers, appeared. *Scilla* with dull greenish flowers, so often seen, could not compare with *S. natalensis* with blue flowers. Only one clump of *Clivia nobilis,* several *Lachenalia,* and an uninteresting species of *Haemanthus,* having the dull red flowers crowded together between two green bracts, were seen in East London. The only *Crinum* met with was *C. Macowanii,* in East London. but in Salisbury we have this, as well as another that looks like *C. bulbispermum.* In our garden we also have a specimen of *C. graminicola* that unfortunately does not have a long enough flower stem to display to advantage the twenty pink flowers this species produces. *Oxalis* are numerous in S. Africa but are liable to become weeds if permitted to grow unchecked. Among bushes the following were outstanding;—*Erythrina acanthocarpa, Rhigozum* *obovatum,* with large yellow flowers, *Cadaba juncea, Greyia Sutherlandii* (only seen in Nurseries), and *Virgilia divaricata.* There must be dozens, perhaps with more interesting flowers, but they were not in bloom. *Asclepias* are weeds of which there are dozens of species, some are worth cultivating for their flowers but all have quaint seed pods to recommend them. Among terrestial orchids I saw just a few in bloom, these were varieties of *Lissochilus, Satyrium,* and *Corycium. Mesembrianthemums, crassulas, aloes,* and succulents of various kinds, were seen all the way from Johannesburg to Cape Town.

EDITOR'S MAIL BAG

Under date of June 26, 1961, Mr. W. M. James, of Saratoga, Calif., writes,—"*Cornus nuttallii* grafted on *C. capitata* is apparently going to bloom in summer instead of the spring. It had flowers last summer and buds are setting heavily now (June 1961). Normally *C. nuttallii* sets buds in the fall. It is deciduous and *C. capitata* is evergreen, and just in bloom now. There is a fine tree of *C. capitata* near here. It should be planted more than it is."

Mr. Howard F. Cooper, Hana, Maui, Hawaii, writes under date of Sept. 4, 1961, that he "will be away for 2½ weeks with the U. S. Air Force in the Phillipines and Japan (action duty), and will return to Hana on or about the 25th of September."

Dr. Thad Howard of San Antonio, Texas, made a short trip to California this spring and stopped off at the writer's home for a very brief visit which was all too short.

Dr. Leo Brewer, of Lawrence Radiation Laboratory, Berkeley, was among those who received the Ernest Orlando Lawrence Memorial Award in 1961. The Award consists of a Medal and a $5,000 cash award, selected by the Atomic Energy Commission's General Advisory Council.

The members will be interested to hear that our Artist, Douglas D. Craft, has been promoted to the rank of Assistant Professor, in the Department of Design, Art Institute of Chicago.

The writer had the privilege of welcoming the amaryllidarians, Miss Irene Stewart and Mrs. Flickinger of Escondido, Calif., to his garden in June of 1961.

On September 30, 1961, Mrs. Leonard Swets, the amaryllid enthusiast of Riverside, California, and her sister, paid us a visit, which was most enjoyable. She brought along a fine flowering scape of *Brunsvigia orientalis* which she donated to the Traub Herbarium for a specimen. Mrs. Swets is apparently the only one to have grown this subject successfully in the United States.

The following information was furnished to Wyndham Hayward by Dr. W. Monke, Director, Botanical Garden and Museum, Berlin-Dahlem, Germany:

Dr. Herman Harms, Prof. at the Akademie der Wissenschaften, Berlin, born Sept. 16, 1870; died Nov. 27, 1942.

Dr. Ferdinand Pax, Prof. of Botany, University at Breslau, born Jan. 26, 1853; died Mar. 1, 1942.

Dr. Mez, Prof. of Botany, Univ. at Koenigsberg, born Mar. 24, 1866; died Jan. 15, 1944.

Miss Kaethe Hoffmann, Instructor at Breslau, later at Berlin. Date of birth not known; died Dec. 30, 1960. (Co-author with Dr. Pax of the Amaryllidaceae in Engler & Prantl, Nat. Pflanzenfam. 1930.)

Mr. Barry W. Clark, 2455 Benefit St., New Orleans 22, La., writes that he is collecting *Amaryllis* species, but he has difficulty in obtaining some of those now under cultivation. He will exchange when his stock permits.

The writer enjoyed a visit by Mr. Burr Clouette, 202 Toro Ave., Salinas, Calif., on Oct. 18, 1961. Mr. Clouette is an enthusiastic amaryllidarian.

Mr. Gerald E. De Vries, 117 E. Bolton St., P. O. Box 225, Savannah, Georgia, visited with the writer on November 10, 1961. Mr. De Vries is an Amaryllis enthusiast, and is interested in helping to organize Amaryllis Clubs. His visit was most enjoyable.

We are saddened to report that A. Percy-Lancaster, of Salisbury, Southern Rhodesia, passed away Sept. 28, 1961. He was the son of Sydney Percy-Lancaster, F. L. S., and was working on the Gloriosa Breeding Project (see pp. 158—162, 1961 PLANT LIFE) with his father.

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RHODODENDRONS AND AZALEAS, by C. G. Bowers. 2nd edition. Macmillan Co., 60 5th Av., New York 11, N. Y. 1960. Illus. pp. 525. $25.00. This second edition of Bowers' classic volume on the "origins, cultivation and development" of Rhododendrons and Azaleas will be generally welcomed. The text has been brought up-to-date. The original 26 color plates and 83 other illustrations have been retained and 2 new color plates have been added. New information on nutrition, physiology and propagation has been added. The subject is presented in a charming literary style, and the book represents a vast mine of information for scholars and technicians and also for the practical gardener and landscape architect. Very highly recommended.

ESSENTIALS OF EARTH HISTORY, by W. L. Stokes. Prentice-Hall, Englewood Cliffs, N. J. 1960. Illus. pp. 502. $8.75. This book is designed (1) to acquaint the reader with the aims, methods and materials of the subject; (2) to present in outline form the essentials of the earth's history, and (3) to point out some of the most significant and meaningful inferences and generalizations that can be drawn from the subject. This attractive, well-written and profusely illustrated introduction to historical geology is highly recommended to the student and general reader. Highly recommended.

THE LIFE OF THE GREEN PLANT, by A. W. Galston. Prentice-Hall, Englewood Cliffs, N. J. 1961. Illus. pp. 116. Paperbound, $1.50; clothbound, $2.95. In this book the life of the green plant is detailed in five sections—the green plant in the economy of nature, the green plant cell, plant nutrition, plant growth, and differentiation and morphogenesis. This well-written and well-illustrated text is highly recommended.

ADAPTATION, by B. Wallace and A. M. Srb. Prentice-Hall, Englewood Cliffs, N. J. 1961. Illus. pp. 113. Paperbound, $1.50; clothbound, $2.95. The objective of this book is to explain how adaptation occurs. The subject is presented in sections —the basis of adaptation, heredity, genetic variation in populations, simple adaptations, more complex adaptations, similarities and dissimilarities between species, mutual adaptations of living things, modification of reproductive behavior, individual adaptations, and the limitation of adaptation. This stimulating text is highly recommended.

HEREDITY, by D. M. Bonner. Prentice-Hall, Englewood Cliffs, N. J. 1961. Illus. pp. 112. Paperbound, $1.50; clothbound, $2.95. The discussion of heredity in this volume is centered around the gene. The subject is presented in sections—the material basis of heredity, the genetic material, genes and biochemical reactions, genes and enzymes, genes in action, the molecular structure of a gene, genetic mechanisms, genes and man, genes and development and heredity and Hiroshima. This stimulating book is highly recommended.

PLANT LIFE, by L. J. and Margery Milne. Prentice-Hall, Englewood Cliffs, N. J. 1959. Illus. pp. 283. $6.75. This stimulating text emphasizes the dynamic aspects of plant science. The authors present a concise, comprehensive discussion of all phases of the subject. The book is profusely illustrated.

SYNTHESIS OF MOLECULAR AND CELLULAR STRUCTURE, edited by Dorothea Rudnick. Ronald Press Co., 15 E. 26th St., New York 10, N. Y. 1961. Illus. pp. 252. $9.00. Nine authorities have contributed to the eight studies included in this volume. The subjects include the physiochemical behavior of nucleic acids; the possibilities of adaptive control of enzyme activity in higher animals; the cell wall in relation to protoplasmic chemistry in plant root tips; the analysis of induction, orgin of competence, and differentiation of cartilage and muscle; the chemical and ultrastructural development of the basement lamella; induced differentiation of tissue within animal organ culture; control of growth and differentiation in plant tissue cultures, and the influence of endocrine and other physiological factors on regeneration in larval Amphibia. Highly recommended.

MOSSES, FERNS, CONIFERS, HORSETAILS, LYCOPODS—PHYLOGENY, by Olaf Hagerup and Vagen Petersson. Ejnar Munksgaard. Copenhagen, Denmark. 1960. Illus. pp. 299. Dan. Kr. 76. This is Volume II of "A Botanical Atlas", and includes excellent drawings of about half of the Danish mosses and liverworts, and all of the Danish ferns, locopods, horsetails and conifers. Besides the adequate text accompanying the drawings, there is a discussion of the phylogeny of plants from algae through angiosperms, including the origin of the seed. The text is in Danish and English (translated by H. Gilbert-Carter). The numerous drawings are outstanding. This volume is indispensable to all who are interested in plants, and it cannot be too highly recommended.

GERM PLASM RESOURCES, edited by R. E. Hodgson. A. A. A. S., 1515 Mass. Av., N. W., Washington 5, D. C. 1961. Illus. pp. 394. $8.50. This symposium of 1959 was planned as a nationwide survey of plant and animal germ plasm to follow up the 1934-35 survey in the "Yearbook of Agriculture". Thirty-three authorities participated in the symposium. The papers are arranged under five headings: origin of germ plasm, need for the utilization of additional sources of germ plasm; developmental programs in crops and livestock; new approaches in the use of plant and animal germ plasm; and perpetuation and protection of breeding stocks. This outstanding book is highly recommended to all who are interested in plant and animal breeding.

FLOWERING PLANTS AND FERNS OF THE TEXAS COASTAL BEND COUNTIES, by F. B. Jones, C. M. Rowell, Jr., and M. C. Johnston. Rob and Bessie Wilder Wildlife Foundation. P. O. Box 1396, Sinton, Texas. 1961. pp. 165. $2.35. This is a list of the more than 1,300 species of higher plants that have been collected in the Coastal Bend Counties of Texas. The data is arranged by families, genera and species. This is followed by an alphabetical index. Recommended to all who are interested in the Texas flora.

PLANT MARVELS IN MINIATURE, by C. Postma. John Day Co., 210 Madison Av., New York 16, N. Y. 1961. Illus. pp. 173. $12.50. In this fascinating study the author presents by means of photographs and a simple explanatory text some of the wonderful beauty and complexity of the plant world. At the

[PLANT LIFE LIBRARY, continued on page 27.]

1. REGIONAL ACTIVITY AND EXHIBITIONS

OFFICIAL NEW ORLEANS AMARYLLIS SHOW 1961

MRS. JOHN KLEIN, JR. *Chairman*

The 13th Official Amaryllis Show at New Orleans with the theme "Rhythm Of The Seasons," sponsored by the Garden Circle affiliated with the American Amaryllis Society, The Federated Council of the New Orleans Garden Clubs and the Louisiana State Federation of Garden Clubs, was held March 25th and 26th, 1961 at Eleanor McMain School. Fifty Six Garden Clubs participated in the Artistic Arrangements and Corsage Divisions.

Mrs. John Klein, Jr. was Show Chairman, Vice Chairmen, Mrs. W. J. Perrin and Mrs. Lynn Messina, Honorary Chairman, Mrs. A. R. Oddo.

The arrangements were judged by six accredited judges and the horticulture entries were judged by nine Official Amaryllis Judges.

Mrs. G. R. Reynolds of Westgate Garden Club received the Silver Tray for the most outstanding arrangement titled "Natures Heirloom". Mrs. E. A. St. John of Metairie Garden Guild also received a Silver Tray, an Award of Distinction, titled "Twilight". Miss Dottie Dittman of Lil Mums Junior Garden Club won the Gold Cup in the Junior Arrangement Division titled "Easter Finery". Mrs. Ecuyer won the Blue Ribbon in the Formal Corsage Division for the second year, titled "On Fifth Avenue". Mrs. J. E. Vinci was awarded the Blue Ribbon for the Informal Corsage titled "Bon Voyage".

Mr. Norman Rusakof won the Ludwig Challenge Cup for the best Ludwig Specimen "Wyndham Hayward". He also won the Rueters Trophy for the most outstanding specimen of the Show "Wyndham Hayward". Mrs. W. R. Latapie was runner up with second best specimen "White Favorite". Mr. Milo C. Virgin won the Klein Award Silver Ice Bucket as sweepstake winner of the Dutch entries in the Show with 10 Blue Ribbons.

The Garden Circle won the Club Ribbon for the most Blue Ribbons. Mrs. Harry St. John won the Harry St. John Memorial Challenge Cup for the most outstanding registered American Hybrid "Harry St. John" (St. John, 1957). Mr. Milo C. Virgin won the Sweepstake Gold Trophy for the most Blue Ribbons in the American Horticulture. McDonogh No. 7 won the Trophy for the most Blue Ribbons in the School Division.

There were six Invitational Arrangements displayed on pedestals, by noncompetitive Guest Artists who were Mrs. W. E. Fourqueran "Palm Sunday". Mrs. Harry W. Brown, "My Rosary". Mrs. A. L. Herberger "Prayer For Peace." Mrs. Charles Hardie, "Ave Maria." Mrs. Clyde G. Welles "Easter Parade," Mrs. A. G. Viskel, "St. Francis And The Birds".

The following Amaryllis Society Awards were made, "White Favorite" 558 (Ludwig) exhibited by Mrs. W. R. Latapie, "Wyndham Hayward'' 462 (Ludwig) exhibited by Mr. Norman Ruskof. ''General Eisenhower'' 657 (VanWaveren) exhibited by Mr. Milo C. Virgin. ''Nivalis'' 448 (Ludwig) exhibited by Mrs. A. J. Haydel. ''Apple Blossom'' 422 (Ludwig) exhibited by Mrs. C. A. Diebold Jr. and ''Cardinal'' 464 (Ludwig) exhibited by Mrs. W. J. Perrin.

The Preliminary Commendation (P. C.) awards were made, ''American Seedling'' Mrs. Rodney Baker. ''American Seedling'' Mr. Milo C. Virgin. ''Harry St. John'' registered 391 (St. John 1957) by Mrs. Harry St. John; and ''American Seedling'' by McDonogh No. 7 School.

There were 210 entries in Horticulture, and over 900 attended the show including a number of visitors from out of State such as Alabama, Mississippi, Texas and Oklahoma.

The 13th Official Amaryllis Show of New Orleans was displayed by Divisions 1 to 9 as per Revised Show Schedule for Official Amaryllis Shows in 1961 Amaryllis Year Book.

Mr. Milo C. Virgin was awarded a Special Trophy for the 2 Floret per scape displayed in a group of 3.

Miss Lynn Latapie and Miss Sharon Jacobs were registrars.

OFFICIAL HOUSTON AMARYLLIS SHOW 1961

Mrs. A. C. Pickard

The Houston Amaryllis Society's second official show was held April 16, 1961, at the River Oaks Forum of Civics, Houston, Texas. The members responded enthusiastically with several hundred specimens in fair condition even though the show date was postponed one week. Many of the nice specimens were spent and those grown in the garden suffered heavy wind and rain damage just as the blooms were showing color.

There is a great fund of experience among amateur competitors working toward some worthwhile achievement serving the purpose of informing the public in the manner of careful classification and standardized exhibitions. All the exhibits were classified in the respective 8 Divisions and judged by local official accredited Amaryllis judges. The floral treat was presented free to hundreds of visitors, many registered from other states.

After the show, visitors toured the Amaryllis gardens of some of the members. In one garden hundreds of named Dutch hybrids were growing and seedlings blooming, all developed by the member growers over a period of a few years.

Through the cooperation of local firms, Houston Judging Council, Holland hybridizers, and a member of the Houston Amaryllis Society, five silver trophies were awarded for outstanding entries. Also, the American Amaryllis Society's ''Award of Merit''. These trophies and trophy winning specimens were exhibited on a special table the ''Court of Honor''.

Competition was close for the highest score. The Silver Trophy has to be won two consecutive years or three times at intervals to be kept permanently by the exhibitor. This beautiful trophy was awarded this time to Mrs. Sally Fox for the handsome Van Meeuween registered clone 'Zenith'. She also received the official American Amaryllis Award of Merit and a named clone of the Van Meeuween strain.

Mrs. Creel Brockman of West Columbia, Texas was awarded the Ludwig Challenge Cup, the American Amaryllis award of Merit, plus two bulbs of Ludwig strain under number for her potted specimen, 'Marie Goretti'.

Mrs. Jesse Haver won the Frank Lipper Trophy and the American Amaryllis Award of Merit for an unnamed American specimen.

Mrs. Chas. Pease won the Silver Trophy of the Houston Judging Council and the American Amaryllis Award of Merit for a miniature Amaryllis, Ludwig's 'Fire Fly'.

For the best entry for a Dutch seedling in the hybridizer class, Mrs. A. C. Pickard won the Becker Jewelry Co. Silver Trophy, also the preliminary commendation from the American Amaryllis Society.

Mrs. Marguerite Palmer received the Award of Merit in the invitational class for the clone 'Boquet'.

Other special awards were given to invitation exhibits (non competitive). Collections of a minimum of 5 were exhibited, including named clones and collections of seedlings with many new interesting colors from the rich dark black red, the delicately tinted pinks and salmons to the purest whites.

Mrs. Frank S. Bova and Mrs. W. D. Wells scored the winners in the collection classes.

The educational division included all stages of growth from seeds to the mature blooming clone as well as the different methods of vegetative propagation, cuttage, reaming and scoring the bulbs with potted results.

The Artistic division (the theme) "Parade of Amaryllis" featuring Amaryllis as the dominating flower was non-competitive, adding much beauty to the show. As an added attraction were poodle trees made of Amaryllis blooms with other foliage.

The show was spectacular with evidence that the Houston Amaryllis Society is achieving its objective—to promote and create a greater knowledge of growing Amaryllis.

OFFICIAL HATTIESBURG AMARYLLIS SHOW 1961

Mrs. R. A. Fowler, *President*
Hattiesburg Amaryllis Society

The Second Official Hattiesburg, Mississippi, Amaryllis Show under the sponsorship of the Hattiesburg Amaryllis Society and the American Amaryllis Society was held April 22-23, 1961 at the Community Center. "International Inspiration" was the theme of the show.

The nine sterling silver goblets were displayed on a circular organdy and lace-covered table in the center of the lounge. Above the table and supported by an ivy-entwined wrought iron trellis was a revolving globe, symbol of the internationality of the show. The silver awards were won by the following:

Most blue ribbons—Mrs. Johnnie Jackson, Hattiesburg, Miss. Best potted Dutch Amaryllis—Mr. James Terry, Hattiesburg, Miss. Horticultural Sweepstakes—Mrs. Johnnie Jackson, Hattiesburg, Miss. Best potted American Amaryllis--Mrs. J. W. Snowden, Hattiesburg, Miss. Best Artistic Design—Mrs. J. O. Mayo, Hattiesburg, Miss. Best cut American Amaryllis—Mrs. Johnnie Jackson, Hattiesburg, Miss. Outstanding entry in Art Class—Mrs. R. L. Ford, Hattiesburg, Miss. Finest Cut specimen, Dutch—Mrs. J. C. Shivers, Poplarville, Miss. Best out of town potted Dutch—Capt. T. J. Pizani, New Orleans, La.

Robert D. Goedert, Amaryllis dealer of Jacksonville, Florida provided the door prizes which were outstanding Indian Hybrid Amaryllis bulbs.

Mr. W. D. Morton, Jr., New Orleans, La. Registrar and Secretary of Judges Council started proceeding for registering an outstanding seedling grown by Mr. James Terry, Hattiesburg, Miss. Name of the clone will be announced later.

The educational exhibit showed methods of propagating Amaryllis from seed and through cuttage. The display showed various stages of the development of bulbs produced by both methods as well as suitable containers, method of potting and soil.

The show attracted several hundred visitors from sixteen cities and six states.

A popular vote of those in attendance listed 'Apple Blossom' as the favorite variety.

OFFICIAL GREATER GULF AMARYLLIS SHOW 1961

W. C. Strain, *Chairman*

The Ninth Annual Greater Gulf Amaryllis Show presented by the Amaryllis Society of Mobile was held April 15 and 16, 1961 at Murphy High School, Mobile, Alabama.

W. C. Strain was Show Chairman and W. R. Lowe and H. E. McCarn were Co-Chairmen.

The Arrangements were judged by accredited Judges and the Horticulture entries were judged by official Amaryllis Judges. The show was attended by approximately 2,500 and was open to all amaryllis growers in the area.

The theme "Come, Stroll with the Amaryllis" was carried out by a statue of Venus as a focal point surrounded by dozens of beautiful amaryllis. There were nine divisions providing for entries in horticulture, arrangements, junior entries, hobby and art. The seedling division in which forty four entries were shown was of unusual interest.

A total of 337 entries were registered in the show.

Mrs. Gertrude Marshall was the winner of the most blue ribbons including Horticultural and artistic arrangements and was awarded a

Sterling Silver Paul Revere Bowl. Mrs. Marshall also won the trophy for the most blue ribbons in the horticultural division.

Mrs. W. P. Cazalas was awarded the trophy for the most blue ribbons in the artistic arrangement division and also the trophy for the most outstanding artistic arrangement of Amaryllis. The most outstanding horticultural potted bulb specimen of Dutch Amaryllis was won by W. C. Strain. Mrs. Hinton Davis was awarded the trophy for the most outstanding horticultural potted specimen of American Hybrid Amaryllis.

Ivan A. Owen won the award for the most outstanding horticultural cut specimen of Dutch amaryllis in the show. The most outstanding horticultural cut specimen of American hybrid Amaryllis was won by Joe Brummitt.

The Invitational trophy awarded for the Blue Ribbon Winner in the Invitational Class was won by Mrs. G. E. Moslander.

The best painting of Amaryllis in the adult division was won by Mrs. Vernica Lassiter and Leon Bridges won the Junior Art award for the best painting of amaryllis.

The Amaryllis Society of Mobile's Junior Trophy was won by Miss Darby Hickson.

OFFICIAL MEN'S AMARYLLIS SHOW, NEW ORLEANS 1961

SANTO N. CUCHINOTTO, *Show Chairman*

The Second Official All-Horticulture Amaryllis Show presented by the Men's Amaryllis Club of New Orleans was held on Saturday and Sunday April 15th and 16th, 1961 at the Wm. C. C. Claiborne School.

Competition was open to the general public except for one class of single blooms restricted to members of the sponsoring club. The show was free and open to the public who viewed a fine array of blooms of many colors. This organization, which has set a goal of having everyone grow and admire amaryllis in their garden, received many compliments on a fine show.

Miss Marian A. Laine, Award of Merit winner in the Dutch hybrid class received the Steckler Seed Co. Award; Mrs. H. E. Dorr, Award of Merit winner in the American hybrid class received the Newsham-Becnel Nursery Award; Mr. T. A. Calamari, Jr., Sweepstakes winner received the Reuter Seed Co. Award for most blue ribbons in the Dutch class; Mr. Lewis Lloyd was the winner of the gold cup for the outstanding seedling; Mr. Toby 'Mullen was the winner of the most blue ribbons in the American hybrid class; Mr. Milo C. Virgin was the recipient of the President's Trophy, and the most blue ribbons won by a member of the Men's Amaryllis Club; Mr. Lewis Lloyd was the winner of the single bloom award. All of these winners received gold cups and ribbons which are permanent awards. The usual ribbons were awarded other winners that participated in the show.

American Amaryllis Society Awards of Merit were presented to Messrs. W. J. Perrin, Henry P. Fontcuberta, Marshall T. Maynard, John Klein, Jr., B. J. Banker, and Miss Marian A. Laine. Messrs. S. P. Gaspereczand and F. C. Hermann were awarded American Amaryllis Society Preliminary Commendation Awards.

The show was under the direction of Mr. Santo N. Cuchinotto, Show Chairman; Mr. J. Mahan, Co-Chairman; and Mr. H. P. Fontcuberta, Club President.

Fig. 2. 1961 Official Valdosta Amaryllis Show—(right) Dr. W. E. Wynens, Chairman of the Show; (left) Mr. Guy Rice, President, Men's Garden Club of Valdosta, Georgia.

OFFICIAL VALDOSTA AMARYLLIS SHOW 1961

Guy Rice, *President, Men's Garden Club of Valdosta, Georgia*

The Men's Garden Club of Valdosta staged their Fifth Amaryllis Show on April 22nd and 23rd 1961. This is the Third show staged under the sponsorship of The American Amaryllis Society, and The Garden Club of Georgia. [Fig. 2].

Top awards were won in the Horticultural Division as follows: Mrs. B. J. Wetherington won the Award of Merit from THE AMERICAN AMARYLLIS SOCIETY for the best named clone 'Picotee'. This also won the Award of Merit from The Garden Club of Georgia.

Mrs. Willis Register won a Preliminary Commendation Certificate from THE AMERICAN AMARYLLIS SOCIETY, for the best entry, from The Hybridizer's Class, grown in a pot. Mr. Guy Rice won a Preliminary Commendation Certificate from THE AMERICAN AMARYLLIS SOCIETY, for the best cut scape in the Hybridizer's Class.

Mrs. Plowden won a Preliminary Commendation Certificate from THE AMERICAN AMARYLLIS SOCIETY, for the best Horticultural entry in the show, for an unnamed variety grown in a pot. Mrs. Richard Parrish won a Preliminary Commendation Certificate from THE AMERICAN AMARYLLIS SOCIETY, for the best unnamed variety on a cut scape.

Mrs. Van Bennett won the Tri-Color Award given by THE GARDEN CLUB OF GEORGIA for the best artistic entry in the show. Mr. Robert Goedert, of Jacksonville, Florida was given an Award of Appreciation for an outstanding Exhibit of species. Mr. Goedert included in this display a magnificent collection of the newest named varieties.

The increasing interest in growing amaryllis, in the Valdosta area was evident in the superb quality of the specimens exhibited in the show.

CORPUS CHRISTI AMARYLLIS SHOW 1961

MRS. CARL C. HENNY, *Secretary,*
Coastal Bend Amaryllis Society, Corpus Christi, Texas

The Coastal Bend Amaryllis Society again staged an Amaryllis Show in connection with the Lola Forrester Flower Show, April 15th and 16th, 1961.

A total of 118 cut Amaryllis scapes were entered by members of the Coastal Bend Amaryllis Society and other residents of Corpus Christi, Texas. All of these were garden grown—some of Dutch parentage, some of the Ludwig Dutch hybrids, and others of American hybrid parentage.

A total of 20 Ludwig Hybrid Amaryllis were entered as potted plants. One of these, 'Wyndham Hayward' entered by Mr. Charles W. Sanders, received the Corpus Christi Council of Garden Club "Award of Merit" for its excellence—having scored 95 points. This bulb produced two scapes of even length—each with 5 florets, and all blooming at the same time.

Mr. Leo Riley received the largest number of blue ribbons (5) for his entries and he received the Ludwig Challenge Cup. His entries were 'Nivalis', 'La Forest Morton', a Dutch Gracilis clone, and two American seedlings.

The Coastal Bend Amaryllis Society Show at the Lola Forrester Flower Show was an outstanding one, and of great interest to the general public.

ANNUAL REPORT—AMARYLLIS FORUM OF MOBILE (ALABAMA) 1960-61

ROBERT E. PARKER, JR.

The Amaryllis Forum of Mobile believes that a diversified program of study and activities is vital to develop a strong and informed membership. In the 1960-61 year—its third year of full activity—apart from the usual concerns of such an organization, the Forum, in fulfillment of this aim, has added some new features and strengthened others. The membership increase during the year of approximately twenty-five percent is evidence of the strength of the program.

The high point of the year was the first competitive amaryllis show sponsored by the Forum. It was based on the theme ''Spring With Amaryllis''. Held on April 22-23, 1961 at the Kate Shepherd Elementary School in Mobile, almost 250 entries were received in the competitive divisions.

A profusion of blooms was also furnished to decorate the stage and other public areas. There were a number of non-competitive hobby tables prepared by the members which dramatized to the spectators the extent of amaryllis culture, both in colors and sizes, in which a hobbyist can participate.

Classifications in the four divisions, with eight sections, included both Dutch and American amaryllis by names and colors, with separate divisions for each, including the cut and potted specimens.

Arrangements were also featured with a number of imaginative entries. A strong effort was made to stress the possibilities of making arrangements featuring amaryllis to further popularize them for this purpose since many persons minimize their use for arrangements.

All judging was by accredited judges and competition was open. The show chairmen were I. A. Owen and W. O. Cobb.

The best horticultural specimen was ''Silver Lining'' exhibited by Mrs. R. E. Chason. The most outstanding artistic arrangement was entered by Mrs. D. F. Ward. It was a dramatic arrangement entitled ''On Mobile Bay'' which used amaryllis and driftwood in harmony.

The membership pledge of the Amaryllis Forum includes, among other things, the statement ''. . . that I will hold no secrets of culture, but will share what knowledge I possess with all members.'' In the spirit of this pledge, regular tours of members' gardens were initiated on Sunday afternoons throughout the spring and summer.

In an informal atmosphere, both the purposes of fellowship and study were accomplished. Acting on the premise that an amaryllis enthusiast likes nothing better than to talk about amaryllis, the tours give the members a full opportunity to discuss various procedures and practices ''on the spot''. The general exchange of ideas has benefitted all the members. They have also been able to give attention to other amaryllids and the use of all in landscaping.

Due to the very favorable growing conditions during this spring and summer in the Mobile area, members have been able to view the propagation and growth of the plants under good conditions. Special study has been made of the effects and growth patterns produced by various feeding programs of the members—ranging from liquid to organic to commercial fertilizer. The effects of various insecticides and fungicides has also been observed first hand.

As will have been understood from the foregoing, the Forum did not recess during the summer months. The programs at the monthly meetings have been devoted to serious study sessions, including on one occasion the study of the generic order of plants, particularly as related to the Family Amaryllidaceae.

Other activities of the year included the placing of a display, which received special recognition, in the Federated Garden Clubs of Mobile County Spring Flower Show.

Special study projects were also undertaken by individual members on which a report will be given at a later date. Included in the tests and experiments are various procedures for forcing blooms, propagating by seeds, problems of bulb deterioration, etc. When some positive conclusions have been established, the Amaryllis Forum hopes to institute a program of the exchange of cultural information with other groups.

The retiring officers of the Amaryllis Forum for the 1960-61 year are J. W. Van Esler, President; W. O. Cobb, Vice-President; Mrs. Ellen Boe, Secretary; and Ennis Brown, Treasurer.

AMARYLLIS PARADE

MRS. A. C. PICKARD, *Houston, Texas*

Offiicial Amaryllis Judging Instructor

Plant Societies, like individuals, undergo constant change. Whether that change is for better or for worse depends on the attitude and action of the individuals that comprise the group.

While we are learning to grow more and better clones of Amaryllis, it is just as essential not only to our own happiness, but to the welfare of our Societies, that each member make a special effort to overcome any tendency toward intolerance. Membership in any organization involves duties as well as privileges. "That's Democracy!" Kindness is an indispensable ingredient here. If we strive to be understanding and rise above resentments, an important step will have been taken toward a goal not only for ourselves, but for the welfare of the organization. We are affiliated with a National Society whose objectives deserve our interest and support to attain greater excellence.

WHY FLOWER SHOWS?

The purpose of any flower show is, in general, to promote interest in the art of gardening. On a more personal basis, flower shows are an incentive to the serious-minded gardener to produce and exhibit flowers better than those grown by his neighbor members.

The primary purpose of such friendly rivalry is to stimulate interest in beautiful flowers, well planned gardens, exchange information on new varieties and methods of culture.

The first rule when competing for high scores in a show is to make sure that the entry meets all the requirements outlined in the schedule.

The schedule committee is the most important, for the schedule can make or break a show. Planning a schedule requires considerable thought and study. Explanation of terms used in the schedule are necessary for proper interpretation. Suggestions to exhibitors might include methods of preparing the entries on the show date that will aid considerably in easing that dreaded rush hour. It is necessary that show rules be set to conform with the revised show schedule for official Amaryllis shows that has been officially adopted by the American Amaryllis Society.

The official schedule has not only improved the categories of classification, but has established a sensible and effective table of awards of merit to be given only for registered Amaryllis clones.

Few blue ribbons and awards are won in official Amaryllis shows by those exhibitors who look their plants over the day before the show and decide they might as well enter cut scapes by the dozen, and looking the garden over, taking lightly the appearance of the flower rush to pot up a few bulbs.

Really successful exhibiting demands early preparation, and the response to bloom is usually not as uniform as anticipated. By good selection, careful handling, and following a systematic procedure, one can make exhibiting the fun and thrill it should be. By so doing, one will have acquired a greater appreciation of what it takes to make specimen blooms score high.

But, after you have done your best to win the highest score, and lose—above all, be a good sport as all gardeners should be. If you console yourself in the conclusion that the winning specimen had to be exceptionally good to beat yours, try a little bit harder to win the next time. Make competition fun! Don't take the joy out of the show. Be fussy about the small points in your exhibits, and each succeeding show will bring you blue ribbons that get bluer and trophies that grow in number.

TO REGISTER OR NOT TO REGISTER CLONAL NAMES?

One of the chief purposes of specialized plant societies is to prevent confusion and errors in clonal names and to keep hybrids true to name. Awards to registered named clones are given to stimulate competition, thus encouraging continued improvement in standards of judging.

To encourage breeders, preliminary commendations may be awarded to seedlings. Once a seeding has proved worthy of recognition, the next step is registration.

An Amaryllis clone worth growing is worth knowing. A name identifies a plant as it does a person—a good clone deserves a good name.

Not all clones registered are introduced, for many are kept in the garden for the personal gratification of the gardener.

The American Amaryllis Society sponsors registration. The information is available from the Registrar.

WHY HAVE JUDGING SCHOOLS?

Schools are the best way to bring to all members the same knowledge in a condensed form. Not solely to train Judges, but to teach how to improve their flower shows by better staging, better exhibiting, better growing methods. All these factors are involved. Also, some of the human qualities in being a good Judge and a better exhibitor.

Judging is not just a business of awarding ribbons. Behind the awards there should be a well rounded knowledge of species, varieties, forms, types, and above all, the attributes of quality and perfection.

The best preparation for judging is growing the material. You will know their characteristics and by the same token appreciate perfection.

The writer does not set herself up as a supreme authority. She has undertaken her task as an Amaryllis Instructor in Judging with genuine humility and has much to learn, having enjoyed a wide experience in the study of growing and Judging Amaryllis for many years. Especially pleased will she be if the efforts put forth will guide and lead Amaryllis Judges into habits of thought and procedure which will result in greater satisfaction to them, to exhibitors and the general public.

JUDGES COUNCIL

When Judges began working in shows, they soon found problems and lack of knowledge and uniformity in Judging Amaryllis. All Judges will realize that they are in need of constant study and review to increase and improve their knowledge and experience of the American Amaryllis Society rules and scoring procedure.

The primary purpose of organizing the Amaryllis Judges Council was a form a unit for advanced study, practice Judging, and point scoring. By discussion in these fields, Judges find meeting often, a convenient help in solving problems which arise from poor show practice, and achieve greater uniformity in the standards, with more understanding and friendliness—and less criticism—between Judges. So, we summarize briefly better ethics between Judges:

> ''A chain is only as strong as its weakest link'' and every Amaryllis Judge should endeavor to be a strong link in the Society.

AMARYLLIS JUDGES CERTIFICATES

Since the last report in the 1961 Amaryllis Year Book (page 31), the following named Amaryllis Judge's Certificates have been issued by the American Amaryllis Society.

5a. (Reissued after a refresher course) Mrs. Wilday Tudury, 155 Homestead Ave., Metairie, La.
7a. (Reissued after a refresher course) Mrs. E. F. Lehmann, 2201 Paris Road, Chalmette, La.
95. Mrs. Jesse Haver, 113 Christianson, Houston 3, Tex. (horticulture only)
96. Mrs. Geo. S. Taylor, Box 62, League City, Texas. (Horticulture only)
97 Mrs. Richard Anderson, 2012 Melody Drive, La Marque, Tex.
98. Mrs. John Klein, Jr., 2504 Mistletoe St., New Orleans 18, La.
99. Mrs. G. J. Durbin, 6303 General Meyer St., New Orleans 14, La.
100. Mrs. R. J. Huxen, 553 Crystal St., New Orleans 24, La.
101. Mr. C. J. Crochet, Route 1, Box 18, Prairieville, La.
102. Mrs. C. J. Crochet, Route 1, Box 18, Prairieville, La.

For information on The National Judges Council see page 163.

[AMARYLLIS ROUND ROBIN NOTES, Mrs. Fred Flick, continued from page 154]

Corpus Cristi plants her seed in beds that were made over an old shell driveway, and has bloom in 18 months.

Mrs. Dusek,—Soil mix: one part compost; one part good garden loam; one part sharp sand. To each bushel, add one four inch pot of a balanced fertilizer.

Bernice Curfman, Ga.—Soil mix: I use a sandy soil with some vermiculite mixed in, then add a teaspoonful of bone meal and one of sheep manure mixed in the bottom of the pot.

Mrs. Bush, N. J.—Soil mix: Sandy loam mixed with peat moss, and I add some bone meal and dried manure.

Ella McCullock, Ontario, Canada,—Soil mix: Woods soil; sand; garden loam; bone meal; dried cow manure; and a teaspoonful of muriate of potash in each pot.

Len Woelfle, Ohio. [Mr. Woelfle is hybridizing *Hymenocallis* and writes of one of his crosses.]—"Pax is a cross of *H. amancaes* x *H. narcissiflora;* and it has a very good obconical cup, with flaring lobes, opens from yellow buds to creamy white, then fades to almost white with yellow shadings. It is easy and durable for me, and reports are that it makes a tremendous bulb and plant. In mid summer, from a spring set large bulb, it will grow to about 36 inches tall with wide 3 to 3½ inch leaves. It carries up to eight blooms on a scape."

Madge Tebben, Illinois.—"I have placed the most of my amaryllis outside where they receive filtered sunshine. Part have been placed on the south side where they get more sun. Will see which give more blooms during the winter. Before putting the bulbs outside, I was giving weekly feedings of muriate of potash, and superphosphate alternately."

[PLANT LIFE LIBRARY, continued from page 14.]

beginning of each chapter there is a slightly enlarged photograph of the various parts of the plant in their familiar form, and additional photographs then show increasing magnification until, at 2000 to 3300 times, complex and beautiful structures are revealed. The plates are grouped under (1) structure of the plant; (2) grasses; (3) flower; (4) spread of the seed; (5) leaf; (6) hairs on the plant; (7) the stalk; (8) wood; (9) roots; and (10) parasites. This book is so outstanding that it is highly recommended to the layman gardener and the scientist alike.

READINGS IN THE HISTORY OF AMERICAN AGRICULTURE, edited by W. D. Rasmussen. Univ. of Illinois Press, Urbana. 1960. Illus. pp. 351. $6.50. The fascinating course of American Agriculture is traced in this illustrated volume of fifty-two selections highlighting the important landmarks in American agricultural history. The material is arranged under the headings—beginnings of American agriculture, 1607-1775; agriculture during the confederation, 1776-1789; gradual improvements in American agriculture, 1789-1861; the first American agricultural revolution, 1861-1914; World War I stimulates demand for farm products, 1914-1919; return to normalcy and agricultural depression, 1920-1932; the New Deal, 1933-1939; and World War II and the second agricultural revolution. This outstanding book is highly recommended to the student and also to all who are interested in the history of our country.

PLANT PATENTS, 1960 SUPPL., publ. by American Association of Nurserymen, 635 Southern Bldg., Washington 5, D. C. pp. 6. This supplement includes patents 1893 through 2007. These are listed under patent number; date granted; common name; originator or discoverer; and assigned to. For easy reference the patents are then listed alphabetically under common names; and also the names and addresses of originators or discoverers and assignees. Highly recommended to all interested in plant patents.

THE NEW PERENNIALS PREFERRED, by Helen Van Pelt Wilson. M. Barrows & Co., 425 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 320. $4.95. This revised edition of the author's "Perennials for Every Garden" incorporates new advances. In addition to the enlarged treatment of the subjects treated in previous editions, there are three new chapters—on shade gardening; on ferns; and on gardening for the "near view" by doorsteps and in door yards.

THE BEGINNING GARDENER, by Katherine N. Cutler, M. Barrows & Co., 425 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 173. $2.95. This new book was written for all beginning gardeners—young and old. It provides information on choosing the right spot and gives the "hows" and "whens" of planting; and also a list of vegetables and flowers.

THE FLOWER ARRANGEMENT CALENDAR, 1962, by Helen Van Pelt Wilson. M. Barrows & Co., 425 Park Av., So., New York 16, N. Y. 1961. $1.50. The publishers sponsor an annual flower arrangement calendar contest. In this little book some of the outstanding photographs of floral arrangements accepted by the publishers are reproduced in calendar form for 1962. This calendar will be useful to those interested in flower arranging.

MARK CATESBY, THE COLONIAL AUDUBON, by G. F. Frick and R. P. Stearns. Univ. of Illinois Press, Urbana. 1961. Illus. pp. 137. $5.00. The objective of this attractive book is to set forth from the original sources a biography of Mark Catesby (1683—1749); to evaluate his work as a naturalist, and to estimate his stature in the history of science. In Part I, a biography of Catesby is presented; and in Part II, Catesby's work as a naturalist is detailed. He was a pioneer in the field of scientific illustration; in botany, zoology, ichthyology, and especially ornithology, he explored new and untried fields, and for more than a century, his work—"The Natural History of Carolina, Florida and the Bahama Islands (1731—43 [1729—47])"—was the best single treatment of the flora and fauna of North America. This important book on Mark Catesby fills a long felt need and is highly recommended to all biologists, and all others who are interested in the history of our Country.

[PLANT LIFE LIBRARY, continued on page 54.]

Fig. 3. *Amaryllis* x *johnsonii* as grown by Douglas D. Craft, Chicago, Illinois. A, complete umbel in bloom; B, longi-section of flower, about 8/10 natural size; C, longi-section of ovary, showing inside of locules; ovules abortive (from a flower almost dried up). Drawings by Douglas D. Craft.

2. SPECIOLOGY

[EVOLUTION, DESCRIPTION, CLASSIFICATION AND PHYLOGENY]

AMARYLLIS x JOHNSONII

Douglas D. Craft

The writer remembers *Amaryllis* x *johnsonii* when as a young high school student he had seen tubs of this beautiful "Johnson Lily" brought to a neighbor's doorstep from dormancy over the winter in her farm cellar. Both or rather each of these tubs must have contained 15 to 20 bulbs per tub and they were indeed a beautiful sight to behold when in bloom. Remembering this from his adolescent boyhood, the writer sent a letter to the kind lady in the foothills of the Catskills. Though she had long since moved, she still treasured her "Johnson Lilies" and sent the author three blooming sized bulbs.

These bulbs were then potted up over their necks in a heavy, rich, garden loam as per the lady's specifications. Last year they bloomed mid-summer in the yard. After being kept dormant in the cellar this year, they were brought to light in a south window in late February. Immediately, buds began to show, two per bulb and the pot was a blaze of color about the first week in April [Fig. 3]. Leaves as well as three or four offsets appeared with the blooms.

Observations: This early hybrid likes heavy soil and seems to be a deciduous clone. In fact it grows much more heartily when it has had a long rest over winter. Flower stalks however appear to be somewhat weak and often must be staked. This may be partially due to its rapid growth cycle. Leaves are long and narrow and reach at least two feet in length. Flower scapes are also long and florets are small, very trumpet shaped as in some of the species. Margins of the flowers are serreated and waved giving them added distinction. This beauty is recommended for all ardent species lovers.

A NEW BOLIVIAN AMARYLLIS

Martin Cardenas, *Bolivia*

This new *Amaryllis* species is characterized by its small flowers with a very short tepaltube and its small seeds. It crosses with species of the subgenus Amaryllis. The size of the flowers are reminiscent of *Amaryllis blumenavia* of the subgenus Sealyana which however has petiolate leaves. It grows on sandy slopes among rocks in a dry (xerophytic) environment.

Amaryllis mollevillquensis Cardenas, **sp. nov.**

Geophyta 30—60 cm. alta. Radicibus paucis 8—10 cm. long. Bulbo ovoidea 4—7 cm. long., 3—7 cm. crasso, albo tunica exteriore brunea. Foliis in anthesi 3—5, loratus 20—40 cm. long., 2—3 cm. latis apice parce acutis, basim attenuatis. Scapo 30—60 cm. long., 5—20 mm. crasso, superne attenuato. Umbella 2—6-flora. Bracteis spathaceis 3—5 mm. long., 4—7 mm. latis, diluto bruneis. Pedicellis 1.5—3 cm. long., viridibus suprene bruneis, inferne albidibus. Ovario paulo trigono 8—10 mm. long..

Fig. 4. *Amaryllis mollevillquensis* Cardenas, *sp. nov.* Reproduction of a photo of the holotype specimen.

4—5 mm. crasso viride nitente. Tubo tepalorum 3—4 mm. long, viridiscente. Paraperigonio brevissimo albo hyalino. Setepalsegmentis lanceolatis 6 cm. long., superne 15 mm. latis, lateralia 13 mm. lata. Petepalsegmentis lanceolatis, superne 5.2 cm. long., 12 mm. late, inferne 8 mm. late. Omnibus segmentis rubi aurantiacus a basim viridiscentibus, interiora albo carinatis. Staminibus tubo adnatis 2.5—5 cm. long, superne curvatis. Filamenta superne rubi salmonea, inferne alba. Stylo 4—5 cm. long., inferne albo, superne rubi salmoneo. Stigma triloba vel paulo trifida. Capsula trilocularis 2—2.5 cm. diam., fusco albescentis. Semina atro brunea vel nigra, minuta, 10 mm. long. Patria: Bolivia, Provinsia Bilbao, Departamento Potosi, prope Mollevillque, 2,700—2,800 m. [Fig. 4]

Geophytic plants, 30—60 cm. tall. Roots few, 8—10 cm. long. *Bulb* ovoid 4—7 cm. long, 3—7 cm. in diam., covered by a gray-brown tunic. *Leaves* at anthesis 3—5. lorate, 20—40 cm. long, 1.5—3 cm. wide, tapering and attenuate at the base. *Scape* 30—60 cm. long, tapering upwards, 5—20 mm. in diam., dark green, purplish at the base. *Spathe* 3—5 cm. long, 4—7 mm. wide, light brown. *Umbel* 2—6-flowered. Pedicels 1.5—3 cm. long, 1.5—2.5 mm. in diam., green-whitish below, brown above. *Ovary* slightly trigonous, 8—10 mm. long, 4—5 mm. in diam., green, shining. *Tepaltube* only 3—4 mm. long, red-greenish. *Setepalsegs* lanceolate, 6 cm. long, upper one 15 mm. wide at the middle, laterals 13 mm. wide. *Petepalsegs* lanceolate, upper two 5.2 cm. long, 12 mm. wide, bottom one only 8 mm. wide. *Paraperigone* 1 mm. long, white hyaline. All of the tepalsegs orange red, greenish at the base, with a white stripe in center inside. *Stamens* adnate to the petepalsegs for the length of the tepaltube, three shorter, 2.5 cm. long, three longer 3 cm. long, all curved. *Filaments* white below, salmon red above, anthers 3 mm. long, pollen yellow. *Style* straight, 4—5 cm. long, white below, salmon red above. *Stigma* trilobed to shortly trifid, red-lilac. *Capsule* 2—2.5 cm. in diam., very light green to whitish when opening. *Seeds* rather small, dark brown to black, 10 mm. long. [Fig. 4].

Bolivia: Province Bilbao, Department Potosi, near Mollevillque, 2,700—2,800 m. M. Cardenas, February 1954, No. 5145 (holotype), in Herbarium Cardenasianum. (Cotypes in US, LIL and Cochabamba University Herbarium).

DARLING RIVER LILY, CRINUM FLACCIDUM

William Morris, *Australia*

Crinum flaccidum is one of the smallest species of the genus. It is fairly widespread in Austrailia having been recorded from Queensland, New South Wales, Victoria, South Australia, and Northern Territory. It is predominantly a plant of the inland waterways and is commonly known as the Darling River Lily. It has a bulb about the size of the Cape Belladonna, *Brunsvigia rosea*, and this bulb is not elongated into a neck as are so many other crinums. If the bulb is growing deeply in the soil, it develops a narrow deciduous pseudo-neck, but this is absent if the bulb is growing shallowly or just at the surface.

The flowers are described as white but some of those that I have seen are tinged pink which very occasionally is deep enough on the back of the tepalsegs to give a slight pinkish cast to the flower. The blooms are extremely variable in shape from small, narrow to larger broad tepalsegs. [Fig. 5] The small tepalsegs are about 2″ x ¼″ (giving a very narrow-seged flower) to 3″ x 1 ¼″ (giving a full, cup-shaped flower). The larger fuller flowers are very lovely and well worth cultivating.

I have only seen this species in two localities. The first was in the Pilliga scrub, a rather large area of very sandy soil covered usually with *Callistris,* Cypress Pines, between Narrakriand and Coonabarabran in northwestern New South Wales. Here in the sand the bulbs are situated 10″ to 15″ deep. They have a long pseudo-neck and usually a poor development of the leaves. When I saw them in January (the beginning of the flowering season), the leaves were only about 6″—10″ long and about ½″—⅝″ wide. This area is subject to heavy frosts and is at an elevation of 800—1,000 ft. The winters are quite cold. In this area very few bulbs were large enough to flower, and only one flower scape was noted. However, many more might appear after a rain. The bulbs were scattered sometimes a dozen or two in clumps but more often only 2—6 together.

Fig. 5. *Crinum flaccidum* in its native habitat in Australia, showing a specimen with broad tepalsegs. Photo by William Morris.

The other locality was along a creek about six miles from Quirindi. This town is the first town across the Dividing Range after leaving the coastal area from the Hunter River valley. The creek drains from the divide which is only about 300 ft. higher than Quirindi (1280 ft.) at this spot, and flows westward. The bulbs are found within a mile or two of its headwaters. In places they are in great numbers as shown in Fig. 6. The photo shows only perhaps a quarter of the scapes which had been in flower since the others were heavy with seeds and had fallen over. Here the bulbs are about 4 to 6 inches below the surface in a heavy black soil which is extremely hard to dig. Farther down the creek, they were also very common in the silt on the flood terraces and here they often are just below the surface. The leaves again are not very large, about 12″—15″ long, and ½″—¾″ wide. These leaves tend to grow up only about 6 inches before twisting and curling towards the ground. As the flower scapes are two to three feet tall, this from a distance gives an effect similar to that of the Cape Belladonna, *Brunsvigia rosea*—they appear to be flowering without leaves. Whether the leaves will grow longer during the late summer and autumn after the rains, I do not know, but in pots here (on the coast at sea level), I have some leaves three feet long and over one inch wide.

Fig. 6. *Crinum flaccidum,* showing great numbers growing naturally in its native habitat. Photo by William Morris.

Both of the above localities have January and February daily shade temperatures of around 100° F. In fact on both days on which I was out digging up bulbs, the shade temperature was above 105° F, and I do not care to guess the temperature in the sun. So this *Crinum* species is used to high summer temperatures and much lower than usual winter temperatures.

BOOPHONE DISTICHA

Grant V. Wallace, *Berkeley, California*

In the Ainsley collection, referred to in my articles on *Nerine* and *Brunsvigia josephinae,* there also appeared two very long-necked, slender bulbs, with striate, light brown coatings. I was delighted to note that the two-ranked, wavy foliage, suggestive of a bamboo rake, was that of *Boophone disticha,* known for its use as arrow poison by the South

African natives and its maddening effect on cattle, as well as for being a very infrequent bloomer. It is said to be "triggered" by veldt fires, which implies that it needs a good baking in order to produce buds.

I wasn't able to simulate a prairie fire; but in August, 1946, one bulb produced a scape. This is short and very stout, bearing a compact umbel, six inches across, composed of a hundred or more *Nerine*-like flowers, three-quarters of an inch in diameter. These open from the outside of the umbel inward; the new ones are old rose, deepening to raspberry-red with age. The white anthers protrude, and the fragrance is very fine. The effect when in full bloom is that of a deep-rose pincushion. After blooming, the pedicels are produced to three times their normal length, thus extending the seed capsules for better distribution. My plant was visited freely by bees but set no seed. In 1948, both bulbs died, possibly from a fungus attack.

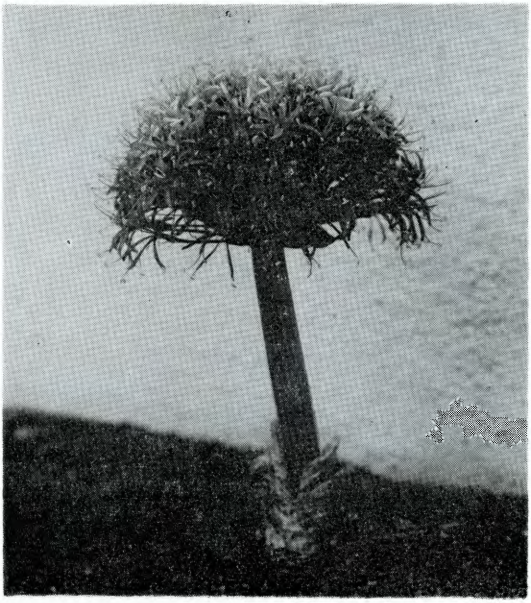

Fig. 7. *Boophone disticha,* as grown by Grant V. Wallace at Berkeley, Calif. Photo by L. S. Hannibal.

When the *Boophone* was in bloom, and later, when it was in the "seed" stage, Mr. Lester S. Hannibal photographed it [Fig. 7]. These pictures may be seen in his paper, entitled "Boophone and Brunsvigia," in the January, 1947, issue of *The National Horticultural Magazine.*

WORSLEYA RAYNERI, THE BLUE AMARYLLIS

Mr. Wallace Stevens of Wanganui, New Zealand furnished the photo of *Worsleyi rayneri* reproduced in Fig 8. It flowered in New Zealand for the first time in January of 1961. The original bulb was given to him by the late Major Albert Pam, who distributed samples to a number of friends in the hope that his particularly selected strain could be preserved. *W. rayneri* comes from the Organ mountains in Brazil.

Fig. 8. *Worsleya rayneri,* The Blue Amaryllis, as grown by Wallace Stevens, New Zealand.

Fig. 9. *Brunsvigia josephinae* (Red.) Ker-Gawl., as grown by Grant V. Wallace, Berkeley, Calif.—(bottom) elongating scapes, 9-4-50, one to right soon overtook the other; (middle), 9-17-50, well advanced, both scapes about same height; (top) 9-30-50, in full bloom. Photos by Grant V. Wallace.

BRUNSVIGIA JOSEPHINAE—A GIANT AMONG AMARYLLIDS

GRANT V. WALLACE, *Berkeley, California*

An enthusiast who collects any rarity—whether it be birds' eggs, buttons, beetles, or *bulbs*—will be sure to form many fine friendships with those of similar tastes. In the present case, this principle was exemplified in a manner that, while it was conducive to sadness at the time, resulted in the successful rearing of a bulb species never before tried in this area.

Since the 1920's, I had been growing a variety of South African bulb material, principally from seeds purchased in that region. About 1931, a friend handed me a catalogue of rare bulbs, bearing the name of Gordon Ainsley, Campbell, California. A visit to his nursery followed shortly. He turned out to be a true *aficionado,* who was actually more interested in collecting bulbs than in selling them. Not only was this the case, but he generously contributed many fine things to my collection, asking in return only a report on results.

Our friendship, with its common interest, endured for more than ten years. Then, in the fall of 1942, Mr. Ainsley passed away. It became my privilege to assist Mrs. Ainsley in disposing of the *Nerine* section of the collection, consisting of several hundred bulbs of all sizes. Most of them were sold to a dealer in southern California; I was permitted to keep a number of interesting-looking specimens for trial. This assortment consisted mostly of *Nerine sarniensis* types (the Guernsey lily of London flower marts); but two unfamiliar bulbs, with shapes and coatings unlike those of *Nerine,* eventually provided the material for this account. (All the material had been grown from seeds, presumably obtained from Cape dealers. No record could be found, but Gordon had once shown me a flatful of *Brunsvigia* seedlings. Apparently, some of them had been mixed in with the *Nerine* seedlings.)

In November, 1942, the two little strangers were planted on the west side of our house in Berkeley, in a frostless strip where a large number of Barr hybrid *Nerines* were thriving. Their leaves turned out to be gray-green and strap-shaped, not unlike those of a typical *Nerine,* at that stage of progress. During the first four winters, only leaves were produced. These became progressively longer and wider as the years passed, finally becoming three or four inches wide and about 18 inches long and tongue-shaped; fairly upright, with the upper third arching. The bulbs, which had been about an inch and a half in diameter when planted, now were reaching a very large size, made evident by shallow excavation around their tops.

The "great day" arrived on September 5, 1946, when a spathe tip appeared from the center of the crown of one of the bulbs. Here follow my notes, as they were set down at the time:

"September 15, 1946. It is just going to open its buds. Tremendous scape, like a little tree trunk."

"September 23, 1946. First flower opened. Red, with chartreuse throat, and chartreuse on outside, half way up from base. Not widely opened; tight funnelform; not conspicuous. Scape and pedicels outweigh flowers, 'century-plant' style. Scape, 20″ tall and 1¼″ thick; pedicels, 12-14″; umbel, 24″ diameter; flowers, about 25. It *is* a *Brunsvigia,* but species is in doubt.''

The following year, these notes appear:

''August 24, 1947. *Brunsvigia* (same bulb that bloomed before) showed a bud, twelve days earlier than last year.''

''September 17, 1947. *Brunsvigia* fully opened. Flowers, about 30; scape, 22″; pedicels, 12-14″; diameter of umbel, 30″.''

Some interesting data were recorded in 1948:

''September 10, 1948. *Brunsvigia* (the same bulb as before) showed its bud; the other bulb has not bloomed as yet. Inflorescence gets larger each year.''

''October 11, 1948. Full bloom. Scape, 24″; diameter of umbel, 30″; flowers, 41; over-all height, 36″; pedicels, 12-14″. The scape averaged one and three-quarters inch of growth each twenty-four hours while it was developing, depending on temperature and moisture—some days, more; others, less.''

On July 17, 1949, both bulbs were transplanted to a raised bed in an exposed area, away from the house. Their winter-hardiness was in question, but the leaves proved to be as frost-resistant as those of the closely related ''belladonna'' *(Brunsvigia rosea).* Both bulbs were the size of a coconut; only one had bloomed so far. The record:

''September 4, 1949. The usual *Brunsvigia* is budding, just ready to open. The other one shows no bud.''

''September 20, 1949. Full bloom; approximately 50 flowers (nine more than last year, and the most ever produced). Not so tall or broad as last year; it had just been moved; not yet established.''

Finally, in 1950, the other bulb decided to bloom, in the unpredictable fashion of most amaryllids:

''October 1, 1950. Both Brunsvigias in bloom; very effective. Both are full size and identical. One has bloomed regularly for four years; the other, for the first time this year. *(Why?)* Took progressive pictures of scape development. [See Fig. 9.] As two plants were blooming together, the abundant bee-visitors caused them to set viable seed about a month later.''

The history from that time to the present (January, 1961) is here presented in condensed form:

1941. Both bulbs bloomed well.

1952. One bloomed weakly; the other, not at all.

1953. Only one bloomed.

1954. No flowers. One bulb died, either from infestation by the narcissus-bulb fly or from a fungus infection; it was completely gutted and full of psocids (booklice).

1955. The survivor bloomed, and had a strong offset.

1956, 1957. Bloomed both seasons.

1958, 1959, 1960. No flowers, but bulb and its offset made a thrifty growth of leaves.

The blooming period fluctuates slightly, between September and October—a little later than *B. rosea.* The growth cycle and cultural requirements are the same as those of the latter.

In the size of bulb and leaves [Fig. 10], this species is surpassed by no other members of the Amaryllidaceae except certain tropical *Crinums.* On the other hand, the individual flowers are almost ridiculously small.

Fig. 10. *Brunsvigia josephinae,* as grown by Grant V. Wallace, Berkeley, Calif.—two specimens in full leaf, Jan. 1, 1951. Photos by Grant V. Wallace.

The scape has an interesting provision to insure the dispersal of seeds. Although the stalk, while active, is extremely thick and fleshy, it dries out completely at the same time the seeds ripen, becoming like straw, and practically weightless. Simultaneously, a point of severance develops at the neck of the bulb, and the scape breaks away cleanly. The dry seed-heads are propelled by the wind across the South African veldt, exactly like our own "tumbleweeds."

I unfortunately failed to grow a supply of seedlings in the productive years, thinking the plant was ironclad and deathless. It is hoped that seeds will be produced in the fall of 1961 if it decides to bloom again.

After inspecting various photographs of flowers and foliage, Dr. Hamilton P. Traub has definitely determined the plant here discussed to be *Brunsvigia josephinae* (Redouté) Ker-Gawl.

The picture of the plant in bloom was also used in the *Journal of the California Horticultural Society,* Volume X, Number 2, April, 1949, together with notes on this and other amaryllids. In that account, I erroneously referred to it as "*Brunsvigia gigantea.*"

BRUNSVIGIA ORIENTALIS FORMA COOPERI

J. P. van der Walt, *Republic of South Africa*

The interesting photograph—reproduced in Fig. 11—was taken near Hermanus, Cape Province, which is about 55 miles south-east of Cape Town and represents one of the most arid coastal areas in all of South Africa. The unique features of this Brunsvigia form are the few flowers, a short scape some eight inches in length, and the brick-red coloring of the pedicels and flowers which practically match each other. The scape in turn is colored a dark red-brown. The plant is obviously a form of *Brunsvigia orientalis* (L.) Ait. ex Ecklon. Practically all features are in agreement with Bakers description of *B. cooperi,* which is considered a synonym of *B. orientalis.*

Fig. 11. *Brunsvigia orientalis* forma *cooperi,* in its native habitat in South Africa. Photo by J. F. van der Walt.

REGISTRATION OF NEW AMARYLLID CLONES

Registrar: Mr. W. D. Morton, Jr.

This department has been included since 1934 to provide a place for the registration of names of cultivated *Amaryllis* and other amaryllids. The procedure is in harmony with the INTERNATIONAL CODE OF BOTANICAL NOMENCLATURE (edition publ. 1956) and the INTERNATIONAL CODE OF NOMENCLATURE FOR CULTIVATED PLANTS (edition publ. 1958). Catalogs of registered names, as well as unregistered validly published names, will be published from time to time as the need arises. The first one, "DESCRIPTIVE CATALOG OF HEMOROCALLIS CLONES, 1893-1948" by Norton Stuntz and Ballard was published in 1949. This may be obtained at $2.50 prepaid from: Dr. Thos. W. Whitaker, Executive Secy., THE AMERICAN PLANT LIFE SOCIETY, Box 150, La Jolla, Calif. CATALOG of HYBRID NERINE CLONES, 1882-1958, by Emma D. Menninger; and CATALOG OF BRUNSVIGIA CULTIVARIS, 1837-1959, by Hamilton P. Traub and L. S. Hannibal were published in 1960 Plant Life, with additions to both in Plant Life 1961. In Plant Life 1961, the first edition of THE GENUS X CRINODONNA was published which serves also as a catalog of cultivars. A catalog of Amaryllis names, and also catalogs of the names of other cultivated amaryllids, are scheduled for publication in future issues.

Only registered clones of Amaryllis and other amaryllids are eligible for awards and honors of the AMERICAN AMARYLLIS SOCIETY. Numbers of registered clones are preceded by a prefix, an abbreviation for the genus concerned. Thus A-390, the "A" standing for *Amaryllis;* Z-1, the "Z" standing for ZEPHYRANTHES, etc.

Correspondence regarding registration of all amaryllis such as *Amaryllis, Lycoris, Brunsvigia, Clivia, Crinum, Hymenocallis,* and so on, should be addressed to Mr. W. D. Morton, Jr., Registrar, 3114 State Street Drive, New Orleans 25, Louisiana. The registration fee is $2.00 for each clone to be registered. Make checks payable to AMERICAN PLANT LIFE SOCIETY.

HYBRID AMARYLLIS CLONES

Registered by Ludwig & Co. Hillegom, Holland:

Amaryllis clone **'Peppermint'**; reg. #A-669, May 25, 1961 (First distributed in 1960). D-5a (Leopoldii); scape 26-20″ tall; spring (late) flowering; umbel 4—5-flowered, sometimes up to 6-flowered; flower length (depth) 3″; 8″-9″ in diameter; the five upper segs are pure white, streaked cardinal red (HCC-822/3) along the main rib, the lowermost seg is pure white; throat greenish white. Outstanding for the striking color combination.

Amaryllis clone **'Royal Dutch'**; reg. #A-670, 1961 (first distributed in 1960). D-5a (Leopoldii); scape 22″-24″ tall; spring (half late) flowering; umbel 4-f'd; flower length (depth) 3″; 7″-8″ in diam.; the end of the segs is orient red (HCC-818/1), changing to very light scarlet (19/1, 19/2 and 19/3) inward, and to pure white and slightly greenish in the throat; stamens and style pure white.

Amaryllis clone **'Sight Show'**; reg. #A-671, May 25, 1961 (first distributed in 1960). D-5a (Leopoldii); scape 26″ tall; spring (half late) flowering; umbel

4-fld; flower length (depth) 3″; 8″-9″ in diam.; the brilliant color ranges from porcelain rose to carmine rose, slightly lighter toward the apexes of the segs, and darker in the throat; stamens and style are rose colored.

Registered by Ralph H. Becker, 1823 Treasure St., New Orleans, La.:

Amaryllis clone **'Winner'**; reg. #A-667, Dec. 30, 1960. Flower length (depth), 3 3/4″, Leopoldii (D-5a); scape 20″ tall; spring flowering, leaves present at flowering; umbel 4-fld.; flowers 7″ in diam.; color orient pink (HCC-819) with greenish stripe in center of segs; two upper opposite segs shading to 822 on each side of center stripe 1/2 way, throat greenish.

Registered by Charles Marden Fitch, 1120 Cove Road, Mamaroneck, New York:

Amaryllis clone **'Talisman Cove'**; reg. A-672, June 7, 1961 (first distributed 2-25-61). Flower length (depth) 3 3/4″, Leopoldii (D-5a); scape 27″ tall; spring flowering; umbel 4—5-fld; flowers 7 1/2″-8″ in diam.; color rose madder (HCC-23/1) to rose Bengal (HCC-25/1) in throat. Bred from Van Meeuwen strain stock.

Registered by Mr. R. W. Eubank, 1301 York St., Corpus Christi, Texas:

Amaryllis clone **'Eubank's White'**; reg. no. A-668; March 3, 1961. D-5a (Leopoldii); scape 19″-20″ tall; spring flowering, foliage present at flowering; umbel 4-flowered; flower length (sideways) 3—3 1/2″; flower diameter 8—8 1/2″; flower color pure white with light chartreuse green in throat, extending partially into the lower part of segs; stigma trifid.

Registered by Mr. Robert L. Solomon, 3806 42nd St., Tampa 10, Florida:

Amaryllis clone **'Debra Solomon'**; reg. #A-673, June 10, 1961 (first distributed in the spring of 1961). D-5a (Leopoldii), scape 16″ tall; spring flowering umbel 4-flowered; flower length (sideways) 3″; 8″ in diameter; flowers rose Bengal (HCC-25/2 to 25), making a perfect blend, throat deep Bengal rose. An outstanding hybrid. Parentage: un-named Indian hybrid (seed parent), Reg. A-424 (pollen parent).

Amaryllis clone **'Connie Fay'**; reg. #A-677, Aug. 23, 1961. D-8 (Double); scape 15″ tall; spring flowering; foliage present at flowering time; umbel 2-flowered; flower length (sideways) 5″; 7 1/2″ in diameter; flowers semi-double rosy red (chrysanthemum crimson?) with some white markings in center of segs. Parentage unnamed seedl. (seed parent) x 'Friendship' (pollen parent).

Registered by Mr. J. W. Terry, 1107 Mamie St., Hattiesburg, Miss.:

Amaryllis clone **'Eternal Youth'**; reg. A-676, Aug. 19, 1961. D-5a (Leopoldii); scape 20″ tall; spring flowering; foliage present at blooming time, umbel 4-flowered; flower length (sideways) 3 1/2″; flower diameter 8″; flower color—upper setsegs delft rose (HCC-20/1) extending 3/4 length of seg, petsegs to ½″ of tip of white; lower setsegs, upper half same as above, lower half lighter, throat greenish-white. Parentage: 'Pink Favorite' (seed parent) x 'Ludwig's Dazzler' (pollen parent).

Registered by Mrs. Donald Mitchel, 1443 Arabella St., New Orleans, La.:

Amaryllis clone **'Donald Mitchel'**; reg. A-675, Aug. 19, 1961. D-5a (Leopoldii); scape 22″ tall; spring flowering; umbel 4-flowered; flower length (sideways) 3 1/2″; flower diameter 9″; flower color Tyrian rose (HCC-24/1), segs enlivened by center white strips; throat greenish-white.

Registered by Mr. W. J. Perrin, 4753 Press Drive, New Orleans 26, La.:

Amaryllis clone **'Grand Mist'**; reg. A-674, July 18, 1961. D-4a (Reginae); scape 18—24" tall; spring flowering; umbel 4-flowered; foliage present at time of flowering; flower length 4 1/2"; flower diameter 7"; flower color misty white with rich green throat, small red markings deep in throat; greenish stripe in center of segs, misty white to the ends. Parentage: 'Maria Goretti' Reg. 445 ♀ x 'White Giant' reg. A-460 ♂.

Originated by a South African breeder (name later); and registered in his behalf by Robert D. Goedert, Box 6534, Jacksonville 5, Florida:

Amaryllis clone **'Fire Bird'**; reg. A-678, Aug. 26, 1961. D-5a (Leopoldii) scape fairly tall; spring flowering; foliage deciduous; umbel 4-flowered; flower diameter 8—9"; bitone, a flaming orange red with darker throat, back of segs white, spotted red.

Amaryllis clone **'Flying Cloud'**; reg. A-679; Aug. 26, 1961. D-5a (Leopoldii); scape fairly tall; spring flowering; foliage deciduous; umbel 4-flowered; flower diameter, about 8"; flower color pure white with green throat.

Originated by a South African breeder (name later); and registered in his behalf by Robert D. Goedert, Box 6534, Jacksonville 5, Florida:

Amaryllis clone **'Mohawk'**; reg. A-680; Aug. 26, 1961. D-5a (Leopoldii); scape fairly tall; spring flowering; foliage deciduous; umbel 4-flowering; flower diameter about 9"; flower color a light red self.

Amaryllis clone **'White Crane'**; reg. A-681, Aug. 26, 1961. D-5a (Leopoldii); scape very tall; spring flowering; foliage deciduous; umbel 4-flowered; flower diameter about 9"; flower color pure white with near white throat, segs somewhat loosely arranged.

HYBRID NERINE CLONES

The following additions (not registered) to the "Catalog of Nerine Cultivars" have been sent in by Emma D. Menninger, Greenoaks, 730 North Old Ranch Road, Arcadia, Calif. (See Plant Life *17:* 61. 1961, for additions up to 1961.)

Name	Grower/Supplier	Description
'Caliph'	G-ER	pink.
'Comet'	S-Barr	salmon scarlet.
'Crusader'	S-Barr	cerise-rose, late.
'Harlequin'	S-Barr	small-flowered salmon, white throat.
'Hailstorm'	G-ER	white.
'Marise'	G-ER	salmon.
'Mrs. C. Goldsmith'	S-Barr	deep blood-crimson.
'Mystic'	S-Barr	light coral to lilac.
'Nile'	G-ER	bright pink.
'Pink Delight'	G-ER	pale pink.

CRINUM ASIATICUM JAPONICUM

Tsuneshige Rokujo, *Tokyo, Japan*

Crinum asiaticum var. *japonicum* is native to south eastern Japan and grows along the coastline facing onto the Pacific Ocean. The northern limit of growth is the Boso Peninsula near Tokyo. Several rather hardy subvariants exist. Presumably the plants were introduced originally on the tropical currents which sweep up along southeastern Asia. The bulbs are not completely winter hardy in Tokyo and some protection is required.

CYTOLOGICAL REPORTS AND THE PLACEMENT OF STERNBERGIA

R. O. FLAGG AND W. S. FLORY

The Blandy Experimental Farm, University of Virginia, Boyce, Va.

Classifications of Amaryllidaceae [1,2,3,4,5,6,7,8,9] have indicated *Sternbergia* W&K (1805) as more nearly allied with American Zephyrantheae than with other Mediterranean amaryllids. In December of 1960 H. P. Traub [10,10a] wrote that he was "moving *Sternbergia* [from Zephyrantheae] to Narcisseae." In considering Zephyrantheae our studies of morphological and distributional data for the taxa involved had already led to serious misgivings [11] about the relationships implied by existing classifications. Under the fillip of Traub's independent action [12], a general review of cytological literature for Mediterranean Amarylloideae was initiated. The following is a short summary of our rather extensive review, together with tentative conclusions. Only the reports of seemingly greatest significance to the placement of *Sternbergia* are mentioned here.

In 1949 Battaglia [13] presented a careful review and report of the cytology of *Sternbergia lutea,* the only member of the genus for which there are cytological reports. In agreement with several previous workers, Battaglia [13] concluded that the basic chromosome number for *S. lutea* is 11. Uncertainties in differing reports were pointed out, and Battaglia produced evidence indicating that Amico's [14] report of 2n=24 chromosomes in *S. lutea* was an error resulting from technique. More recently Mookerjea [15] and Sharma *[16] have reported finding a diploid complement of 20 chromosomes in *S. lutea.* This suggests that *S. lutea* may have a basic chromosome number of 10 or of 11. The outstanding morphological feature in the cytological reports on *S. lutea* is the occurrence of a preponderance of subterminally constricted (cephalobrachial) chromosomes in the somatic complements. This cytological picture is strikingly different from that presented by representatives of American Zephyrantheae (x = 6) studied in this laboratory.

In 1955 Mookerjea [15] concluded that "*Sternbergia* represents an evolutionary line, possibly an offshoot from the *Allium* stock" while *Habranthus* and *Sprekelia* originated quite differently. This implied exclusion of *Sternbergia* from Zephyrantheae.

Mookerjea [15] did not compare *S. lutea* cytologically with Narcisseae or Galantheae. She placed *Sternbergia* in Galantheae through a misinterpretation of Hutchinson's [7] writing. Hutchinson [7,8] classified *Sternbergia* under Zephyrantheae. His key to the tribes of the Amaryllidaceae was such that *Sternbergia* species could be "keyed out" to either Zephyrantheae or Galantheae. For that reason Hutchinson [7,8] listed the name *Sternbergia* in brackets under Galantheae to show im-

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* The figures for **S. lutea** used by Sharma (1956) are quite evidently duplicates of those presented by Mookerjea (1955).

proper placement. Apparently through oversight Mookerjea[15] assumed that Hutchinson[7] assigned *Sternbergia* to Galantheae.

Fernandes[17] has stated that "the data from cytology are not in accord with the idea of considering *Lapiedra* close to *Sternbergia* from the systematic point of view." He regarded *Lapiedra* as closely related to *Leucojum* and *Galanthus* and suggested that *Lapiedra martinezii* and *Leucojum autumnale* originated from a common ancestor[17,18]. Fernandes would apparently exclude *Sternbergia* from Galantheae on a cytological basis.

Fernandes has made extensive cytotaxonomic studies of *Narcissus.* His 1951 paper[19] on the phylogeny of *Narcissus* species summarizes much of that work. Regarding the section *Hermione* Fernandes[19] pointed out "*existence des nombres de bases* 10 *et* 11" and "*dominance dans les garnitures de chromosomes cephalobrachiaux.*" A comparison of published drawings shows that this parallel with the cytological reports for *Sternbergia lutea* extends also to chromosome size.

In traditional classifications *Sternbergia* has been excluded from Narcisseae by its lack of a corona or rudiments of a corona. The section *Hermione* not only shows chromosomal similarity to *S. lutea* but also contains those species of *Narcissus* with coronas least developed. Furthermore, the presence and the absence of a corona or rudiments of one are not necessarily significant characters for distinguishing supra-generic groups of amaryllids. This might be most sharply illustrated by the fact that while some collections of *Zephyranthes pulchella* have rudimentary coronal development in the form of squamae visible to the naked eye, e.g. *Clint T-37,* others have none visible even at a magnification of 10X, e.g. *Flagg T-52-P.*

There is both cytological and morphological evidence suggesting that *Sternbergia* should be classified near *Narcissus.* Breeding tests are planned to give additional information on the proper placement of *Sternbergia.*

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Fig. 12. Leaves of Louisiana *Hymenocallis,* (left), *H. eulae,* plant from Castor-Ringgold area (Dormon No. 3); (right) *H. galvestonsis* plant from Prairieville, La. (Dormon No. 1). See text for description.

LOUISIANA HYMENOCALLIS NOTES, 1961

Caroline Dormon

The foliage of the native *Hymenocallis* is quite attractive, and the plants do not require as much space as most of the Crinums.

The species from the Castor-Ringgold area is worth growing just for the pretty leaves. The fan is fairly full, (Fig. 12) the glaucous-green blades about 1½ inches wide, slightly recurved. These appear in late winter and die off in late spring. The flowers appear in August. All of the August-blooming species have the glaucous-green foliage. A flower scape of this was figured in 1961 Plant Life, page 41 (from Castor, La.). The bulb is 7.5 inches in circumference, 3 inches long, including neck; leaves are 2 inches wide, 15 to 24 inches long, glaucous; flowers appear in late August. See plant to left, *H. eulae,* in Fig. 12.

The spring-blooming species from South-central Louisiana have shining light-green leaves, about 1 inch or less in width (Fig. 12). These appear in spring, and the flowers bloom with the leaves. The foliage of these is quite similar, and the specimens from near Bunkie and from Lake-Prairieville area may be variations of the same species. A dwarf species from Prairieville, La. (Dormon No. 1) was mentioned in 1961 Plant Life, page 42. The bulb of this is 5.5 in. in circ., 2.5 in. long, including neck; leaves are shining green, 1 in. wide, 9—15 in. long; flowers appear in April. See plant to right, *H. galvestonensis,* in Fig. 12.

LONG LOST AMERICAN **CRINUM** FOUND

Hamilton P. Traub

In 1959, Mrs. Carl Shirley, 1540 Forsythe, of Beaumont, Texas, sent the writer bulbs and seeds of a ''large Crinum americanum'' which she collected locally in the City of Beaumont on both sides of the Neches River, on the west side in Jefferson County, and on the east bank in Orange County. Mrs. Shirley indicated that the rhizome to which the bulbs were attached were different from those of the common *Crinum americanum*—''without exception the rhizome went down; never laterally as rhizomes usually do. I really do not know how deep they went; we were never able to get to the bottom of them.''

The bulbs were potted in an 8-inch earthen pot which was set in a saucer so that it could be given *Crinum americanum* treatment during the growing season. This means that when in active growth, water is liberally applied and is allowed to stand in the saucer. Under this treatment, the larger bulb produced a 3-flowered scape late in September 1961. It proved to be a very lovely, slightly fragrant, *Crinum* with flowers presenting a 'proudly' upright stance. It was possible to match this up with the available meagre descriptions, and with Herbert's plate in Bot. Mag. Lond. 53: pl. 2635. 1816 of *Crinum strictum,* habitat unknown, a plant lost in culture in Europe over a century ago.

Although the habitat of *C. strictum* was apparently unknown, Herbert (in Amaryll. 253-254. 1837) surmised that it was native to Mexico: "I make no doubt of its being a Mexican plant, from whence Mr. Tate, who sent it to me as it arrived (by some mistake labeled as a Neottia from Ceylon), imported many plants at the period. It has no oriental affinities." At the time that it was described in 1816, Texas was part of Mexico. Texas became a republic in 1836, and an American State in 1845. Thus Herbert was apparently technically correct in his surmise. It could have been collected in the general area of the Gulf Coast where Mrs. Shirley found it that is now part of the United States. How far the species ranges southward is not known at present, but it may reach along the Gulf Coast into present day Mexico. Only further exploration can settle this point.

Crinum strictum sets seeds readily and thus can be easily propagated and should be offered by dealers in amaryllids. It is more easily grown than *Crinum americanum.* It has another virtue—it is not too rampant growing and will appeal to those who collect the dwarfer crinums.

Crinum strictum Herbert

Descr. ampl. in Bot. Mag. Lond. 53: pl. 2635. 1816; Amaryll. 253-254. 1837; Baker, Amaryll. 86. 1888. Syn.— **C. herbertianum** Roem. et Schult.f., Syst. **7:** 871. 1830.

Bulb small, ovoid, without any distinct neck. **Leaves** evergreen, 6, suberect, 35—41 cm. long, 4.1—4.3—4.7 cm. wide, narrowly lorate-lanceolate, apex bluntly acute, with hyaline margin, minutely toothed at varying intervals, up to 8 mm. apart, moderate yellow-green (pod green HCC-061). **Scape** flattish, with rounded edges, rusty-reddish in lower 1/3, rest moderate yellow-green, 22.5—30 cm. long, 10 x 13 mm. in diam. at the base, 9 x 11 mm. in diam. at the apex. **Spathe** lanceolate, margins infolded, streaked reddish over moderate yellow-green, 8.5—9 cm. long. 2.2—2.5 cm. wide at the base, tapering to a bluntly acute to truncately-notched apex. **Umbel** 3- or 4-flowerd. **Buds** creamy white streaked reddish in upper 9/10 on outside, upright at first, then nodding slightly below horizontal by rounding of the upper 1/3 of the tepaltube before opening; and then almost upright on opening with the upper ¼ of the tepaltube slightly curved. **Flowers** fragrant, ovary pod green, tepaltube light yellowish-green in lower 9/10, cream-colored in upper 1/10; tepalsegs white, streaked reddish on the outside upper 9/10. stamens and style red in upper ¾; flowers wide open with segs recurved, stamens and style prominently exserted. **Pedicels** 3—4 mm. long **Ovary** oblong 1.4 cm. long, 8 x 9 mm. in diam.; ovules few per cell. **Tepaltube** permanently slightly curved in upper ¼, 8.4 cm. long, 6 x 7 mm. in diam. at the base, 5 x 6 mm. in diam. at the apex. **Tepalsegs** narrowly lanceolate, acute (apiculate), 10.8 cm. long, 1.5 cm. wide. **Stamens** 6.6 cm. long, anthers 1.3 cm. long, pollen yellow. **Style** 3.2 cm. longer than the stamens, **stigma** minute.

Specimen: Traub **888a+b** (TRA), 9-26-61; grown at La Jolla, Calif., from a bulb collected by Mrs. Carl Shirley, in Jefferson County, Texas.

AMARYLLID GENERA AND SPECIES

HAROLD N. MOLDENKE

[In this department the descriptions of amaryllid genera and species, particularly recent ones, translated from foreign languages, will be published from time to time sc that these will be available to the readers.]

Pancratium mexicanum Le Conte, in Ann. Lyceum Nat. Hist. New York 3: 143-144, pl. 4, figs. 1-3. 1836.—Bulb stoloniferous; leaves 6—8, linear-lorate, obtuse, rather concave, somewhat broader at the middle, striate, dorsally convex, not carinate, flat at the apex; scape double, striate, becoming somewhat glaucous, 2—6 flowered; ovary ovatetrigonous, pyramidal; tepaltube subtrigonous, with rounded angles, becoming greenish, striate; petals white, linear, upright, concave, longer than the tube, the exterior ones canaliculate, becoming greenish beneath; corona white, becoming somewhat greenish at the very base, more or less stellate, irregularly erose at the margin, mostly bearing very many small acuminate mucros; filaments from the sinuses of the corona, incurved, white; anthers vertical, yellow; pistil declinate, incurved, longer than the filaments, green at the apex; capsule withering and splitting into pieces before the maturation of the seeds; seeds increasing in size after the breaking up of the capsule.

(a) Bulb producing only a single scape; leaves 8, 18 inches long; scape 19 inches long; petals subhorizontal; corona at first expanded, funnel-form, finally exactly rotate or disciform, one-third as long as the petals.

(b) Taller; bulb producing only a single scape; leaves 6, 24 inches long; scape 30 inches tall; petals horizontal or even somewhat deflexed; corona funnel-form, occasionally exactly rotate or disk-shaped, scarcely stellate, less than one-third as long as the petals, now and then bearing an acuminate mucro on the margin.

(c) Early-blossoming; bulb always producing two scapes; leaves 6, 12 inches long; scape 12 inches long; petals expanded, not rotate; corona funnel-form, never rotate, half as long as the petals.

(d) Bulb producing only one scape; leaves 6, 12 inches long; scape 12 inches long; petals expanded, subhorizontal; corona exactly rotate, with erose teeth, one-third as long as the petals.

Pancratium coronarium Le Conte, in Ann. Lyceum Nat. Hist. New York 3: 145 pl. 4. figs. 7—9. 1836.—Bulb not stoloniferous, producing one scape; leaves 8, linear-lorate, obtuse, 24 inches long, wider at the middle, striate, dorsally convex, not carinate, canaliculate toward the base and forming a concave semi-cylinder, expanded at the apex; scape 24 inches long, 4-flowered, striate, two-edged, not glaucous; ovary small, ovate-trigonous; tube subtrigonous, with rounded angles, becoming greenish; petals white, not yellowish-white, linear, upright, striate, concave, longer than the corona, canaliculate, the outer ones becoming greenish beneath; corona ample, funnel-form, not rotate, white, stellate, the staminiferous teeth broad, entire, bearing an acuminate tooth on both sides, the sinuses deep, irregularly erose-dentate, the very base green-stellate, finally yellowish-white; filaments one-third as long as the corona, from the coronal teeth, incurved, white; anthers vertical, yellow; pistil green toward the apex, declinate, incurved, scarcely longer than the filaments; capsule splitting into pieces and withering before the maturation of the seeds; seeds increasing in size after the breaking up of the capsule.

Pancratium rotatum Le Conte, in Ann. Lyceum Nat. Hist. New York 3: 144, pl. 4, figs. 4—5. 1836.—Bulb stoloniferous, producing one scape; leaves 8, linear-lorate, obtuse, 18 inches long, wider at the middle, striate, rather concave, dorsally convex, not carinate, flat at the apex; scape 18 inches long, 4-flowered, two-edged, glaucous, striate; ovary oblong-ovate, subtrigonous; (tepal) tube subtrigonous, with rounded angles, becoming pale greenish; petals yellowish-white, striate, linear, upright, horizontal, or even subrecurved, concave, somewhat canaliculate, twice as long as the corona, involute at the margins, the outer ones becoming greenish beneath; corona white, becoming greenish at the very base, funnel-form, sometimes exactly rotate, never disk-form, with rather deep sinuses, irregularly erose at the margin, the teeth staminiferous, mostly truncate; filaments issuing from the coronal teeth, incurved, white, anthers vertical, yellow; pistil green, declinate, incurved, longer than the filaments; capsule remaining unbroken to the maturation of the seed.

(b) Smaller in all parts.

Crinum strictum var. traubii Moldenke, **var. nov.**

Foliis sempervirentibus usque ad 9 loratis glabris atroviridibus usque ad 61 cm. longis, 6.7 cm. latis, apice obtuse acutis, marginibus sparse minuteque dentatis; scapo 43.5 cm. alto; spatha lanceolata 6.5 cm. longa; umbella 6-flora; floribus albis aspectu, sed tubo tepalorum rubiginoso-rubello vel pallide flavidulo-viridi, sub apice pallidissime rubello-albolutescenti; duobus partibus superioribus staminorum stylique purpureo-rubris, stylo interdum usque ad gulam purpureo; alabastris ante anthesin declinatis sed tubo tepalorum per anthesin erecto prope apici paulo curvato; pedicellis 9 mm. longis; ovaria 1.2 cm. longo; tubo tepalorum 11.3 cm. longo; segmentis tepalorum oblanceolatis 9.2—9.4 cm.

longis, 1.5—1.6 cm. latis; filamentis 5.4—5.6 cm. longis; staminibus styloque divergentibus curvatis; antheris 1 cm. longis; stylo stamina excedenti; stigmate minuto.

Specimens: Traub **555a+b,** 8-20-57; Traub **675a+b,** 9-30-58, holotype (TRA), grown from bulbs collected by Ruth Patrick Hodge, 5 mi. n. Beaumont, Hardin County, Texas, July 5, 1952. See also Plant Life 14: 51—52, fig. 7. 1958. It differs from **Crinum strictum** Herb., in a number of particulars—the umbel is 7-fld, the foliage is longer and deep green in color, the flowers in the umbel are not held "proudly upright," etc.

CLASSIFICATION OF THE AMARYLLIDACEAE

Hamilton P. Traub

Since the publication of the writer's last revision of the Amaryllidaceae (Traub, 1957), additional study has indicated some necessary changes which are included in the classification presented below. The tribe Miluleae in the subfamily Allioideae has been added in harmony with the interpretation of Stearn (1960). The genus *Sternbergia* has been removed from the tribe Zephyrantheae and placed in the tribe Narcisseae (Traub, 1961). The genera *Elisena* and *Pseudostenomesson* have been reduced to the synonymy of the genus *Hymenocallis* (Traub, 1962). Still other changes have been made to bring the classification up-to-date. It should also be noted that the subfamily Amarylloideae has been divided into two infrafamilies and this is apparently justified on the basis of the morphological and chromosome data.

I. CLASSIFICATION OF THE **AMARYLLIDACEAE**—SUBFAMILIES AND TRIBES

Family **AMARYLLIDACEAE** (105 genera; 1,644 species)

1a. Ovary superior:

  2a. Inflorescence spicitate or umbellate (30 genera; 714 species) .... SUBFAMILY I. **ALLIOIDEAE**
  x= 5, 6, 7, 8, 9, 10, 11, 15

    3a. Flowers actinomorphic, except in **Agapanthus** in the Tribe Apapantheae:

      4a. Inflorescence spicitate (1 genus; 1 species) . . .. Tribe 1. **MILULEAE** x=?

      4b. Inflorescence umbellate:
        5a. Rootstock usually a corm or bulb (18 genera; 712 species) . . .. Tribe 2. **ALLIEAE**
        x= 5, 6, 7, 8, 9

        5b. Rootstock a rhizome or sub-bulbous in **Tulbaghia** (2 genera; 34 species). . Tribe 3. **AGAPANTHEAE**
        x= 6, 15

    3b. Flowers usually zygomorphic; sometimes actinomorphic (9 genera; 14 species) . . . . Tribe 4. **GILLIESIEAE**
    x= 10, (11)

  2b. Inflorescence a raceme, a bostryx, sub-umbellate; or terminal solitary flowers on a scape (3 genera; 17 species) .... SUBFAMILY II. **HEMEROCALLOIDEAE**
  x= 11, 12, 14
  Tribe 5. **HEMEROCALLEAE**
  x= 11, 12, 14

1b. Ovary inferior:

  6a. Scape leafy in the lower part, inflorescence sub-umbellate (2 genera; 3 species) .... SUBFAMILY III. **IXIOLIRIOIDEAE**
  x= 12
  Tribe 6. **IXIOLIRIEAE**
  x= 12

6b. Scape not leafy; inflorescence umbellate; (70 genera; 930 spp.) ....SUBFAMILY IV. **AMARYLLOIDEAE**

  7a. Filaments usually not markedly modified; if modified, then usually not conspicously so (45 genera; 768 species) INFRAFAMILY I. **AMARYLLOIDINAE**

    8a. Fruit not baccate (except in **Gethyllis** under **Gethylleae,** below)

      9a. Bulb coats when broken do not reveal minute fibers:

        10a. Anthers schistandrous (see also **Lapiedra** under **Galantheae):**

          11a. Paraperigone; if present, usually not conspicuous, except in Placea in tribe Amarylleae (see also **Sternbergia** under Narcisseae, below).

            12a. Spathe united into a tube for part of its length below, except in **Rhodophiala** (8 genera; 128 spp.) ....Tribe 7. **ZEPHYRANTHEAE**

            12b. Spathe-valves free (see also **Rhodophiala** under 12a, above):

              13a. Tepaltube usually not enlarging markedly toward the apex; tepalsegs longer than the tepaltube:

                14a. Scape solid (3 genera; 30 spp.) . ...Tribe 8. **LYCOREAE**

                14b. Scape hollow (3 genera; 55 spp.) . . ..Tribe 9. **AMARYLLEAE**

              13b. Tepaltube usually enlarging markedly toward the apex; tepalsegs usually shorter than the tepaltube (5 genera; 53 spp.) ....Tribe 10. **CYRTANTHEAE**

          11b. Paraperigone usually present and conspicuous, except in **Sternbergia** (5 genera; 28 spp.) . . ..Tribe 11. **NARCISSEAE**

        10b. Anthers porandrous, except in **Lapiedra** (3 genera; 23 spp.)....Tribe 12. **GALANTHEAE**

      9b. Bulb coats when broken reveal minute fibers, except in secondarily cartilaginously thickened coats:

        15a. Plants usually relatively larger (8 genera; 311 spp.) .... Tribe 13. **CRINEAE**

        15b. Plants relatively smaller.

          16a. Fruit baccate, except in **Apodolirion** (3 genera; 28 spp.) .....Tribe 14. **GETHYLLEAE**

          16b. Fruit not baccate (3 genera; 23 spp.) . ...Tribe 15. **HESSEAE**

    8b. Fruit baccate (see also **Gethyllis** under Gethylleae, above), (4 genera; 89 spp.) . . . .Tribe 16. HAEMANTHEAE

  7b. Filaments usually markedly modified (25 genera; 162 species) ....INFRAFAMILY II. **PANCRATIOIDINAE**

17a. Scape solid; filaments often modified into a conspicuous cup:

18a. Seeds flat, winged, or angular, hard (7 genera; 48 spp.) . . . . Tribe 17. **PANCRATIEAE**

18b. Seeds fleshy, oval or angular (8 genera; 90 spp.) . . . . Tribe 18. **EUCHAREAE**

17b. Scape hollow; filaments usually variously modified, but not into a staminal cup; or scales on inner surface of tepaltube:

19a. Scales on inner surface of tepaltube (1 genus; 1 spp.) . . . . Tribe 19. **LEPIDOPHARYNGEAE**

19b. Filaments usually variously modified (9 genera; 23 spp.) . . . . Tribe 20. **EUSTEPHIEAE**

II. GROUPING OF GENERA UNDER SUBFAMILIES, INFRAFAMILIES, TRIBES

Subfamily I. **ALLIOIDEAE** (714 spp.) x= 5, 6, 7, 8, 9, 10, 11, 15
Tribe 1. **MILULEAE** (1 sp.) x=?
1. MILULA (1 sp.) x= ?

Tribe 2. **ALLIEAE** (665 spp.) x= 5, 6, 7, 8, 9
Subtribe 1. **ALLIINAE** (614 spp.) 6, 7, 8, 9
2. ALLIUM (550 spp.) x= 7, 8, 9
3. NOTHOSCORDUM (17 spp.) x= 8, 9
4. STEINMANNIA (1 sp.) x= ?
5. IPHEION (24 spp.) x= 6
6. TRISTAGMA (7 spp.) x= ?
7. LEUCOCORYNE (14 spp.) x= ?
8. LATACE (1 sp.) x= ?

Subtribe 2. **BRODIAEINAE** (41 spp.) x= 5, 6, 7, 8, 9
9. MUILLA (4 spp.) x= ?
10. ANDROSTEPHIUM (2 spp.) x= ?
11. TRITELEIOPSIS (1 sp.) x= ?
12. TRITELEIA (15 spp.) x= 5, 7, 8
13. BLOOMERIA (2 spp.) x= 9
14. BRODIAEA (10 spp.) x= 5, 6, 7, 8
15. DICHELOSTEMMA (6 spp.) x= 8, 9

Subtribe 3. **MILLINAE** (10 spp.) x=?
16. DANDYA (1 sp.) x= ?
17. BESSERA (2 spp.) x= ?
18. PETRONYMPHE (1 sp.) x= ?
19. MILLA (6 spp.) x= ?

Tribe 3. **AGAPANTHEAE** (34 spp.) x= 6, 15
20. TULBAGHIA (25 spp.) x= 6
21. AGAPANTHUS (9 spp.) x= 15

Tribe 4. **GILLIESIEAE** (14 spp.) x= 10, (11)
22. SPEEA (1 sp.) x= ?
23. SCHICKENDANTZIELLA (1 sp.) x= ?
24. TRICHLORA (1 sp.) x= ?
25. ERINNA (1 sp.) x= ?
26. SOLARIA (2 spp.) x= ?
27. MIERSIA (2 spp.) x= 10. (11)
28. GETHYUM (1 sp.) x= ?
29. GILLIESIA (4 spp.) x= ?
30. ANCRUMIA (1 sp.) x= ?

Subfamily II. **HEMEROCALLOIDEAE** (17 spp.) x= 11, 12, 14
Tribe 5. **HEMEROCALLEAE** (17 spp.) x= 11, 12, 14
31. HEMEROCALLIS (15 spp.) x= 11
32. HESPEROCALLIS (1 sp.) x= 12
33. LEUCOCRINUM (1sp.) x= 14

Subfamily III. **IXIOLIRIOIDEAE** (3 spp.) x= 12
Tribe 6. **IXIOLIRIEAE** (3 spp.) x= 12
34. IXIOLIRION (1 sp.) x= 12
35. KOLKAPOWSKIA (2 spp.) x= ?

Subfamily IV. **AMARYLLOIDEAE** (930 spp.) x= 6, 7, 8, 9, 10, 11, 12, 14, 15, 22, 23, 26, 34, 37

INFRAFAMILY I. **AMARYLLOIDINAE** (768 spp.) x= 6, 7, 8, 9, 10, 11, 12, 14, 15

Tribe 7. **ZEPHYRANTHEAE** (128 spp.) x= 6, 7, 9, 11
36. ZEPHYRANTHES (62 spp.) x= 6
37. PYROLIRION (11 spp.) x= 7
38. HAYLOCKIA (1 sp.) x= ?
39. HABRANTHUS (19 spp.) x= 6, 11
40. SPREKELIA (1 sp.) x= ?
41. RHODOPHIALA (31 spp.) x= 9
42. X RHODOBRANTHUS (1 sp.) x= ?
43. X SYDNEYA (2 spp.) x= ?

Tribe 8. **LYCOREAE** (30 spp.) x= 6, 7, 8, 9, 11, 12, 15
44. UNGERNIA (8 spp.) x= 12
45. LYCORIS (15 spp.) x= 7, 8, 9, 11, 15
46. GRIFFINIA (7 spp.) x= ?

Tribe 9. **AMARYLLEAE** (55 spp.) x= 11
47. WORSLEYA (1 spp.) x= ?
48. AMARYLLIS (48 spp.) x= 11
49. PLACEA (6 spp.) x= ?

Tribe 10. **CYRTANTHEAE** (53 spp.) x= 8, 11
50. HANNONIA (1 sp.) x= ?
51. ANOIGANTHUS (5 spp.) x= 8
52. VALLOTA (1 sp.) x= 8
53. CYRTANTHUS (45 spp.) x= 8, 11
54. X VALLOTANTHUS (1 sp.) x= ?

Tribe 11. **NARCISSEAE** (28 spp.) x= 7, 10, 11, 12, 14
55. STERNBERGIA (5 spp.) x= 11, 12
56. NARCISSUS (22 spp.) x= 7, 10, 11
57. TAPEINANTHUS (1 sp.) x= (7), 14

Tribe 12. **GALANTHEAE** (23 spp.) x= 7, 8, 9, 11, 12
58. LEUCOJUM (11 spp.) x= 7, 8, 9, 11
59. LAPIEDRA (2 spp.) x= 11
60. GALANTHUS (10 spp.) x= 12

Tribe 13. **CRINEAE** (311 spp.) x= 11, 12
61. CRINUM (148 spp.) x= 11
62. BRUNSVIGIA (16 spp.) x= 11
63. NERINE (35 spp.) x= 11, 12
64. X CRINODONNA (2 spp.) x= ?
65. X BRUNSERINE (2 spp.) x= ?
66. BOOPHONE (2 spp.) x= ?
67. AMMOCHARIS (5 spp.) x= 11
68. CYBISTETES (1 sp.) x= 11

Tribe 14. **GETHYLLEAE** (28 spp.) x= ?
69. APODOLIRION (6 spp.) x= ?
70. GETHYLLIS (21 spp.) x= ?
71. KLIINGIA (1 sp.) x= ?

Tribe 15. **HESSEAE** (23 spp.) x= ?
72. HESSEA (15 spp.) x= ?
73. CARPOLYZA (1 sp.) x= ?
74. STRUMARIA (7 spp.) x= ?

Tribe 16. **HAEMANTHEAE** (89 spp.) x= 8, 9, 11, 12
75. HAEMANTHUS (77 spp.) x= 8, 9
76. CLIVIA (5 spp.) x= 11
77. CHOANANTHUS (2 spp.) x= ?
78. CRYPTOSTEPHANUS (5 spp.) x= 12

INFRAFAMILY II. **PANCRATIOIDINAE** (162 spp.) x= 10, 11, 12, 20, 22, 23, 26, 34, 37

Tribe 17. **PANCRATIEAE** (48 spp.) x= 10, 11, 23
79. CHLIDANTHUS (3 spp.) x= 10
80. RAUHIA (1 sp.) x= ?
81. VAGARIA (1 sp.) x= ?
82. PANCRATIUM (20 spp.) x= 11, 12
83. PARAMONGAIA (1 sp.) x= ?
84. PAMIANTHE (1 sp.) x= 23
85. STENOMESSON (21 spp.) x= ?

Tribe 18. **EUCHAREAE** (90 spp.) x= 10, 11, 12, 20, 22, 23, 26, 37
86. HYLINE (2 spp.) x= 10
87. URECOLINA (3 spp.) x= ?
88. EUCHARIS (21 spp.) x= 11, 34
89. PLAGIOLIRION (1 sp.) x= ?
90. CALLIPHRURIA (2 spp.) x= ?
91. HYMENOCALLIS (56 spp.) 12, 20, 22, 23, 26, 37
92. CALOSTEMMA (3 spp.) x= ?
93. FURYCLES (2 spp.) x= 10

Tribe 19. **LEPIDOPHARYNGINEAE** (1 sp.) x= ?
94. LEPIDOPHARYNX (1 sp.) x= ?

Tribe 20. **EUSTEPHIEAE** (23 spp.) x= 23
95. PHAEDRANASSA (5 spp.) x= 23
96. CASTELLANOA (1 sp.) x= ?
97. CALLIPSYCHE (3 spp.) x= ?
98. PHYCELLA (7 spp.) x= ?
99. EUSTEPHIA (2 spp.) x= ?
100. HIERONYMIELLA (1 sp.) x= ?
101. STRICKLANDIA (1 sp.) x= ?
102. EUCROSIA (1 sp.) x= ?
103. EUSTEPHIOPSIS (2 spp.) x= ?

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[PLANT LIFE LIBRARY, continued from page 27.]

SOUTHERN CALIFORNIA GARDENS, by Victoria Padilla. Univ. California Press, Berkeley and Los Angeles. 1961. Illus. pp. 377. $10.00. This attractive new book was written for the lay reader who gardens in southern California. The account begins with a general coverage of the topography, climatic regions, and the settlers in southern California. It proceeds on the basis of five historical periods from the Spanish-Mexican period, 1769—1847 on through the other periods to the recent period of expanding industrialism, 1935—1958. This is followed by an evaluation of the contributions of outstanding horticulturists; and the account concludes with the consideration of the trees, the rose, cacti and succulents, the flower industry, cut flower business, parks and botanical gardens, and the evolution of gardening in southern California. There are various notes; an appendix of climatic data; a selected bibliography; a general index and an index of plant names (these two indices should be combined for ease in using). It is to be expected that some outstanding omissions should occur in a first edition. Absent is the consideration of the bulbous plants for the winter-rainfall garden, a type of gardening so well-suited to the area; and the amaryllids and other bulbous plants for the spring and summer irrigated garden. There is no reference to George Compère who first hybridized *Amaryllis* (syn.- *Hippeastrum*) in southern California, and from whom the Howards got their first stock. The names of plants are sometimes out of date or non-existent: X *Crinodonna* is given as *Amarcrinum,* a synonym. The non-existent name "Brunsvigia immaculata" is used for *Amaryllis immaculata* (syn.- *Hippeastrum candidum*). No mention is made of *Brunsvigia* x *parkeri,* the outstanding hybrids so well-suited to the area. The development of the polyploid *Hemerocallis* in the decade ending in 1958 is not mentioned; and no reference is made to Mrs. Emma D. Menninger's outstanding hybrid Nerines. Other cases will be noted. These constructive suggestions should not be interpreted as detracting from the book as a whole since these can be ironed out in the next edition. This excellent book, beautifully illustrated, will be welcomed by all who are interested in California gardening; and it is highly recommended.

[PLANT LIFE LIBRARY, continued on page 72.]

KEY TO THE SUBGENERA, ALLIANCES AND SPECIES OF HYMENOCALLIS

Hamilton P. Traub

I. INTRODUCTION

The genus *Hymenocallis* was founded by Salisbury in 1812 by segregating from the genus *Pancratium* several species native to America. Herbert (1837) recognized the genus *Hymenocallis* (14 species) and related genera *Choretis* Herb. (2 species), *Ismene* Herb. (4 species and 1 hybrid), and *Elisena* Herb. (1 species). Baker (1888) reduced *Choretis* and *Ismene* to the synonymy of an enlarged genus *Hymenocallis* (31 species), but recognized the genus *Elisena* (3 species) as distinct. Sealy (1937) proposed the monotypic genus *Leptochiton** by segregating *Hymenocallis quitoensis* from the subgenus *Ismene*. Velarde (1949) proposed the genus *Pseudostenomesson* (2 species). Recently Sealy (1954) published a valuable revision of what is here recognized as the subgenus *Hymenocallis* of the genus *Hymenocallis,* largely on the basis of the dried specimens in the Kew and British Museum herbaria. On that basis it was not possible for him to fill in the very great gap concerning the *Hymenocallis* species of the southeastern United States, but we are none the less grateful to him for his revision, particularly for the thorough literature search. When no new data are available, Sealy's revision is followed in the key presented here. The key is summarized from the writer's unpublished manuscript of the AMARYLLIDACEAE at the request of members of the SOCIETY. It is presented with special reference to the *Hymenocallis* species of the southeastern United States. It is one of a series to be published by the writer on *Hymenocallis* during the next several years.

In the key, the genera *Leptochiton**, *Elisena, Pseudostenomesson* and *Ismene* have been reduced to the rank of subgenera of the genus *Hymenocallis.* This disposition of the taxa (Fig. 13) is apparently justified on the basis of the morphological characters (see text discussions and the key), the breeding behavior, and the chromosome data (Table 1).

The floral and vegetative characters of the plants included are similar in general outline, with various minor differences of subgeneric and specific importance. This conforms to the Adansonian principle (Adanson, 1763-64; Sneath, 1957) that all of the characters are to be considered in classifying organisms. Thus the classification of the species of *Hymenocallis* is a very difficult task.

In the subgenera *Hymenocallis, Elisena* and *Pseudostenomesson,* the stamens are more or less straight, but in *Ismene* they are incurved. The staminal cup is straight in all subgenera, except in *Elisena,* where it is initially straight but ultimately permanently deflexed at right angles to the ovary and tepaltube. The flowers are held horizontally to suberect, except in *Pseudostenomesson,* in which they are pendulous. These slight differences, together with other slight differences, are used in the key to set the subgenera part.

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* **Leptochiton** was proposed on an untenable basis. In **Hymenocallis** the ovules have central placentation, that is, the ovules are attached at right angles to the length of the ovary in the center in a double row in each cell. When there are 18—20 ovules per cell, as in **H. quitoensis** (syn.- **Leptochiton quitoensis**), they are attached to a relatively long central axis. In the **Henryae Alliance** (of subgenus **Hymenocallis**), for example, where there are 6—9, rarely 4—5, ovules per cell, in a double row, the central axis is somewhat shorter and it is without ovules in the upper part. Finally, in the **Caroliniana Alliance** (of the subgenus **Hymenocallis**), for instance where there are 2, rarely or 3, ovules per cell (opposite each other when there are 2), they are attached at the extreme base of the axis. Thus there is a **quantitative** rather than a qualitative difference involved, and this is not of generic importance. Thus **Leptochiton** (Bot. Mag. Lond. pl. 9491. 1937) has to be abandoned. The difference between **Hymenocallis,** on the one hand, and **Pancratium** and **Pamianthe,** on the other, with reference to ovules, is that in the first they develop into large **fleshy,** green or whitish-greenish seeds, and in the latter two into **hard,** black, angular, or **hard,** black, flat seeds.

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II. MORPHOLOGICAL CONSIDERATIONS

The writer began the intensive study of the *Hymenocallis* species of the southeastern United States in the 1930's. The study was pursued as time permitted over the years. He soon found that this group presented one of the most difficult problems in taxonomy. The floral parts are extremely delicate and the herbarium specimens made by the usual method, which serves well for most plants, and has not been markedly changed over a long period, does give very poor results when applied to *Hymenocallis* unless great care is taken. It was realized that a method had to be devised to preserve the delicate floral parts in a more satisfactory condition. After experimentation, a satisfactory method—drying the delicate parts between a sandwich of *cellulose acetate*—was devised (Traub, 1950; 1951). This proved to be equally applicable to other amaryllids with which he is working. Thus it was possible to attack the problem of the southeastern United States *Hymenocallis* effectively. In addition, it was clear that the plants had to be studied in the living condition whenever practicable, and that descriptions should be made from living material whenever possible.

The studies were started in Florida in the 1930's, where the plants were studied in the wild; and were continued under greenhouse conditions at Beltsville, Maryland, in the 1940's to 1952. From 1952 to 1954, the work was continued at Arcadia, Calif., under greenhouse conditions, and thereafter, up to the present time, the plants have been grown in a frost-free spot on the Pacific Ocean at La Jolla, Calif. Records were made from living plants, and these were then preserved according to the new method. Thus a reliable permanent record was accumulated for later reference.

This project could not have been successfully pursued had it not been for the energy and foresight of Mrs. Mary G. Henry, who first made a comprehensive collection of living *Hymenocallis* species of the southeastern United States beginning in the 1930's. This material was naturalized at the Henry Arboretum, at Gladwyne, Penna. Mrs. Henry generously shared this material with the writer. Mrs. Morris Clint, Brownsville, Texas, and Dr. Thad Howard, San Antonio, Texas, collected *Hymenocallis* species in Mexico, and Miss Caroline Dormon, Saline, La., collected Louisiana *Hymenocallis,* which they shared with the writer. Dr. W. S. Flory, Jr., furnished three *Hymenocallis* bulbs. The writer is most grateful to all of these cooperators who made the study possible.

Unfortunately, in many cases, species of *Hymenocallis* were proposed—Rafinesque, Herbert, Small—often without an adequate knowledge of the group as a whole, and/or with such haphazard descriptions that it is not possible to connect them definitely with even the living plants should they be available. It should be noted that Small (1933) proposed six species. Typical of these is *H. kimballiae* Small, *nom. subnudum* (1933). It is so haphazardly characterized that it has to be ranked as a *nomen subnudum.* It could only be validated if the type could be found at the New York Botanical Garden, or if living material could be had. The type was unavailable, but Mrs. Henry obtained living material from Mrs. *Kimball,* of Mobile, Ala. When this bloomed for the writer in 1955, a new description was made and published, and thus the name was validated (Plant Life 12: 44-46. 1956). However, for purposes of priority, the date of validation (1956) is effective, and not the year 1933. The remaining five species proposed by Small are in the same category. So far none have been validated, but Sealy (1954) has reduced them to the synonymy of various other species.

Method of procedure.—Thus it is clear that a fresh start had to be made on the basis of living material and adequately preserved herbarium specimens. Once various species could be recognized on such a basis, then it would be possible to go back to the published names in order to recognize priority whenever possible. Only later could the dried specimens in the herbaria of the southeastern United States be studied in an attempt to attach the correct names to the plants represented.

The method of procedure was as follows: The characters of the plants as revealed in the descriptions made from living plants, reinforced by the specimens made by the new method, were tabulated. This at once revealed that there was a very wide range in flowering dates—from April to October and later. Thus gene exchange would be effectively blocked in cases of taxa with blooming dates that did not overlap. The first grouping was on that basis. It brought together specimens of several taxa which had to be sorted out on the basis of morphological characrers into tentative 'species'. The whole *Hymenocallis* complex of the southeastern United States had been named 'Caroliniana Alliance', but after the tentative species had been segregated, it was plain that more than one alliance was involved. The ovary of one group was usually globose, rarely somewhat oblongish, with 2, rarely 1 or 3, ovules per cell, and in the other group, the ovary was definitely oblong, rarely somewhat pyriform, with usually 6—9 ovules per cell. Other characters were correlated with these two groups as shown in the key. The first, containing *H. caroliniana* (L.) Herb., was named the CAROLINIANA ALLIANCE, and the second, containing the new species *H. henryae,* was named the HENRYAE ALLIANCE. This further clarified the matters.

The final stage was concerned in definitely defining the species in each of these two alliances. They were given tentative names. The taxa were then checked with descriptions in the literature in order to apply the first valid name for each.

It is obvious that it has not been possible to integrate the *Hymenocallis* specimens in the herbaria in this first report, but this will follow later. A start is being made with the study of the specimens in the U. S. National Herbarium, the Missouri Botanical Garden Herbarium, the Florida Experiment Station Herbarium, the University of Georgia Herbarium, and the Southern Methodist University Herbarium.

Hymenocallis caroliniana.—The writer follows the lead of Sealy (1954) in recognizing the Linnean name *Pancratium carolinianum* (=*Hymenocallis caroliniana* (L.) Herb.) which is based on the account and figure by Catesby in 1731. The plant collected by Howell in Alabama in 1913, that Sealy connected with the name was not represented in the many collections of Mrs. Henry. However, a wide-ranging taxon—from Georgia and Kentucky westward to southern Missouri, Arkansas and Louisiana—was revealed which is apparently the one represented by Catesby's account and figure. This is 4—9-flowered, rarely 3-flowered on young bulbs attached to the mother bulb; tepaltube (5.2—6.2)—6.7—12 cm. long; staminal cup 3.3—4 cm. long; filaments 2.3—3.5 cm. long. The Howell plant—umbel 5—7-flowered; tepaltube 4.5—5.5cm. long; cup 4—4.5 cm. long; filaments 1.3—1.4 cm. long—may be a depauperate specimen of *H. caroliniana* as interpreted here, but the difference in the length of the filaments seems to be rather extreme. For the present, the disposition of the Howell plant will be left open in the hope that it may be found again.

It now remains to indicate briefly the evolutionary trends for the genera *Hyline* and *Hymenocallis.* The comments here will be confined to the 'alliances' of the subgenus *Hymenocallis* of the genus *Hymenocallis*—the subgenera *Elisena, Pseudostenomesson* and *Ismene* have been briefly mentioned above, and are characterized more fully in the key at the end of the paper.

THE GENUS HYLINE

The genus *Hyline* is reported to have no tepaltube, a point which has to be checked in living plants now under cultivation in the writer's garden. *Hyline* is relatively primitive in having many ovules per locule, but as has been indicated above, this is a quantative character and has to be considered with care with reference to generic distinctions. In other respects it is nearest to the species in the Caribaea Alliance (in subgenus *Hymenocallis* of the genus *Hymenocallis*). It is a tropical Brasilian genus requiring much moisture.

GENUS HYMENOCALLIS—SUBGENUS HYMENOCALLIS

I. CARIBAEA ALLIANCE.—These are tropical and subtropical species that require much moisture; distributed in the West Indes, the Mexican Gulf-rim, the northern coast of South America, and some parts of peninsular and western Florida. They have sessile, evergreen leaves, and the floral characters are much alike. The group as shown in the key needs further revision.

II. LITTORALIS ALLIANCE.—This group is apparently an offshoot from the same stock that gave rise to the Caribaea Alliance (Fig. 13). The bases of the tepalsegs are shortly adnate to the base of the staminal cup. There are three ecological groups—one, with evergreen leaves, requires much moisture throughout the year and is confined to the humid Gulf-rim of Mexico and the northern coast of South America—*H. littoralis*—and West Africa—*H. senegambica.* The second group, also with evergreen leaves is found in river beds that may be dry for part of the year—*H. acutifolia.* The third, with deciduous leaves, is found in interior Mexico.—*H. riparia.* This alliance also needs further revision.

III. CAROLINIANA ALLIANCE.—This group has been mentioned above. It is distributed over a very great area having semi- to subtropical conditions in its southern range, and temperate conditions in its northern range. This group is characterized by an evolutionary explosion (see Table 1). At least one species, *H. caroliniana,* is highly variable within limits. The widely varying climatic and

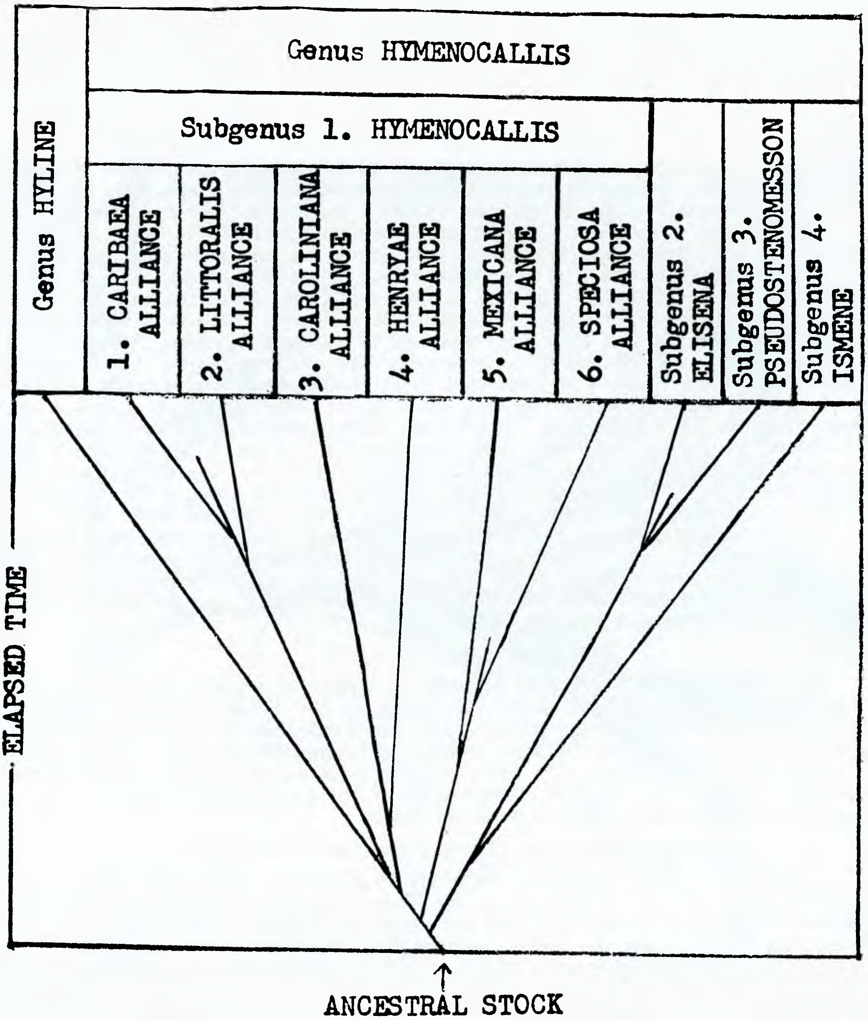

Fig. 13. A generalized diagram to illustrate a postulated phylogeny of the genus *Hyline,* and the infrageneric groups of the genus *Hymenocallis,* with the lineages plotted against time. See text discussion.

soil conditions apparently are factors in the evolutionary process through natural selection. This subject will be discussed under caryological data below. This Alliance has the largest number of species—all with deciduous leaves. Although a fresh start has been made in delimiting the species, this group will be revised further in future reports.

IV. HENRYAE ALLIANCE.—This group is confined to peninsular and west Florida. The species are characterized by the oblong to somewhat pyriform ovary which is correlated with a relatively larger number of ovules as contrasted with a lesser number for the Caroliniana Alliance.

V. MEXICANA ALLIANCE.—This group is characterized by the deciduous, usually broadly-elliptic, elliptic-lorate, etc., sometimes sub-petiolate rarely sub-linear leaves, and is confined to Mexico. It tolerates dry conditions during part of the year, and bloom during the rainy season.

VI. SPECIOSA ALLIANCE.—This group is confined to the West Indies, and the humid coastal Gulf-rim of Mexico and northern South America. They are shade plants which have specialized in distinctively evergreen petiolate leaves.

III. BREEDING BEHAVIOR

This subject can be considered here only briefly for want of space. The species of the Andean section intercross to a considerable extent. *H. narcissiflora* of the Andean section has been crossed with *H. speciosa* of the subgenus *Hymenocallis,* and other crosses of this kind have been reported with other species, but data on flowering is indefinite. Sufficient work has been performed to show that there is potential gene exchange within the genus and that these plants are thus phylogenetically related.

IV. CARYOLOGICAL DATA

Since 1932, reports of the chromosome numbers of *Hymenocallis* species have been published by various authors. These data have never been grouped under infrageneric natural groups and thus their significance has not been fully realized. Now that the infrageneric taxa and the species have been delimited as outlined in the previous sections and the morphological data have been summarized in the key that follows, it is possible to group the available chromosome data according to these taxa and thus to test them (see Table 1).

Chromosome numbers have been reported for all of the subgeneric groups, except for the Henryae Alliance, and the subgenus Pseudostenomesson. The data indicate that the basic chromosome number for the genus as a whole is apparently $x=12$ (as found as a relict example in *H. quitoensis* in the subgenus *Ismene*). From the $2n=24$ level apparently the polyploid numbers of the various species have evolved. This indicates that in *Hymenocallis* not only gene mutations but also polyploidy has been and is an important factor in the evolution of the genus. Once the polyploid level was reached, then apparently secondary basic numbers, $x=20$, 22, 23, 26, 37, have evolved. On the basis of the published data, the *normal* diploid numbers have a very wide range, $2n=24$, 40, 44, 46, 48, 52, 69 and 74, not taking into consideration the variation in *somatic* numbers which again cover a wide range. This great variability is evidence that the genus *Hymenocallis* as a whole has, and is, undergoing marked evolutionary change. This is also indicated by the necessity of recognizing six alliances under the subgenus *Hymenocallis.* As indicated previously, there has been an evolutionary explosion—as shown by the morphological characters—in the Caroliniana Alliance, and this is borne out also by the chromosome data which show a wide range—$2n=40$, 44, 52 and 69. However, this evolutionary process, as shown by the chromosome data, has not been equally intense for all Alliances. There is relative uniformity—$2n=46$—in the reported numbers for the Speciosa Alliance. There apparently gene mutation is now the more important factor in evolution.

Dr. W. S. Flory, Jr., and his associates at Blandy Experimental Farm, University of Virginia, have been studying the chromosomes of the same material used by the writer whenever possible, and they will report their findings in a separate paper.

Table 1. Catalog of Chromosome Numbers—Genera **Hyline** and **Hymenocallis.**

Genus, subgenus and species	Normal somatic number (2n)	Variation in somatic number (2n)	Authority (See Literature cited)
Genus **Hyline,** x= 10			
Hy. gardneriana	20		Mookerjea, 1955
Genus **Hymenocallis,** x= 12,* 20,** 22,** 23,** 26,** 37**			
Subgenus 1. **Hymenocallis,** x= 12, 20, 22, 23, 26			
1. **Caribaea Alliance,** x= 12			
H. caribaea (type)			
H. pedalis (as senegambica)	48	50,68	Sharma & Bal, 1956
2. **Littoralis Alliance,** x= 22, 23			
H. littoralis (type)	46		Sato, 1938
	44	11,46	Sharma & Bal, 1956
3. **Caroliniana Alliance,** x= 20, 22, 26			
H. caroliniana (type)			
H. galvestonensis	52		Flory, 1939
H. rotata	40		Nagao et al, 1932
	44		Sharma & Bal, 1956
(as **H. lacera** ***)	69	46	Sato, 1938
4. **Henryae Alliance,** x= ?			
H. henryae (type)			
5. **Mexicana Alliance,** x= 22			
H. mexicana (type) (as **H. concinna**)	?	54,58,76,88	Sharma & Bal, 1956
H. harrisiana	44	22 + f, 30, 76, 88, 92	Sharma & Bal, 1956
6. **Speciosa Alliance,** x= 23			
H. speciosa (type)	46		Sato, 1938
(as Pancratium speciosum)	46		Inariyama, 1937
H. macrostephana	46	92	Snoad, 1955
Subgenus 2. **Pseudostenomesson,** x= ?			
H. morrisonii (type)			
Subgenus 3. **Elisena,** x= 23			
H. longipetala (type)	46		Snoad, 1952
Subgenus 4. **Ismene,** x= 12, 23, 37			
H. quitoensis (as **Leptochiton**)	24		Snoad, 1952
H. amancaes	46		Snoad, 1955
H. narcissiflora (as **H. calathina**)	74	24,49,62,63, 64,76,77...	Mookerjea, 1955
		86—23(?).	Snoad, 1955
H. x spofforthiae			
clone 'Sulphur Queen'	74	37,59,63...	Mookerjea, 1955
clone 'Daphne'	44	42,54,59, 66,72,98...	Sharma & Bal, 1956

* The basic number for the entire genus is x=12.
** Secondary basic numbers due to further evolution within the genus.
*** The nomenclature of this entry is in doubt.

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KEY TO THE SUBGENERA, ALLIANCES AND SPECIES OF THE GENUS **HYMENOCALLIS**

Abbreviations: leaves—**lvs;** flowered—**fld;** tepaltube—**tube;** telpalsegs—**segs;** staminal cup—**cup;** filaments—**fils.**

1a. Stamens more or less straight:
2a. Flowers not pendulous:
3a. Cup not deflexed:

Subgenus I. **HYMENOCALLIS**

4a. Lvs sessile; never with well-developed petiole; at most sub-petiolate in Mexicana Alliance, below, and then usually variable on the same plant:

5a. Leaves **not** narrowly or broadly elliptic, or broadly oblanceolate, or sub-petiolate:

6a. Anthers extrorse, versatile; lvs usually evergreen, rarely deciduous; suboblong, or broad oblong-sword-shaped or oblong oblanceolate or sword-shaped; apex acute or obtuse or rounded; tapering downwards below the middle to the lorate basal part; 2—10.6 cm. wide at the greatest width:

7a. Segs not shortly adnate to the base of the cup; lvs 3.5—10.6 cm. wide . . .. I. **CARIBAEA ALLIANCE**

8a. Lvs rounded at the apex: Lvs 4—5.5 cm. wide; 4—13-fld; tube (4.5)—6.5—9 cm. long; segs 8—11 cm. long; cup 3—3.5 cm. long; fils (3.5—4)—4.5—6 cm. long; ovules 2 per cell (W. I.) . . .. 1. **arenicola**

8b. Lvs acute or obtuse at the apex:

9a. Tube 4.5—6.5 cm. long: Lvs 5—7.5—(10) cm. wide; 8—10- or more fld; segs (8)—9—11—(12) cm. long; cup funnel-shaped, margins erect, 2—3 cm. long; 2 ovules per cell (W. I.) .... 2. **caribaea**

9b. Tube 8—22 cm. long:

10a. Tube as long as or shorter than the segs; **except** 12b **H. expansa** var **dominicensis:**

11a. Ovules 6, sometimes 4—5 per cell; fils 6—6.8 cm. long: Lvs 6—10.6 cm. wide; 8—(12?)-fld; tube 8.7—12.2 cm. long; segs 11.2—12 cm. long; cup funnel-shaped, narrow, tubulose below, 2—2.5 cm. long; Oct.—Nov.—Dec. — flowering (w. Fla.) . . .. 3. **kimballiae**

11b. Ovules 2, rarely 3, per cell . . .. 4. **expansa**

12a. Fils 4.5—6 cm. long; 10—20-fld: Lvs 3.8—7.5 cm. wide; tube 8—10.6 cm. long; segs 9—14.5 cm. long; cup 2.5—3.5 cm. long, tubulose below, funnel-shaped above, margins erect (W. I.) . . 4a. **expansa** var. **expansa**

12b. Fils 3—3.3 cm. long; 3-fld: Tube 9—10 cm. long; segs 7—7.5 cm. long; cup 2.2—2.3 cm. long (W. I.—Dominica) . . . . 4b. **expansa** var. **dominicensis**

10b. Tube longer than the segs **(see also 12b, above):**

13a. Cup less than 2 cm. long: Lvs 5.5—6.4 cm. wide; 9—16-fld; tube 10—14 cm. long; segs very narrow 8—11 cm. long; fils 4.5—5 cm. long; ovules 4, sometimes 3 or 5 per cell; (Guat.) . . 5. **tenuiflora**

13b. Cup more than 2 cm. long:

14a. Tube 10—15 cm. long; ovules 2 per cell: Lvs 4.5—10 cm. long; 6—10 fld; segs 9—14 cm. long; cup funnel-shaped, margins spreading, 2—3 cm. long; fils 4—6 cm. long (Fla. and W. I.) . . . . 6. **latifolia**

14b. Tube 14.5—22.5 cm. long; ovules 4—6 per cell: Lvs. 3.5—7.5 cm. wide; 5—14-or more -fld; segs 10—15 cm. long; cup 2.5—3.5 cm. long; fils 5—6 cm. long . . . . 7. **pedalis**

15a. Leaves not variegated (So. Amer) . 7a. **pedalis** var. **pedalis**

15b. Leaves variegated (cult.) . . . . 7b. **pedalis** var. **variegata**

7b. Segs shortly adnate to the base of the cup; lvs 1.4—7.4 cm. wide . II. **LITTORALIS ALLIANCE**

16a. Tube 17.5—20 cm. long, or 14—17 cm. long: Lvs 2—3.8 cm. wide; 5—11-fld; segs 7.5—8—9—11, rarely 12—12.5 cm. long; cup funnel-shaped, margins wide-spreading-rotate, 2—3—3.5 cm. long; fils 4—6 cm. long; ovules 4—5, sometimes 8, per cell (Colombia, Guiana and Mexico) . 8. **littoralis**

16b. Tube 7.5—14.8-fld:

17a. Sept.-Oct.flowering species:

18a. Leaves lighter green (yellowish-green): Lvs narrowly to broadly lorate-lanceolate, apex acute, 40—61 cm. long, 2.7—7.4 cm. wide; or oblanceolate, apex bluntly acute, 41—60 cm. long, 5—5.5 cm. wide; 6—9-fld; tube 9.8—14.8 cm. long; segs 9.5—11.8 cm. long; cup 2.5—3.3 cm. long; fils 4.5—5.8 cm. long; ovules 5—6 per cell (Mexico—State of Vera Cruz). . . . . 9. **dryandri**

18b. Leaves deeper green:

19a. Lvs lorate-lanceolate, narrowing below, acute, 43—73 cm. long, 2.5—4 cm. wide; 9-fld; tube 12.2—13.5 cm. long; segs 10.5—10.8 cm. long; cup 2.7—3.5 cm. long; fils 5.5—5.6 cm. long; ovules 5—7, sometimes 4 or 8—10 per cell; (west Africa) . . . . 10. **senegambica**

19b. Lvs linear-lorate, acute, 30—62 cm. long; 1.4—2.1 cm. wide; 3—6-fld; tube 7.5—12 cm. long; segs 8.5—12 cm. long; cup 2.3—3.5—(4?) cm. long; fils 4—6 cm. long; ovules 4—6, sometimes 8, per cell (Mexico) . . . . 11. **acutifolia**

17b. June—July flowering species: Lvs linear-lorate, with translucent margin; 37—56 cm. long; 1.9 cm. wide; 4—7-fld; tube 10—12 cm. long; segs 10.8—11 cm. long; cup 2.6 cm. long; fils 5—5.2 cm. long; ovules 4 per locule (Mexico) . . . . 12. **riparia**

6b. Anthers introrse, ± erect at anthesis, not versatile. Lvs deciduous, linear or linear-lorate to broadly lorate, or ensiform, or oblanceolate, shortly narrowed to the obtuse apex, slightly tapered to the base, or tapered below the middle and noticeably narrowed in lower part, or rarely long-oblong, biflabellately arranged; (0.8)-1.3-4.6 cm. wide at the greatest width:

20a. Ovary globose, rarely somewhat oblongish; ovules 1—2, rarely 3 (in one sp. 4—5) per cell:

III. **CAROLINIANA ALLIANCE**

21a. May-June-July flowering species:

22a. Fils 1.3—1.4 cm. long; tube 4.5—5.5 cm. long: Lvs 1.3—1.7 cm. wide; 5—7-fld; segs 7—8 cm. long; cup

4—4.5 cm. long; fils 1.3—1.4 cm. long; ovules 2 per cell (Alabama) See A. H. Howell, 1913, specimens (BM,K) . . . . 13. **sp.**

22b. Fils 1.8—3.5 cm. long; tube 5—12 cm. long:

23a. Cup funnel-shaped, 5.5 cm. long; May flowering: Lvs 2.3—2.8 cm. wide; 4-fld; tube 8—8.2 cm. long; segs 9.6—10.5 cm. long; fils 2.1 cm. long; ovules 2 per cell (Georgia . . . . 14. **coronaria**

23b. Cup 2—4 cm. long:

24a. Umbel 2— or more-fld; June-July flowering; spathe functional:

25a. Fils 1.8—1.9 cm. long: Lvs 1.3—1.5 cm. wide; 4—7-fld; tube 5—7 cm. long; segs 6.5—7.5—8—9 cm. long; cup (2)-2.5—3.5 cm. long; ovules 2 per cell (Texas, Louisiana, Oklahoma, and Arkansas) . . . . 15. **galvestonensis**

25b. Fils 2.3—3.5 cm. long:

26a. Scape 39—54 cm. tall: Lvs 1.8—4.2 cm. wide; 4—9-fld, rarely 3-fld on young bulbs attached to mother bulbs; tube (5.2—6.2)—6.7—12 cm. long; segs (5—7) 7.4 — 10.3 cm. long; cup 3.3—4 cm. long; fils 2.3—3.5 cm. long; ovules 2, rarely 1 per cell (s. e. USA, Georgia and Kentucky westward to so. Missouri, Arkansas and Louisiana) . . . . 16. **caroliniana**

26b. Scape 22—30 cm. tall:

27a. Umbel 2-fld; lvs **not** long-oblong, 16—19.7 cm. long, 1.7—2 cm. wide; 2-fld; tube 8—9.3 cm. long; segs 9.2—9.4 cm. long; cup 3.1—3.3 cm. long; fils 2.4—2.9 cm. long (Georgia and South Carolina) . . . . . 17. **rotata**

27b. Umbel 4—6-fld; lvs long-oblong, biflabellately arranged, 22 cm. long, 3.7 cm. wide; tube (5.4)

—8—8.2 cm. long; segs 10.2—10.5 cm. long; cup 3.1—3.2 cm. long; fils 2.4 cm. long; ovules 2—3 per cell (w. Florida) . 18. **choctawensis**

24b. Umbel 1-fld; spathe non-functional: Lvs 1.5—1.6 cm. wide; tube 6 cm. long; segs 6.5 cm. long; cup 2.7 cm. long; fils 3.1 cm. long; ovules 2 per cell (South Carolina) . . . . 19. **pymaea**

21b. Late July-August and later flowering species:

28a. Ovules 2, rarely 1 or 3, per cell; segs 0.7—1.3 cm. wide:

29a. Fils 2.6 — 3.1 — 3.7 cm. long; cup 3.1—3.8 cm. long; segs 0.7—1 cm. wide:
Lvs 2.3—3.2 cm. wide; 6—9-fld, sometimes 3—5-fld; tube 8.2—11.8 cm. long; segs 8.1—10.7 cm. long; ovules 1—2, rarely 3, per cell; Aug.-flowering (Texas and Louisiana) . . 20. **eulae**

29b. Fils 4.2—5 cm. long; cup 3.8—4.2 cm. long; segs 0.8—1.3 cm. wide:
Lvs 4—4.2 cm. wide; 7—8-fld; tube 9.3—10.5 cm. long; segs 11.5—14 cm. long; ovules 2—3 per cell; late July-Aug. flowering (Georgia) . . . . 21. **moldenkiana**

28b. Ovules 4—5 per cell; segs 0.5—0.7 cm. wide:
Lvs 2.1—2.4 cm. wide; 5-fld; tube 8.6 cm. long; segs 8.6—9.1 cm. long; cup funnel-shaped, margins not incised, 3.3—3.5 cm. long; fils 2.9 cm. long; (North Carolina) . . . . 22. **palusvirensis**

20b. Ovary oblong or somewhat pyriform; (1.4)—1.8—2.5 cm. long; ovules 6—9, rarely 3—5, per cell:

IV. **HENRYAE ALLIANCE**

29a. Umbel 4—7-fld:
Lvs (0.7)-1.1—1.8—2.8 cm. wide; tube 7—11—12.8 cm. long; segs 6.5—8.5—9 cm. long; cup 2—2.5 cm. long; fils 3—3.5 cm. long; ovules 4—5, sometimes 8, per cell (Cuba—Santa Clara Province) . . . . . . 23. **praticola**

29b. Umbel usually 1—3-fld, rarely up to 4-fld:

30a. Cup 4.5—5.2 cm. long; umbel 2-fld, sometimes 3—4-fld under cult.:
Lvs 1.3—2.6 cm. wide; tube

7.7—9 cm. long; segs 8.7—10.2 cm. long; fils 2.2—3.1 cm. long; ovules 6, rarely 4—5 per cell (peninsular Florida) . . . . 24. **floridana**

30b. Cup 1.6—3.8 cm. long; umbel 1—3-fld:

31a. Umbel 3-fld:

32a. Cup 3.4 cm. long, subrotate above, shortly tubulose below:
Lvs 1.2—1.7 cm. wide; tube 9.5 cm. long; segs 9.6—10.6 cm. long; fils 3.1 cm. long; ovules 7—8 per cell; late July-flowering (w. Florida) . 25. **henryae**

nel-shaped, margins erect.
32b. Cup 2.2 cm. long, fun-
Lvs 2.1—3.1 cm. wide; tube 7.5—8.2 cm. long; segs 9.8—10.8 cm. long; fils 3.1—4 cm. long: ovules 8 per cell; late Aug.-Sept. flowering (s. peninsular Florida) . . 26. **puntagordensis**

31b. Umbel 1-fld:

33a. Lvs 5—7—8—10 mm wide; spathe non-functional: tube (6.4)—9—9.4 cm. long; segs 8.5—11.5 cm. long; cup 3—3.8 cm. long; fils 2.6—3.4 cm. long; ovules 8—9, 3—4 in depauperate plants (peninsular Florida) . . . . 27. **palmeri**

33b. Lvs 4 mm wide; tube 3—3.5 cm. long; segs 5 cm. long; cup 1.6—1.7 cm. long; fils 2—2.5 cm. long; ovary oblong (number of ovules per cell unknown) (e. coastal Florida) . . . . . 28. **humilis**

5b. Lvs deciduous, sub-linear bluntly acute, or broadly-elliptic, shortly acuminate, cuneate at the base, or elliptic-lorate, obtuse, or oblanceolate, bluntly acute, or suboblong, apex obtuse, or oblong-elliptic, or oblong-ensiform, acute; tapering to a sub-petiolate base; (subpetiolate leaves are not constant and may be produced on the same plant with other types; or may appear in different years); ovules usually 2, rarely 3, per cell:
IV. **MEXICANA ALLIANCE**

34a. Lvs **not** sub-linear; or linear lanceolate:

35a. Tube straight, usually 10—15 cm., rarely 5 cm. long:

36a. Cup 2.5—3 cm. long:

37a. Cup funnel-shaped, 2.7—3 cm. long; Lvs 7.5—9 cm. wide; 4—5-fld; tube 10 cm. long; segs 6.5—7.5 cm. long; fils 2.5—3 cm. long (Mexico) 29. **eucharidifolia**

37b. Cup rotate from a tubulose base:

38a. Leaves broad-elliptic or elliptic-lorate; cup 2.7—3 cm. long . . . . 30. **choretis**

39a. Lvs 6.2—8 cm. wide; 2—4-fld; tube 14—15 cm. long; segs 7—9 cm. long; fils 2.5—3.5 cm. long (Mexico) . . . . 30a. **choretis** var. **choretis**

39b. Tube 5 cm. long; segs subequaling it in length (Mexico—Oaxaca) . . . . 30b. **choretis** var. **oahacensis**

38b. Lvs oblanceolate, bluntly acute or bluntly and widely cuspidate, long tapered downward; cup 2.5 cm. long: 1—4-fld; tube 11.5—14 cm. long; segs 8 cm. long; fils 3 cm. long (Mexico) . . . . 31. **horsmannii**

36b. Cup 1.3—1.8 cm. long: Lvs 3—5.1 cm. wide; 1—6-fld; tube funnel-shaped, margins spreading, 10—13 cm. long; segs 6—7.5 cm. long; fils 2.5—3.5 cm. long (Mexico) . . . . . 32. **harrisiana**

35b. Tube curved, 3.5—5 cm. long: Lvs 2—3.7 cm. wide (4.6 cm. wide in cult.); 2—8-fld; segs 5.5—6.7 cm. long; cup funnel-shaped, 1.5—2 cm. long; fils 2—3 cm. long (Mexico) . . . . 33. **mexicana**

34b. Leaves sub-linear (almost linear); or linear-lanceolate:

40a. Tube 10 cm. long; lvs 6—12 cm. wide; 3—4-fld; segs 6.5—8 cm. long; cup 2 cm. long; fils 3 cm. long (Mexico—Sonora) . . . . 34. **sonorensis**

40b. Tube 3.5—4 cm. long; lvs 6—8 cm. wide; 1—4-fld; segs 6.5—7 cm. long; cup 3—3.2 cm. long; fils 2 cm. long (Mexico—Morelos)) . . . . 35. **graminifolia**

4b. Lvs with a well-developed petiole; ovules 1 or 2 per cell:

V. **SPECIOSA ALLIANCE**

41a. Leaf-blades broad elliptic or broad-oblong-elliptic, wedge-shaped at the base:

42a. Tube 12.5—20 cm. long (n. So. Amer. & Trinidad) . . . . 36. **tubiflora**

42b. Tube 3—5.5 cm. long or 9.5—10 cm. long:

43a. Cup deeply cleft between the fils, often almost to the base (Brasil ?) . . . . 37. **schizostephana**

43b. Cup toothed but not cleft downwards:

  44a. Leaf blades very broad-elliptic, about twice as long as broad, 10.5—30 cm. long; 4—15 cm. wide:

    45a. Tube 3—5.5 cm. long; fils 3.5—4 cm. long; leaf-blades 15.5—30 cm. long, 7.5—15 cm. wide (W. I.) ....38. **ovata**

    45b. Tube 5—7 cm. long; fils 2.8—3 cm. long:

      46a. Leaf-blades 10.5 cm. long; 4 cm. wide (W. I.)......38a. **ovata** var. **ovalifolia**

      46b. Leaf-blades 18—23 cm. long, 7.5—12.5 cm. wide (Guat.) . . ..38b. **ovata** var. **ornata**

  44b. Leaf-blades elliptic or oblong-elliptic, three to five times as long as broad, 26—65.5 cm. long, 6.3—15.5 cm. wide:

    47a. Leaf-blades 32—33 cm. long, 6.3—8 cm. wide; petioles 6—7 cm. long (W. I.—Barbados) . . . 39. **fragrans**

    47b. Leaf-blades 26 — 65.5 cm. long, 8—15.5 cm. wide; petioles 9—30 cm. long (W. I. and Mexico) . ...40. **speciosa**

41b. Leaf-blades ovate, cordate at the base (Mexico) . ...41. **cordifolia**

3b. Cup at first straight, but finally permanently deflexed at right angles with the tube and ovary:

Subgenus II. **ELISENA** (Herb.) McBride

48a. Segs 10 cm. long:

  49a. Stamens criss-cross: hybrid—**H. narcissiflora** x **H. longipetala** .....42. **x festalis**

  49b. All stamens straight (Peru and Ecuador) . ...43. **longipetala**

48b. Segs 3.8—5 cm. long; fils 1.3—3.2 cm. long:

  50a. Tube 2 cm. long (Peru).........44. **ringens**

  50b. Tube under 1.3 cm. long:

    51a. Pedicels 6 mm long; segs 7.4 cm. long; fils 5.2 cm. long (Peru) . . ..45. **velardei**

    51b. Pedicels 1.3—2 cm. long; segs 5 cm. long; fils 1.3 cm. long (Peru) . . ..46. **sublimis**

2b. Flowers pendulous; relatively small:

Subgenus III. **PSEUDOSTENOMESSON** (Velarde) Traub

52a. Flowers whitish-green . . ..47. **morrisonii**

52b. Flowers green . . ..48. **vargasii**

1b. Stamens incurved:

Subgenus IV. **ISMENE** (Salisb.) Baker ex Traub

53a. Umbel 1-flowered; leaves sessile, deciduous . . ..Section 1. **Quitoensae**

Ovules 18—20 per cell, (Ecuador) ......49. **quitoensis**

53b. Umbel more than 1-fld; leaves attached to an aerial deciduous pseudostem; ovules 2—6 per cell ....Section 2. **Narcissiflorae**

54a. Tube greenish-yellow, rest of flower yellow or sulfur-colored:

55a. Flowers yellow (Peru) . . ..50. **amancaes**

56a. Cup not cleft into lobes; scent agreeable (Peru) . ...50a. **amancaes** var. **amancaes**

56b. Cup cleft into lobes, scent unpleasant (Peru) . . ..50b. **amancaes** var. **foetida**

55b. Flowers sulfur-colored: hybrid—**H. narcissiflora** x **H. Amancaes** ....51. **x spofforthiae**

54b. Flowers white or greenish-white:

57a. Tube straight:

58a. Tube 7.6—10 cm. long:

59a. Pedicels very short; fils arcuate-incurved, 2.5 cm. long; hybrid—**H. speciosa** x **H. narcissiflora**....52. **x macrostephana**

59b. Ovary sessile; fils abruptly incurved, 1.3 cm. long (Peru and Bolivia) . . ..53. **narcissiflora**

58b. Tube 3.8—5 cm. long:
Ovary sessile or flowers pedicellate; fils 1.3 cm. long (Peru)....54. **macleana**

57b. Tube curved:
60a. Segs 7.6—10 cm. long; flowers white (Peru) . ...55. **deflexa**

60b. Segs 5 cm. long; tube green, segs white (Andes) . . ..56. **nutans**

Descr. ampl. et spp. nov.

Cited specimens greenhouse grown at Beltsville, Md., are marked with an asterisk (*); those greenhouse grown at Arcadia, Calif., are marked with two asterisks (**); and those grown outdoors, La Jolla, Calif., are marked with three asterisks (***). Cited specimens not so marked were collected in the wild.

3. **Hymenocallis kimballiae** Small ex Traub, plant Life **14:** 44-46. 1958. Syn.- **H. kimballiae** Small, S. E. Flora, 323, 1053, 1933, **nom. subnudum.** Specimen: **Traub** ***523a+b** (TRA), Estuary, Appalachicola River, west Florida; from bulbs collected by Mrs. Kimball, via Mrs. Mary G. Henry.

9. **Hymenocallis dryandri** (Ker.-Gawl.) Sweet, Hort. Brit. ed. 2. p. 513. 1830. Syn.- **Pancratium dryandri** Ker-Gawl. Genus Pancratium (Quart. J. Sc. & Arts **3:** 326) 11. (1817). Specimens: **Traub** *****893a+b+c; *****894a+b; *****701a+b; *****657a+b; *****658a+b** (TRA); from bulbs collected by Otto Nagel in 1955, on or near the shore of Lago de Catemaco, State of Vera Cruz, Mex. r'c'd via Mrs. Morris Clint.

10. **Hymenocallis senegambica** Kunth & Bouché, In. Sem. Hort. Berol. 1848, p. 12, pro parte. Kunth, Enum. Pl. 5: 676. 1850, pro parte. Specimens: **Traub** ***591a+b** (cult.); ***662a+b** (cult.) ***663a+b** (cult.) (TRA). All r'c'd from cultivation.

12. **Hymenocallis riparia** Greenm., in Proc. Am. Acad. **41:** 235. 1906. Specimens: **Traub *****895; *****696a+b,** from bulbs collected by Mrs. Morris Clint, State of Michoacan, Mex.

14. **Hymenocallis coronaria** (Le Conte) Kunth, **descr. ampl.** Enum. Pl. **5:** 855. 1850. Syn- **Pancratium coronarium** Le Conte, in Ann. Lyceum Nat. Hist. New York **3:** 145, t. 4, figs. 7—9. 1836. Specimens: **Traub *284a+b+c; *285** (TRA), from bulbs collected by Scott on Savannah River, in Georgia, r'c'd via Dr. Flory.

Foliis anguste oblanceolatis 35—56 cm. longis, 2.3—2.8 cm. latis; scapo 38 cm. longo; spatha lanceolata 6 cm. longa; umbella 4-flora; floribus albis; ovario sessili globoso 1.2 cm. longo; ovulis in quoque loculo 3; tubo tepalorum 8—8.2 cm. longo; segmentis tepalorum 9.6—10.5 cm. longis; poculo staminorum infundibulariformi 5.5 cm. longo; filamentis 2.1 cm. longis; antheris introrsis.

15. **Hymenocallis galvestonensis** (Herb.) Baker, Amaryll. 126. 1888. Syn- **Choretis galvestonensis** Herb., Amaryll. 221, pl. 41, figs. 34,35. 1837; **Hymenocallis liriosme** Raf. ex Shinners, Field & Lab. 19: 102—103. 1951. Specimens: Traub ****286,** Houma, La. (TRA); Caroline Dormon **882,** Prairieville, La. (TRA); **884,** Lake, La. (TRA); Whitehouse **12,144,** Wharton Co., Tex. (SMU); V. L. Cory **56,020,** Red River Co., Tex. (SMU); Fred B. Jones, **1189,** Regugio Co., Tex. (SMU); L. H. Shinners, **19,442,** Austin Co., Tex. (SMU); John H. Loring, **70,** McCurtain Co., Okla. (SMU); Delzie Demaree, **24,343,** Drew Co., Ark. (SMU).

16. **Hymenocallis caroliniana** (L.) Herb., **descr. ampl.** Herbert, App. 44. 1821; Sweet, Hort. Brit. ed. 2. p. 513. 1830. Syn- **Pancratium carolinianum** L. Sp. Pl. **1:** 291. 1753; Miller, Gard. Dict. ed. 8, no. 6. 1768; Walter, Fl. Carol. 120. 1788; Ker(-Gawl). Rev. Genus Pancratium, 4 (Quart. J. Sc. & Arts, **3:** 319). 1817, quoad syn.; **Pancratium maritimum** L. sec. Purch, Fl. Amer. Septentr. **1:** 222. 1814; Elliott, Sketch Bot. South-Carolina & Georgia, **1:** 383. 1817; **non** L.; **Pancratium occidentale** Le Conte, in Am. Lyceum Nat. Hist. New York, **3:** 146. 1836. **Hymenocallis occidentalis** (Le Conte) Kunth, Enum. Pl. 5: 856. 1850.

Foliis 6—12 anguste oblanceolatis usque oblanceolatis infra angustatis raro elliptico-loratis obtuse acutis 25—43 cm. longis, 1.8—4 cm. latis; scapo 34—54 cm. alto; spatha lineari-lanceolata usque lanceolata acuta vel obtuse acuta vel subtruncate acuta 3.7—6 cm. longa; umbella 3—9 flora; floribus suavaviter fragrantibus; tubo tepalorum pallide subviridi, cetero floris albo; ovario sessili globoso; ovulis in quoque loculo 2 raro 1; tubo tepalorum 5.8—10 cm. longo; segmentis tepalorum 7.4—10 cm. longis; poculo staminorum 3.3—4 cm. longo superne infundibulariformi usque cupuliformi, inferne brevitubuloso, marginibus inter filamenta irregulariter incisis; filamentis 2.3—3.5 cm. longis; antheris introrsis erectis; granulis pollinis flavis; stylo stamina excedenti; stigmate minuto.

Specimens:—GEORGIA: Bibb County, near Stratton Sta., **Traub *264; *265a+b+c** (TRA). ALABAMA: Conecuh County, s. w. Evergeen, **Traub *238a+b+c; *241; *243** (TRA); Butler County, n. McKenzie, **Traub *257, *258a+b, *259, *260** (TRA). MISSISSIPPI: Tunica County, n. Clarksdale, **Traub *273, *274, *275a+b, *277** (TRA). LOUISIANA: Avoyelles Parish, near Bunkie, Caroline Dormon, **883** (TRA). KENTUCKY: Mammoth Cave, **Traub *244a+b** (TRA). INDIANA: Spencer County, s.e. of Hatfield, **Traub *233, *234a+b+c** (TRA). All from bulbs collected by Mrs. Mary G. Henry, except the Caroline Dormon specimen.

17. **Hymenocallis rotata** (Ker-Gawl.) Herb. **descr. ampl.** Herb. App. 44. 1821; Amaryll. 217. 1837. Syn- **Pancratium rotatum** Ker-Gawl., in Bot. Mag. Lond. pl. 827. 1805; Genus Pancratium (in Quart. J. Sc. & Arts **3:** 327) 12. 1817; **Pancratium mexicanum** Le Conte, in Ann. Lyceum Nat. Hist. New York **3:** 143, pl. 4, figs. 1—3. 1836, **non** L.; **Pancratium rotatum** var. **biflorum** Ker-Gawl., in Bot. Mag. Lond. pl. 1082. 1808. Specimens: Traub ***250a+b,** Marion Co., S. C.; ***281,** Baxley, Ga. (TRA); all from bulbs collected by Mrs. Mary G. Henry.

Foliis lanceolatis usque oblanceolatis 16—30 cm. longis, 1.7—2 cm. latis; scapo 27—30 cm. longo; spatha lanceolata 2.5—3.2 cm. longa; umbella biflora interdum in statu culto 3—4-flora; floribus albis; ovario sessili globoso 1—1.4 cm. longo; ovulis in quoque loculo 2 vel 3; tubo tepalorum 8—9.3 cm. longo; segmentis tepalorum 9.2—9.4 cm. longis; poculo staminorum rotato 3.1—3.3 cm. longo; filamentis 2.4—2.9 cm. longis; antheris introrsis.

18. **Hymenocallis choctawensis** Traub, **sp. nov.** Specimens: Traub ***262; 263a+b,** holotype (TRA), Walton Co., Fla. From bulbs collected by Mrs. Mary G. Henry.

Foliis loratis 24 cm. longis, 3.7 cm. latis, biflabellatis; scapo 22 cm. longo; spatha 3.6 cm. longa; umbella 4—6-flora; ovario sessili globoso 1.2 cm. longo; ovulis in quoque loculo 2 vel 3; tubo teparlorum 5.2—8.2 cm. longo; segmentis tepalorum 9.2—10.3 cm. longis; poculo staminorum rotato 3.1—3.2 cm. longo; filamentis 2.7—3.2 cm. longis; antheris introrsis.

19. **Hymenocallis pygmaea** Traub, **sp. nov.**

Foliis elliptico-oblanceolatis usque anguste oblanceolatis 15—22 cm. longis, 1.5—1.6 cm. latis, apice obtuse acutis; scapo 14.7 cm. longo; spatha bivalvata 2.3 cm. longa rudimentaria inutili; umbella uniflora; flora recto; paulo fragranti; tubo tepalorum parteque superiore tertia styli viridibus, cetero floris albo; ovario sessili globoso, ovulis in quoque loculo 2; tubo tepalorum 6 cm. longo; segmentis tepalorum 6.5 cm. longis; poculo staminorum 2.7 cm. longo, superne rotato, inferne brevitubuloso; filamentis 2 cm. longis; antheris introrsis 1.2 cm. longis; granulis pollinis flavis.

Specimen: Traub ***279**, holotype (TRA), Horry Co., S. C. From bulbs collected by Mrs. Mary G. Henry.

20. **Hymenocallis eulae** Shinners, **descr. ampl.** Shinners, Field & Lab. 19: 103. 1951.

Specimens: Whitehouse, **16,448** (holotype), cult. van Zandt Co., Tex. (SMU & TRA); Traub ***268a+b**, Clarksville, Tex. (TRA); grown from bulbs collected by Mrs. Mary G. Henry; *****876a+b**, Ringold, La. (TRA), from bulbs collected by Caroline Dormon; Caroline Dormon **886**, Castor, La. (TRA).

Foliis deciduis oblanceolatis 18—33 cm. longis, 2.3—3.2 cm. latis; scapo in Augusto-Septembri emergenti 64—75 cm. longo; spatha lanceolata 3.2—4 cm. longa; umbella (3—)6—9-flora; floribus albis fragrantibus; ovario sessili globoso 1.1 cm. longo; ovulis in quoque loculo 1 vel 2, raro 3; tubo tepalorum 8.2—12 cm. longo, segmentis 8.2—10.8 cm. longis; poculo staminorum 3.1—3.4 cm. longo; filamentis 3.1—3.8 cm. longis; antheris introrsis.

21. **Hymenocallis moldenkiana** Traub, **sp. nov.**

Specimens: Traub ***271a+b; *272a+b**, holotype, (TRA), Appling Co., Ga.; from bulbs collected by Mrs. Mary G. Henry.

Foliis 14—17 oblanceolatis 42—45 cm. longis, 3.8—4.2 cm. latis, usque ad basin angustatis, apice obtuse acutis; scapo 56 cm. longo; spatha 2-valvata lanceolata acuta 5—5.5 cm. longa; umbella 7—8-flora, floribus 6 ab initio eadem tempestate florentibus albis fragrantibus; ovario sessili globoso 1.1—1.4 cm. longo, 0.8—1cm. diametro; ovulis in quoque loculo 2 vel 3; tubo tepalorum 9.3—10.5 cm. longo, 6—7 mm. diametro, segmentis lanceolatis; segmentis setepalorum 12—14 cm. longis, 0.8—1 cm. latis, segmentis petepalorum 11.5—13 cm. longis, 1.1—1.3 cm. latis; poculo staminorum lato superne infundibulariformi, inferne brevitubuloso, 3.8—4.2 cm. longo, margine irregulariter inciso; filamentis 4.2—5 cm. longis. Named in honor of the well-known plant scientist, Dr. Harold N. Moldenke.

22. **Hymenocallis palusvirensis** Traub, **sp. nov.**

Specimens: ***251a+b+c**, holotype (TRA), Brunswick Co., N. C., from bulbs collected by Mrs. Mary G. Henry.

Foliis lineari-lanceolatis 38—47 cm. longis, 2.1—2.4 cm. latis; scapo 40 cm. longo; spatha lanceolata 3.8 cm. longa; umbella 5-flora; floribus albis; ovario sessili globoso 1.1 cm. longo; ovulis in quoque loculo 5; tubo tepalorum 8.6 cm. longo; segmentis tepalorum 8.6—9.1 cm. longis; poculo staminorum infundibulariformi 3.3—3.5 cm. longo; filamentis 2.9 cm. longis; antheris introrsis.

23. **Hymenocallis praticola** Britton & Wilson, in Mem. Torr. Bot. Club **16:** 60. 1920. Specimen: J. G. Jack, **1,555,736** (US), Cuba, Santa Clara Prov.

24. **Hymenocallis floridana** (Raf.) Morton **descr. ampl.** in Yearbook Amer. Amaryllis Soc. (Herbertia) **2:** 81. 1935. Syn- **Pancratium rotatum** Le Conte, in Ann. Lyceum Nat. Hist. New York **3:** 144, pl. 4, figs 4—6. 1836, **non** Ker-Gawl.; **Tomodon floridanum** Raf., Fl. Tellur. **4:** 22. 1838.

Foliis anguste oblanceolatis 35—36 cm. longis, 2—2.6 cm. latis; scapo 27 cm. longo; spatha lanceolata 5.3—5.8 cm. longa; umbella biflora, interdum in statu culto 4-flora; floribus albis; ovario sessili oblongo 1.6—1.7 cm. longo; ovulis in quoque loculo 6, interdum 4 vel 5; tubo tepalorum 7.7—9 cm. longo; segmentis tepalorum 8.7—10.2 cm. longis; poculo staminorum lato, superne in fundibulariformi, inferne brevitubuloso, 4.5—5.2 cm. longo; filamentis 2.2—3.1 cm. longis; antheris introrsis.

Specimens: Traub ***278a+b+c** (TRA), Lake Jessup, Fla.; Traub ***280** (TRA), Hernando Co., Fla. All from bulbs collected by Mrs. Mary G. Henry.

25. **Hymenocallis henryae** Traub, **sp. nov.**

Foliis anguste oblanceolatis 27.5—42.5 cm. longis, 1.2—1.7 cm. latis, ad basin angustatis, apice acutis; scapo 53 cm. alto; spatha 2-valvata lanceolata 3.5—4.5 cm. longa; umbella 3-flora; floribus rectis fragrantibus; tubo tepalorum, segmentis tepalorum, stylo stigmateque viridbus; poculo staminorum filamentisque albis; ovario sessili oblongo; ovulis in quoque loculo 7 vel 8; tubo tepalorum 9.5 cm. longo; segmentis tepalorum 9.6—10.6 cm. longis; poculo staminorum 3.4 cm. alto, superne rotato, inferne brevitubuloso; filamentis 3.1 cm. longis; antheris introrsis.

Specimen: Traub **282a+b**, holotype (TRA), Santa Rosa, Fla. From bulbs collected by Mrs. Mary G. Henry.

26. **Hymenocallis puntagordensis** Traub, **sp. nov.**

Foliis 8 lineari-loratis 28—33 cm. longis, 2.1—3.1 cm. latis, obtuse acutis; scapo 41 cm. longo; spatha lanceolata, 7.5—8 cm. longa; umbella triflora; floribus albido-subviridibus albisque fragrantibus; ovario sessili oblongo usque subpyriformi; ovulis in quoque loculo 8; tubo tepalorum 7—8.2 cm. longo; segmentis tepalorum 10—11 cm. longis; poculo staminorum infundibulariformi 2.2 cm. longo; filamentis 3.9—4.2 cm. longis; antheris introrsis; granulis flavis.

Specimen: Traub *****878a+b**, holotype (TRA), Punta Gorda, Fla. From bulbs collected by Mr. C. L. Burlingham.

27. **Hymenocallis palmeri** S. Wats., in Proc. Am. Acad. **14:** 301. 1879; Garden & Forest **1:** 139, cum ic. 1888; Traub, in Taxon **5:** 195—196. 1956. Specimens: Clara Adams & Wm. Guild **524** (TRA) St. Petersburg, Fla.; Traub ***525; *526; *527; *528** (TRA), St. Petersburg, Fla., from bulbs collected by Wm. Guild; B. B. and S. S. Ward **1607** (TRA), Collier Co. Fla.

33. **Hymenocallis mexicana** (L.) Herb. ex Druce, Dillenian Herbaria, 176. 1907. Syn- **Pancratium mexicanum** L. Sp. Pl. **1:** 290. 1753; Willd. L. Sp. Pl. 2.42. 1799; Ait. Hort. Kew **1:** 410. 1789; **Hymenocallis dillenii** Roem. Syn. Monogr. **4:** 174. 1847. Specimens: Robt. L. Dressler **261a+b** (TRA) s. e. Lagos, State of Jalisco, Mex.; Traub *****231**, *****672** (TRA), s. e. Guadalajara, State of Jalisco, Mex., from bulbs collected by Mrs. Morris Clint.

[PLANT LIFE LIBRARY, continued from page 54.]

STUDIES IN PALEOBOTANY, by H. N. Andrews. John Wiley & Sons, 440 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 487. $11.75. This excellent introductory text by an outstanding authority is concerned primarily with the evolution of vascular plants on the basis of the fossil record. The presentation is occasionally reinforced with discussions on related living groups. There are also chapters on the bryophytic plants, and some paleozoic and mesozoic floras by the author; and an introduction to palynology by C. J. Felix. The illustrations are outstanding. This attractive, well-written book is very highly recommended.

DEVELOPMENTAL GENETICS AND LETHAL FACTORS, by E. Hadorn. (Trans. by Ursula Mittwoch). John Wiley & Sons, 440 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 355. $8.50. The objective of this book, dealing with the pathology of development on the basis of the study of lethal factors, is to provide a synthesis between embryology and genetics. The Mendelian lethal factors are a striking illustration of the role played by the genetic material in the process of development, shedding light on the highly specific relationships between individual mutations and the processes leading to the formation of characters. In addition, since lethal factors make up a high proportion of mutations, they contribute a large body of material which needs to be incorporated into any general theory of the gene and its mutability. Highly recommended.

METABOLIC PATHWAYS IN MICROORGANISMS, by V. H. Cheldelin. John Wiley & Sons, 440 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 91. $3.50. This volume deals with the pathways of carbohydrate metabolism in microbial systems, emphasizing metabolic peculiarities of acetic acid bacteria. The book also discusses the theory and techniques involved in the use of the radiorespirometer, an apparatus for distinguishing between the pentose cycle, the Krebs cycles, and the Entnor-Dondoroff pathway. There is also a general discussion of carbohydrate metabolic pathways and their importance for the overall economy of the cell, synthesis, and obtaining energy. Highly recommended.

MICROBIAL CELL WALLS, by M. R. J. Salton. John Wiley & Sons, 440 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 94. $3.50. This book describes the general physical, chemical and biochemical properties of microbial cell walls which contribute the major structural components of microorganisms. Emphasis is placed on some of the unusual features of the chemical substances and structures found in bacterial cell walls, and on some of the unique biochemical processes involved in the formation of the cell walls and the manner by which antibiotics prevent the assembly of the walls. Highly recommended.

WEED CONTROL: AS A SCIENCE, by G. C. Klingman and L. J. Noordhoff. John Wiley & Sons, 440 Park Av., So., New York 16, N. Y. 1961. Illus. pp. 421. $8.50. The objective of this book is to bring together the techniques for weed control. The first part of the book is devoted to fundamentals on which weed control is based; the second part to the chemical and physical properties of various herbicides; and the third part to practical application. This is an excellent text not only for the student, but also for the practicing agriculturist and horticulturist; and others interested in weed control. Highly recommended.

INVERTEBRATE PALEONTOLOGY, by W. H. Easton. Harper & Brothers, 49 E. 33rd St., New York 16, N. Y. 1960. Illus. pp. 701. $10.00. This text by an outstanding authority was written for the professional geologist and for use in intermediate courses. It emphasizes the functional approach to invertebrate paleontology. After a condensed review of some basic concepts in biology, zoology and paleontology, the subject is presented in customary systematic order. This excellent text is highly recommended.

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3. GENETICS AND BREEDING

REPORT ON SPREKELIA BREEDING, 1961

KATHERINE L. CLINT,

2005 Palm Boulevard, Brownsville, Texas

The lack of regular and recurrent blooming of *Sprekelia formosissima* is a problem common to many of us. Although much has been written on the subject it is hoped that this report will offer a slightly different approach to the situation. That we have found success in our venture is due primarily to the kindness of friends who so generously shared their bulbs with us, for I believe that the clue lies in the behavior of different forms rather than solely in the limiting factors of climate and culture. Our experience has shown that by selective breeding of adaptable forms further improvement may be realized.

Sprekelia formosissima has an extremely wide range—from Mexico to South America—so it is understandable that many forms and variations occur within this range. Since it is known that bulbs grow under varied conditions of climate and environment in their native habitats, it is to be expected that their cultural requirements, adaptability and blooming performance will also vary. Comparatively few of these forms have found their way into cultivation and fewer still into the trade. We have secured bulbs at intervals from several commercial sources, variously listed as *Sprekelia formosissima* or *Sprekelia formosissima* var. *superba*. All of these appeared to be of the same general type which blooms sparingly or not at all for us. Dr. Traub sent us bulbs of *Sprekelia formosissima* var. *superba* which were indeed different, but they are not too happy here.

In 1952, Mrs. Chester Wheelock, of Brownsville, Texas, gave us some glaucous-leaved bulbs collected near Guadalajara, Jalisco, Mexico. These were later identified as *Sprekelia* by the collector. Deciduous, with a long dormant period, this form has steadily refused to bloom. However, growth has been phenomenal this year in tile-drained beds, so it is hoped that the increased size of the bulbs apparently needed here in the Valley will soon be reached. Larger bulbs of this same form may have been collected in early June of this year in the state of Michoacan when we were accompanied on an extensive trip through Mexico by Dr. Walter S. Flory and Dr. Raymond O. Flagg, of the University of Virginia.

In 1953, we were given a few bulbs by Fred B. Jones, of Corpus Christi, Texas, who had received them from Dr. Cesar Vargas of Peru. Much to our surprise, these bulbs not only flowered well soon after planting but gave a repeat bloom in the late fall. Moreover, they continue to flower profusely under ordinary garden care. Unlike the bulbs in the trade, leaf growth of this *Sprekelia* is neat and attractive and the flowers, though smaller, are a dark velvety red and very lovely. One may imagine that the performance of this Peruvian form gave a real boost to our interest in *Sprekelia*. Dr. Flory reports that this form is very sulky in Virginia, where it not only refuses to bloom but remains dormant most of the year, which seems to indicate that it will not be successful everywhere.

In the fall of 1956, Len Woelfle, of Cincinnati, Ohio, sent us 3 different forms of *Sprekelia:* a small-flowered red with yellow markings, obtained from the late D. J. W. Chandler, of Australia, a large dark red and a large light red, both of the latter secured from Rex Pearce. The light red bloomed well and we found the flowers enchantingly different. In our garden the color was near pink with a sparkling glisten of gold, and the form quite unlike any we had ever seen.

In 1954, Dr. Flory reported seeing an odd little *Sprekelia* near the home of Mrs. Pedro A. Chapa, of Cuernavaca, Morelos, Mexico. Mrs. Chapa is a native of Brownsville and an old friend. She has brought us many fine plants and seeds from Mexico so when I mentioned the *Sprekelia* in 1956, she obligingly sent us a few bulbs and many seed. These bloomed well (in several distinct shades of red) in the spring of 1957 and 1958 but soon afterwards went into a decline due to poor drainage and salt seepage. They are now making a come-back in tile-drained beds and should soon recover sufficiently for their performance to be evaluated.

In January 1957, we received from Frank Harrison, of Rancho del Cielo in the mountains of the state of Tamaulipas, Mexico, two more clones of *Sprekelia.* One of these he had obtained from a nursery in Cuidad Victoria, Tamaulipas, Mexico. The other, raised from seed secured from Rex Pearce, turned out to be a real find. The flower is large and well formed, brilliant red with white stripes down the center of the segments, the amount of white varying with the season. Blooming habit equals or perhaps excels that of the Peruvian *Sprekelia.* Dr. Traub (1959) has named this form 'Harrison's Orientred'. Later, we received this same clone from Sydney Wiedermann and Dr. Thad Howard, of San Antonio, Texas, each of whom reported that the bulbs gave excellent blooming results in that city.

Early in the summer of 1957, Luciano Guerra, of Mission, Texas, brought us a quantity of bulbs collected near San Vicente, Hidalgo, Mexico. This group is interesting from many angles. Virtually evergreen, growth habit is intermediate with only a short above-ground neck. The blossoms are extremely variable in size, form and color and seem to be much more than moderately self-fertile. In the wild, very small bulbs produce two scapes, but under culture here in south Texas (as with most *Sprekelia* and many other bulbs) must attain a good size before flowering. Once this size has been reached, the San Vicente *Sprekelia* will blossom at intervals throughout the entire year.

Late in 1956, Dr. Traub had suggested that attempts should be made to cross the various forms of *Sprekelia* for a full range of color. Spring rains gave us heavy bloom during March and April of 1957 so, even though we had repeatedly failed to set seed on *Sprekelia* in the past, a number of crosses and their reciprocals were made. Much to our surprise, six large capsules ripened seed representing the following crosses: Peruvian form x Woelfle's light red and the reciprocal; two crosses (involving different clones) of the Peruvian x 'Harrison's Orientred' and two crosses (again using different bulbs) of the reciprocal. During this same season, Frank Harrison sent us a few seeds from his 'Orientred'. He wrote that this was the first seed to form on any of his bulbs and that he was not aware whether it was a ''self'' or a chance cross with his ''Victoria'' form. We can now report that evidence is clear that the seeds came from a chance cross of the two forms.

Germination was good and in the spring of 1958 the seedlings were set a few inches or so apart in close rows in the ground under lath. We had planned to move them as they grew but space was not available so the bulbs were forced to remain in this crowded condition for three years. Very little care was given to them during this period. Despite all of these difficulties, the first few flowers appeared in the fall of 1959. Blooming continued through the winter, spring and early summer of 1960 and began again in the fall. Though very few seedlings were at that time involved and very sketchy records were kept, it began to look as if we had the start of a free-blooming hybrid race of *Sprekelia.*

Late in March of 1961, 290 of the surviving seedlings were transferred to a new raised bed. Very few had been lost but a great many were very small due to the crowding of the larger bulbs. Complete records were set up so that each seedling could be evaluated for form, color and blooming rate. Results from April 1 to August 15 have been more than gratifying. Our records show that most of the mature bulbs have already produced 3 flowers and many have given 4, which includes bulbs blooming for the first time this season. Individual flowers have been consistently good to fine and a rewarding number can be called superior. One of the biggest improvements has been a marked broadening of the segments even in the smaller blooms of the very young seedlings. Much to our disappointment, none of the offspring seem to have inherited the neat growth habit of their Peruvian parent and, so far, the near pink of Woelfle's light red has not appeared. Perhaps either or both of these characters will show up in the F_2 generation. Though hybrid vigor is apparent, the seedlings do not form offsets as freely as their parents. They seem to be about 99% to 100% self-sterile but cross readily among themselves and with any other clone. This is in contrast to their parents, which refuse to seed within their own group in this area. In fact, among the 12—15 clonal variations we are now growing, only Clint #835, the San Vicente *Sprekelia,* is self-fertile. At the same time, all will set seed when pollen from a different group is used.

Though it is too early for a complete analysis, we feel certain that a comprehensive breeding program will be most rewarding. This spring and summer our enthusiasm almost ran away with us, resulting in 18 new lots of seedlings. These include many crosses for F_2, a few crossbacks and the addition of new blood with the use of some of the finer clones of the San Vicente collection and a pert little *Sprekelia* from Ludwig which was sent to us by Claude W. Davis, of Baton Rouge, Louisiana. Flowers of this are a light brick red, held at such an upturned angle that they are almost horizontal.

Our *Sprekelia* seedlings are still untried in other sections of the country. Considering the waywardness of the genus, it may be necessary for those who live in the north to breed their own race of hybrids, using clones which are adaptable to their area.

LYCORIS NOTES — 1960

Sam Caldwell, *Tennessee*

Lycorises are at once the most exciting and exasperating things I grow. Their habits are intriguing, since the blooms come at one time and the leaves at another. If "beauty is its own excuse for being," the flowers of most species amply justify their existence. But some of them have the annoying habit of refusing to bloom in spite of my best efforts to satisfy them.

From July till early October I trek frequently over the home grounds, peering anxiously at bare earth around label stakes to catch a first glimpse of fat "spearheads" pushing upward, promising glory to come. Sometimes they're right on schedule and delight me by showing up in profusion. Then again, certain ones may be off season, few in number or missing altogether. Newly acquired bulbs may take a fearful length of time to get established. I had one species for six years before it bloomed. Reasons for delay and failures are evident at times and at other times they are not.

The "Magic Lilies" *(L. squamigera)* I have known since childhood. The first species other than that, that I can recall planting was a "red spider-lily" bulb given me in 1927. It was of course, *L. radiata,* but at the time we thought it was *Nerine sarniensis.*

Since returning home in 1946 from World War II I have planted the different lycorises offered in the usual trade catalogs, plus a number of others secured through friendship with bulb importers. Records on these plantings have been kept through the years. Then I've learned much from reading and from talking with fellow lycoris fanciers. But I still confess an enormous ignorance of the special requirements of some of these bulbs.

Currently there seems to be a gratifying increase of interest in lycorises. Dr. Hamilton Traub has done fine work toward clearing up problems of nomenclature and identification, but among the commercial dealers there is still coufusion in these fields. We still need answers to cultural problems with some species, and I hope other growers will contribute experience reports for publication in HERBERTIA. The following observations and notes will serve to bring up to date certain matters on which I have reported previously in this publication.

HYBRIDIZING

To date (December, 1960) not one of my hybrid (I hope) seedling lycorises has bloomed, and my patience is wearing a little thin. First planned crosses were made in 1953, but the few seedlings resulting must have been left too long crowded in their original pot, for they never made normal growth. Pollinations in 1954, '55 and '56, however, gave me dozens of husky young bulbs. Some of the *L. radiata* X *L. sprengeri* and the reciprocal cross bulbs I really expected to see in bloom this past year, but they disappointed me.

Probably in ground beds in a milder climate, seedling lycorises will bloom quicker—when around five years old. I still start my seeds in pots, wintered in a cold greenhouse, but now shift one- and two-year bulbs to a protected ground bed for growing on. This should speed up things.

As reported in HERBERTIA for 1958, I have both failures and apparent successes in attempting to get viable seeds by crossing various lycoris species. Since that report, several other seemingly successful cross-pollinations have been effected, so that my complete list of hybrid (?) bulbs growing along to blooming size is now as follows:

L. haywardi X L. sanguinea and reciprocal
L. haywardi X L. "sperryi" and reciprocal
L. radiata X L. haywardi
L. radiata X L. sprengeri and reciprocal
L. radiata X L. "sperryi"
L. sprengeri X L. haywardi
L. sprengeri X L. "sperryi"

In addition there are a few small lots of bulbs of uncertain parentage. The *L. radiata* used is a fertile strain.

Proof of actual successful hybrids, of course, will come only with their blooming. Meanwhile it seems to me that here is one of the most open fields of horticultural endeavor—especially for gardeners in the Lower South. Anyone interested in details on simple hybridizing techniques will find accounts of my own experimental work in the aforementioned 1958 HERBERTIA and in *Bulletin 5* (March 1960) of the *Louisiana Society for Horticultural Research* (available for $1.50 from Mrs. U. B. Evans, Haphazard Plantation, Ferriday, La.).

LYCORIS "SPERRYI" [Fig. 14.]

Information on the hardy golden lycoris that I wrote about in the 1958 HERBERTIA had been supplied me at the time by people in the Nashville, Tennessee area who knew it. Since then I have had opportunity to get acquainted with it first-hand, having observed its growth and bloom for three years. This is a wonderfully beautiful lycoris and valuable, too, because of its hardiness.

In brief, the history is that in 1925 a Nashville woman, the late Mrs. Henry Sperry, collected bulbs of what she called an ''orange spider-lily'' in the hills near Huchow, China, while visiting her daughter, a Methodist missionary stationed there. Mrs. Sperry brought them home, and for more than 30 years they grew and were treasured just as pretty flowers by her family and a few friends. No one knew that they were lycorises. In 1957 they were called to my attention, and I felt at once that here was something unusual. One of the greatest thrills in years of gardening came in August, 1958, when I saw a clump with four fine scapes in bloom in the Nashville garden of Miss Aileen Bishop.

Fig. 14. *Lycoris "sperryi"* in garden clump, Nashville, Tenn. Aug. 15, 1958. Scapes 24″ to 31″ tall; umbels 7″ to 8½″ across. Photo by Sam Caldwell.

Lycoris ''sperryi,'' a name we are using for convenience until it is properly identified or named, is a big and showy flower, in general resembling *L. aurea.* Scapes have varied in height from 22 to 31 inches, topped with umbels seven and a half to eight inches across, made up in most cases of six flowers. However, one five-flowered and one seven-flowered umbel have been observed among some 20 scapes that I've seen. Individual flowers are large—three and a half to four inches across—and flattened segments measure three-eighths to one-half inch in width. The color is rather stronger than in *L. aurea* and is close to ''strong orange yellow,'' Munsell Hue 7.5YR 7/11 on the Nickerson Color Fan. The blooms are fertile, setting very large seeds—to three-eighths of an inch in diameter—to their own pollen and apparently crossing with several other species.

Leaves look much like those of *L. squamigera* but are notable for their late appearance. In fact, the leaves of *L. ''sperryi''* and of the new *L. chinensis*, both pushing up in early March, are the very last of the ''spring foliage'' lycorises to show up in my plantings. This accounts partly for their hardiness, since the leaves naturally escape the coldest winter weather.

From the first it was quite clear that *L. ''sperryi''* is different from and far hardier than both *L. aurea* and *L. traubii,* the two well known yellow-flowered species. I thought, however, that it would probably turn out to be identical to *L. chinensis,* the newly named hardy yellow lycoris growing at the USDA Plant Introduction Garden in Glenn Dale, Maryland. As yet it has not been possible to make a direct comparison of fresh blooms (my one bulb of *L. chinensis* has never flowered), but foliage comparisons and certain other evidence tend to indicate at this time that they are not the same.

Lycoris ''sperryi''—or whatever its final designation may be—will be most important in extending northward the zone in which a yellow lycoris may be grown outdoors. I regret that there is absolutely no supply of bulbs at this time. The very few people in Nashvile who have them will not part with them. And at best, the number here must be small. In 1958 Miss Bishop allowed me to dig and reset one of the two clumps in her garden. We were able to learn that it had been planted originally in 1942, presumably with one bulb. Yet after 16 years, when I lifted the clump there were only five large bulbs and one small offset.

I collect all seeds and have distributed a few seedling bulbs. Sadly, the entire 1960 seed crop was eaten by a chipmunk. Whether conditions will ever be so that we can get bulbs out of China, I do not know. Mrs. Sperry's daughter tells me that they were fairly plentiful in the hills and mountains between Huchow and Hangchow in Chekiang Province.

NEW ACQUISITIONS

During the past year or two a few American bulb dealers have been offering ''Lycoris cinnabarina.'' The name also has appeared in the wholesale catalog of the Van Tubergen firm in Holland, from whom, I

suppose, our dealers secured their bulbs. My impression is that botanists do not recognize this as a valid name, but hearing the plant described as "an orange *L. radiata,*" I added a few bulbs to my collection a year ago. They were small, much like those of *L. sanguinea,* and on the whole have been slow to make any kind of start. Very little foliage has been produced, and I anticipate a wait of at least two years for bloom. My guess is that it will resemble *L. sanguinea.*

In August of this year I received three nice bulbs of *L. kiushiana* from B. Y. Morrison, Pass Christian, Mississippi, who had secured them direct from a bulb fancier in Japan. These I shall watch with interest. One Japanese authority gives it species status; another describes it as a larger flowered variety of *L. sanguinea.*

Incidentally, I had known of Mr. Morrison and his USDA and American Horticultural Society work for years, but met him personally only last fall when I stopped for a day at "Back Acres," the fascinating home, garden and nursery near Pass Christian, over which he is a guiding spirit. It was a joy to find someone else as nutty about odd plants—and especially lycorises—as I am. I envy him the balmy Gulf Coast climate where lycoris leaves grow lush and bulbs wax fat and bloom much better than they do for me. But I gathered that some species are reluctant to flower even in that favored spot.

By far the most interesting new lycoris that I grew in 1960 also came from Mr. Morrison, under the simple designation, "White No. 1." [Fig. 15] He has numerous bulbs supposed to bear "white" flowers, secured at various times from New Orleans seed stores, from other commercial sources and from southern farm women. My own experience with lycorises of this sort—bulbs bought under such labels as "alba," "albiflora," "albiflora carnea," "albiflora rosea," and the like—is that most of them run uniformly to the salmony pastel type that Dr. Traub named *L. elsiae* (HERBERTIA, 1958). Mr. Morrison has plenty of that kind, all right, but he also gets many variants. I saw a Kodachrome of one large clump in which flowers ranged all the way from white through cream, apricot and pinkish tints to quite deep salmon. And during the past bloom season I had wonderfully enthusiastic "lycoris bulletins" from him telling of pale, clear yellows.

Bulbs he sent me as "White No. 1" and "White No. 2" were planted in a deep box in my small greenhouse, where they flowered in late August. Delicately tinted flowers of this sort look different in different lights, tend to change from day to day and finally fade to near white. It is difficult to record on color film, on paper with the aid of a color chart, or even in the mind, a precise impression of the exact colors. When "White No. 2" opened I thought it was typical *L. elsiae;* the form was the same and the color was about as I remembered it. But later, when my own *L. elsiae* bloomed I concluded that "White No. 2" actually had been a deeper pink—at least, in the fresh flowers.

Fig. 15. (See opposite page)—*Lycoris* (White No. 1), an unidentified lycoris bought in New Orleans seed store by B. Y. Morrison. It somewhat resembles both *L. elsiae* and *L. houdyshelii.* Photo by Sam Caldwell.

There is no doubt, however, that "White No. 1" is distinct and different from *L. elsiae.* Segments are broader and much more reflexed and rolled back at the tips. Long-extending stamens and pistils give a width of over eight inches to the umbel, making it a larger lycoris than *L. elsiae.* The three scapes produced on my bulbs were respectively 11, 14 and 16 inches high and had five, six and six flowers to the umbel. Color at first is a soft pinkish yellow—not greatly different from *L. elsiae* coloring but with more yellowish influence—and this ages almost to white, while retaining yellow-cream tints. Mature, nearly white flowers remind one of *L. houdyshelii.*

I carefully fertilized flowers on two of the scapes with pollen from *L. radiata* and *L. "sperryi,"* which happened to be in bloom, but got no "takes." The third scape developed to its own pollen, apparently, one capsule containing a single large, shiny, black seed, which I planted.

Since these blooms were produced quickly from recently dug bulbs reset in a greenhouse box, measurements given above may not be typical. I suspect that scapes from established bulbs will be taller. In any event, it is a very fine lycoris.

Both of these numbered "whites" began pushing up foliage blades in the manner of *L. radiata,* soon after flowers faded, but blades are broader and longer than in *radiata*—in fact, quite like *L. elsiae* foliage. As yet I know nothing of how hardy these bulbs are. They have proved, of course, well adapted to the Gulf Coast country, but I fear that, like *L. elsiae,* they will exist but not exactly thrive and bloom freely in middle Tennessee.

I hope that Dr. Traub and other botanists can decide whether these variants among the "white" lycorises should be classed as different species or just varieties of species we have already. Meanwhile, they are interesting and beautiful garden material for whoever can grow them.

HARDINESS

We need more observant gardeners to report on the performance of lycorises in different localities. While other factors undoubtedly affect their flowering, it is reasonably certain in the Upper South that the severity of winters has much to do with it. After a particularly bitter winter we have learned not to expect much bloom on *L. radiata,* which is widely grown here. This seems reasonable, in view of the fact that near-zero temperatures and drying winds damage the persistent foliage.

But several strains of *L. radiata* are in cultivation, and some of these may tolerate more cold than others. 1960 was not a very good lycoris year in the Nashville area—rather to have been expected, because the 1959-60 winter was long and cold and brought 37 inches of snow.

Fig. 16. (See opposite page)—Delicately colored *Lycoris elsiae* does well where winters are not too cold. Photo by Sam Caldwell.

When fall came, bloom on *L. radiata* was generally sparse. Yet the fertile strain of this species, though blooming toward the end of August which is later than usual, made a grand display—fully up to normal. Also there were isolated clumps of *L. radiata* imported from Japan in recent years that bloomed very well. And quite late—on October 5—I observed in a local nursery a block of several hundred bulbs of a fine, large form of *L. radiata* that seemed to be giving nearly 100% bloom. The owner said they were long-established bulbs, secured through regular trade channels—presumably from Japan—some years ago. It is true that they are situated on a south slope in a sandy clay that suits them just right, but I am going to try bulbs of that stock in different situations to see if they are extra reliable in flower production. It takes so many years actually to learn anything definite about matters of this sort that I hope other people are working at them, too.

Reluctantly, I have given up trying to grow *L. traubii* outdoors here. Bulbs held on for a while outdoors but never bloomed. Then sub-zero weather in the 1957-58 winter killed all of mine outright. I know of one planting in a protected spot in a Memphis, Tennessee garden where they have done very well. But our Nashville winters are colder.

Some of the "border line" types, such as delicately colored *L. elsiae* [Fig. 16], which just barely gets by outside for me, I am trying out now in a permanent ground bed surrounded by a board frame. A sash covered with polyethylene film is put over it in bad weather.

PROBLEMS

Everyone who gardens has problems. Following are questions about lycorises that I'd like to have answered. Perhaps some reader can help.

1. Is there really such a plant anywhere in cultivation as *L. squamigera* var. *purpurea?* The few times I have found bulbs thus listed, they turned out to be something else. "L. purpurea" is seen in catalogs and lists from time to time. These, in my experience, invariably prove to be the fine hardy species, *L. sprengeri.* An interesting angle is that "L. purpurea" bulbs are usually offered at 50c to $2.00 each, while *L. sprengeri,* when bought under its correct name, costs about $5.00.
2. What is the true identity of the lycoris we can currently buy as *L. sanguinea?* Certainly it does not produce either the "dull red" or the "blood-red-scarlet" flowers I read of in a couple of supposedly authoritative descriptions of the species. Bulbs I have from several sources all give in July plain little flowers nearest to "strong reddish orange," Munsell Hue 10R 6/12, which fades badly in sun. Could they be *L. sanguinea* var. *cyrtanthiflora,* said to have "flowers apricot-colored, bleaching in the sun to a gray color"?
3. Has anyone ever made a direct comparison of *L. argentea* and *L. haywardii?* I think it's possible they may be the same thing.

4. If the yellow lycoris of St. Augustine, Florida is true *L. aurea,* as most of us assume, how do we reconcile facts with the description (in *Amaryllidaceae: Tribe Amarylleae),* "leaves produced in May . . . flowers . . . in August"? Flowers, as they come in September and October in St. Augustine, are close enough to the description, perhaps, but "leaves in May" is completely off, since they actually start in October or possibly late September in Florida.

[EDITORIAL NOTE :—The application of the name *Lycoris aurea* will be determined by the writer in the not too distant future by an examination of the herbarium specimens in European Botanical Institutions. The true *L. aurea* apparently is a hardier plant than the St. Augustine plant, and thus most likely has the habit of producing leaves in May in northern locations. Only the examination of the type material can settle this point.—Hamilton P. Traub]

HYBRIDIZING CYRTANTHUS

GORDON MCNEIL, *North Transvaal,*
Republic of South Africa

It was the late Miss K. C. Stanford of BLOEMERF, Stellenbosch, well known to most readers of HERBERTIA, who first interested me in the possiblities of hybridising the Ifafa Lilies. On a visit to us she showed so much enthusiasm over a particularly fine clump of CYRTANTHUS SANGUINEUS in full bloom that I, there and then, became bitten by the bug. Miss Stanford, on her return home, sent me bulbs of *C. obliquus* and *C. spiralis* to use in the experiments.

My first break occurred in 1953 when the seedlings, from a pod of the cream form of *C. mackenii* pollinated with *C. sanguineus,* began to flower. Colors ranged from a very pale salmon to the tomato red of *C. sanguineus;* trumpets, five to nine on a 12″ stem, averaged 2½″ long by 1½″ wide across the slightly reflexed lobes. This F1 selfed gave some very nice plants (Fig.17) ; the flowers are bigger (often as big as those of *C. sanguineus);* the color range is considerably extended from a very pale pink (the color of trout's flesh) to a dark red; heads are multiflowered on longer stems; the tepalsegs often appear as if dusted with gold (a characteristic of some forms of *C. galpinii* but not of either *C. sanguineus* or *C. mackenii);* there also appeared typical *C. sanguineus* flowers but streaked with darker red—one green lobed (chimeric, I believe) ; one with five flowers instead of the usual one or two, etc. Some of these are now in the F3 stage but still show great variation and also a steady retrogression to *C. sanguineus.* The F2 seeds give the best results. The bulbs are tender and produce few offsets. However another cross *(C. parviflorus* by *C. mackenii* x *C. sanguineus)* has recently flowered and is much more promising as a hardy garden flower. It appears closer to *C. parviflorus* and *C. mackenii* in its foliage, hardiness and ability to produce numerous offsets and has most delightful trumpets; 1½″ to ¾″ wide; 3 to 9 on a long stem (18″) ; in color, pastel shades of pink, salmon, tomato red and red.

I have many other hybrids—attempts to get my first break, using *C. sanguineus* pollen on various colors forms of *C. mackenii;* on *C. o'brienii* and *C. parviflorus.* These most resemble, I believe, Mrs. Henry's *Cyrtanthus* hybrids. Some are very nice and all are hardy.

Of unflowered crosses I have the following: *C. sanguineus* x *C. obliguus; C. sanguineus* x *C. tuckii* var. *viridilobus* & the reverse; *C. sanguineus* x *Vallota speciosa; C. sanguineus* x *Anoiganthus luteus; C. sanguineus* x *Anoiganthus breviflorus* & the reverse; *C. sanguineus* x *C. galpinii* & the reverse; *C. sanguineus* x *Clivia miniata* & the reverse; and a *Vallota* x *C. obliguus* cross from Sweden which should prove a beauty.

Fig. 17. Hybrid *Cyrtanthus* raised by Gordon McNeil, South Africa.

Apropos the intergeneric crosses, *Cyrtanthus* & *Anciganthus* are very close and differ only in that *Anoiganthus* has "no tepaltube" (actually from my observation *A. luteus* has a tepaltube, though short) and in the opinion of Dr. Dyer (see HERBERTIA, 1939) should probably not have been separated; *Vallota* has the same basic chromosome number as *Cyrtanthus,* x = 8; *Clivia,* in the opinion of Dr. Wilsenach of the University of the Witwaterstrand, is related to *Cyrtanthus.* Another *Cyrtanthus (C. thorncroftii)* that I am using in the experiments also has, like *Anoiganthus* breviflorus, "no tepaltube."

Through the kindness of Dr. Ising I have obtained triploid and tetraploid plants of *Cyrtanthus,* which will flower this coming spring and which I feel sure, will prove outstanding parents; particularly the tetraploids.

I am only beginning. There is an immense amount of work yet to be done and I hope this introduction to the subject may inspire others with more time to start hybridising the Ifafa Lilies of which there are in Africa (see Dyer—HERBERTIA, 1939) some 44 species. As pot plants they are excellent; also as cut flowers. Many are delightfully scented and a mass planting of *C. mackenii* in any of its color forms is a joy indeed.

HYBRID BRUNSVIGIA AND X CRINODONNA NOTES, 1961

HAMILTON P. TRAUB, *California*

The season of 1961 was unusual from the standpoint of flowering dates. During the previous winter season only about 3.5 inches of rain fell and this may have something to do with the results.

Brunsvigia rosea var. *major,* the early-flowering, many-flowered form of the Cape Belladonna, (and *B. purpurascens* var. *major* from Van Tubergen, which is the same plant under a different name), and also X *Crinodonna trubii (B.* x *parkeri* x *Crinum moorei),* and *Crinum moorei rosalba,* began to flower in the first week in June, and continued on through July. Later other X *Crinodonna* clones began to flower so that there was a continual bloom on through to October.

One outstanding record for the early flowering of X *Crinodonna traubii* from seeds was set. From a lot of seedlings of *Brunsvigia* x *parkeri (Zwanenburg Group) x Brunsvigia rosea major,* raised from autumn 1959 seeds, one plant bloomed in the last week in June, 1961, about 21 months from seed planting time. This same plant again flowered in October. It is hoped that such performance can be obtained on a greater scale.

VEGETATIVE PROPAGATION OF BRUNSVIGIA ROSEA.—Each of two bulbs of *B. rosea major* were cut vertically into quarters in October 1960, and placed *in a pot of sand* with the sand between the quarters, and watered regularly. On August 2, 1961, when the cut pieces were removed, it was found that each quarter had produced two bulblet sprouts. This is a 1—8 increase. Thus in the case of some *Brunsvigia* x *parkeri* bulbs that do not make offsets, this method should be tried. It is hoped that Mr. Hannibal and others will report on such experiments in future issues of the Year Book.

CRITERION FOR HYBRIDITY.—In the case of crosses between *Brunsvigia rosea* or *B.* x *parkeri* on the one hand, and *Crinum moorei* or *C. bulbispermum,* on the other, it is possible to tell soon after the seedlings sprout. The seedlings soon produce several leaves; soon show a true neck and in addition remain evergreen. Seedlings that are not hybrids usually make only a few leaves; do not make a true neck, and go dormant in late spring.

NOTES ON CRINUM BREEDING

L. S. Hannibal

"The field of *Crinum* breeding is wide open—There is much to be learned of this group." We credit Dr. Thad Howard for this frank recognition of a longstanding difficulty; one which deserves rather considerably more attention than has been granted in the past. Of all the better known Amaryllidaceae the *Crinum* species have been the most neglected. Breeding has been nearly static in this group because we seemingly lack information or the knowhow on what plants to use and how to cross them in an advantageous manner. There are several reasons which may account for this: First we have never collected many of the higher mountain species which have possibilities as hardy breeders and secondly we have overlooked the potentialities of several fertile hybrids which are capable of producing viable second generation seedlings.

Basically the problem also resolves about our past inability to recognize and use the interrelations of various species and breed with those closely related forms where incompatabilities are less likely to occur. Crinums are no more difficult than Nerines or Daffodils. For the layman there is no better way to solve the problem than to evaluate the seeding and growing habits of our known hybrids. Vigorous free seeding hybrids normally indicate close parental relationships whereas reluctant seeders or slow growing seedlings may suggest wider evolutionary interrelationships. More can be learned than suspected, as examples will show.

Unquestionably everyone knows *Crinum moorei.* It is native to a good portion of the Union of South Africa and many local strains exist. With a few exceptions most plants are free seeders and many intraspecific crosses exist, yet, few represent significant improvements over long existing garden forms. The writer considers only a few worthy of description: One grown here in Fair Oaks requires rather deep shade to grow properly. The foliage is a dense green and the clone throws rather deep pink blossoms with broad tepalsegs. A second carries relatively clean foliage on a long pseudo-neck and the blossoms which are rather open and flat faced are carried on a tall scape. Both plants are decided improvements over the average garden stock, but require relatively warm weather to flower and rarely produce seed. The desirable features found in the foliage and blossoms may not be transmitted to their progeny even in F-2 backcrosses. In this specific instance we can note that even intraspecific breeding has its difficulties.

As far as interspecific *Crinum* hybrids are concerned many people have used *C. moorei* as a breeder. It will cross with a great number of other species but, with the exception of the Powellii hybrids and *Crinodonna,* only a few of these hybrids have ever reached the market. A lack of hardiness, reluctance to flower, few offsets, or poor floral form have kept most of these hybrids off the market. In the various *Crinodonna* crosses the floral coloring and width of the tepalsegs is controlled essentially by the particular *Brunsvigia rosea* cultivar employed in the cross. The same applies to the Powellii hybrids as will be clarified below.

Crinum bulbispermum has been known for 150 years or more. The white flowered form from the Cape of Good Hope (Ex. *C. capense alba)* has been a garden favorite in England due to its winter hardiness. This variant has become an escape in a number of semi-tropical areas, particularly in Costa Rica where it has confused honest botanists to no end. This white flowered strain from the Cape peninsula when crossed with *C. moorei* (probably the white flowered form var. *schmidtii)* has given rise to the clone *C.* x *powelli album.* Similar crosses with pale pink forms of *C. moorei* has given rise to very light pink Powelli forms. In contrast, light pink forms of *C. bulbispermum* like the photosensetive form distributed by Wyndham Hayward some twenty years ago (A plant which flowered pink on overcast days) has been the source of a number of light rose or coral pink Powellii forms. Major Pam's 'Pink Queen' is an excellent example of this color type. Then some ten years ago Dr. Rodin obtained seeds of a deep red flowered *C. bulbispermum* for the University of California Botanical Garden at Berkeley. This plant is a type which is very common to the entire Orange River basin in the eastern part of the Cape Province. This particular form was first described by John Barrow in his official report of 1801 on his travels into the interior of the Cape Area on page 205. A good reproduction in color has been featured recently in the Cape Provincial Administration's illustrated booklet on 'Protected Wildflowers of the Cape'. Mature bulbs of this red flowered form are quite large and very free flowering. The plant makes several scapes during the early summer and each umbel carries 15 to 25 blossoms. The strain produces few selfed seedlings and these are seldom hardy enough to survive a cool California winter, but pollen from the white or pale pink *C. bulbispermum* clones take on the red with rather striking results as the intraspecific seedlings grow vigorously enough to flower in four or five years. The blossoms from these crosses are rather pale pink. In contrast the Powell hybrids obtained by crossing with *C. moorei* are almost blood red. Offhand it appears that *C. moorei* contributes very little of the color to the Powellii hybrids, but that *C. bulbispermum* color in the hybrid is considerably intensified by *C. moorei.*

The white Powellii hybrid is absolutely sterile. Major Pam's 'Pink Queen' and one or two others occasionally produce malformed seed, and *C.* x 'Cecil Houdyshel' which is presumably a Powellii hybrid often sets some near normal seed. The writer has flowered several F-2 plants derived from 'Cecil Houdyshel'. These are poorer forms of the parent and have shown no inclination to produce seed.

A third hardy species of Crinum with breeding possibilities is the white flowered *C. yemense.* This plant is often confused with *C. latifolium* from the Asiatic area. Presumably these two species and others growing in the higher elevations of tropical East Africa all have a common ancestry. *C. latifolium* requires warm humid conditions, but *C. yemense* which comes from the mile high cloud moistened rim of the western edge of the Arabian plateau is equipped to survive long dry spells and grow with a minumum of moisture. Like *C. bulbispermum* it can tolerate some frost and prolonged cold spells which isolates and identifies it from its near Asiatic relatives. It is best recognized by the large seed which are often two inches in diameter. The reserve moisture permits such seed to lie dormant for three or four months until winter conditions favor germination. The van Tubergen form of *C. yemense* (Gardeners Chron. & Gard. Illustrated, P.421, May 1960) is not quite as large or as hardy as the form *C. yemense* var. *burbankii* (Gard. Chron & G. I., Vol. 144, #23, P. 293). However both plants are good garden subjects and have exceptionally clean and attractive foliage. The Luther Burbank hybrid *C.* x 'White Queen' (HERBERTIA 1935, P. 160) may be a *C. moorei* x *C. yemense* cross. The hybrid has clean upright saber like leaves resembling the Yemen species and white flowers which are intermediate in form. The cross has been duplicated by the writer. 'White Queen' requires near full sun and a warm summer in order to flower. From all appearances the cross is sterile and no color is introduced by *C. moorei* into the blossoms although red pigment is evident at the leaf base.

Fig. 18. Crinum hybrid, "Miss Elsie."

A hardy hybrid belonging to the subtribe *Platyaster* is the little known *C.* x 'Miss Elsie' (Fig 17). It appears to be an American development but the parentages involved are unknown. The foliage is quite erect and near needle tipped like a Yucca. Five to eight pure white spidery like blossoms are carried on each scape some 36 to 42 inches above the ground. Occasionally seeds form but rarely grow much larger than a pea. To date none has been known to germinate.

One can cite *C.* x 'Ellen Bosanquet', 'George Harwood' and a number of other hybrids. All are completely sterile or yield a few aborted seed. With the exception of *C.* x 'Cecil Houdyshel' none have been known to actually produce a hardy F-2 hybrid. The general conclusion is that most of the small aborted seed is parthenogenetic and not sexual, and that this accounts for the fact that seed sets at all. Hybrid seeds of the initial F-1 cross (which is sexual) generally fall into three classes: Seeds which produce plants showing hybrid vigor and are capable of flowering in three to five years, seeds which yield slower growing plants with no greater vigor than the parents, and seeds which produce plants significantly less vigorous than the parents where genetic incompatibilities may exist. F-2 seeds, if sexual, appear to be obtainable only from F-1 plants showing considerable hybrid vigor like *C.* x 'Cecil Houdyshel'. and even in this instance the F-2 seedlings have far less vigor than the F-1 hybrid. Similarly the semi-vigorous F-1 hybrids seemingly yield only aborted parthenogenetic seeds, or are sterile.

As far as known there is only one hybrid *Crinum* of the hardy class (which excludes the tropical Asian hybrids) that is capable of producing vigorous F-2 segregates and this plant is the long ignored *C.* x 'Luther Burbank'. The great broad recurving leaves of this hybrid resemble those of *C. bulbispermum* and have generally misled most *Crinum* collectors into assuming that *C. bulbispermum* was employed by Luther Burbank in this cross. However the black anthers and open shape of many of the blossoms to the F-2 segregates suggests that *C. macowani* may be one parent. The breeding behavior with *C. moorei* and *C. bulbispermum* apparently eliminates these species as the latent parents as will be discussed below. But despite these difficulties regarding parentages the plant is a free seeder and has wide possibilities as a breeder. For example either *C.* x 'Luther Burbank' or its seedlings will cross with *C. moorei* when the latter is the pollen parent and give rise to some very slow growing seedlings with slender *moorei* like foliage. The plants are very difficult to flower and are apparently sterile. In no way do they resemble the Powellii hybrids. In contrast *C.* x 'Luther Burbank' will cross with all of the *C. bulbispermum* variants to yield intensely vigorous hybrids which are easily flowered in three or four years. Those crosses on the white form of *C. bulbispermum* resemble *C.* x 'Louis Bosanquet' so closely in foliage, open umbel, and flower form that there is a possibility that this was the combination used by Mr. Bosanquet.

Similar crosses on the red flowered 'Orange River Lily' also resemble *C.* x 'Louis Bosanquet'. but the plants are far larger and much more vigorous and the blossoms are colored a deep coral pink. The initial hybrid obtained between a Burbank F-2 seedling and the Orange River Lily has been named 'Cape Dawn'. Interestingly enough several Burbank F-2 seedlings have acted as pollen parents in this cross and all bulbs flowered to date have been clonal in similarity. The tall scapes carry umbels of seventeen to twenty blossoms on relatively long pedicels. The bright colors make a good show in the garden and individual umbels are particularly suitable for floral arrangements due to the open spacing and lasting quality of the blossoms. The new hybrid apparently produces no seed on selfing but evidence indicates that backcrosses may occur. As a consequence the writer has initiated a two objective breeding program: First to obtain improved segregates in the Burbank seedling group, and secondly to intercross these with the 'Orange River Lily' or its lighter colored intraspecific crosses to obtain a complete series of light to deep pink segregates. A third phase is to explore the possibility of obtaining backcrosses. Since seeds of the 'Cape Dawn' type have been distributed to *Crinum* fanciers we should be hearing from others concerning the 'Cape Dawn' siblings. They too should participate in this third phase study.

In summing up our observation, *Crinum* hybrids are better understood than first supposed. We have some inkling as to which parents accentuate or suppress color, and we have some clearer views where to look for viable or semiviable hybrids. The one field not explored is that of backcrossing using pollen from hybrids on parental species—There are possibilities here. There are also possibilities in repeating old crosses to obtain improved forms and colors. And above all there are additional hardy species to obtain and cross in order to open up the breeding field. Unquestionably *C. yemense* and *C. johnsonii* should cross and give fertile hybrids which can be interworked with *C. latifolium, C. macowanii, C. gouwsii.* Several of the other South African species also warrant additional investigation. Finally the work should not be limited to hardy forms, but extended to the subtropical Crinums. Our friends in Florida and along the Gulf should have a field day too.

ZEPHYRANTHES BREEDING NOTES

E. L. Brasol, *Florida*

Zephyranthes candida has the capability of producing numerous bulblets by the splitting of the mother bulb as in some sorts of *Narcissus.* It was with the purpose of transferring this reproductive habit to hybrids that the trials of crossing *Z. candida* with other Zephyranthes species was undertaken many years ago.

Z. candida is the latest in the season to bloom, and thus I had to use pollen from stragglers of any species which bloomed at such a late date. One of these stragglers was *Z.* x *ajax* and there was one other. Only the cross of *Z.* candida ♀ x *Z.* x *ajax* ♂ set seeds. Among the seedling progeny there were two color variations:

(a) one with yellow flowers smaller than *Z.* x *ajax,* a very shy bloomer, fairly late blooming, later than *Z.* x *ajax,* but earlier than *Z. candida,* which is named *Zephyranthes* x *ajax* 'Brasol's Yellow' (syn.-"Candjax").

(b) one with cream-colored flowers larger than those of *Z. candida,* a profuse bloomer among the earlier sorts, which is named *Zephyranthes* x *ajax* 'Brasol's Cream' (syn.- "Candidax").

The synonyms indicated have been used up to the present, but these names are not acceptable according to the Code for naming cultivated plants since they are so nearly alike that confusion would result. Therefore, the more distinct names are proposed.

Since all back crosses are members of an original hybrid, the back cross *Z. candida* ♀ x *Z.* x *ajax* ♂ remains part of the latter. *Z.* x *ajax* is the result of *Z. candida* x *Z. citrina* (see PLANT LIFE *15:* 39. 1959.)

I began to sell them under the synonym names in the late thirties, but these names were never published and thus the transition to the properly published names is easy.

However, neither of these hybrids acquired the feature of bulb-splitting, and so far neither of them ever set any offsets for me, and the cultivars have been propagated by means of seeds. Now that a new color has been added to the dainty array of Rain Lilies, one may be satisfied since "all's well that ends well."

HYMENOCALLIS REPORT FROM OHIO

Len Woelfle

The summer of 1961 was not particularly fruitful as far as hybridizing *Hymenocallis* is concerned. From hundreds of pollinations only four capsules of seed developed and of these two disappeared while the writer was away on business. I would guess they became a choice tidbit for a hungry bunny—we now have more than our share of his kind.

Bloom from *Hymenocallis* (subgenus Ismene) was unusually good this year. Most of my bulbs of 'Pax' bloomed, with up to seven blooms per scape. These were followed in quick succession by 'Icon' and 'Helios'. Then came the species *H. Amancaes, H. longipetala, H. narcissiflora, H. macleana* and the older hybrid clones 'Advance'. and 'Sulphur Queen' and the hybrid *H.* x *festalis.*

Hymenocallis 'Pax' seems to be a truly outstanding hybrid in the Ismene section. It is colored essentially like 'Olympia' but has slightly smaller cups, and with the culture we must give them here, taller scapes and more blooms. This may not be true where fall digging and winter storage are not required. It differs from 'Icon' and 'Sulphur Queen' in that these have very pale yellow coloring and greenish keel markings inside the cup, whereas in 'Pax' the keel markings are yellow and the green is almost entirely absent.

'Icon' is the writer's cross #5003. To all outward appearances it is exactly like the 'Sulphur Queen' in growth and flower, as suggested by the name 'Icon', meaning a likeness, or image. Unlike the 'Sulphur Queen' however, it does not seem to have the habit of deformed blooms and crooked perianth tubes. These malformations are probably inherited from the seed parent, *H. narcissiflora* (syn. *H. calathina),* on which the flowers in the umbel all face in the same direction, while in the pollen parent *H. amancaes,* the placement is radial. The old clone 'Sulphur Queen' seems unable to decide which way the blooms should face.

'Helios' is the writer's cross #5208—of the same parentage as 'Sulphur Queen' and 'Icon'. This is truly a pastel yellow, several shades darker than 'Icon' and 'Sulphur Queen' and the color does not break to white after the flower opens. Here it seems to retain its color until the flower wilts.

It is my hope that these three new hybrids in the 'Sulphur Queen' complex, 'Helios', 'Icon' and 'Pax' can soon be made available commercially, so that all who are interested in these exotic amaryllids may have them.

The future should give us others, intermediate between the large-cupped *Ismene* section and the small cupped Amerindian Lilies from North America. Several crosses have been made and perhaps more definite information can be given in future issues of PLANT LIFE. Progress is slow in developing new hybrids in this group, but the near future holds promise of many good things to come.

NEW SOUTHERN AMARYLLIS HYBRIDIZERS AND GROWERS

BECKWITH D. SMITH,

3479 Rockhaven Circle, N. E., Atlanta 5, Georgia

This summer, through correspondence with Mrs. H. W. Law, Chula, Georgia, I learned of a new strain of *Amaryllis* grown by Mr. O. J. Woodward of Tifton, Georgia. It develops that during 1933, or earlier, Mr. Woodward was Horticulturist at the Georgia Coastal Experiment Farm at Tifton, when he was growing the Mead strain *Amaryllis.* He selected a good red to improve on and subsequently originated a number of beautiful hybrids. Mrs. Law relates that his home is ideally located on low land of black, alluvial soil, with numerous large pines and other trees for shade. I hope to visit Mr. Woodward with Mrs. Law in the spring of 1962, when his hybrid Amaryllis are blooming.

Another comparatively new hybridizer, importer and grower is the Experimental Farm at Tampa, Florida, managed by Mr. Robert L. Solomon, P. O. Box 11653, Tampa 10, Florida. I bought many beautiful Dutch bulbs from this new grower in the early spring, and was particularly pleased with a group of large flowering California hybrids purchased from this source. This concern is offering many fine items in amaryllids, and I am sure will develop some beautiful new clones as a result of hybridizing the best available Dutch stocks.

A third grower of considerable note is Mrs. J. S. Barry, operating Barry's Nursery, at Route 1, Box 7, Prairieville, Louisiana. Mrs. Barry, for a number of years has been hybridizing fine quality Dutch bulbs and

[NEW AMARYLLIS HYBRIDIZERS, B. D. Smith, continued on page 128.]

CHROMOSOME BALANCE IN CYRTANTHUS

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I. INTRODUCTION

The genus *Cyrtanthus* contains nearly fifty species, endemic to the south-eastern part of Africa. A monograph of the genus was published in 1939 by Dyer. Only little is known, so far, of the chromosomes of *Cyrtanthus,* and of the closely related genera *Anoiganthus* and *Vallota.* *Cyrtanthus*-chromosomes were studied for the first time by Taylor (1926) who determined $2n = 16$ in *Cyrtanthus parviflorus.* Later Sato (1938 and 1942) reported the number $2n=22$ for *C. obliquus* and $2n=16$ for *Vallota speciosa.* Mookerjea (1955) counted $2n=20$ in *Cyrtanthus "Ifafa Lily"* ("a horticultural species"). It should be observed, however, that one cell with 16 chromosomes was found too. In *"C. sanguinea"* $2n=18$ was reported by the same author. The chromosome number $2n = 16$, and preliminary data on chromosome morphology, were given by Gouws (1949) for *Cyrtanthus tuckii* var. *transvaalensis, Anoiganthus breviflorus* and *Vallota speciosa.* The chromosomes of *Cyrthanthus lutescens* ($2n=16$) and of *Vallota purpurea* ($=$ *V. speciosa*) ($2n=16$) were studied by Tjio and Levan (1950). The chromosome pictures given by these authors for *C. lutescens* are in good agreement with the idiogram of Gouws (1949) for *Anoiganthus breviflorus.* Transposing the chromosomes D and E of Gouws as well as F and G, complete correspondence is reached between the two systems.

In the present paper some cytological investigations in *Cyrtanthus* and *Vallota* are reported. An amphidiploid was artificially produced from a cross between two of these species. By back-crossing to the diploid and further crossings among the different levels of polyploidy, a wide variation in chromosome numbers was obtained. An analysis of the polyploid and aneuploid materials is the main object of the present paper.

II. MATERIAL AND METHODS

The material analysed comprises the following species:-

1. *Cyrtanthus parviflorus*	Origin unknown.
2. *Cyrtanthus lutescens*	Origin unknown.
3. *Cyrtanthus mackenii*	Botanical Gardens, Lund.
4. *Cyrtanthus "hybrida pink"*	South Africa (commercial variety).
5. *Cyrtanthus falcatus*	Botanical Gardens, Kew.
6. *Cyrtanthus sanguineus*	South Africa.
7. *Cyrtanthus obliquus*	South Africa.
8. *Vallota speciosa*	Origin unknown

Cyrtanthus parviflorus, C. lutescens and *C. mackenii* are dealt with in some detail. In some crosses also *C. "hybrida pink"* is included.

The technique of crossing is very simple in the present plant. It is not necessary to emasculate in advance, as the stigma is receptive one or two days before the anthers open. By using a new toothpick for every pollination, contamination with undesired pollen is avoided. The anthers are removed directly after pollination. Since the plants are grown in a fly-proof greenhouse, isolation of the flowers is unnecessary.

The cytological technique used, will be described in a special paper by Oestergren and Heneen. Their schedule, with some adjustments for the present material, is the following:

Root tips are treated with a 0.1% solution of colchicine for about eight hours. This treatment is usually performed while the roots are still on the plant. One or two healthy roots growing through the hole in the bottom of the pot are immersed into the colchicine solution. After that the terminal 2-3 cms of the root tips are cut off and treated for four hours at 15 centigrades with 8-hydroxy-quinoline solution, usually in the concentration of 0.002 M. The roots are trimmed so that only the terminal cm is fixed. The fixative has the following constituents: -

Methanol	60 ml.
Chloroform	30 ml.
Distilled water	20 ml.
Dinitrophenol	1 g.
Picric Acid	1 g.
Mercuric chloride	1.1 g.

The roots are fixed overnight. Material can be left in the fixative for a few days without damage. The roots are hydrolysed in 1-N HCl at 60°C for 8 minutes and stained in the Feulgen reagent for two hours. After the staining the material is treated with pectinase (5 g. pectinase* in 100 ml. distilled water) for two hours. By means of this treatment the middle lamella is dissolved, leaving the tissue soft and easy to squash. A longer time in pectinase is not harmful but may make the material too soft for easy handling.

The extreme tips of the roots are squashed in 45% acetic acid under plastic coverslips. (Astrolon plastic 0.25 mm). Cells are easily separated from each other a monolayer resulting. By gentle pressure on the coverslip the surplus of acetic acid is removed and absorbed by filter paper. Spreading of the chromosomes is improved by gentle tapping with a match on top of the coverslip. Rubber solution is applied around the plastic coverslip and left for about half an hour to dry.

The slide is next scanned under the microscope for useful mitoses. Successful slides are made permanent as follows. They are placed overnight in acetone for dissolving the plastic coverslips. The rubber frames are soluble in xylol, but may more easily be removed manually by a forceps when the slides are still in acetone. The slides are passed through a series of acetone + xylol and three jars of xylol before being mounted in Permount or Balsam.

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* A commercial sample from Nutritional Biochemicals Corporation, Cleveland 28, Ohio.

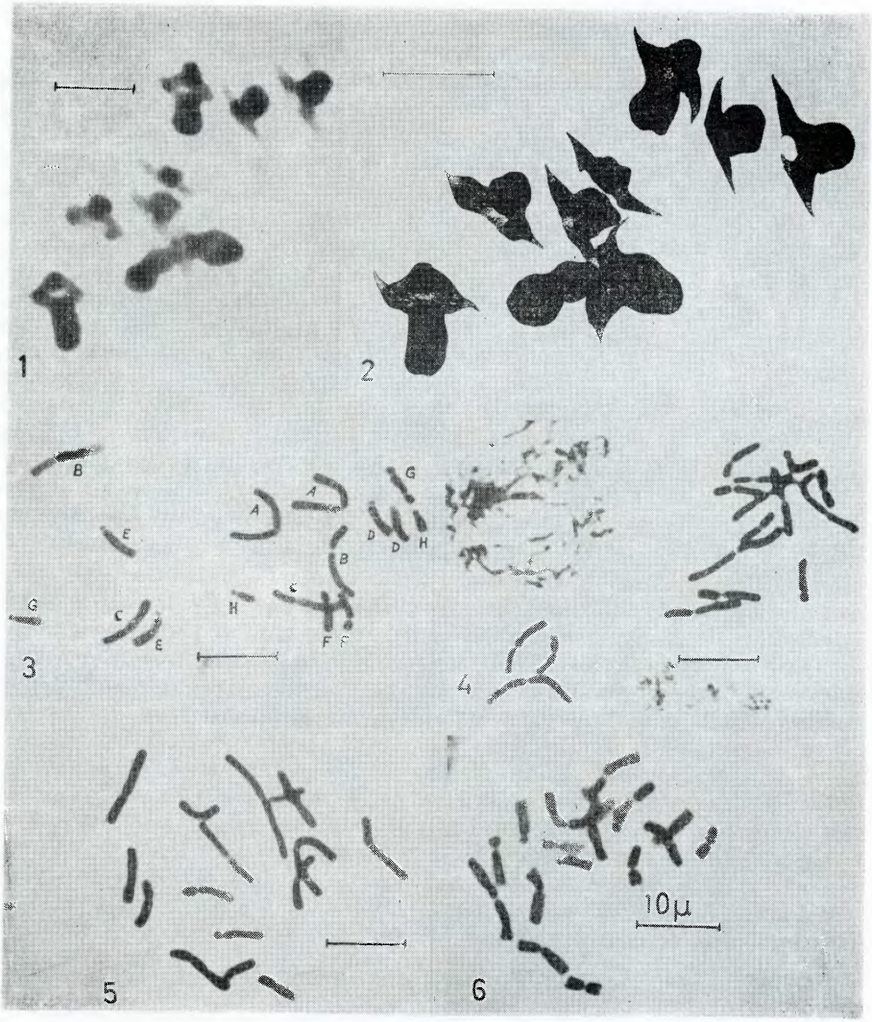

Plate 1. 1, Metaphase I of *C. parviflorus;* 2, A drawing of the same plate; 3, Somatic metaphase plate of *C. parviflorus* x *C. lutescens.* Note the heteromorphic chromosome pair G; 4, Somatic metaphase plate of *C. obliquus;* 5, Somatic metaphase plate of *C. falcatus;* 6, Somatic metaphase plate of *C. sanguineus.*

III. CYTOLOGICAL RESULTS

1. *Chromosome morphology of the diploids.*

The somatic chromosome number is 2n=16 in all species studied: *Cyrtanthus lutescens, C. parviflorus, C. mackenii, C. sanguineus, C. obliquus, C. falcatus* and *Vallota speciosa.* Somatic metaphase plates of the hybrid *C. parviflorus* x *C. lutescens,* and of the species *C. obliquus, C. falcatus* and *C. sanguineus* are given in Plate 1. Karyotypes of all the seven species, and of the hybrid *C. parviflorus* x *C. lutescens,* are given in Plate 2. The chromosomes are arranged into eight homologous pairs, given the letters A to H. It is clearly seen from Plate 2 that there are similarities between the chromosome complements of *C. lutescens, C. parviflorus* and *C. mackenii,* which together form one group. Another group is formed by *C. sanguineus, C. obliquus, V. speciosa* and *C. falcatus.* In the former group no differences are observed between the karyotypes of *C. lutescens* and *C. mackenii.* Both of them have a characteristic secondary constriction on the long arm of chromosome G. *C. parviflorus* does not show this constriction and, furthermore, the long arm of G is slightly shorter than in the former two species. In the hybrid between *C. parviflorus* and *C. lutescens* the two types of chromosome G are apparent (Plate 2). The species of the latter group exhibit clear karyotypic differences especially in chromosomes E. and F. *C. falcatus* is characterized by a pronounced secondary constriction in the long arm of chromosome C.

As mentioned, the three species *C. parviflorus, C. lutescens* and *C. mackenii* (for convenience abbreviated C.p., C.l. and C.M.) will be dealt with more in detail. Their eight chromosome pairs form five easily identifiable groups, for which the following symbols, roughly indicating relative length and centromeric position are proposed:

Chromosomes	Symbols
A	V
B and C	L
D and E	j
F and G	l
H	i

Pair A—group V is the longest chromosome of the complement. Its centromere is nearly median.

Pairs B and C—Group L are the second longest chromosomes. Their centromeres are submedian.

Pairs D and E—group j are of medium size. D is usually slightly shorter than E. The centromere is almost terminal. The short arms of these two pairs are of similar length and smaller than any of the other chromosome arms in the complement.

Pairs F and G—group l are of medium size, and their centromeres are subterminal. Chromosome F can be distinguished from chromosome G by its slightly longer short arm. In addition it has a secondary con-

Plate 2. Karyotypes of **Cyrtanthus lutescens, C. parviflorus, C. parviflorus** x **C. lutescens, C. mackenii, C. sanguineus, C. obliquus, Vallota speciosa** and **C. falcatus.**

striction on the short arm dividing it into unequal parts: one longer distal and one shorter proximal part. It is probable that this secondary constriction is concerned with the nucleolus formation.

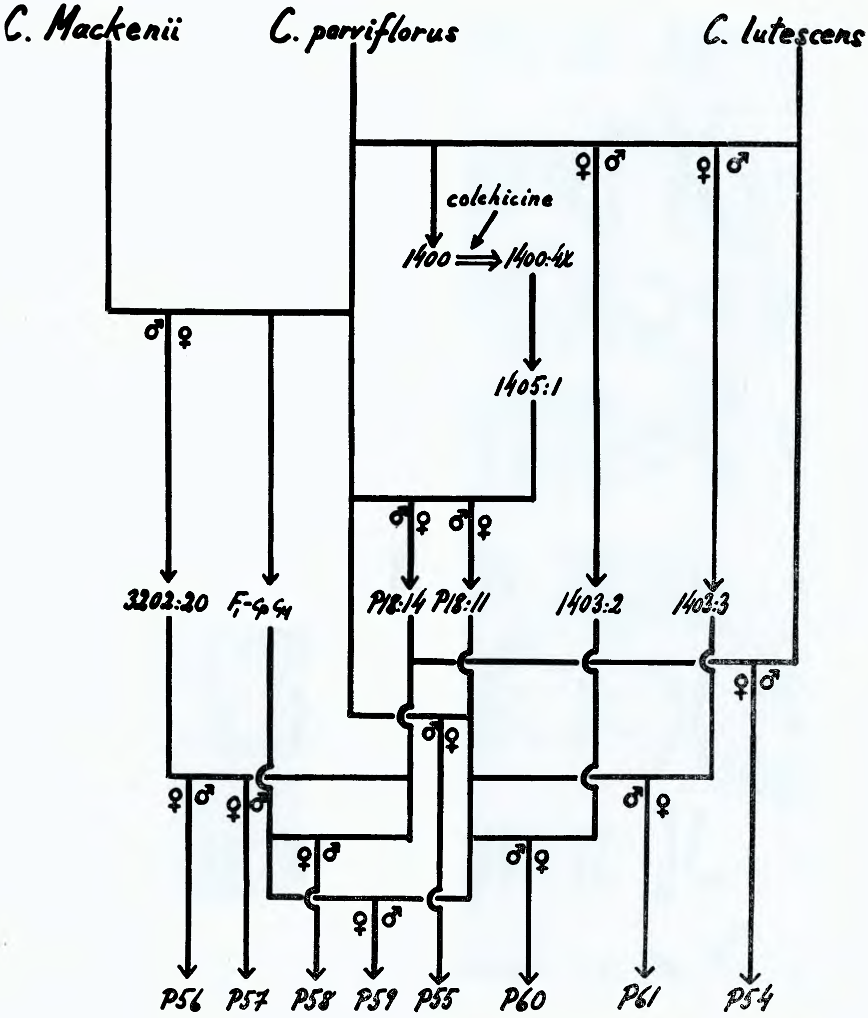

Plate 3. Programme of the crosses given in Table I.

Pair H—group i is the shortest chromosome of the complement, and its centromere is subterminal. Its short arm is slightly longer than that of group j (D and E).

The different groups may be identified even on meiotic chromosomes (Plate 1, fig. 1 and 2).

In order to describe the chromosome constitution of any individual, diploid, polyploid or aneuploid, the number of chromosomes present in each group is given below the symbol of that group. For example,
VLjli
24442 represents the constitution of the normal diploid complement. For the sake of simplicity the five number formula will be given without the group symbols, thus, the normal complement: 24442. It should be observed that in groups L, j and l, which include two chromosome pairs each, extra chromosomes of aneuploid complements are not individually defined by the formulas. For example, the formula 25542 indicates a double trisomic for one chromosome of group L (B or C) and one of group j (D or E). Accordingly, there will be four combinations possible: 2x+B+D, 2x+B+E, 2x+C+D and 2x+C+E.

2. *Origin of the chromosome number variation.*

In 1952 a cross between C.p. and C.l. was made. The seeds obtained from this cross were treated with colchicine. Out of 155 seedlings only one survived. In 1955 this plant came into flower. Two flower stalks were formed, one of which developed from a lateral bulb. The flowers of the latter stalk had a darker red colour than those of the primary stalk. After transplanting to a separate pot, this lateral bulb gave still more intensively red flowers than when attached to the diploid bulb. This plant turned out to be a tetraploid with 2n=32 and was labelled 1400:4x. After selfing, five flowers gave four capsules containing 54 seeds, from which 47 plants resulted.

In the tetraploid offspring one plant, no. 1405:1 (2n=4x=32), was pollinated with pollen from C.p. In this cross two near-triploid offspring plants, P 18:11 and P 18:14, resulted, both with the chromosome number 2n=23. They were found to be disomic for the largest chromosome of the set (A). These two individuals were crossed with diploid species and diploid hybrid plants. A chart over these crosses is shown in Plate 3. Two other charts arranged in the same way are given in Plate 4. These charts will be considered when dealing with the different types of crosses.

3. *Crosses 3x x 2x. The trisomics.*

In Plate 3, the origin of eight crosses between hypotriploid and diploid plants is represented. The chromosome numbers in the offspring of these are given in Table I.

In this table a striking difference in distribution of chromosome numbers is apparent, depending on the direction of the cross. In the reciprocal crosses between the diploid and the hypotriploid, the range of chromosome numbers is more limited when the triploid is used as father. This is due to the stronger selection of chromosome combinations among pollen grains than among egg cells. In female gametes the different chromosome constitutions are nearly equally viable. Most of the offspring are aneuploid and represent an extremely wide range of chromosome combinations, as shown in Table II. None of the offsprings is

Table I. Chromosome numbers in offspring of the reciprocal crosses hypotriploid (23) x diploid (16).

Cross	Mother	Father	Number of:				Chromosome number							Mean chromosome number
			capsules	seeds	plants	plants studied	16	17	18	19	20	21	22	
P 54	P 18:14	C.l.	3	61	50	45	1	8	10*	13	5	5	3	
P 55	P 18:11	C.p.	1	17	9	6	—	2	1	3	—	—	—	
Sum	3x-V	2x	4	78	59	51	1	10	11	16	5	5	3	18.80±.21
P 56	3202:20**	P 18:14	1	8	4	4	3	1	—	—	—	—	—	
P 57	"	"	2	29	20	14	6	6	2	—	—	—	—	
P 58	F_1-CpCM	"	4	32	21	16	6	5	2	1	—	2	—	
P 59	"	P 18:11	4	39	27	27	8	14	4	1	—	—	—	
P 60	1403:2***	"	6	91	78	73	19	41	13	—	—	—	—	
P 61	1403:3***	"	1	9	9	8	4*	3	1	—	—	—	—	
Sum	2x	3x-V	18	208	159	142	46	70	22	2	—	2	—	16.92±.07

* One plant of these contained a very small centric fragment in addition to the number of chromosomes given.

** No. 3202:20 is a F_1-plant from a cross C.p. x C.M.

*** Nos. 1403:2 and 1403:3 are F_1-plants from a cross C.p. x C.l.

Table II. Detailed chromosome constitution in offspring of the cross of table I.

No. of plants		No. of chromosomes in the groups						No. of genetic types
P 54 P 55	P 56— —P 61	V	L	j	l	i	2n	
1	46	2	4	4	4	2	16	1
3	12	2	5	4	4	2	17	2
2	13	2	4	5	4	2	17	2
2	24	2	4	4	5	2	17	2
3	21	2	4	4	4	3	17	1
10	70	Sum 2x+1					17	7
		2	6	4	4	2	18	1
2	4	2	5	5	4	2	18	4
	1	2	5	4	5	2	18	4
3	4	2	5	4	4	3	18	2
	1	2	4	6	4	2	18	1
	2	2	4	5	5	2	18	4
	3	2	4	5	4	3	18	2
1		2	4	4	6	2	18	1
4	7	2	4	4	5	3	18	2
10*	22	Sum 2x+2					18	21
2		2	6	5	4	2	19	2
		2	6	4	5	2	19	2
		2	6	4	4	3	19	1
1		2	5	6	4	2	19	2
5		2	5	5	5	2	19	8
3		2	5	5	4	3	19	4
2		2	5	4	6	2	19	2
		2	5	4	5	3	19	4
1		2	4	6	5	2	19	2
1		2	4	6	4	3	19	1
		2	4	5	6	2	19	2
	1	2	4	5	5	3	19	4
1	1	2	4	4	6	3	19	1
16	2	Sum 2x+3					19	35
		2	6	6	4	2	20	1
1		2	6	5	5	2	20	4
		2	6	5	4	3	20	2
		2	6	4	6	2	20	1
		2	6	4	5	3	20	2
2		2	5	6	5	2	20	4
		2	5	6	4	3	20	2
		2	5	5	6	2	20	4
2		2	5	5	5	3	20	8
		2	5	4	6	3	20	2
		2	4	6	6	2	20	1
		2	4	6	5	3	20	2
		2	4	5	6	3	20	2
5		Sum 2x+4					20	35
1		2	6	6	5	2	21	2
	1	2	6	6	4	3	21	1
		2	6	5	6	2	21	2
2		2	6	5	5	3	21	4
1		2	6	4	6	3	21	1
		2	5	6	6	2	21	2
1		2	5	6	5	3	21	4
		2	5	5	6	3	21	4
		2	4	6	6	3	21	1
5	1*	Sum 2x+5					21	21
2		2	6	6	6	2	22	1
1		2	6	6	5	3	22	2
		2	6	5	6	3	22	2
		2	5	6	6	3	22	2
3		Sum 2x+6					22	7
		2	6	6	6	3	23	1

* These values are deviating from the equivalent ones in table I because two of the individuals could not be placed in a definite group, due to the presence of structural changes. However, in most of the individuals showing such changes, the chromosome constitution can be determined.

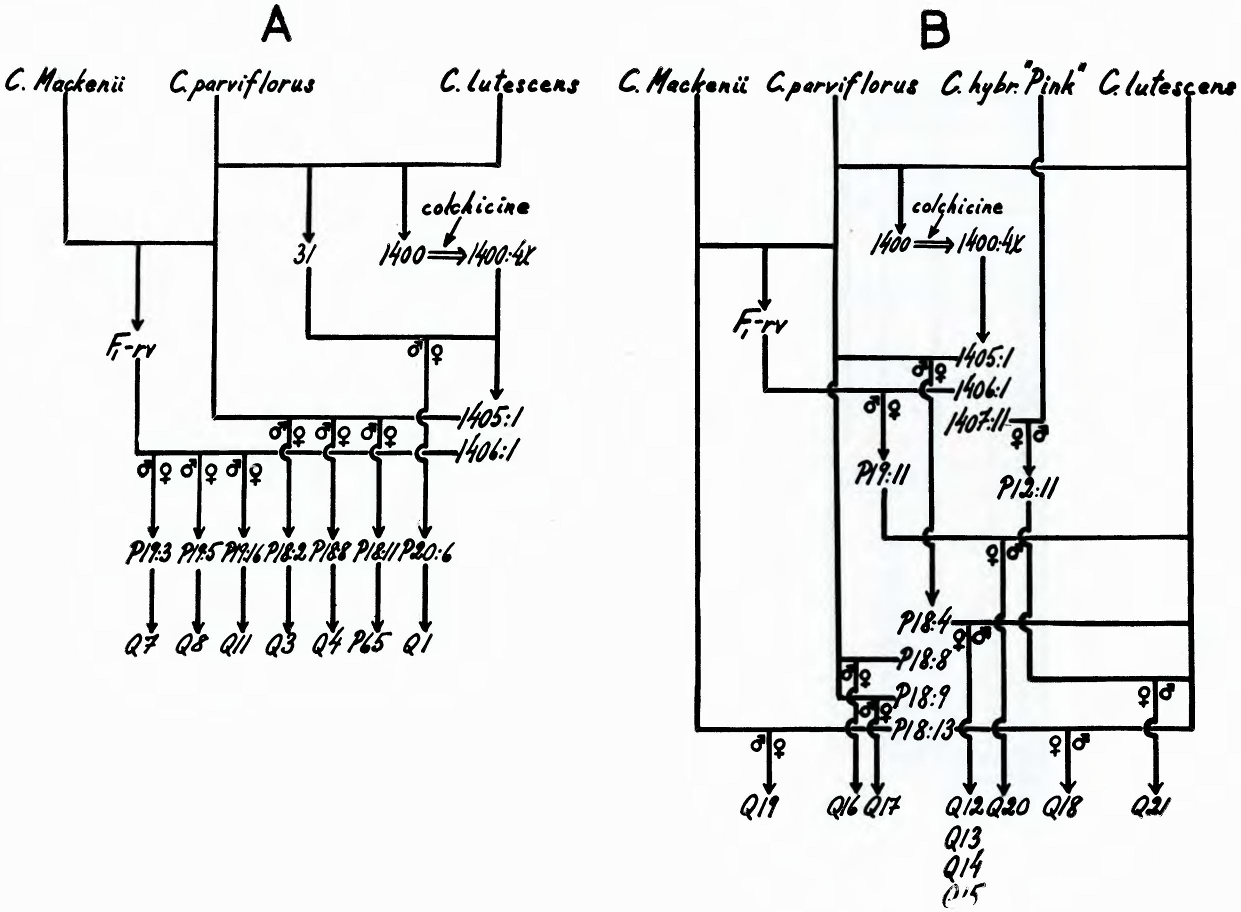

Plate 4. For caption see opposite page.

trisomic for chromosome A. This is because one of the A chromosomes is missing in the hypotriploid parents, which have the constitution 26663.

In the cross diploid x hypotriploid (P56—P61), different extra chromosomes are present in the offspring in different frequencies, *viz.*:

Table III. Detailed chromosome constitution in offspring of crosses: 3x x 2x and (3x+j) x 2x.

Plant number	No. of chromosomes						Plant number	No. of chromosomes					
	V	L	j	l	i	2n		V	L	j	l	i	2n
3x x 2x							(3x+j) x 2x						
Q12: 5	2	4	4	4	3	17	Q20: 3	3	4	6	5	2	20
8	2	4	4	4	3	17	4	3	4	5	6	2	20
9	3	5	5	6	3	22	5	3	6	6	5	3	23
13	3	5	4	6	3	21	6	2	6	6	4	3	21
14	3	5	5	5	3	21	8	3	5	6	5	3	22
15	3	4	6	5	3	21	10	2	6	5	5	2	20
16	3	6	6	4	3	22	11	3	5	6	6	2	22
Q13: 7	3	6	6	4	2	21	12	2	6	5	6	3	22
11	3	4	4	5	2	18	13	2	5	6	5	2	20
13	2	6	5	5	3	21	14	3	5	6	5	2	21
16	2	4	6	5	2	19	16	2	5	5	5	2	19
Q14: 3	3	6	5	5	2	21	27	2	4	5	4	2	17
7	2	5	4	4	3	18	28	2	5	6	5	2	20
8	2	6	5	5	3	21	—	—	—	—	—	—	—
10	3	6	5	5	3	22	—	—	—	—	—	—	—
12	2	4	5	5	2	18	—	—	—	—	—	—	—
18	3	5	5	5	3	21	—	—	—	—	—	—	—
Q15: 4	2	4	4	6	3	19	—	—	—	—	—	—	—
Sum	46	89	88	88	49	360		32	66	73	66	30	267
No. of plants						18							13
Mean	2.6	4.9	4.9	4.9	2.7	20.0		2.5	5.1	5.6	5.1	2.3	20.5
Exp. mean	2.5	5.0	5.0	5.0	2.5	20.0		2.5	5.0	5.5	5.0	2.5	20.5
3x x 2x													
Q21: 1	2	4	5	4	2	17							
2	2	6	5	6	3	22	(3x-V) x 2x		See Table II.				
3	3	4	5	6	3	21							
4	2	4	5	4	2	17							
5	3	6	6	6	2	23							
6	3	4	4	5	2	18							
7	2	5	4	6	2	19							
8	3	4	5	4	2	18							
9	3	4	5	5	2	19							
10	3	5	5	5	3	21							
Sum	26	46	49	51	23	195		100	244	239	236	122	941
No. of plants						10							50
Mean	2.6	4.6	4.9	5.1	2.3	19.5		2.0	4.9	4.8	4.7	2.4	18.8
Exp. mean	2.5	5.0	5.0	5.0	2.5	20.0		2.0	5.0	5.0	5.0	2.5	19.5

Chromosome B or C	16 %	(8 % per chromosome)
Chromosome D or E	19 %	(10 % per chromosome)
Chromosome F or G	26 %	(13 % per chromosome)
Chromosome H	38 %	

There is a negative correlation between chromosome size and incidence in trisomics. Very likely, small extra chromosomes will cause

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Plate 4. For figures see opposite page.
A. Programme of the crosses given in Table IX.
B. Programme of the crosses given in Table III. *C. hybr. "Pink"* is a diploid of the same chromosome morphology as *C. mackenii,* obtained as a commercial variety from South Africa. The shape of the flowers is about the same as in *C. mackenii,* but the colour is pink instead of white. When the plant is selfed, it is segregating only in pink and white.

less retardation in pollen tube growth than large extra chromosomes. Possibly, there are also differences in pollen viability depending on the size of the extra chromosome.

In another cross, a hypertriploid plant (P19:11) with the constitution 36763 was pollinated with pollen from a diploid plant (Plate 4B). The chromosome formulas of thirteen individuals are presented in the right part of Table III. Only two of them (nos. 13 and 28) have identical chromosome combinations (25652). One plant, no. 27, is a simple trisomic: 2x + j. The mean chromosome number is 20.54, that is about the same as in the parents (20.50). As seen, every plant is trisomic for the extra chromosome of the mother plant.

Table IV. Chromosome numbers in offspring of crosses: ±triploid x diploid.

Type of cross	Chromosome numbers 16	17	18	19	20	21	22	23	24	No. of plants	Mean chr. number	Ex-pected mean	Significance in difference	
(3x-V) x 2x	1	10	11	16	5	5	3			51	18.80±.21	19.50	t=3.35	P<.01
3x x 2x		4	5	4	—	10	4	1		28	19.82±.35	20.00	t= .51	P> .6
(3x+j) x 2x		1	—	1	5	2	3	1		13	20.54±.43	20.50	t= .09	P> .9

Table V. Chromosome loss in triploid meiosis on the female side.

Cross no.	Cross type	No. of plants	No. of chromosomes V	L	j	l	i	Sum
P54,P55	(3x-V) x 2x	50	—	244	239	236	122	841
Q12,Q13,Q14,Q15	3x x 2x	18	46	89	88	88	49	360
Q21	3x x 2x	10	26	46	49	51	23	195
Q20	(3x+j) x 2x	13	32	66	—	66	30	194
	Sum:	91	104	445	376	441	224	1590
No. of chromosomes from the father			41	182	156	182	91	652
No. of chromosomes from the mother			63	263	220	259	133	938
Expected* no. chr. from the mother			61.5	273	234	273	136.5	978
Difference: Expected—Observed			—1.5	10	14	14	3.5	40
$\frac{\text{Difference}}{\text{Expected}}$ in per cent			—2.4	3.7	6.0	5.1	2.6	4.1

* If 50 % of the gametes have one and 50 % have two chromosome of each type.

Crosses of the type euploid triploid x diploid (36663 x 24442) have also been made. In the offspring of these crosses some individuals were studied. Their chromosome formulas and chromosome numbers are given in Table III. This table also included the mean chromosome numbers of the offspring from the crosses P54 and P55 recorded in Table II. As is seen, the mean chromosome numbers agree very well with the expected values, that is the mean of the parental chromosome numbers.

The distribution of chromosome numbers in the offsprings of ± triploid x diploid are summarized in Table IV. Only in the first cross, there is a significant deviation ($P < 0.01$) from the expected mean. In the second, in which the euploid 3x was used as mother, no individuals with $2n = 20$ have been found so far.

The data of Table III may be used for calculating the chromosome elimination during triploid female meiosis, since the father plants in all

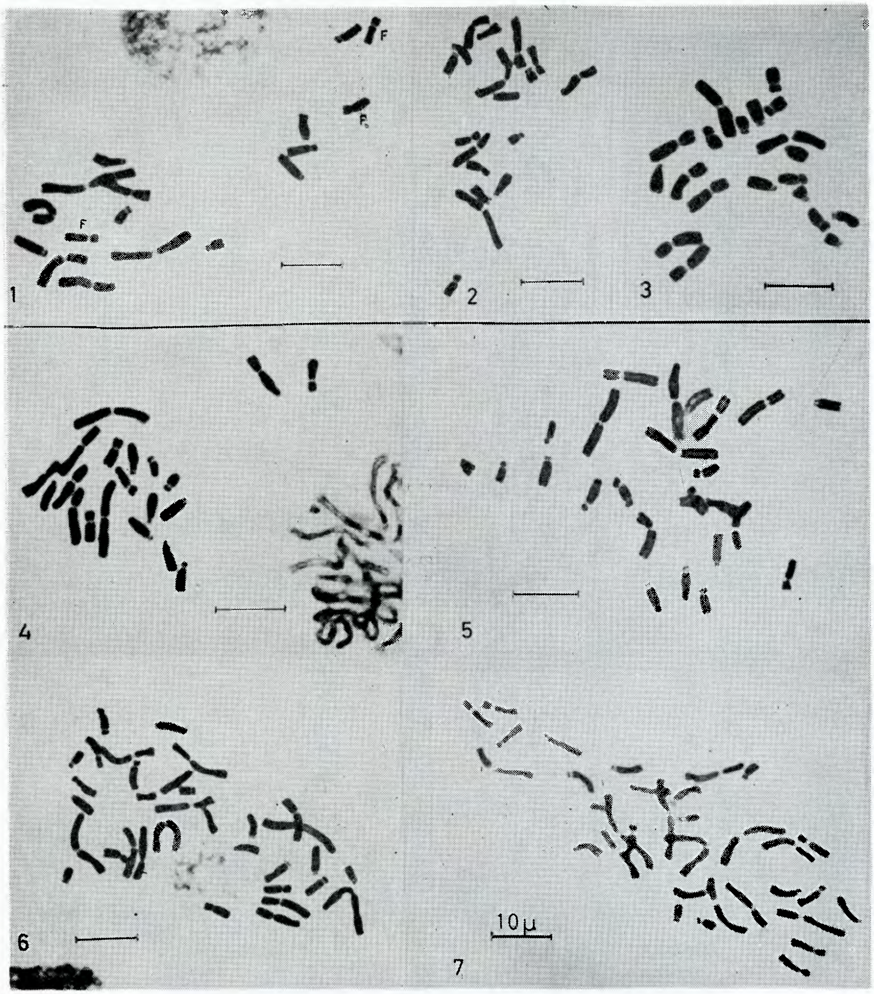

Plate 5. Somatic metaphase plates from:

	Plant no.	2n	Constitution
1.	Q41:5	17	24452 (=2x+F)
2.	P60:51	18	24552
3.	P54:24	20	25553
4.	P54:33	20	25652
5.	P88:8	24	36663 (3x)
6.	P12:2	32	49784
7.	P48:20	32	48884 (4x)

Table VI. Chromosome constitution of offspring from 4x x 2x crosses.

Constitution		No. of plants	Constitution		No. of plants	Constitution		No. of plants	Constitution		No. of plants	Constitution		No. of plants
2n=	VLjli		2n=	VLjli		2n=	VLjli		2n=	VLjli		2n=	VLjli	
3x—2	25663	4	3x—1	26663	15	3x	36663	93	3x+1	46663	2	3x+2	38663	1
	26563	1		35663	14	3x+1—1	45663	1		37663	4			
	26653	1		36563	15		37563	1		36763	13			
	35653	1		36653	7		36753	1		36673	6			
	35662	4		36662	4		36672	1		36664	1			
	36562	2	3x+1—2	27653	1		36564	1	3x+2—1	47563	1			
	36652	1		35573	1		35664	1		26674	1			
				35672	1		26673	2						
							27663	2						
Sum		14			58	Sum		103	Sum		28			1

cases contribute 8 chromosomes. A necessary assumption is, that there is no selective viability of the gametes or zygotes. In the cross (3x-V) x 2x, chromosomes of group V are disregarded, as the hypotriploid mother is disomic for chromosome A, and in the cross (3x+j) x 2x chromosomes of group j are excluded because of the presence of an extra chromosome of this group in the hypertriploid mother (Table V).

It appears from Table V, that the mean number of chromosomes eliminated during triploid female meiosis is rather low (4.1%). The mean loss of each gamete is

$$\frac{4.1 \times 24}{100 \times 2} = 0.49 \text{ chromosome.}$$

The tendency of being eliminated varies in the different groups. The highest incidence of elimination is observed in group j. This may be associated with the fact that the chromosomes of this group (D and E) have extremely short arms, which may predispose to a higher tendency of forming univalents. The lowest elimination was found in group V (chromosome A), with its big metacentric chromosomes less likely to form univalents.

Somatic metaphase plates from aneuploid, triploid and tetraploid individuals are shown in Plate 5.

4. Crosses 4x x 2x. The triploids.

Crosses were made between tetraploids and diploids. Usually offspring is only obtained when the tetraploid is used as mother. The chromosome combinations in offsprings of such crosses (48884 x 24442) are given in Table VI.

Nearly all the offsprings in this table originate from a cross between plant no. 1400:4x and C.l. The 204 individuals are classified into 32 chromosome combination types. Half of these individuals (103) have the expected triploid chromosome number 2n=24. Ten of these are actually aneuploid triploids, in which the loss of a chromosome of one group is compensated by the gain of a chromosome of another group (3x+1-1=24). It is probable that even more such compensations are concealed within the chromosome groups L, j or l, which include two different chromosomes each. However, from a theoretical estimation such a probability is less than one in the 93 triploid individuals. The formula for estimating the probability of compensation is given below.

The numbers of individual plants, di-, tri- or tetrasomic for each of the different chromosomes of the complement are given in Table VII. In the case of plants aneuploid for chromosomes of groups L, j or l, the number of individuals is calculated according to the formula shown in the same table. This calculation is based on the assumption that the two chromosome types in each of these groups have the same odds of being in aneuploid condition, i.e. that they behave in the same way in tetraploid meiosis.

Table VII. Frequency of individuals in Table VI, di—, tri—, and tetrasomic for the different chromosomes

Chromosome group	2 (k)	3 (l)	4 (m)	4 (r)	5 (s)	6 (t)	7 (u)	8 (v)	Sum N
V	27	173	4	—	—	—	—	—	204
L	—	—	—	0	27	167	9	1	204
j	—	—	—	0	22	168	14	0	204
l	—	—	—	0	12	180	12	0	204
i	13	187	4	—	—	—	—	—	204

k, l, m, r, s, t, u and v are the absolute frequency of plants for each chromosome condition.

$$\begin{array}{c|ccc} & k & l & m \\ \hline k & r & \frac{s}{2} & \sqrt{rv} \\ \hline l & \frac{s}{2} & t-2\sqrt{rv} & \frac{u}{2} \\ \hline m & \sqrt{rv} & \frac{u}{2} & v \\ \hline \end{array}$$

$$k = r + \frac{s}{2} + \sqrt{rv}$$

$$l = \frac{s}{2} + \frac{u}{2} + t - 2\sqrt{rv}$$

$$m = v + \frac{u}{2} + \sqrt{rv}$$

27 plants are disomic for chromosome A, 4 are tetrasomic, while the rest (173) are trisomic. The method of calculating the frequency of individuals with regard to chromosome B is given below as an example:

$$k_B = 0 + \frac{27}{2} + \sqrt{1 \times 0} = 13.5$$

$$l_B = \frac{27}{2} + \frac{9}{2} + 167 - 2\sqrt{1 \times 0} = 185$$

$$m_B = 1 + \frac{9}{2} + \sqrt{1 \times 0} = 5.5$$

Under the previous assumption that chromosomes B and C have the same behavior, thus $k_C = k_B$, $l_C = l_B$ and $m_C = m_B$, the incidence of either of these two chromosomes in a dissomic condition is estimated by reduplication of k_B. A summary of these values is shown in Table VIII.

Table VIII. Frequency of triploid individuals, aneuploid for different chromosomes. (In parenthesis: numbers expected from the actual sums of rows and columns.)

	Chromosome	Zygotic condition: Disomic		Tetrasomic		Sum:	
V	A	27	(21.45)	4	(9.55)	31	(18.25)
L	B and C	27	(26.29)	11	(11.71)	38	(36.50)
j	D and E	22	(24.90)	14	(11.10)	36	(36.50)
l	F and G	12	(16.60)	12	(7.40)	24	(36.50)
i	H	13	(11.76)	4	(5.24)	17	(18.25)
	Sum:	101	(73.00)	45	(73.00)	146	

1. $\chi^2 = \frac{28^2}{73} + \frac{28^2}{73} = 21.48^{xxx}$ $p < .001$ $f = 1$

2. $\chi^2 = \frac{12.75^2}{18.25} + \frac{1.50^2}{36.50} + \frac{.50^2}{36.50} + \frac{12.50^2}{36.50} + \frac{1.25^2}{18.25} = 13.34^{xx}$ $p < .01$ $f = 4$

3. $\chi^2 = \frac{5.55^2}{21.45} + \frac{5.55^2}{9.55} + \frac{.71^2}{26.29} + \frac{.71^2}{11.71} + \ldots. = 10.38^{x}$ $p < .05$ $f = 4$

From the data of Table VIII, the following points can be discussed:

1. Is there an equal chance of having one chromosome extra or less in the gametic set of the egg cell on the tetraploid level? If the chance is the same, then the disomic and tetrasomic condition of the triploid offspring will be of the same frequency (73:73). However, the observed ratio between the disomic and tetrasomic condition is 101:45. The significant difference between the actual and the expected values indicates the probable loss of chromosomes in the EMC division of the tetraploid plant. The rate of chromosome loss per egg cell can be estimated as follows:

No. of chromosomes expected in the egg cells of 204 individuals = 204 x 16 = 3264.

Observed loss = 101 — 45 = 56.

Loss percentage: $\frac{56}{3264} \times 100 = 1.72\%$.

Loss per egg cell: $\frac{1.72 \times 32}{100 \times 2} = .275$ chromosome.

As seen this figure is much lower than for triploid plants.

2. Is the sum of deviations from the trisomic condition equal for the eight different chromosomes? It was demonstrated by χ^2-test that differences occur among the five chromosome groups ($p < 0.01$). These differences are concentrated to groups V (A) and 1 (F and G); in the former there is a more irregular distribution of the chromosomes, while in the latter there is a more regular distribution than expected.

3. Are the chromosome losses at random in the different chromosome types or is there a varying degree of loss? By χ^2-test the differences found are only significant at the 5%-level. More data are needed to obtain decisive information on this point.

The frequency of plants which are pseudo-euploid triploid can be calculated by means of the following formula:

$$\frac{k_B m_C + k_C m_B}{N^2} + \frac{k_D m_E + k_E m_D}{N^2} + \frac{k_F m_G + k_G m_F}{N^2} = \frac{2(k_B m_B + k_D m_D + k_F m_F)}{N^2}$$

(k and m are calculated according to the formulas given in Table VII.)

Thus, the frequency of pseudo-euploid triploids in the 93 apparently euploid triploid individuals given in Table VI can be calculated as follows:

$$\frac{93 \times 2\ (13.5 \times 5.5 + 11 \times 7 + 6 \times 6)}{204 \times 204} = 0.84$$

Consequently less than one per cent (0.90%) of the triploid individuals will be aneuploid in relation to groups L, j and 1.

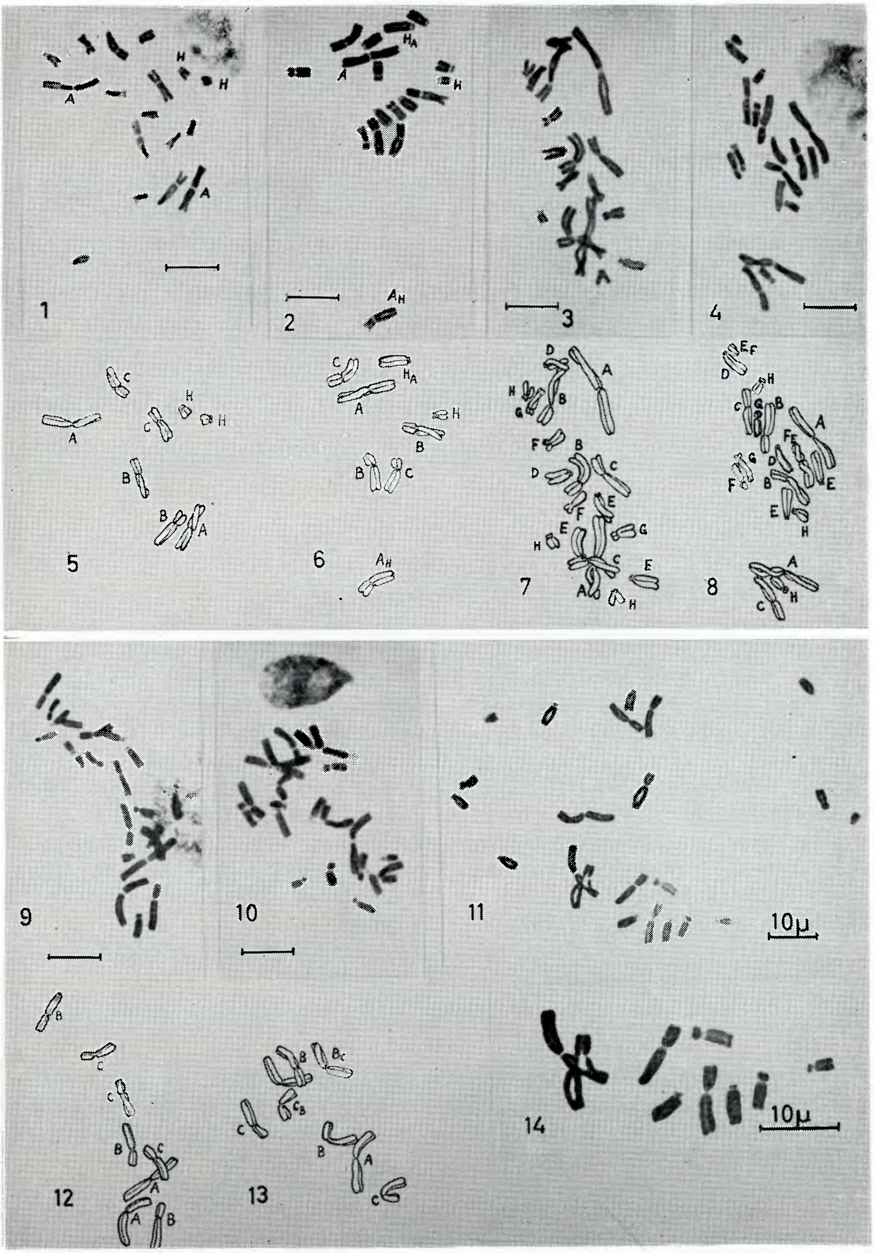

Plate 6. See opposite page for caption.

5. *Selfing of triploids and near-triploids.*

Some data obtained from selfing one triploid and two hypo-triploid plants are given in Table IX.

Table IX. Chromosome constitution in offspring from one selfed triploid and two selfed hypo-triploids.

Cross number:	P65	Q1	Q8	Q9
Mother plant: *	P18:11	P20:6	P19:5	P19:5
Chromosome constitution of mother plant:	26663	35662	36663	36663
Chromosome constitution of offspring plants:	25553	34452	48874 48864 48663 38674 46783	48684 48783

* The origin of these plants is given in Plate 4A.

Since the material studied is very limited, only restricted conclusions can be drawn. The chromosome numbers of the seven plants obtained after selfing the triploid individual P19:5 are 27, 28, 28, 30, 30, 30 and 31. Thus each of these plants has higher chromosome number than the mother plant (2n=24) and their average number is 29.14 ± 0.39. Probably differential zygotic viability is responsible for the low seed-setting in selfed triploids and for the unexpected distribution of chromosome numbers in the offspring.

6. *Structural variation in aneuploids.*

During the course of the investigation, several structural chromosome changes were detected. In all 30 individuals out of 511 studied showed at least one translocation or inversion each. As seen from Table X, 29 of these plants were aneuploids and one was triploid. Nine of these 30 individuals were shown to be chimerical, having both normal and translocated karyotypes. Since usually only one or two roots were studied from each individual, it is likely that more of them, perhaps all,

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Plate 6. Somatic metaphase plates illustrating the phenomenon of spontaneous structural changes. In order to elucidate the situation parallel drawings of some chromosomes are given.

See opposite page for figures.

Fig.	Plate No.	2n	constitution
1 and 5.	P54:50	17	24452
2 and 6.	P54:50	17	24452, translocation between V and i.
3 and 7.	P58: 3	18	24543
4 and 8.	P58: 3	18	24543, translocation between j and l.
9 and 12.	P54:29	22	26653
10 and 13.	P54:29	22	26653, translocation between L and L.
11.	P19:14	22	26653, chromatid exchange between V and L.
14.	P19:14	22	26653, detail of Fig. 11, enlarged.

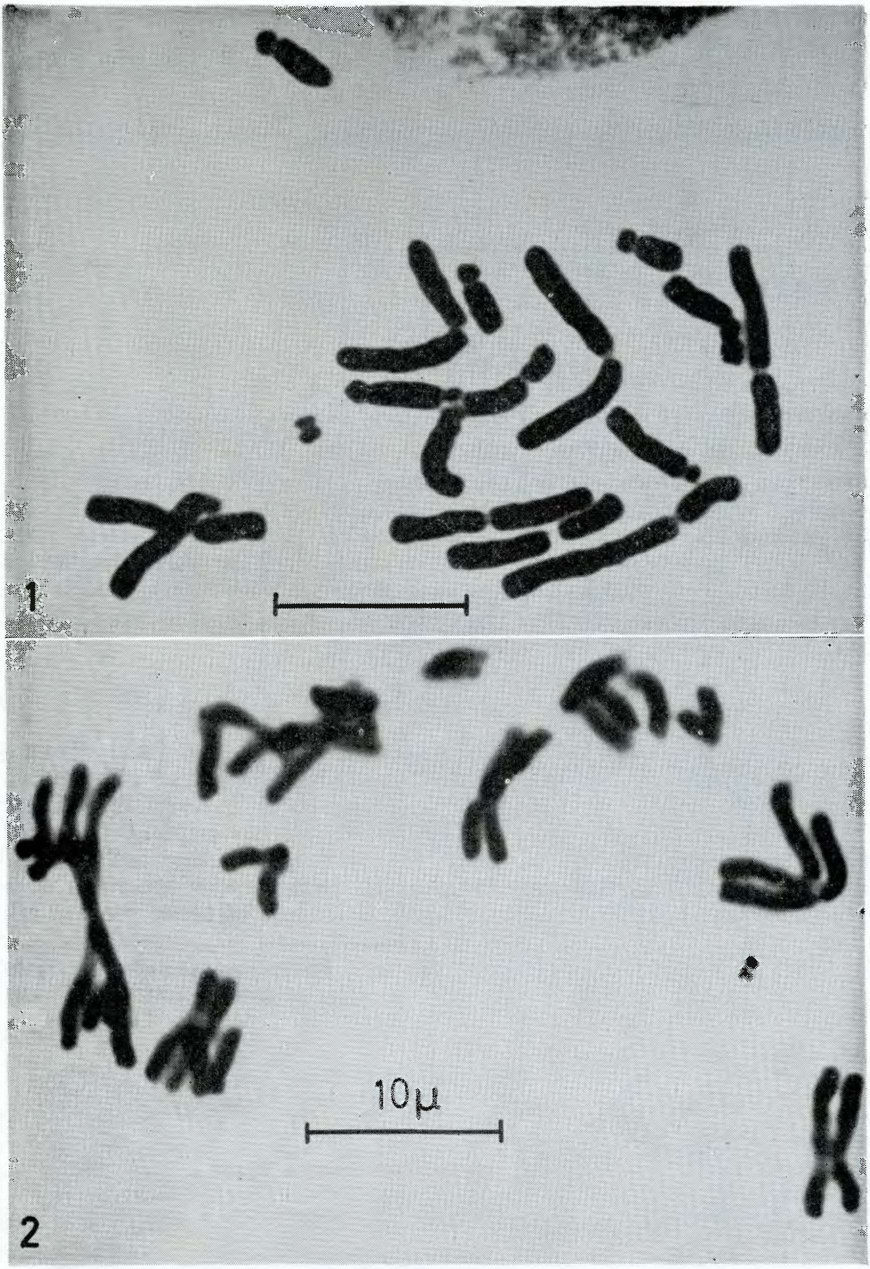

Plate 7. Somatic metaphase plates showing small centric fragments.
Fig. 1. Plant no. P56:1 (2x+j) two or three translocations.
Fig. 2. Plant no. P61:4 (2x + small fragment).

are chimerical. The studied plants are still too few to give information about translocation frequency in different trisomics.

Table X. Chromosome number distribution of the plants, which have shown aberrations.

Chromosome number	No. of plants	Plants showing Structural changes	Chimerical
2x=16	56		
17	90	13	7
18	39	3	1
19	23	3	
20	11	1	
21	20	1	
22	25	1	1
23	64	3	
23+1—1	3		
24	99	1	
24+1—1	13	1	
25	32		
25+1—1	2	1	
26	3		
27	1		
28	2		
29	1	1	
30	6		
31	3		
32	10		
32+1—1	3		
33	4	1	
34	1		
Sum:	511	30	9

Three clear cases of structural aberrations in chimerical plants are shown in Plate 6 (Figs. 1-12). Figs. 13 and 14 demonstrate a chromatid exchange between the chromosomes A and B (or C). Small centric fragments are found in some plants. Sometimes they have arisen through mitotic translocation as in plant P56:1 (2x+j). Here the fragment occurred only in the cells of one of the roots studied (Plate 7, Fig. 1). As compared to the chromosomes of another root, two chromosomes of the group j had been replaced by the fragment plus a long chromosome having a median centromere. However, both roots had at least three other chromosomes, which could not be assigned to definite groups. Fragments can be found even in plants showing no other sign of structural changes. Then it is very likely that they have originated in one of the parents. One such case is demonstrated by plant no. P61:4, which has an extremely small fragment in addition to the normal diploid complement. The plant comes from a cross: 2x x (3x-V). Each arm of the fragment is less than one μ long. They are also much slenderer than normal chromosome arms (Plate 7, Fig. 2).

IV. MORPHOLOGICAL RESULTS

Eight morphological characters have been studied quantitatively in relation to the chromosome constitution of the different types of plants. The measurements refer to the first flower and to the longest leaf of the plant. Plate 8 is a diagrammatic drawing showing the different characters analyzed. The mean values ± standard error for these measurements are given in Tables XI and XII.

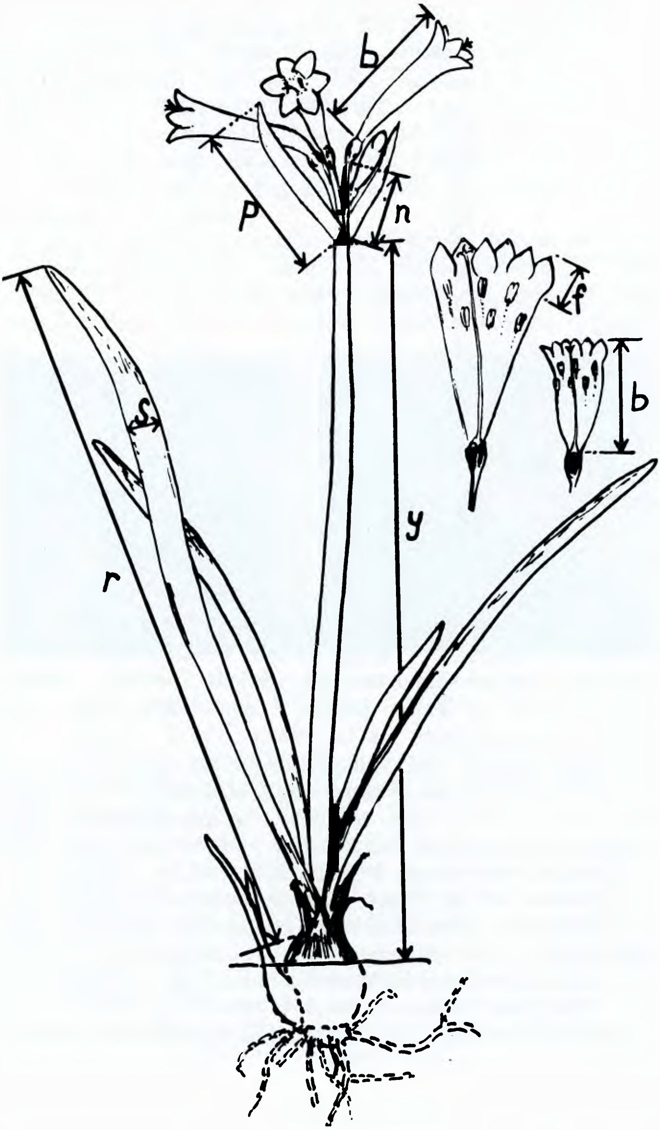

Plate 8. A diagrammatic drawing of an individual plant showing the morphological characteristics taken into consideration. The large and the small dissected flowers represent *C. lutescens* (or *C. mackenii*) respectively *C. parviflorus*.

Table XI. Measurements of morphologic characters in diploid, triploid and tetraploid individuals.

Material	Origin	No. of chromosomes	No. of plants	No. of flowers per peduncle (a)	Length of perianth mm. (b)	Length of perianth lobes mm. (f)	Length of the longest pedicel mm. (n)	Length of the longest spath-valve mm. (p)	Peduncle length mm. (y)	Length of the longest leaf mm. (r)	Breadth of the longest leaf mm. (s)
C. lutescens	C.l.	16	16	5.50±.34	52.13± .33	6.28±.11	20.5± .9	34.7±1.0	384±10	323±19	9.28±.33
2x — F_1	C.p. x C.l.	16	11	7.27±.52	39.64± .91	4.91±.15	19.3±1.5	29.4±4.1	313±17	306±22	6.59±.41
2x — F_2	C.p. x C.l.	16	86	5.23±.17	39.86± .60	5.20±.09	18.6± .6	29.3± .6	273± 8	259± 6	6.75±.14
C. parviflorus	C.p.	16	16	10.75±.54	28.50± .24	3.97±.12	21.9± .8	25.4± .8	339±19	275±12	6.28±.30
2x — F_1	C.p. x C.M.	16	32	7.66±.38	43.59± .70	6.39±.13	22.4± .9	33.7± .9	369±15	283±10	6.30±.25
C. Mackenii	C.M.	16	9	4.44±.38	54.89± .92	7.44±.23	23.1±2.0	34.0±1.8	387±25	391±15	7.67±.36
4x — F_1	C.p. x C.l.	32	1*	6.25	49.00	6.38	20.5	32.5	308	375	9.00
4x — F_2	C.p. x C.l.	32±	50	5.38±.24	48.66± .69	6.47±.14	18.3± .6	29.7± .8	334±12	372±10	9.43±.23
3x — B	4x F_1 x C.l.	24±	83	4.64±.17	48.19± .45	5.57±.07	18.4± .4	29.3± .5	391± 8	350± 7	7.70±.14
3x — B	4x F_2 x C.l.	24±	17	4.76±.44	46.68±1.25	6.09±.21	20.4±1.2	30.1±1.3	323±15	346±13	9.25±.40
3x — B	4x F_1 x C.p.	24±	5	4.80±.92	39.80± .47	4.70±.25	19.6±2.2	27.6±2.2	316± 9	314± 6	8.70±.38
3x — B	4x F_2 x C.p.	24±	17	6.65±.60	39.09±1.07	5.03±.18	20.2±1.2	28.8±1.9	297±21	311±13	8.50±.37
3x — F_2	4x F_1 x 2xF_1	24±	35	6.83±.30	44.84± .84	5.87±.15	21.2± .6	30.0±1.0	386±16	373± 7	8.89±.24

* One individual but four measurements from different inflorescences.

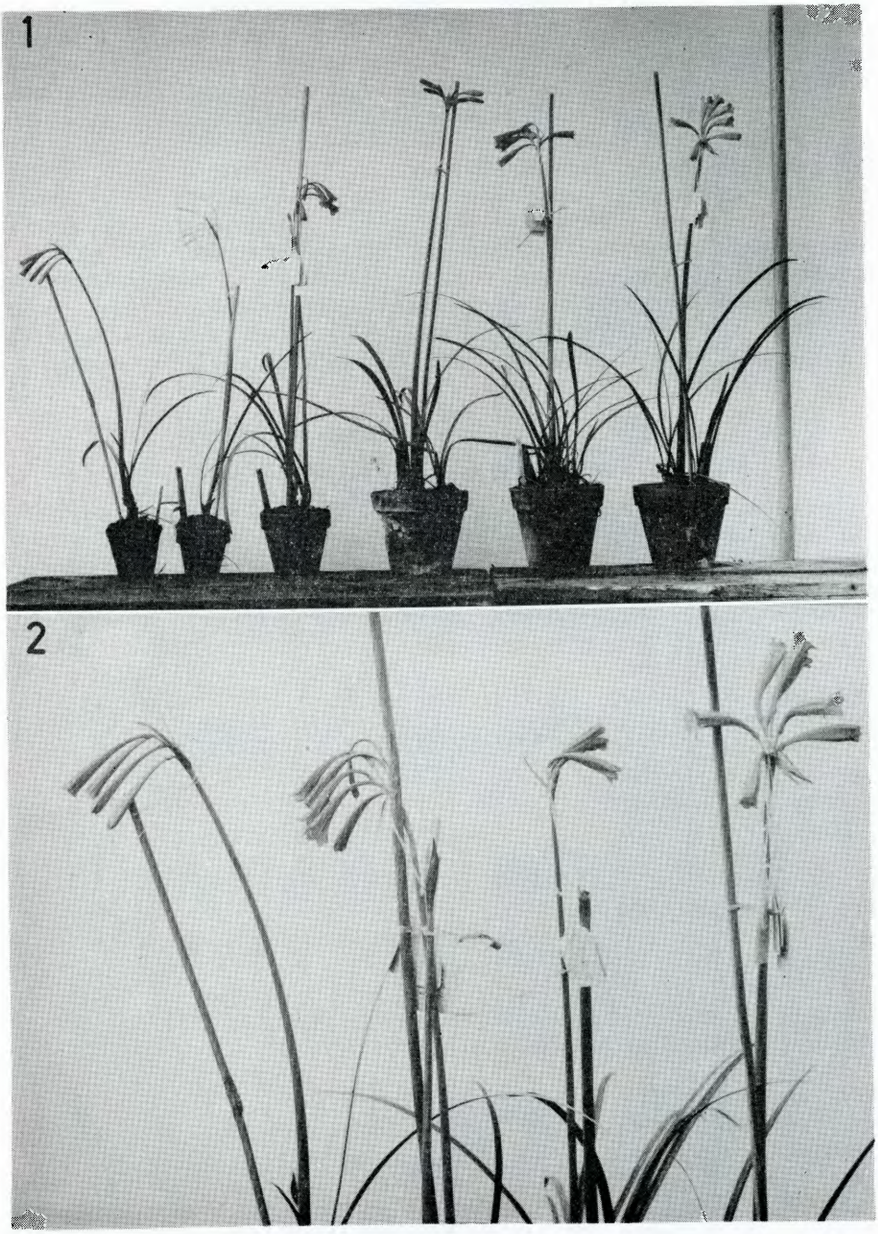

Plate 9. For caption see opposite page.

Because of the nature of the material it has been impossible to keep conditions identical for all plants studied. Thus, some variation has occurred in factors such as age of plant, season of flowering, pot size etc.

The colour of the flower in a certain combination of species depends on the species involved. In *C. parviflorus* it is bright red, in *lutescens* yellow and in *Mackenii* white. Among the tetraploid and triploid plants, some have yellow flowers though the majority has red or yellowish red ones.

As seen from Table XI, clear differences occur between C.p. and C.l. in the number of flowers, length of perianth and length of perianth lobes. The differences in length of spath-valve, peduncle length as well as length and breadth of the leaves are less pronounced. The diploid hybrid is intermediate between the parents in most characters. In peduncle length and in the breadth of the leaves, however, it is very close to C.p. The flowers are larger in tetraploid F_1- and F_2- plants than in the corresponding diploids. Furthermore, the leaves are longer and broader in tetraploid individuals (Plate 9).

The characters of the triploids depend to a great extent on the diploid species used as a father. Back-crossing of the tetraploids to C.l. gives fewer and larger flowers than when crossing with C.p. Crosses of the type: 4x F_1 (C.p. x C.l.) x 2x C.M. have also been made. The offsprings from such crosses which should have a high degree of heterozygosity are under investigation.

In Table XII the measurements taken from the trisomic plants and their diploid sibs are recorded. Due to the small number of these plants only few conclusions can be drawn. It is seen, however, that aneuploids are only slightly reduced in vigour compared with the diploids. Even double trisomic plants are nearly normal in their morphological characteristics (Plate 10).

One of the trisomic types is showing a new morphological trait. As seen in Plate 11, the leaves of the plants, which are trisomic for chromosome C, are much more drooping than those of any other plants. This new morphological character indicates a change of physiologic balance induced by the extra chromosome. Studies are planned to examine whether this action is effected by a few genetic factors in the extra chromosome and in one or two of the other chromosomes, or whether it is the result of many minor factors scattered over the genome. The cross (3x+C) x 2x should yield useful material for this study.

V. SEED-SETTING

It is important to study the fertility of the original species as well as of the different chromosome combinations experimentally obtained.

Plate 9. For figures see opposite page.
Individual plants of the following level of ploidy:
Fig. 1. 2x, P57:10 and *C. lutescens.*
±3x, P12: 6 (26663) and P18:7 (36663).
±4x, P11:18 and P32:24.
Fig. 2. 2x, P57:10.
±3x, P12: 6 (26663) and P18:9 (26653).
±4x, P32:24.

Table XII. Measurements of morphologic characters in diploid, trisomic and double trisomic individuals

Cross number	Constitution	No. of chromosomes	No. of plants	No. of flowers per peduncle (a)	Length of perianth mm. (b)	Length of perianth lobes mm. (f)	Length of the longest pedicel mm. (n)	Length of the longest spath-valve mm. (p)	Peduncle length mm. (y)	Length of the longest leaf mm. (r)	Breadth of the longest leaf mm. (s)
P56,P57,P58	2x	16	11	6.36±.28	44.18±1.53	5.55±.20	26.3±2.1	34.3±1.6	417±25	370±14	7.77±.28
P59	2x	16	6	6.67±.71	39.00±1.10	5.75±.21	26.2±4.6	29.0±3.2	337±43	302±10	7.50±.32
P60,P61	2x	16	9	7.11±.72	38.50± .98	5.33±.28	18.8±1.2	27.9±1.3	307±24	307±24	8.00±.42
P56-P61	2x	16	26	6.69±.31	41.02± .92	5.52±.13	23.6±1.4	30.8±1.2	360±12	332±12	7.79±.20
P56-P61	2x+i	17	11	7.45±.37	36.27±1.19	5.55±.30	22.6±2.0	35.8±3.4	387±28	356±18	7.73±.33
P56-P61	2x+l	17	12	6.67±.51	35.29±1.30	5.33±.28	22.4±1.8	28.3±1.2	308±21	301±12	7.08±.29
P56-P61	2x+j	17	4	7.00±.41	34.00± .71	4.88±.13	19.8±3.0	27.8±1.9	315±47	293±25	8.38±.72
P56-P61	2x+L	17	5	6.80±.97	39.30±2.15	6.30±.58	18.2±1.8	32.8±4.3	294± 7	276±19	6.90±.62
P56-P61	2x+1	17	32	7.00±.27	36.09± .75	5.50±.18	21.5±1.1	31.5±1.5	334±18	315±10	7.44±.21
P56-P61	2x+2	18	12	5.67±.76	34.38±1.21	5.58±.36	18.3±1.8	28.3±1.9	310±37	315±16	7.21±.41

As the number of aborted embryos per capsule has not been counted, it is not possible to give exact data on fertility. The seed-setting has been recorded, however, and it may be expected to be strongly correlated with fertility. The seed-setting, i.e. number of seeds per capsule is recorded in Table XIII. There are differences in seed-setting between the three species. The mean value for C.l. is 35.85 seeds per capsule, for C.p. 26.72 and for C.M. 17.23. The hybrid between C.p. and C.l. has a lower value than in the parents viz. 22.33, and the hybrid between C.p. and C.M. has nearly similar value (21.47). Most probably the reduced seed-setting in the clone of C.M. is due to a special genotypic constitution. This is shown by the fact, that when pollinated with pollen from other species it gives usually many more seeds per capsule. Segregation of genetic factors may also be responsible for the low seed-setting in F_2-plants of C.p. x C.l. Another possibility is that the low rate of seed-setting in F_1- and F_2- plants is due to the presence of chromosome G in a heterozygous condition.

Plate 10. Diploid and aneuploid individual plants of the following constitution: (from left to right)

P 57:10	(24442)	2x
P 58:17	(24442)	2x
P 58: 1	(24443)	2x+i
P 58: 9	(24443)	2x+i
P 58:13	(25542)	2x+L+j
P 60:24	(25452)	2x+L+l
P 54:40	(25462)	2x+L+l+l
Q 21: 7	(25462)	2x+L+l+l
P 54:13	(26553)	2x+L+L+j+l+i

Table XIII. Seed-setting after selfing or intercrossing of diploid, triploid and tetraploid individuals.

	Number of seeds per capsule												No. of capsules	Seed per capsule m	± $\frac{s}{\sqrt{n}}$	No. of Capsules per flower
	0	1 — 5	— 10	— 15	— 20	— 25	— 30	— 35	— 40	— 45	— 50	50 —				
2x selfed:																
C. parviflorus			7	9	26	21	17	29	15	7	3		134	26.72	.84	.78
C. lutescens				1	5	5	19	22	27	19	8	5	111	35.85	.82	
C. Mackenii			2	19	16	10	1						48	17.23	.64	
C. hybr. Pink			2	6	4	2	1						15	16.07	1.50	
2002:11 *		1	3	2	2	7	6	7	1	4	1		34	26.59	1.87	
F₁CpCl		1	15	39	30	29	20	13	10	6	5	1	169	22.33	.82	
F₁CpClI		1	10	21	32	17	28	8	8				125	21.47	.74	
F₂CpCl		19	61	84	61	36	27	20	12	6	1	1	328	17.64	.54	
4x selfed:																
F₁CpCl		3	7	11	5	1							27	11.70	.94	
F₂CpCl		23	23	26	6	1							79	9.24	.52	
other 4x		22	17	10	4								53	7.51	.60	
4x x 4x (crosses)		17	30	11	8	1							67	8.78	.59	
Sum 4x		65	77	58	23	3							226	8.99	.32	.66
3x selfed:																
(4x F₁ x Cp)		7	1										8	3.75	.72	
(4x F₁ x Cl)		1	3	1									5	7.40	1.96	
other 3x		48	39	5									92	5.74	.29	
3x x 3x (crosses)	1	5	4										10	4.44	1.00	
Sum 3x	1	61	47	6									115	5.56	.26	.18
2x x 4x:	62	17	2										81	.59	.17	.42
4x x 2x:																
4x F₁ x 2x			2	4	4	3	7	4	2	—	—	1	27	24.78	1.94	
4x F₂ x 2x	1	3	8	15	18	16	9	12	4	4	—	4	94	23.13	1.22	
other 4x x 2x		7	7	5	10	8	3	2	1				43	16.16	1.37	
Sum 4x x 2x	1	10	17	24	32	27	19	18	7	4	—	5	164	21.57	.88	.75
2x x 3x:																
Cp x 3x		16	11	1	2	—	1						31	7.35	1.04	
Cl x 3x		6	4	4									14	7.50	.92	
other 2x x 3x	3	14	23	13	6	2	1	—	1				63	9.78	.86	
Sum 2x x 3x	3	36	38	18	8	2	2	—	1				108	8.79	.60	.26
3x x 2x:																
(4x F₁ x Cp) x 2x		3	5	6	1	2							17	11.59	1.46	
(4x F₁ x Cl) x 2x		2	6	16	7	2	1	1					35	13.91	1.06	
other 3x x 2x		22	60	39	36	23	15	5	2	2	1		205	14.98	.62	
Sum 3x x 2x		27	71	61	44	27	16	6	2	2	1		257	14.61	.53	.47
4x x 3x		19	16	7									42	6.43	.56	.26
3x x 4x	6	47	12										65	3.45	.28	.28

* No. 2002:11 is a F₂-plant from a cross Cp x Cl which was selected on account of many large, white flowers and especially on account of its wrinkled capsules. This last character is unique and is found only in this plant.

Table XIV. Seed-setting in single trisomics and their diploid sibs.

	Number of seeds per capsule											No. of capsules	Seeds per capsule		No. of capsules per flower
	0 — 5	5 — 10	10 — 15	15 — 20	20 — 25	25 — 30	30 — 35	35 — 40	40 — 45	45 — 50	50 —		m	± $\frac{s}{\sqrt{n}}$	
2x selfed:															
P54,P55							2					2	31.50		
P56,P57,P58		1	5	1	11	6	2	3	3	3		35	27.71	1.84	
P59		1	3	7	8	5	5	1	1			33	22.94	1.48	
P60,P61		3	6	8	7	6	3	2				35	21.46	1.41	
2x x 2x crosses				3	4	2	4	5	—	—	1	19	29.95	2.19	
Sum:		7	14	19	30	19	16	11	4	3	1	124	25.08	.88	.653
2x x (2x+1):															
L		5	4	6	14	8	4	1	3	1		46	23.46	1.47	
j		1	—	1	—	1						3	17.00	5.51	
l		4	3	11	13	20	8	9	4	9	2	83	29.59	1.23	
i	1	1	4	10	4	9	2	7	3	3		44	27.02	1.76	
Sum:	1	11	11	28	31	38	14	17	10	13	2	176	27.13	.85	.725
(2x+1) x 2x:															
L	1	2	4	3	5	3	1	1				20	20.30	1.95	
j	1	—	1	1	2	—	1	1				7	21.57	4.41	
l	2	2	4	10	12	7	4	2	1	1		45	22.80	1.40	
i	1	4	10	8	11	7	4	1				46	20.17	1.21	
Sum:	5	8	19	22	30	17	10	5	1	1		118	21.80	.82	.641
(2x+1) selfed*:															
L	2	2	4	3	2	2	1	1				17	17.47	2.58	
j		1	1	1	3	1						7	19.57	2.58	
l	3	11	11	7	17	1	1	2				53	17.28	1.06	
i		7	18	11	8	4	1	—	2			51	17.75	1.13	
Sum:	5	21	34	22	30	8	3	3	2			128	17.62	.72	.688

* Even crosses in which the two plants are of the same trisomic type are included here.

The seed-setting after selfing of tetraploid plants is reduced by 50 per cent as compared with the seed-setting on the diploid level. That this is not due to a lower number of embryos per capsule is shown by the fact, that when the tetraploids are pollinated with haploid pollen, their seed-setting is about the same as in diploid plants.

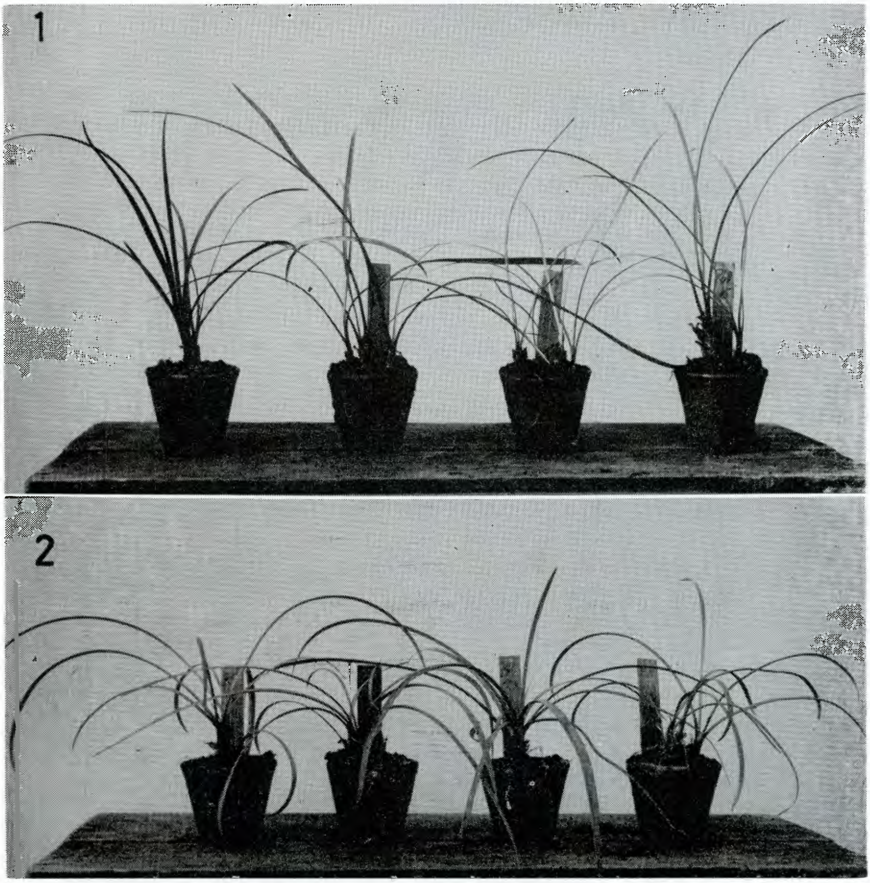

Plate 11.
Fig. 1. Individual plants trisomic for chromosome B (L).
Fig. 2. Individual plants trisomic for chromosome C (L).

Diploid plants, when pollinated with pollen from triploids give less than one half of the normal number of seeds. This is most probably due to high embryo mortality. In the reciprocal direction the cross has a higher seed-setting in spite of producing a much higher frequency of imbalanced offspring plants (See Table I). Thus, the embryo mortality in 2x x 3x crosses must depend largely on interaction between embryo—endosperm or between embryo—mother plant.

The seed-setting is very low both in tetraploid x triploid and triploid x tetraploid crosses. This is surprisingly different from the high seed-setting of diploid x triploid and triploid x diploid crosses. The reason even in this case may be an interaction between embryo, endosperm and mother plant.

A few seeds were obtained after pollinations of diploid plants with pollen from tetraploids. Usually such seeds do not germinate. A few plants have come through, however, but they have not yet been examined with respect to chromosome number. In crosses of this type, capsules of nearly normal size are often formed, but containing only thin, apparently empty seeds.

The data presented in Table XIV gives an idea of the seed-setting in trisomic plants. The seed-setting after selfing is

$$\text{about } 70\% \ \frac{(17.62)}{(25.08)}$$

and after crossing with diploids about 87%, of normal diploid seed-setting. Diploids pollinated with pollen from trisomics have about normal fertility.

VI. DISCUSSION

Two points of specific interest will be discussed here. The first one is the high tolerance to aneuploidy shown by *Cyrtanthus.* Such a tolerance, also found in *Hyacinthus* (Darlington and Mather 1944; Darlington, Hair and Hurcombe 1951), was ascribed to a special kind of intra-chromosomal balance in this plant. It was demonstrated that: ''unbalanced multiples of the chromosome set were as satisfactory or nearly so, as the balanced multiples, thus indicating that each chromosome was internally balanced to an unusual extent.'' This theory was confirmed by the fact, that only two varieties of *Hyacinthus* out of 106 studied had visible structural changes. Darlington (1956) gives one more example of internal chromosome balance, viz. *Narcissus bulbocodium,* stating: ''Having a *Hyacinthus*-like disregard of balance it also fills the whole range from 2x to 3x, and has up to four heterochromatic B-chromosomes as well.'' A similar tolerance is found in some other plants. Aneuploids of *Sorghum vulgare* (Price and Ross, 1957) and of *Collinsia heterophylla* (Dhillon and Garber, 1960) show only a slight reduction in vitality as compared to diploids. In *Collinsia* even heptasomic plants (2x+5) have been reported. *Cyrtanthus* has at least the same degree of tolerance to aneuploidy as *Hyacinthus.* The spontaneous structural changes in aneuploid *Cyrtanthus* plants, if propagated, will constitute an especially interesting material for testing the theory of intra-chromosomal balance.

The origin of the structural changes in *Cyrtanthus* is the second point of interest. As the aneuploid individuals are all descendants of the same amphididiploid individual (no. 1400:4x), they are also heterozygous for many loci. Structural heterozygosity is only revealed in chromosome G. This does not mean, however, that structural differences are not present in the other chromosomes. Minor changes as well as exchanges of equal parts will escape detection in mitosis. Therefore it cannot yet be excluded that somatic inter-chromosomal pairing can be the reason for the spontaneous structural changes found. Then, however, they will be equally frequent in the heterozygous diploid individuals as well.

A second, more likely explanation, is that the aneuploid condition in some way causes chromosome instability. Giles (1941) found a high frequency of breakage in meiosis and pollen mitosis of triploid hybrid *Tradescantia* as compared with the diploid and tetraploid parents. He ascribes this increase of spontaneous chromosome breakage in part to the hybrid condition and in part to chromosomal unbalance of the pollen grains. In the root tip mitosis, however, there were no differences in frequency of bridges and fragments. The frequency was very low: 0.025% aberrations per chromosome.

Nichols (1941) studied spontaneous chromosome aberrations in root tip cells of *Allium cepa.* He found a high frequency of breakage in root tip cells of germinating seeds and five months old seedlings (about 0.125% chromatid aberrations per chromosome). In root tips from onion bulbs, however, not a single aberration was found in 600 cells analyzed. Nichols writes: "This rather surprising result must mean that the conditions in the bulb are less conducive to chromosome breakage and rearrangement than in seedlings and in young plants."

Brock (1955) reported spontaneous chromosome breakage and spindle abnormalities in endosperms of *Hyacinthus orientalis.* Numerically unbalanced endosperms had a high frequency of breakage, sometimes causing endosperm failure and embryo abortion.

Rutishauser (1956) describes spontaneous chromosome breakage in the endosperms of *Trillium grandiflorum.* In root cells no aberrant chromosomes were found. The presence of fragment chromosomes raises the breakage frequency. From his results, Rutishauser concludes that the spontaneous chromosome breakage is genetically controlled.

The trisomics of *Datura* have a tendency to produce unrelated types of extra chromosomes in the offspring. Such types are produced in a different frequency by different trisomics (Blakeslee and Avery, 1938; Darlington, 1906). According to Blakeslee and Avery, "Primaries throw an average of .86 per cent new mutants; secondaries an average of .62 per cent. Both form better mutation machines than do 2n parents which throw .16 per cent new trisomics" . . . "Why the presence of one extra chromosome increases the chromosomal mutation rate is not clear. The increase is perhaps in some way caused by interference with meiotic divisions."

Fragment chromosomes have been reported in the progenies of aneuploids of *Datura stramonium* (Blakeslee and Avery, 1938), maize (Mc Clintock, 1929), wheat (Sears, 1954) and barley (Tsuchiya, 1959). Whether these are caused by mitotic or meiotic disturbances is not clear.

Spontaneous structural changes of somatic chromosomes have been described even in the diploid offspring of trisomic *Crepis.* Navashin (1931) studied the offspring from two trisomic plants and from one aberrant plant possessing a very small spherical fragment in addition to the normal chromosome complement. Out of ten morphologically abnormal plants, three (one from each parental plant) turned out to be chimerical for structural changes. These three were all diploid. Navashin writes (p. 204) : "It seems probable that there exists some peculiar condition in certain individuals, which makes their chromosome structure and the chromosomal distribution labile and subject to frequent alterations in various ways." He suggests that "some heritable instability of chromosome behaviour" was present in the actual material. It is interesting to see that these plants were morphologicaly abnormal in spite of being diploid. Maybe something had happened to the chromosomes already in the preceding generation, even if they looked normal. Unfortunately meiosis was not studied.

VII. SUMMARY

A cyto-genetic investigation of the genus *Cyrtanthus* has given the following preliminary results:

(1) The chromosome number 2n=16 was determined for six *Cyrtanthus* species and for the related *Vallota speciosa.*

(2) The chromosome morphology shows great clarity and distinctness, permitting secure identification of five chromosome types.

(3) A tetraploid (amphidiploid) strain was started by colchicine treatment of a diploid specific hybrid.

(4) An abundant material of individuals with different chromosome numbers was produced by crossing. For each plant, the exact combination of the five chromosome types (see 2. above) was determined. Among the about 500 individuals thus analyzed, 84 distinct karyotypes were described.

(5) While there was no indication of structural instability in normal diploids, 30 cases of spontaneous aberrations have been observed, 29 of them in aneuploid plants.

(6) A number of morphological traits was measured and correlated with chromosome constitution. *Cyrtanthus* is characterized by a remarkably high tolerance to aneuploidy.

(7) Seed-setting was analyzed in relation to polyploidy and aneuploidy.

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NEMATODES ON HEMEROCALLIS

It is our sad duty to report that nematodes on *Hemerocallis* in the East and South have become a menacing pest that may present a great problem to all who grow daylilies. All who order plants should specify that they must be nematode-free.

[NEW AMARYLLIS HYBRIDIZERS, B. D. Smith, continued from page 94.]

is also working with many species which she is crossing with the Dutch hybrids. These include work with *A. johnsonii, A. striata,* Dr. Nelson's *A. belladonna* and others. At this nursery you will find many thousands of outstanding hybrids. Mrs. Barry has already originated clones from crosses such as 'Salmon Joy' x Bouquet, 'Champion's Reward' x 'American Express', and many of the Dutch named clones in red, pink and white. The writer has been fortunate to obtain some of Mrs. Barry's hybrids to run trials on in the north Georgia area. Since a number of these bulbs are new originations, I am looking forward avidly to bringing them to bloom.

We welcome all of these growers, as it is through their efforts, and others who are experimenting with and originating new strains of *Amaryllis,* that we will be able to obtain more beautiful *Amaryllis* in future years.

[PLANT LIFE LIBRARY, continued from page 72]

PHYSIOLOGY OF PLANTS, by P. Font Quer. Harper & Brothers, 49 E. 33rd St., New York 16, N. Y. 1960. Illus. pp. 128. $2.25. This concise text by an outstanding authority discusses the subject of plant physiology under seven sections —the functions of water, the chemistry of plants, growth, multiplication and reproduction, genetics, hereditary characters, and plant movements.

GARDENS IN WINTER, by Elizabeth Lawrence. Harper & Brothers, 49 E. 33rd St., New York 16, N. Y. Illus. pp. 218. $4.50. In the past, Miss Lawrence has favored us with two delightful books—"A Southern Garden" and "The Little Bulbs"—which were briefly reviewed in these columns, and now another charming book from her pen has arrived. It is doubly outstanding because Miss Caroline Dormon has contributed the artistic drawings. The book is filled with garden lore concerning the winter garden, a subject so much neglected in the United States. Although Miss Lawrence writes from the haven of her North Carolina garden, she includes references to the gardening experiences of others known to her through correspondence. This outstanding gardening book is highly recommended to all.

THE ENCYCLOPEDIA OF THE BIOLOGICAL SCIENCES, edited by Peter Gray. Reinhold Publ. Corp., 430 Park Av., New York 22, N. Y. 1961. Illus. pp. 1119. $20.00. This outstanding new reference work, international in scope, containing an abundant harvest of up-to-date information about the biological sciences, fills a definite need and will be welcomed. The articles are concise, yet they are inclusive enough to present the subject properly. As an example of the originality of the work, it should be noted that the contributions of Michel Adanson to science are given adequate coverage for the first time in any encyclopedia. This stimulating authoritative survey of the biological sciences is indispensable to all biologists. It cannot be recommended too highly.

ENCYCLOPEDIA OF MICROSCOPIC STAINS, by E. Gurr. Williams & Wilkins Co., Baltimore 2, Md., exclusive U. S. agents. 1960. Illus. pp. 498. $10.50. This authoritative book is intended as a reference work and a laboratory guide on the applications, structures, composition, molecular weights and properties of a very large number of dyes and other substances used for staining microscopic tissue preparations, etc. In Sect. I, stains, indicators, etc., are arranged in alphabetical order; in Sect. II, dyes and indicators are arranged in order of ascending molecular weights; in Sect. III, diazonium and tetrazonium salts (stabilized) are listed with structures and molecular weights; and in Sect. IV, tetrazolium salts and formozans are listed. Highly recommended.

MORPHOLOGY OF THE ANGIOSPERMS, by A. J. Eames. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. 1961. Illus. pp. 518. $13.50. This comprehensive text on all phases of the morphology of the angiosperms by an outstanding authority was written for the teacher and advanced student. The text incorporates recent advances, and emphasizes evolutionary modifications and phyletic implications. After considering the plant body as a whole, chapters are devoted to the inflorescence, the flower, the androecium and stamen, pollen, gynoecium, the ovule, archesporium, fertilization, and seed and fruit. The book concludes with chapters on the morphology of selected families, and a discussion of the phylogeny of angiosperms. Highly recommended.

FUNDAMENTAL PRINCIPLES OF BACTERIOLOGY, by A. J. Salle. 5th ed. McGraw-Hill Book Co., 330 W. 42nd St., New York 36, N. Y. 1961. Illus. pp. 811. $11.00. This 5th edition of an outstanding text incorporating recent advances in bacteriology will be generally welcomed. The text was written for beginning students who plan to major in bacteriology, microbiology and related fields—public health, sanitary engineering, nursing, optometry, agriculture, etc. The book is sufficiently broad to provide the needed sound grounding. In the presentation, the use of chemistry, for a clearer understanding of the composition of bacteria and the reactions they produce, is emphasized. Two new chapters—"Bacterial Genetics" by W. R. Romig, and "Bacteriology of the Sea", by C. E. ZoBell, have been added. The text is highly recommended.

Fig. 19. *Amaryllis calyptrata,* one of the "Green Amaryllis," as grown at the Los Angeles State & County Arboretum, Arcadia, Calif. Photo by Jack V. McCaskill.

4. AMARYLLID CULTURE

[REGIONAL ADAPTATION, SOILS, FERTILIZATION, IRRIGATION, USE IN LANDSCAPE, DISEASE AND INSECT CONTROL, ETC.]

GROWING OF **AMARYLLIS CALYPTRATA** IN CALIFORNIA

W. QUINN BUCK,
Los Angeles State and County Arboretum, Arcadia

In early October of 1958, the Arboretum received several kinds of exotic seed from Mrs. E. G. McGhee of Sao Paulo, Brazil. One of the packets contained seed of *Amaryllis calyptrata,* an epiphytic Brazilian species that we had not had before.

On October 9, 1958, these seed were planted in an open, humus compost, and germination began in two weeks. On November 3rd, thirty small seedlings were put into three-inch pots in a fairly rich potting mixture. Growth was quite rapid, and on June 1, 1959, they were shifted into six-inch pots. By May 12, 1960, they again were shifted, this time into nine-inch pots. Growth continued to be rapid, and the plants were becoming handsomer and more impressive.

At almost exactly two years of age the first of these *Amaryllis calyptrata* seedlings bloomed, sending up a strong spike at the side of its huge bulb. The buds opened slowly, becoming two clear green flowers of most unusual shape and of very heavy substance [Fig. 19]. The narrow petals were flaring, whereas the sepals arched inward and almost touched. The flowers were short-lived, and no pods resulted from self-pollination.

No more spikes appeared until May of 1961. The second bulb produced a two-flowered spike almost exactly like the first. This time two pods were set after self-pollination, and good seed filled the pods when they finally ripened after two months. Pollen put on the white hybrid 'Nivalis' gave a few viable seed, and pollen stored for ten days and then used on Ludwig's 'Dazzler' gave two good pods of viable seed.

Interestingly, the pods matured on the whites in exactly a month, and the seed had already germinated before the selfed pods on the *Amaryllis calyptrata* parent were ripe.

The third spike again was a duplication in form and color. The fourth, late in July, 1961, however, was different in both. The color was a soft, creamy green, with real pink and orange brightening stamens and pistils. In this clone the sepals did not arch inward but stood almost straight up, giving a more typical flower shape. This, the best of the ones to flower, set no seed.

Other spikes are now appearing, and No. 2 is sending up its second and third spike for the year. The flowering season in our latitude has not become set, but it appears that the fall might account for more of the spikes.

We hope to be able to combine characters from desirable clones in working for improved form and color in this species. The crosses with whites will be extremely interesting to watch; these small seedlings are starting off vigorously and encouragingly.

Growing this species in the greenhouse has given large, handsome plants and monster bulbs quickly, and it has aroused our interest for continuing with it.

AMARYLLIS STRIATA NATURALIZED IN HAWAII

Howard F. Cooper, *Hana, Maui, Hawaii*

The time of arrival of *Amaryllis striata* in Hawaii is apparently lost in the hazy past; most likely it was brought in by the early European or American settlers. It is obvious, however, when one observes these plants growing in abandoned home lots, and particularly in neglected graveyards, that this species has found a congenial home in Hawaii. This species seems to thrive on abuse, and though it apparently does not seed naturally under prevailing conditions in the vicinity of Hana, it does seem to maintain itself without difficulty and to spread gradually by offsets which are formed in great abundance. [Editorial note.—Cut flower scapes of *Amaryllis striata* sent for identification by Mr. Cooper to the writer by air mail arrived in good condition, and when self-pollinated, and placed in water, produced seeds.—*H. P. Traub*] The plants seem to prefer partial shade and rocky soil conditions. Flowering is increased however as the shade is removed. Bulbs will send up several scapes during the year—mostly in February and June. Scattered flowers are present at any time of the year.

I have found in my short experience with *Amaryllis* that the species, *A. striata*, makes an ideal seed parent with pollen from other *Amaryllis* species. Many crosses with Dutch hybrids have been made to date but as these seedlings are not yet a year old, no blooms have been obtained. It will be interesting to see how they turn out.

As a border planting, few plant species can compete with this prolific flowering *Amaryllis*. When hundreds of *A. striata* are seen in bloom at once, without any human care or attention—it is a sight to see indeed.

1960-61 AMARYLLIS SEASON — HYBRIDS AND SPECIES

Robert D. Goedert, *Florida*

The 1960-61 season ushered in new trends in *Amaryllis* hybridizing and a marked interest particularly in those hybrids and species suitable for the border. As evidenced by the new introductions, the Dutch hybridizers show more interest in the blends, bitones and stripes. New forms are also being introduced. This is a refreshing departure from the solid colors formals that have been the vogue for many years. It will, in my opinion, lend character to the named clones in the future, and I feel, will create much more interest in the culture of *Amaryllis.*

It will make distinctive individuals of many of the named clones and one will not have to read the name tag to identify the clone.

Many northern gardeners are learning that *Amaryllis* are very worthwhile border plants. They are finding by growing *Amaryllis* in the border, they can maintain a large collection quite easily. The bulbs are dug each fall and stored in the basement or other place at about 50 degrees F. until planting time in the spring.

Many *Amaryllis* enthusiasts in the South are purchasing more of the small size Dutch hybrids and find they establish themselves more readily in the border than the mature bulbs. In this regard, the 20/22 cm. size in white will normally give a fair flower spike but in the other colors, one should possibly purchase the 22/24 cm. size if flowers are wanted the first season. *Amaryllis* fans have concerned themselves mostly with the show flower types in the past and the hybridizers have practically totally neglected further development of those suitable for the border. This is very regretful. Any awaking to this need would surely make these magnificent flowers more popular. Many of the show varieties are not suitable border plants. The flower is too heavy, they don't flower as freely as they should and they are more exacting in the requirements than they should be for this border use.

Before I discuss the named clones, I would like to touch on some of the unnamed hybrid strains that are available. The Hadeco Strain Amaryllis from South Africa increased in popularity last season. These bulbs, being grown in the southern hemisphere, are available from about the middle of September on, and can easily be flowered in 5 to 6 weeks. At present they are available in mahogany red (orange red), violet red, wine red, rose, pink, and white line pink. Named clones of this strain will be tested during the 1961-62 season and should make their appearance on the American market in two to three years. They were developed by crossing the Dutch Strains on certain hybrids that had naturalized in South Africa. Many fans are now purchasing these to enjoy early flowers. They also do well as border plants in the South, being raised in the open fields of South Africa. This strain will possibly compete materially with the Dutch Strain in the future.

There are numerous firms in India that offer *Amaryllis* and other bulbs to the world trade. The quality of the *Amaryllis* offered varies greatly and one has no assurance of quality when ordering from this area. There is no such thing as a control or standarization of produce among the growers. What one firm provides as a Dutch Strain may be an inferior cross on the Dutch Strain, while other firms provide the true Dutch strain. It is understood that some firms go out and buy on the open market when you order from them. The quality will vary each time bulbs are purchased. It is understood that some firms in the area are trying to obtain controls on the quality of bulbs exported. It is hoped they will be successful for there are some excellent *Amaryllis* grown there which I would like to touch on.

Ludwig and Company have sold large quantities of seed to Indian firms and this strain is the main Dutch Strain grown in the area. Some of the pinks, whites, and white lined pinks, however, are the Van Tubergen Strain. Many firms, to increase their stocks, have crossed the Dutch with the Indian and Australian strains and offered these as Dutch Strain. Some of these are excellent, but unless they are properly selected, will contain a number of inferior flowering sorts among them.

The Dutch strain from India is usually sold in mixture or in selected colors. If you are fortunate enough to obtain the true Dutch strain bulbs that have been properly selected, they are very worth while and can be purchased more reasonably priced than from Holland.

The Indian growers have also imported seed of the Australian Tunia strain. These amaryllis hybrids are sold by selected colors and in mixture. The true Tunia's from Australian are an excellent strain with very large flowers and a wide color range. They are mostly striped or bitones with stripes. There are some especially interesting colors in them such as yellow and red stripes and orange and brown tones. The better Australian Tunia hybrids are excellent and different. They should become more widely used as they are very vigorous.

There are many hybrids available in India of the Australian Tunia strain crossed with the Dutch strain. This is possibly the best strain for the border today of the large exhibition type. The color range is much extended over either the parent stock and some have mammoth flowers. There are many types and forms of flower and these are most interesting and worthy of trial. They are vigorous and make fine border plants.

Although a marked new interest in garden sorts is being shown, interest in the named clones continues. A large number of new clones are being offered each year. South African and Indian growers soon will be offering named clones. With the increase in number of clones each year it will become more important that these are properly tested before being offered and that only those of merit should be registered and offered to the public.

The *Amaryllis* fancier will have to become more discriminative. A collector should not grow inferior clones just for the sheer sake of collecting numbers. New clones should be worthy of introduction or eliminated.

New clones are always exciting to try, but one must never overlook the proven older ones that have performed well for many years. These must be mentioned. It is better to grow a number that do well for you than to experience disappointment and failure with new higher priced clones. There are many old ones that have proven noteworthy. Some do well in one part of the country while others may grow better for you under your particular culture, soil, and climate. If one would make a list of noteworthy older clones, the following would possibly be included in most lists:

'Apple Blossom', 'Bouquet', 'Ludwig's Dazzler', 'Ludwig's Scarlet', 'Maria Goretti', 'Leading Lady', 'Beacon', Red Master', Salmonette', 'Moreno', 'Daintiness', 'Alcyone', 'Queen Superiora', 'Doris Lilian', 'Cleopatra', 'Pinksterflower', 'White Giant', 'Tristan', 'American Express' [Fig. 20], 'Wyndham Hayward', and 'Delilah'. This list does not include all the worthy older clones for you possibly could list others that do particularly well in your area, but generally these can be expected to perform well in most areas.

Fig. 20. Hybrid *Amaryllis* clone 'American Express' (Ludwig), grown at Baton Rouge, Louisiana. Photo by Prof. Claude W. Davis.

Each year many new clones appear. It is impossible to properly evaluate these from one year's observation, but these observations will help in choosing those to try.

The whites are a strong class and many new ones are being introduced. Ludwig's 'White Favorite' appears to perform up to expectations. While it is still very scare, it will be a strong contender in this color. W. S. Warmenhoven's new white, "Snow Queen", was well received. It appears to be an improvement over his older clones; being larger and more vigorous. Since Ludwig has a clone of this name, Warmenhoven's "Snow Queen" will be renamed 'Oasis' when registered. 'White Crane' is a very strong growing new white. It makes large flat blossoms on a very tall scape and should make a fine show clone. 'Queen of the White' should also be mentioned, while it is a very old variety, it is making a new comeback. Many fine reports were received on 'Queen of the Whites'. It should again make itself felt at the shows. 'White Christmas' and 'Christmas Gift' are becoming popular both being fine clones. 'Christmas Gift' is a very late flowering clone that is a very welcome addition for this reason.

The bicolors and striped clones are becoming more popular each year as better ones become available. 'Candy Cane', 'Apple Blossom', 'Beacon', 'Fantasy' and 'Love's Desire' continue to perform well. 'Zenith' appears to have the edge as a show flower in the red and white striped class. The clones sold under the name, "Picotee", still perform well, and with the reduction in price this coming season, will be more widely grown. Although these clones vary from near white with faint red picotee edge to nearly all red, they have an airy appearance about them that is refreshing and the color is generally very clean.

The new Warmenhoven clones, 'Floriade' and 'Golden Trumphator', are new departures in *Amaryllis* and point to new trends in this area that is a step away from the solid colors that have been in vogue. 'Floriade' is a most beautiful and striking clone. It has a crepy transparent appearance and is white flushed faintly pink with just a few fine pencil lines of pink in the lower three tepalsegs. It is a wonderful new pastel colored *Amaryllis* and a wonderful addition to any collection. 'Golden Trumphator' is a similar pastel in another color, being a light salmon with coppery orange overtone. These two will surely prove popular. Warmenhoven's "Rose Queen" (to be renamed before being registered) is an interesting orange pink with lighter heart that has a coppery cast. It is different and a fine addition. 'Little Diamond' like "Rose Queen", although not yet in general distribution channels and not registered, was purchased in Holland and distributed in limited quantities last season. 'Little Diamond' is the most beautiful pink you can picture. It is not a solid color but a very finely veined pink and white that appears pure pink. It has extra large flowers on a rather short spike. It is what many have been looking for in a pink, being round to a nicety and very flat. 'Pink Beauty', another Warmenhoven clone is somewhat similarly colored, being white finely striped rose. The rose striping is more pronounced, being a darker color. It, however, makes a huge flower on a very tall spike, and is a wonderful new clone. 'Maryland', a large white with pencil lines of clear red, is very striking. Like the other Warmenhoven varieties mentioned here, 'Maryland' has not been registered. It is understood that plans are being made to register these clones so they may be shown at official shows this coming season. Van Meeuwen's clone 'Verona' should also be mentioned. It is a beautiful salmon and white variety that has that clean refreshing look. 'Five Star General' is still popular though difficult to grow. It is a sparkling clean red and white.

The salmon and orange color class improves each year. 'Orange Wonder', a coppery orange, is popular even at a high price. Many say it is tops in the orange colored clones. 'Delilah', as grown in the South, is a fine light orange or salmon orange, that has a clean color and should become popular. Many of the older salmons and orange reds are still good performers and very popular. 'Bouquet', 'Halley', 'Cleopatra', 'Anna Paulowna', 'Bordeaux', and 'Queen's Page' all perform well. There are some interesting new clones in this color. 'Rilona' is a soft buff that is a new color among Amaryllis. It is still unregistered although a small number of bulbs were distributed last season. It will not be generally available for several years. It did create much interest among those that saw it. 'Golden Trumphator' should again be mentioned, although more a two tone, for it is one not be overlooked in this color.

The rose pink and light rose colored *Amaryllis* are showing inprovement. 'Daintiness' is still among the better ones in this color, and one of the lighter colored clones. Van Meeuwen's 'Queen of the Pinks' and 'Queen of Sheba' are strong contenders as leaders in the medium rose pink color class. Van Meeuwen's "Pink Perfection" (unregistered and requiring renaming) is a strong growing medium rose pink with violet cast. Ludwig's 'La Forest Morton,' a medium light rose pink with lavender cast, is very beautiful and becoming very popular. The new 'Flora Queen' is one of the lighter colored rose pinks that has a wonderful clean color. It is a grand improvement in this color. In the light colored clones, 'Spring Dream', a salmon pink, is winning many admirers.

In the deep rose colored clones, 'Doris Lilian', 'Diamond', 'Moreno', and 'Violetta' remain popular. 'Bella Vista', Ludwig's new variety, has beautiful coloring and is a worthy addition to this group. Ludwig's 'Lucky Strike' is a good one. It is very hard to say just where Warmenhoven's new clone, 'Elvira Armayo' belongs. Some call it a wine red, others, a violet red. It is lighter than most other wine reds and possibly can be placed in the violet rose class. It is a new color and a worthy new one.

The light reds have never been a strong class and very few *Amaryllis* fall in this class as most light reds have a distinct orange cast. A few new clones are appearing in this color that are very nice. 'Mohawk', a new medium light red, has a beautiful self color and is large and very thrifty. It is a welcome addition which many will want to try this coming season. 'Red Emperor' is another new light red that is bearded and makes large flowers on a tall spike. These two new reds should prove to be popular.

There are a number of good orange reds,—'Haley', 'Cherokee', 'Friendship,' 'Prince of Orange' and 'Attraction' to name a few. This has not been a popular color but more are showing interest in the orange reds. Ludwig's 'Traffic Stop' is one of the newest introductions to this color. 'Don Camillo' is another fine orange red.

The medium reds include many good clones. Ludwig's 'Scarlet', one of the old standbys keeps performing even better each year. There are too many of these to mention. 'Blazing Star', one of the newer ones that is becoming very popular, grows large very easily. Ludwig's 'Goliath' is a huge variety that is extremely popular. There never is enough of this clone to go around and it will be a number of years before it is available to everyone. 'Giant Goliath' is also a very popular clone especially as a pot flower in the North.

There are a number of dark reds that are excellent. 'Queen Superiora' is possibly the grandfather of this color and can still compete with the best. Ludwig's 'Fire Dance' is a popular show clone. 'Alcyone' is outstanding that has a wonderful color. It is not a giant but what it lacks in size it makes up for in purity of color. Van Meeuwen's 'Hades,' and Warmenhoven's new 'Rotterdam,' are beautiful new dark reds that have a fiery light red sheen.

'Red Master' still is the leader of the dark wine red class but some strong contenders are appearing. 'Purple Queen' (W. Warmenhoven and Sons variety) is a large wine red with purple cast that is considered by many as the best in this color. Van Meeuwen's 'Charlemagne'' is a huge new wine red that has caused quite a lot of comment.

Interest is still being shown in the species but few are commercially available. Possibly the most noteworthy species reintroduced this past season was *Amaryllis belladonna* var. *belladonna* found growing in muddy clay soil near Iquitos, Peru. About 200 of these bulbs were distributed in the United States this past year. This appears to be a most robust form of *Amaryllis belladonna* yet found. Bulbs of this variety will grow to a diameter of 4″. It is hoped someone will propogate this variety and make it commercially available as it should prove to be an excellent pot plant. About 200 bulbs of a species from Matto Grosso, Brazil were also distributed this past season. This species is believed to be *Amaryllis striata* var. *crocata.* Mature bulbs of this species are only 1 to 1½″ in diameter. It grows easily in a pot if given a warm condition and plenty of moisture during the growing season. It makes numerous offsets and the flower is very large for the size of the bulb—about 5″ orange red and white. This species though not positively identified should prove most noteworthy as a pot flower and should prove helpful in developing a noteworthy small bulbed strain suitable for pot culture. A most needed type in my opinion that could be established in pots and make a most decorative plant in any home. It has very deep dark green foliage and reddish cast to back of leaves.

A very large bulbed and large flowered species or hybrid was found naturalized in Hawaii. This has been tentatively identified as *Amaryllis aulica* var. *platypetala.* It has a large red flower and is very strong growing. It apparently is a recurrent flowering species as the bulb tested flowered in the spring and again in August. This species has considerable vigor and is very noteworthy.

A few bulbs of an *Amaryllis* described by Dr. Cesar Vargas as species *Amaryllis intiflora* was tested. This species has a medium sized solid red flower a little larger than the gracilis amaryllis hybrids. It appears to be strong growing, making medium sized bulbs. It should prove worth while in breeding medium-sized amaryllis.

A shipment of 50 hybrid *Amaryllis* from Lima, Peru was imported this past season and a few of these flowered. They appear to be very vigorous of a medium size. The spikes have usually six flowers and are of proper size not to appear crowded. Some of these had very clear colors. They are said to be the most noteworthy hybrids available in Lima.

Twenty different clones from a leading Brazilian hybridizer were imported this past season. A few of these flowered and were very good. It is however understood that these are sold in Europe and have been used extensively in recent years by Dutch Hybridizers. These should all flower this coming season.

Great progress is being made in show clones but hybridizers are neglecting to develop hardier and more vigorous stock for the garden and noteworthy easily flowered clones or strains for pot culture. It is hoped that greater interest will be shown in this area in the future for if the amaryllis is to become as popular as it should, more vigorous and easier flowering stock must be developed, or the interest in amaryllis will rise and fade as it has for the past two centuries. There is room in every home for an easily flowering potted amaryllis and room in every garden for a bed of amaryllis that will consistently flower each year.

BOTTOM HEAT FOR AMARYLLIS

MYLES E. HILL, *Arizona*

I got the idea for supplying bottom heat to potted *Amaryllis,* using Christmas tree electric light bulbs, on a cord, during the holidays. I used the kind that will remain lighted even though one or more bulbs on the cord may burn out. The lights are set in one gallon cans so that each light bulb is at the bottom of a gallon can with a potted *Amaryllis* nested above it. The light current is then turned on. This operation is carried out in a cool dark room—I used an old photographic dark room. As controls similar potted *Amaryllis* were placed beside them but given no bottom heat. However, the conditions otherwise were not controlled as to temperature. Records are made of the number of weeks in darkness with and without bottom heat for Dutch hybrid *Amaryllis,* and also the number of weeks in a lighted room. At this writing no flowering results are available, but it was considered worth while to report the inexpensive method of applying bottom heat for forcing *Amaryllis* which others may wish to use. My results will be reported later.

TREATING AMARYLLIS BULBS AND SOILS

MASON M. TURNER, *California*

One may treat his soil mixture in a sealed garbage can with chloropicrin at the rate of 5 milliliters per cubic foot of soil. Chloropicrin works best when the soil temperature is between 60° and 90° F. Most disease organisms are killed along with nematodes, soil insects, and weeds.

Chloropicrin is a heavy pale yellow liquid, which readily volatilizes into a pungent tear gas. Its chemical name is trichloronitromethane (CCl_3NO_2). The pure material is completely volatile and leaves no residue in the soil after aeration.

Chloropicrin can also be applied to field or bed soil directly with a hand applicator, but one may also use a pipette with a rubber bulb attached. It is important that the gas be confined by sprinkling the soil surfaces with water immediately after treatment or preferably by covering with a gas-proof cover which should be left on the soil for at least 24 hours.

Methyl bromide can also be used for the same purpose. It is more volatile and is released under a gas-proof cover (polyethylene sheet is excellent). One-pound cans with instructions for use are available at many nursery supply firms. After treatment, the soil must be well aerated so as to preclude any toxic effects on the plant.

The bulbs are treated prior to planting by completely dusting with a mixture* of insecticides and fungicide toxicants—Captan, Dieldrin, DDT, and Sulphur—formulated to give effective control of insects and diseases. Such a mixture may be obtained from your local garden supply dealer.

Prior to potting *Amaryllis* bulbs, I treat the soil mixture in a sealed garbage can with chloropicrin at the rate of 5 milliliters per cubic foot of soil for a period of 24 hours. After treatment, the soil is well aerated so as to preclude any toxic effects on the plant. Fumes should not be inhaled because they are toxic.

I have made comparative tests, using treated and un-treated soil, and have found that the plants grown in the treated soil are superior in growth and bloom. This stimulation is apparently due to the control of soil borne diseases and other pests. Before planting, the bulbs were completely dusted with a mixture of insecticides and fungicide toxicants—Captan, Dieldrin and D. D. T.—formulated to give effective control of insects and diseases. Such a mixture may be obtained from your garden supply dealer. Before treatment, the dead or damaged roots are removed.

The treated bulbs are potted in 8- or 10-inch plastic pots, taking care to work down into the soil and remaining roots. The potting mixture used consists of 1/3 garden loam; 1/3 coarse sand, and 1/3 granulated peat. When planted, 2/3 of the bulb is above the soil level. This mixture apparently provides good drainage and soil aeration which is so essential in keeping the bulbs healthy. After watering, the planted pots are placed on the greenhouse bench where a temperature of 60° F. is provided for several weeks.

CAUTION.—

Chloropicrin and methyl bromide are toxic to human beings and

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* A commercial product known as Artho Soil and Bulb Dust. It is a combination of insecticide and fungicide formulated as follows:

Active Ingredients	**By Wt.**
Captan	5%
Dieldrin	5%
Dichloro Diphenyl Trichloroethane	10%
Sulphur	40%
Inert Ingredients	40%
	100%

precautionary measures as indicated on the original packages should be carefully observed.

EXPERIENCE WITH HYBRID AMARYLLIS

Gladys L. Williams, *California*

It was noted that the little seedlings of Dutch hybrid Amaryllis growing in a seed bed outside lost their leaves during the cold frosty weather, but produced new ones and grew nicely as soon as the weather warmed up. This led me to experiment in growing hybrid Amaryllis.

Last year (1960), I made a number of crosses—some Dutch on Dutch hybrids, and some Dutch on selected Howard & Smith hybrid Amaryllis. The seeds were planted as soon as mature in May and June in pure compost in pots. The pots were soaked in water and placed in polyethylene bags stored in the shade. Germination was almost 100%. My garden space is limited, and I was fortunate in having a friend also interested in growing hybrid Amaryllis, who made a large part of her yard available for the experiments.

Her garden soil is a sandy loam. In a prepared bed, using composted manure, superphosphate and potash, 60 small 4 months old seedlings, 1/4 inch diameter bulblets, were planted. At 8 months of age the bulblets were 3/4 inch in diameter.

In another bed, I have set out 400 seedlings in the last two weeks of January (1960). The bulblets were 3/4 to 1 inch in diameter at about 8 months of age.

Last year (1959) in April, I planted 300 seedlings of American hybrid Amaryllis, crossed with Dutch hybrids, one year or less in age. These are now 21 months old from seeds. They were mulched with old strawy manure to keep down the weeds. I dug down to measure the bulb size in early February and was happy to find that some were 2½ inches in diameter. I am hoping that some will bloom this spring.

NOTES ON AMARYLLID GROWING

Irene Stewart, *Escondido, California*

When the writer moved from the Upper Rio Grande Valley in West Texas an arid country, in the autumn of 1949, and settled in Southern California, she thought her troubles in growing amaryllids were at an end. There was a rude awakening.

One is told to plant *Amaryllis* "in full sun". This was done, on a terraced slope, where the drainage should have been good. That winter there was not the zero weather experienced formerly, but lots of rain. The soil being heavy a considerable toll of the largest and best bulbs was taken by rotting and the foliage of the remaining lot was fairly cooked by the bright sun. The whole collection was again moved to a location only receiving the afternoon sun, no better success resulted. Seedlings were eaten by snails, which abounded. A third move was made, under the outer branches and to the East of a large Pepper tree, almost at once a change was noted. Better foliage and a greater number of blossoms, which appear intermittently, not just in the spring. Seeds germinated and as there were no other plantings near, snails were less in evidence, so courage returned.

Many amaryllid species have been tried, only two will be specifically mentioned. Shortly after arrival a bulb of *Haemanthus katharinae* was planted in a bed on the South side of the house, it has multiplied to six stalks and this summer produced four flower scapes. In spite of poison and hand picking, snails disfigure the palm-like foliage. Personal opinion is that, although eye-catching the flowers are not nearly so beautiful as those of others in the family.

Vallota purpurea, Scarborough Lily, has been experimented with several times unsuccessfully until now. As formerly planted, the bulbs were covered with soil to the depth of one inch, as directed, only to have them rot. Two years ago, a bulb was purchased from a Coast Nurseryman—he cautioned—''Plant in open ground with half the bulb exposed''. This was done but not where it received all-day sun. It has thrived, has three off-shoots and now has a very promising bud, well above the foliage. Which only goes to show that many methods advised do not always pan out and that it is only by ''Trial and error'' that one learns.

AMARYLLIS BLOOMS 22 MONTHS FROM SEEDS

MRS. H. L. HARRIS, *Texas*

For years one of my fondest ambitions has been to bring *Amaryllis* into bloom from seed in less than three years; so in the Summer of 1959 I set out to see if I could make my dream come true. I began by preparing my growing medium, a mixture of sandy loam, garden compost and sharp sand in the ratio of 2-1-1, which gave me a good friable soil and one that drained well. I used seed from choice Leopoldii type Dutch hybrid crosses and planted them in redwood flats on June 3rd, 1959

I believe Mother Nature must have smiled on me, for in no time at all it seemed as though every one of the thin black wafers had sprouted into small green blades. These grew rapidly and with regular applications of fertilizer were soon large enough to be transplanted into larger flats. This I did on September 6th. 1959 and the seedling bulbs were then placed on a regular bi-weekly feeding schedule, consisting of alternate applications of Fish Emulsion and Ortho-Gro, both mixed according to direction for proper strength.

During the Winter of 1959 my husband built a small plastic greenhouse, this was placed over the flats to protect them from the cold north winds and rains that we have during the winter months. The feeding schedule was continued through the winter months and the plants responded by growing by leaps and bounds, and as soon as spring arrived the little greenhouse was removed so they could enjoy the warm sunshine.

The bulbs were transplanted to a well prepared garden bed on May 7th, 1960, bulb size at that time averaged about four inches in circumference and the regular feeding schedule was continued through the remainder of 1960.

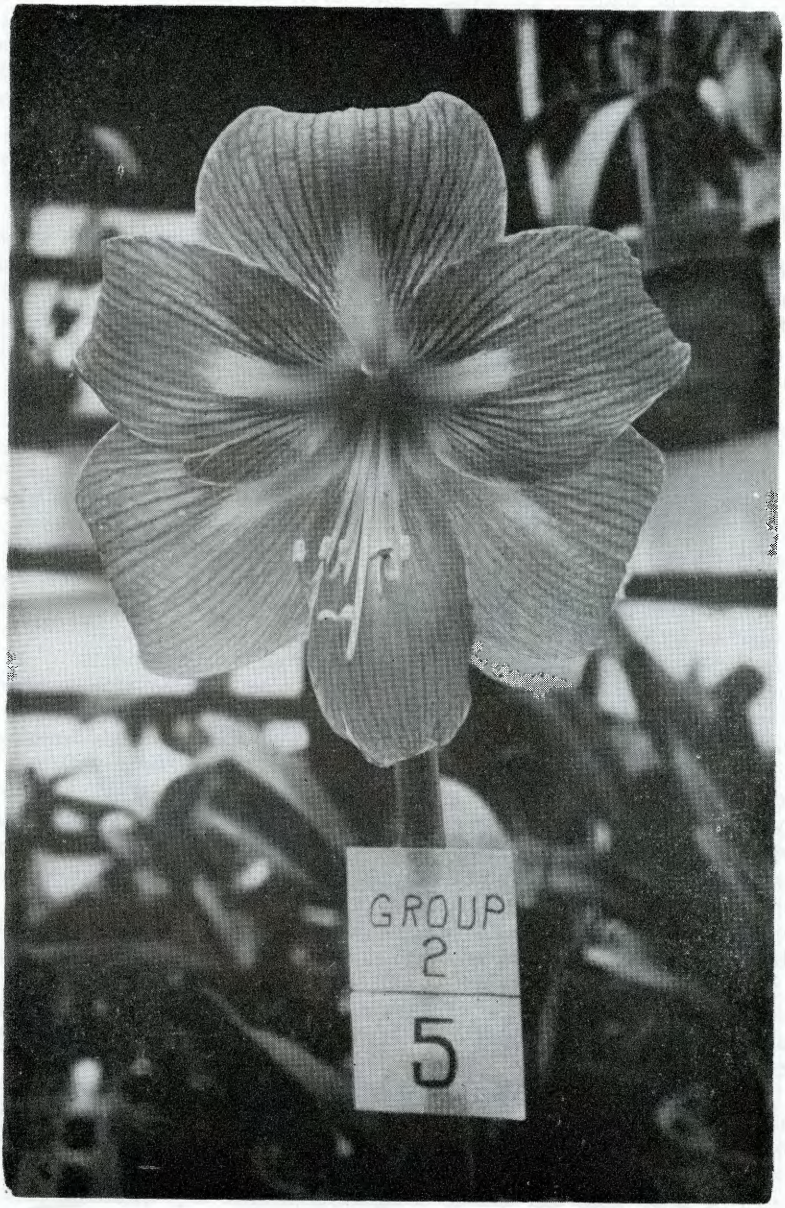

Fig. 21. Hybrid Amaryllis—unnamed clone originated by Mrs. H. L. Harris, Corpus Christi, Texas. See text for description.

Much to my surprise and delight in early March of 1961 I discovered bloom scapes emerging from seven of the bulbs which then averaged eight inches in circumference. The scapes grew rapidly and the buds opened into lovely flowers in varying shades of orange-red and salmon, some of solid color and others with lighter striping and contrasting throat. The blossoms were Leopoldii, type D-5A, [Fig. 21] of heavy substance and measuring seven and one half inches across the face. I entered three of them in the Amaryllis Exhibit at our annual Lola Forrester Show, Corpus Christi, Texas, and was rewarded by receiving a blue ribbon on each.

The 1961 Season is just about over and the lovely blossoms and strong healthy bulbs and foliage spell a very happy end to ''My Dreams Come True''. I am anxiously awaiting next Spring as I am confident that in the Season of 1962, the rest of the bulbs will flower, and will be equally as rewarding as the ones that bloomed in just ''Twenty-Two Months From Seed''.

AMARYLLIS SPECIES NOTES

JOSEPH C. SMITH, *California*

The popularity of *Amaryllis* as a plant for specialization is indicated by the increasing quantity of these bulbs that are imported into this country each year from many parts of the world, and by the increasing interest and attendance at the various amaryllis shows. Along with the general enthusiasm for amaryllis hybrids there is an increasing number of amateurs who grow the species and even do hybridizing work with these original forms as they come from various parts of South America. Thus the demand for species is now sufficient to encourage nurserymen to import and offer them for sale. The various catalogs issued this season contain several listings not seen in previous seasons.

This mounting number of specialists in *Amaryllis* species is encouraging indeed to those who have worked in this field for a number of years. Experience has taught us that in one locality it is not usually possible to grow well all the more than fifty *Amaryllis* species now known to science. With sincerely interested specialists popping up in many parts of the country, including our newest state, Hawaii, we will soon find an area that suits the particular requirements of each individual species. With this accomplished, species bulbs should increase as rapidly as they do at home, and with the full cooperation of the growers in the various areas, there should be an abundance of material available with which to carry out the most interesting hobby of specializing in *Amaryllis* species.

In southern California the species that are winter growing and require a dry summer dormant period do very well. This includes *Amaryllis aulica, A. psittacina,* and *A. correiensis.* Also, the summer growing species that will tolerate a mild wet winter dormancy can be grown here with the aid of irrigation in our dry summer months. This group includes *Amaryllis immaculata,* the forms of A. *Elegans, A. striata, and A. vittata,* as well as *Amaryllis aglaiae* and *A. cybister* among others. These two major growing conditions for this area can be further modified by moisture control, protected planting, and greenhouse culture, to allow many other species to be grown. The *Amaryllis belladonna* forms especially *Amaryllis belladonna major,* from the West Indies, are among the more difficult ones to grow here. A report from Hawaii indicates that *Amaryllis striata* naturalizes there. This area should hurry to stock all the forms of this beautiful species especially forma *crocata* which is the more tender form and not now generally available.

Since reporting in the last Amaryllis Year Book the author has again flowered *Amaryllis aulica* in the garden in November. In April *Amaryllis cybister* flowered beautifully for the first time in an out of doors planting. In July *Amaryllis correiensis* flowered again in a garden planting. A very nice form of *Amaryllis belladonna* received from the Organ Mountain region of Brazil has flowers similar to the miniature hybrid forms now available from India. Mature bulbs of *Amaryllis calyptrata* also received from the Organ Mountains of Brazil have not yet flowered. This season again *Amaryllis aglaiae* did not flower for the author. This was apparently due to moving the bulbs at the wrong season as these bulbs need to be established to bloom well. They tend to pull themselves down deep in the soil and become well anchored before blooming. *Amaryllis evansiae* is another species the author had had no success with. Bulbs tend to decline or rot outright here. Reports on the experience of other growers would be welcome in these pages on the cultural problems with *Amaryllis* species.

WEST COAST VALLOTA CULTURE

ROY HANSBERRY, *Modesto, California*

For at least thirty years, my mother of Puyallup, Washington, has grown a small-flowered red amaryllid which she prized for its free-flowering habit. When I visited her in the fall of 1958, I got a peanut-sized bulblet from the single large bulb she then had. This was rooted in sand and planted in the greenhouse in the usual potting mixture. After two years in the greenhouse, during which time it was not dried off, the pot was transferred to a lathhouse. The bulb bloomed in April and again in June, 1961. Both scapes bore seven florets. A color photo of the plant was identified by Dr. Traub as *Vallota purpurea,* a native of South Africa.

Detailed cultural instructions are given in the usual reference books, but in spite of the admonition not to disturb the roots nor dry up the plant, my mother handled the bulbs like *Amaryllis* that she grew. Each fall the plants were placed in the attic until the leaves dried up. The bulbs were brought back downstairs about January and watered. I expect the well-lighted but unheated attic and the wet western Washington winter climate helped to keep the bulbs in fairly good condition. The bulbs bloomed off and on all summer. The habit of blooming in full foliage adds to the beauty of this most attractive house plant.

NERINES IN THE SAN FRANCISCO BAY AREA

GRANT V. WALLACE, *Berkeley, California*

This account deals not only with hybrid *Nerines,* but with other members of that genus which the writer has grown in Berkeley.

In March, 1925, two dozen seeds of Barr hybrid nerines were received from the firm of Barr and Sons, Reading, England (as it was styled at that time). This genus belongs to the "green-seeded" group of amaryllids, in common with the closely related *Brunsvigia, Haemanthus Boophone, Cybistetes, Ammocharis, Clivia, Crinum,* and the like. For protection, the seeds were accordingly packed in a small, wide-mouthed bottle, surrounded with cotton.

I was unaware, at the time, that the hybrids' leaves are not winter-hardy like those of *Brunsvigia rosea.* As the season was well advanced, no frost occurred. The seeds were planted in pots of our native Berkeley soil—a clay loam—without being sprouted in peat moss. In six weeks, *every one* had germinated! My rabbit's foot must have been functioning 100 per cent, for such green seeds are usually more exacting in their requirements.

Fig. 22. (left) *Nerine curvifolia* var. *fothergillii major;* and (right) Barr *Nerine* hybrids; as grown by Grant V. Wallace, Berkeley, Calif. Photos by Grant V. Wallace.

The seedlings were kept in pots (near the house) for the following four winters. In the summer of 1930, I somewhat rashly planted the now full-sized bulbs in an exposed area, far from the house. In October, several plants bloomed. However, as winter advanced, a series of light frosts nipped the leaves, but caused no damage to the bulb tissues. As subsequent experience indicated, frostbitten foliage results in meager flower production the following fall; a good leaf growth is essential to the setting of buds within the bulbs, just as it is with *Narcissus.*

Warned by this damage, I moved the collection to a frostless strip on the west side of the house, adjoining the driveway and beneath the overhang of the eaves. The fall of 1931 produced few blooms, owing to frostbite. Since that time—for twenty-nine years—the original colony has produced ever-increasing numbers of bulbs, with a full quota of flowers. Offsets are freely formed, forming sizable clumps.

Seeds are produced in quantity, often sprouting where they fall in the bed, which has been treated to about the composition of good potting soil.

The flower crop has been increasingly large and beautiful in each successive year [Figs. 22 & 23]. One may expect about 75 per cent bloom; some plants will rest for a season, but will proceed to set buds for the following year. This results in a sort of alternation, or rotation, which is of benefit to their vigor.

The colors range from pale blush pink through brilliant cerise, vermilion, dark red, salmon pink, and flaming scarlet. All have light-reflecting cells in the tepalsegs, giving the effect, under sunlight, of being sprinkled with diamond dust.

Some flowers have wavy segments; others have flat ones. Some have segments sharply recurved; in others, they are only slightly curved. One individual will be a definite "self," while its neighbor will show a median stripe of darker hue.

Fig. 23. Barr *Nerine* hybrids—(left) mixed seedlings; and (right) mixed seedlings in a vase. Photos by Grant V. Wallace.

In habit, they range from small, dainty forms, with scapes six or eight inches high, to tall, stout types with many-flowered umbels, usually salmon pink in color, but revealing the ancestry of the scarlet *Nerine curvifolia* var. *fothergillii major* [Fig. 22] better known as "*fothergillii*" in their size and vigor. The dominant ancestral form of the smaller types seems to be the Guernsey lily of the London flower marts (*N. sarniensis*), which has flaming scarlet flowers. Many hybrids are of this color, but there is a tendency for scarlet to be modified by the coloring of certain pink species, such as *N. bowdenii.* This results in a large percentage of individuals with brilliant cerise blooms—a color which many people do not favor, but which makes a lovely bouquet if unmixed with other shades. It should be noted here that nerines are ideal for cut flowers; they will keep in water for at least a week, and will proceed to set seed if left long enough in the vase. One strange hybrid form has deep-red flowers that fade to purple along the edges with age.

The leaves show two dominant ancestral trends in their coloring. Some are glaucous, reflecting *fothergillii* and *sarniensis* influence, while some are dark green, which is usual with most other species. All are strap-shaped and scarcely channeled.

The growth cycle is very definite, and should be strictly adhered to by the gardener. About the first of May, the leaves die off naturally, and the bulbs become completely dormant. This state lasts until the middle of August, during which period the soil should be kept completely dry. Full sun is desirable; remember that these plants originated in South Africa, where it really gets hot. About August 15, water thoroughly. Growth of leaves and scapes will then start almost immediately. Don't let the plants become dry until the leaves start to brown off about the middle of April; this returns us to the beginning of the dormant period referred to above.

Following the initial August watering, the first flowers will appear late in September; the season lasts until late in November, with the peak in mid-October.

Pests and diseases are virtually nonexistent, to a degree that is comparable with the related *Brunsvigia rosea.* Snails, slugs, narcissus-bulb fly—all seem to shun nerines. Occasionally, a minor attack of the fungus known as "brown rot" may appear just beneath the bulb coating, but this seems not to thrive or to cause much damage.

To sum up: The *Nerine* hybrid strain is the "easiest" bulb that I have ever tried. Just remember to keep it away from frost when the leaves are growing; it asks nothing else.

When the bulbs are planted (or replanted, owing to increase), a layer of bonemeal applied well below their bases is beneficial. Unlike *Brunsvigia rosea,* moving the bulbs does not materially impede blooming.

An account of other *Nerine* types that the writer has tried in Berkeley may be of interest.

Nerine bowdenii, a true species, from the collection of Mrs. Anson S. Blake, of Kensington. Winter hardy; pink flowers in November, preceded by the leaves.

N. flexuosa, another true species from the same source. Of dwarf habit; flowers pink, with wavy tepalsegs; somewhat irregular, like *Sprekelia.* Inconspicuous; of botanical interest only. Winter hardy.

A type similar to *N. mansellii,* one bulb of which I picked up on the path of an old Berkeley home. Small and slender; flowers in the brick-red or vermilion color range; tepalsegs very wavy. Hardier than the Barr hybrid, but not completely so.

N. filifolia, a distinct species with rushlike leaves and small, pink flowers that resemble those of *N. flexuosa.* Evergreen and winter hardy; it has no dormant period in Berkeley.

N. curvifolia var. *fothergillii major* [Fig. 22]. A lovely species, with long scapes and large, brilliant scarlet flowers, which have sharply recurved tepalsegs and protruding stamens, reminiscent of a pincushion —a feature shared with the *sarniensis* type. While the hybrids have bulbs about an inch and a half in diameter, with short necks, this species has bulbs twice that size, with long necks. Strangely, it sets no seeds. Its blooming period is a month earlier than that of the hybrids—even those containing *fothergillii* blood nevertheless bloom later than the parent species. The bulbs were presented to me by a good friend, dealer, and fellow collector, the late Gordon Ainsley, of Campbell, California. Following his death in 1942, I was privileged to assist Mrs. Ainsley in disposing of the amaryllids in the collection.

Mixed with a quantity of *Nerine sarniensis* bulbs (some of which I retained for trial) were a few that had very light-colored coatings. These turned out to be very large, tall-growing plants, apparently nerines, with pale-green, winter-hardy foliage and pink flowers that were suggestive of both *bowdenii* and *flexuosa.* The blooming period is in November and December. This *may* be the hybrid listed in the old Barr catalogue as 'Hera.' If such is not the case, its ancestry would be interesting to trace, because of its great size compared with that of the supposed parents. On the other hand, it may be a true species. Dr. Hamilton P. Traub will receive bulbs for determination, and it may be that he will have something significant to report in a subsequent issue.

REPORT ON THE MINIATURE AMARYLLIDS

LEN WOELFLE

I am pleased to note the current popularity of the miniature amaryllids as garden subjects here and abroad. Thanks to the collectors, for the many new species and varieties of *Zephyranthes, Habranthus, Rhodophiala, Sprekelia,* etc., a wealth of new material has recently been made available to us.

We can now look forward to the day when orangy hues, pinks and perhaps even white sprekelias may be selected from the hybrids being developed, or soon to come.

Beautiful new hybrids have already been developed in the *Zephyranthes,* and one of the most outstanding ones is 'Ruth Page' developed by Dr. T. M. Howard of San Antonio, Texas, from a cross between *Z. rosea* and *Z. citrina.*

During the past season I have been especially privileged to try a number of Dr. Howard's newer introductions, 'Alamo', 'Apricot Queen', 'Marcia', 'Maria Louisa', 'Peachy' and 'Prairie Sunset'. With no pampering and only a modicum of care they have all grown and bloomed beautifully, almost with neglect.

I particularly liked the larger flowered varieties like 'Marcia', 'Maria Louisa' and 'Prairie Sunset'. I liked the vigorous growth of the broad foliage and the strong scapes, the flaring trumpet shaped perianth tubes; but I suppose I liked most of all the ease with which they thrived in the poorest soil in my garden, giving a great measure of reward for so little attention.

The delicate blendings of pink, yellow and white in the clone 'Prairie Sunset' might have been plucked from the evening sky. 'Maria Louisa' was the most generous with bloom, but this may have been because the bulbs were larger. I look forward to another season when they will all have become a little more mature.

I understand that Dr. Howard will make some of these available to the amaryllid fans in 1962. I am pleased to recommend them to anyone who is seeking something new in the miniatures. Each is different, all are excellent. For a new thrill in gardening try them.

My own efforts to hybridize the group have not been rewarding to date. Efforts to cross *Sprekelia* with the early blooming varieties of *Zephyranthes* so far have failed entirely. Last season I used pollen of the *Rhodophiala* on a number of late blooming *Zephyranthes* and obtained seed. There was little or no germination from the seed, and those seedlings which did develop were lost during the winter months, due no doubt to improper culture. I hope again to obtain seed from like efforts this season.

Rhodophiala species and hybrid should be hardy in many parts of the United States and crosses between these and the *Zephyranthes* would give multi-flowered miniatures in a variety of colors not now available. I would suggest that others try to experiment along these lines, if they have the materials at hand. Nothing could be lost, but much could be gained.

A PRACTICAL AND USEFUL DAYLILY DIGGER

W. Quinn Buck

Los Angeles State and County Arboretum, Arcadia, California

Some years ago, Tom Craig, the prominent daylily and iris breeder, told the writer about a specially made tool that he had found extremely useful in digging iris because it was possible to dig a single rhizome without disturbing the whole clump. This tool seemed to be something that would be equally good for digging daylilies.

A local welder made up several such tools, taking a curved piece of automobile spring twelve to thirteen inches long and welding it to the end of a six-inch piece of three-quarter-inch galvanized pipe for a handle. The digging end was then rounded off and given a reasonably sharp cutting edge.

These first models became indispensable tools, being especially useful for the difficult task of roguing daylily seedlings, but they did have faults. The cutting edge was not satisfactory, and the handles became quite uncomfortable in use. Dr. Hamilton P. Traub, who also had been using this first digger, suggested changing the cutting edge to make it an inverted ''V'', and he also suggested a bend in the spring steel to increase leverage.

A new welder had to be located, because the original one had become a specialist in making street sweeper brushes and he no longer could be bothered with such small jobs. The new welder made up several models incorporating these changes, and rubber motorcycle handlebar grips were put on the handles a bead being welded on the pipe to hold them.

The diggers having the right-angle bend proved less satisfactory than the original curved spring steel; so we have ended up by liking best a model having the V-notch cutting end on the curved steel. The handlebar grips make the tool far more comfortable to use. This digger now seems good enough to recommend it to others who have the job of digging out many seedlings.

AMARYLLIS ARRANGEMENTS FOR THE HOME

MRS. B. E. SEALE, *Dallas, Texas*

Flowers add a distinctive note of beauty to the decoration of the home, not only for special festive occasions, but for every day living. Flower arranging is a self expressive, creative art and can become a fascinating hobby. Interest in correct Flower Arrangements for the home is very evident and it is increasing. A knowledge of Flower Arrangement has almost become a ''must'' with modern American women. Whether they live in a house of French Provincial, English, Colonial, Modern or Contemporary architecture and furnished to conform, there are designs that are suitable for each Period and for the Contemporary with the ''New Look'' in a Modern setting.

The pioneers in Flower Arrangement have established principles and a few rules; given instruction and inspiration that have developed a contemporary flower arranging art in this country. A knowledge of these principles will help those who feel that they can not arrange the flowers they have grown—because they do not have the ''Knack''. All can do it well enough to give pleasure and add beauty to the home if they will apply the important principles and standards of excellence.

Flower arrangement has gone far beyond placing beautiful flowers in a beautiful container; it is the ''ART OF COMPOSITION''. This is the result of putting together in a pleasing and orderly fashion different elements to make an arragement or composition that gives a sense of completeness and visual satisfaction. An arrangement has four definite considerations: the material (flowers and/or foliage), the container, the placement (with emphasis on background), and the occasion. Three elements have shape, size, color and texture.

There are some other qualities that apply to good arrangements. There must be Design, Proper Relation of Flowers and Container, Balance, Rhythm, Proportion, Unity, Harmony of Color Combinations, Suitability of Material, Distinction and Originality.

Design is the plan or pattern of the Arrangement or Composition. The Design may be inspired by the flowers and their fitness for the particular setting or placement. Good Design is seldom ''Coldly Calculated'', it is usually a result that evolves The inexperienced often feel uncertain because they can not visualize completely the finished arrangement when they start work. They must trust the unseen, the uncreated and work confidently that they shall make a worthy composition. The floral artist attempting to build a Design must recognize that line is the basic factor of the composition. There are several design forms to which flowers and/or foliage are easily adapted, namely, the Triangle, the Rectangle (vertical or horizontal), the Circle and its variations (the Semi-circle, Hogarthian or ''S'' Curve), the Fan and the Zigzag.

Any flower arrangement is a Line Arrangement, a Mass Arrangement or a combination of both. A Line Arrangement is made with a small amount of material, while a Mass Arrangement contains a large amount of material placed to give a full, yet not a crowded look to the finished composition. The Oriental influence in arranging has given the triangle form a tremendous popularity; it has been the Design form in the Orient for many centuries. The Design will be determined largely by the flowers and/or other material selected, the container and the placement in the room. Whether the flowers are chosen for the container or the container for the flowers, the two must belong together in order for the arrangement to be pleasing.

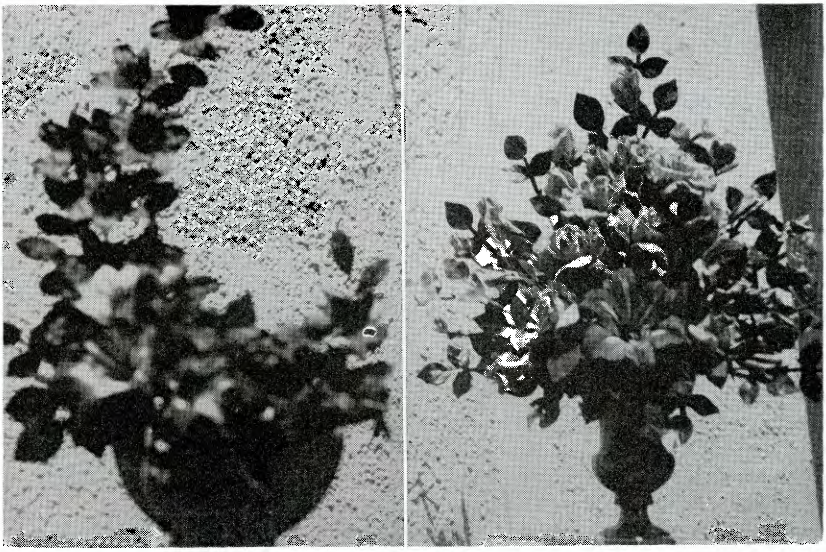

Fig. 24. Floral arrangements by Mrs. B. E. Seale—(left) crescent with three *Amaryllis* as the center of interest; (right) variously colored flowers with one large *Amaryllis* as the center of interest.

Balance is visual stability and it is achieved by the grouping of the individual forms around an invisible axis in such away as to create stability. Balance is a distribution of weight, achieved by size and/or color of the material. Symmetrical or Asymmetrical Balance may be obtained by placement.

Proportion is the graceful relationship of one part of an Arrangement or Composition to another part. It is closely allied to scale or size.

There should be Color Harmony and Textural Harmony for pleasing relationship. Color in Flower Arrangements can enhance the beauty of Design, but does not make Design. Good Design remains good with color absent. There are four general types of Color Harmony: Monochromatic or tints, shades and intensities of one color; Analogous or neighboring colors; Complementary colors (opposite each other on the color wheel); and Triadic colors (three colors equally distant from each other on the color wheel). Flowers of one color or kind should be massed together; massed colors are better than spotty ones. Dark and heavy flowers are better at the base of an arrangement; place the lighter colored ones, small flowers and buds toward the top. If there are several shades, they should graduate from top to bottom with increasing intensity. The Center of Interest is often called the Focal Point or the Primary Accent. One large *Amaryllis* [Fig. 24] or three smaller *Amaryllis* blossoms may be used as the Center of Interest.

Rhythm is measured motion; the eye should follow thru the Arrangement with a feeling of motion. There should be an easy flowing of lines, forms and color.

Now this final quality of a good Arrangement. It should have "Distinction", which is another word for "Originality". All who arrange flowers should strive to make their arrangements and compositions different from those that other people make; strive to create something that will be out of the ordinary. Distinction and Originality are usually achieved after one becomes familiar with the mechanical details and from practice.

It is not necessary to be an artist or a genius to arrange flowers. All principles are based on reason and when one becomes familiar with their use by practice and experience, limitless is the pleasure, beauty and enjoyment you can create for your home and in the participation in local Flower Shows. We should not look at an Arrangement and say "What a beautiful Arrangement", but rather say "What beautiful flowers".

Let us not overlook the use of *Amaryllis* seed-pods in making Arrangements. We treasure them for propagating purposes, yet they have a very subtle charm used with *Amaryllis* blossons and other flowers. I use them in Line and Line-Mass Arrangements. Use them while the scape is stiff and green and the seed-pod is green.

Because of their size, form, coloring and dramatic appearance, a few *Amaryllis* in an Arrangement is more effective than many. However, an Arrangement, using *Amaryllis* entirely, with selected foliage, can be very exotic. Every flower, bud and leaf counts as a meaningful part of the Design. Place all *Amaryllis* blossoms in a simple plan that gives full value to their dramatic beauty. Avoid unnecessary bulk by thinning out some of the leaves on a branch of foliage to give pattern and design.

Foliage plays a dominant part in many Arrangements. The flowers appear more natural when the foliage has been placed at the base or back of the Arrangement. Lengths of Philodendron Vine, combined with Chinese Evergreen, make fine attributes for combining with *Amaryllis* blossoms. Fresh green, unopened canna leaves are effective with white, pink or red Amaryllis. Curled dark red and green canna leaves give height to an Arrangement; they are effectively used with red *Amaryllis.*

White caladium foliage, with its magnificent pattern of green veining, white stock or snap-dragon, and gypsophila, are beautiful with white *Amaryllis.* Mass the stock or snap-dragon and gypsophila into definable areas, with seven to nine *Amaryllis* blossoms of various sizes to form the body of the Arrangement; place three white caladium leaves at the rim of the container—use as an Easter Arrangement.

For a Line Arrangement, use three *Amaryllis* buds and about eight small and medium size Amaryllis blossoms with self foliage and lengths of wisteria vine and place in a low container. For a Stylized Modern Line: make a pleasing pattern of foliage, using seven or nine *Amaryllis* or Peruvian Daffodil leaves, then place three *Amaryllis* of any chosen color, (three red, three pink or three white), in a vertical line. For a Modern Mass: arrange the background foliage; combine two shades of pink *Amaryllis* and dark red *Amaryllis* to give opportunity for color blending—for this, a vase or container of cranberry glass is pleasing. The red *Amaryllis* should be placed at the base, because dark colors are visually heavier than lighter ones and when we consider color as weight, brilliant color is the heaviest because it dominates attention.

Amaryllis and Azaleas combine well for a Crescent Arrangement. Fresh green rose leaves may be used as background and at the base, with three *Amaryllis* for the Center of Interest at the base of the Crescent [Fig. 24].

Flowers express many things: they are symbols of Love, Happiness, Beauty and Life. Growing flowers is a happy pastime and the arranging of plant material is an enchanting joy.

AMARYLLIS ROUND ROBIN NOTES, 1961

MRS. FRED FLICK, *Chairman*

Carthage, Indiana

[The following notes have been extracted from Round Robin letters by Mrs. Flick.]

Gladys Dusek, Texas,—"You are so right about feeding amaryllis. I don't believe that you can over feed them, and they certainly do repay you in bloom. Most of mine send up three scapes with from four to six blooms per scape. They get manure water about every ten days. I feed them bonemeal twice a year, and some balanced fertilizer in between. The hardy *A. johnsonii* and the *A. belladonna* thrive in the yard without much attention."

Marion Bush, N. J.—"I think that I have found the secret for those who live in the north. Mix plenty of peat moss and fertilizer with the soil. In the summer I take them all out of the pots, including the Dutch hybrids, and mix the peat moss and fertilizer into each spot where I set a bulb. When I pot them up in the fall I do the same thing. Ever since I have been doing this I have had more blooms and this year was the best of all."

Mrs. E. G. Frels, Texas,—Soil mix: pea gravel; burr compost (this is the burrs from the cotton); chicken manure; bone meal; vermiculite; and a little oyster shell. Mrs. Frels writes that a friend of hers at

[AMARYLLIS ROUND ROBIN NOTES, Mrs. Fred Flick, continued on page 26.]

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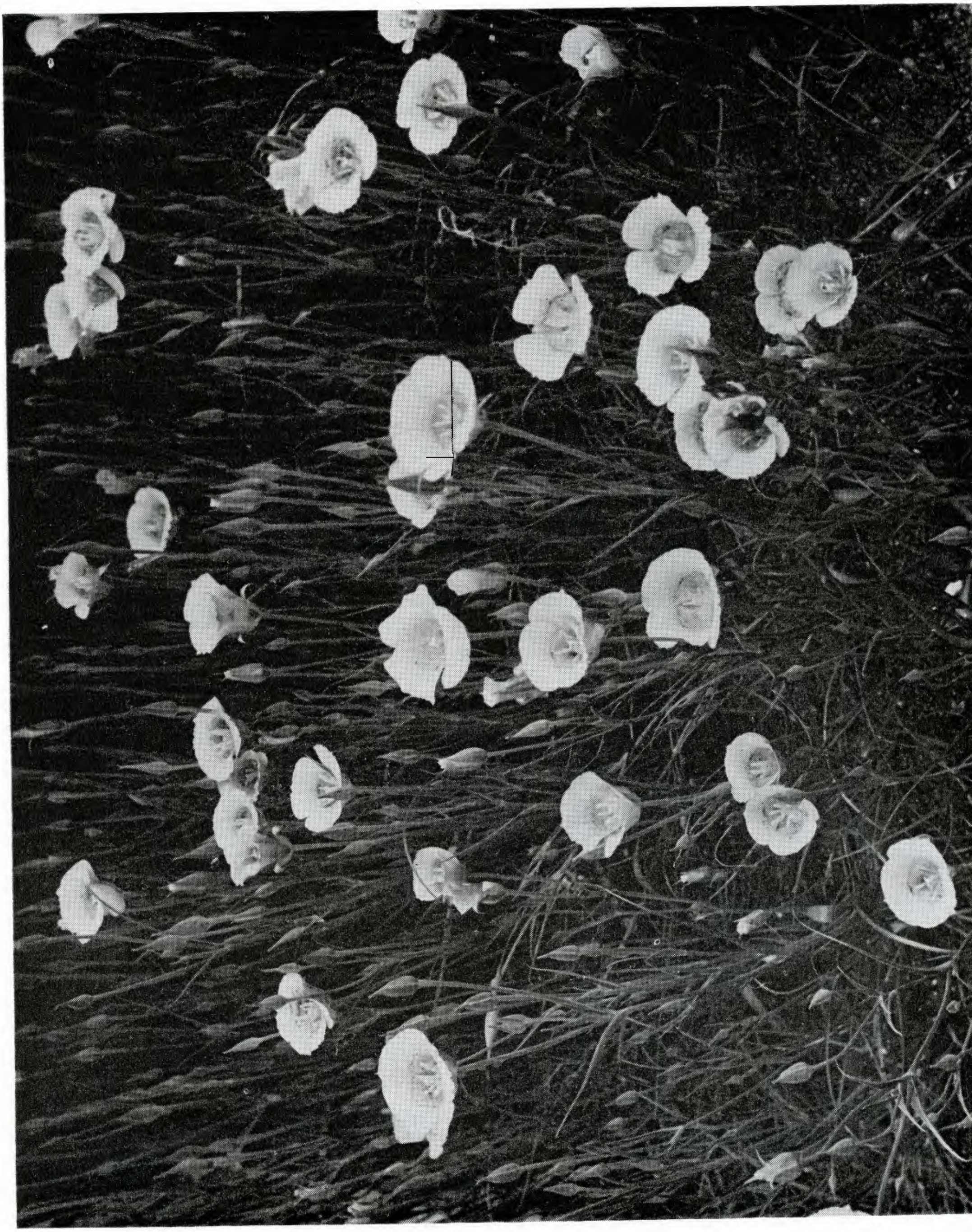

CALOCHORTUS

W. M. JAMES

The word 'calochortus' means "beautiful grass" and refers to the appearance of the foliage, both of the mature plants and the seedlings. The early Spanish Californians called it Mariposa, which is their word for butterfly The intricate and colorful markings on the petals reminded them of a butterfly wing. So both the scientific name and the common name in California indicate clearly the attractiveness of the plant and its flowers.

A brief review of the botanical history of *Calochortus* will provide a good background for examination of the genus. The name was first proposed in 1814 from plants collected by Lewis and Clark in what is now Idaho. Douglas in both trips to North America found and named several species. A number of new species were discovered during extensive botanical exploration in the West during 1880 to 1900. In 1901 Carl Pudy of Ukiah, California presented a revision of the genus. He probably knew more about many of the species than any previous or subsequent writer, both in the field and in his garden. Some of the species are so variable that there has been and still is some question about classification among the taxonomists. In 1930 Beal published a report on the cytology of the genus which proved to be an aid in determining the natural relationships among many of the species. In 1940 Ownby published a Monograph of the Genus *Calochortus* in which he includes a total of fifty seven species and thirteen varieties (and various subsections which we will not consider). Incidentally, some forty of these species are found in California.

Section I Eucalochortus
Section II Mariposa
Section III Cyclobothra

Calochortus is found only in Western North America. Its habitat extends from southern British Columbia to Guatemala and from the Pacific Ocean eastward to western Nebraska and the Dakotas. It belongs to the Lily Family and grows from a bulb. In Sections I and II the bulbs are membranous-coated and in Section III they are fibrous-reticulate coated. Most species set seed in abundance and it germinates readily. In some instances, offsets to the main bulb are formed and many species form stem bulblets in the axil of some of the lower leaves.

In general, culture is not too difficult if CERTAIN, DEFINITE requirements are provided. Protection from gophers is necessary. Good drainage is essential. Strangely enough, some species grow naturally in very heavy soils, but that is only where certain weather and moisture conditions prevail. Very few of them are found in damp soil. Most of

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Fig. 25. (See opposite page)—*Calochortus luteus* Doug. ex Lindl., as grown in the garden of W. M. James, Saratoga, Calif. About half (0.53) natural size. Photo by W. M. James.

them prefer sandy or rocky soil on a slope and generally where grasses and other herbaceous plants are not too thick. They are found mostly on soils of low fertility, so should not be fertilized. Decomposed granite or light volcanic soil is excellent. Most kinds are better without leaf mold.

Many species are very subject to Mildew (Botrytis). This means that it is almost impossible to grow varieties from regions with a natural low humidity in a region with continual high humidity. I learned this the hard way. After starting with a good collection of bulbs and a quantity of seed of some kinds, it was disappointing to lose them all in about three years because of the mildew induced by coastal fogs which were frequent where I was living.

Chickering has written an excellent Monograph on growing *Calochortus.* Apparently he spent considerable time traveling, which enabled him to accumulate a good collection of species and varieties and a record of where various kinds grew in quantity. I cannot remember definitely when, but I probably first became acquainted with *Calochortus* about 1912. During the years since then I have found them only as somewhat isolated, widely scattered individuals except on two occasions which I will detail later on.

It should be mentioned that there seems to be very little data available on the life duration of an individual *Calochortus* bulb. So much depends on the soil and climate in the garden where the bulbs have been planted. Apparently these bulbs can grow year after year in their native habitat without blooming and then suddenly produce a mass of flowers.

This brief introduction brings us to the description of some of the calochortus individuals which I have observed growing naturally.

Section I. EUCALOCHORTUS are often called Globe Tulips. In some localities certain individuals are called Fairy Lanterns. The plants are medium high and generally grow on slopes where there is at least partial shade. The flowers are semi-pendulous and generally somewhat globular in shape. The white *C. albus* is widely distributed in Coastal areas and also in the Sierra Nevada regions. A Coastal form which is found sometimes in relatively damp areas is the one the children often call Fairy Lanterns. Back from the Coast in the warmer, drier regions two yellow ones—*C. pulchellus* and *C. amabilis*—and one pink—*C. amoenus*—are also found. These do fairly well under cultivation and increase readily from seed. They are not nearly as showy as those in the Mariposa Section, but are pretty and interesting and desirable in a collection.

Section II. MARIPOSA contains the largest, prettiest and most interesting individuals of the genus. The flowers are erect and bell-shaped (campanulate). Some species have only one flower on the stem (monochasial) while others are loosely branched (subumbellate) near the top of the stem and produce several flowers.

Calochortus venustus is probably as good as any to start with. A very lengthy article could be written on the varieties and strains of this one. It is widely distributed in the Coastal ranges from San Francisco south to Los Angeles County and in the Sierra Nevadas from Shasta County south. It is probably the most variable in color and the most difficult to identify. Colors vary in different shades of red, yellow, lavender and white. Sometimes one color will predominate in a locality and represent a strain or variety. Sometimes several colors are found fairly close together.

A Forest Ranger stationed at Santa Barbara told me about the location of a large stand of *Calochortus* he had found in the Los Padres National Forest. It was in the higher foothills on the edge of Cuyama Valley, east of Santa Maria. For a few miles the dirt road followed a creek bed, climbing rather fast. After passing a couple of deserted homesteaders cabins, the dirt road disappeared completely and there were only occasional glimpses of the Ranger's car tracks in the grass as a guide. Then zig-zagging up several grassy slopes we emerged on a rolling meadow that was thickly covered with a few acres of *C. venustus* in a variety of colors.

About a month later I returned to this place expecting to get a big supply of seed. There was scarcely a single plant left! Grasshoppers had eaten everything and were still there looking for more. I took a few bulbs home, but these soon died from mildew. Strangely enough these plants were growing in a rather heavy adobe soil. The area had been opened for grazing when the ground was too wet and it had been severely compacted by the cattle. The bulbs I dug were very shallow—about one half inch deep.

Calochortus luteus is another one that is quite widely distributed in the Coast Ranges and in the interior. Certain forms seem to predominate in restricted areas. It is a bright yellow, but the different forms vary in color markings and because of this are sometimes difficult to identify. My experience with what I think is the type of *C. luteus* is worth repeating.

My daughter and her husband live at Novato in Marin County, a few miles north of San Francisco. For two seasons I saw only a few very widely scattered individuals of *C. luteus* in bloom on the hillside in back of their home. Then the third time that I saw them, early in June 1960, many of these plants were in bloom. They were in colonies scattered over quite an area. In a swale where there were many flowers a bulldozer had already started work on a housing project. So I dug a quantity of the bulbs. Later a large amount of seed was collected. These were planted in special soil in my garden near Saratoga. The bulbs bloomed prolifically in June 1961 and the seed came up like grass. [See Fig. 23]

In 1961 there was only about the same showing of blooming plants at Novata that I saw for two successive seasons prior to 1960. This is hard to account for. The rainfall for both 1960 and 1961 were both below normal. However, in 1960 there were no late spring rains. In 1961 there were several light rains during spring. The calochortus plants are difficult to find in the grass until after the flower bud has started development. Because of this I made no effort to determine how many plants started growing. Possibly the late rains provided conditions favorable enough for the mildew to destroy many of the calochortus plants. Beal considers this plant a triploid, and yet it sets seed freely.

Chickering reports lack of blooming some years in occasional instances. Apparently the plant can start growing and later die back without completing a full cycle of growth. And do this repeatedly until conditions are favorable for flowering.

Calochortus clavatus is probably the largest plant and has the largest flower of the genus. I have seen it growing as scattered individuals in eastern Ventura County. Ownby reports its range in dry hills of the southern Sierra Nevada from El Dorado County to Mariposa County and in the south Coast Ranges from Stanislaus County to Los Angeles County. Chickering reports seeing it once in enough quantity on the old Ridge Route Road in Los Angeles County to make the slope where it was growing appear yellow. With the exception of *C. kennedyi,* I would prefer this species above all others which I have seen.

Calochortus kennedyi is a true desert species. Sometimes the flowers bloom almost on the ground. Plants growing under a low bush will have a flower stalk a foot or more high. I have found it in the Mojave Desert a few miles south of the City of Mojave and near the entrance to Frazier Mountain Park. In the southern part of its range the flowers are vermilion, sometimes orange. Eastward a yellow form is found. In Arizona the yellow form is more frequent. Although this is the most brilliantly colored of the genus, it is also the most difficult to grow under ordinary garden conditions.

Calochortus catalinae grows in a rather restricted range in Southern California. In some parts of its range it is plentiful enough to be called the ''Common Mariposa''. It is found from Santa Barbara County in the north southward through Orange County. It is white and not too difficult in the garden.

Chickering reports seeing the brush burned one fall on a mountain side in Ventura County. The following spring the burned over area was a mass of *C. catalinae* flowers. The next season, after the brush, dodder etc., had started to grow again, there were very few Mariposa flowers. This is another example showing that this bulbous plant is able to produce only vegetative growth for some time until conditions are favorable for reproductive growth.

The seeds of many California plants can remain dormant for several years until growth conditions are favorable. I have seen *Pinus muricata* seed come up like grass after a fire. Otherwise the seeds remain in the cones in a viable condition on the trees for years. *Dendromecon rigidum* has an explosive pod which will throw the seed ten feet. After a fire a heavy germination often occurs. Ordinarily this seed is very difficult to germinate. Thirty days stratification at forty degrees Fahrenheit gives satisfactory results, but the easiet way is to plant the seed in a flat, water it thoroughly, then pile about six inches of dry straw over the flat, set it on fire and let it burn off. And the Bakersfield area is famous for the annual wild flowers which bloom only every seven or eight years when there is a season wet enough.

So much for the Mariposa Section. There are many more I would like to become acquainted with, but they are becoming more and more difficult to find as "Civilization" spreads and the population increases.

Section III. CYCLOBOTHRA are sometimes called Star Tulips. The flowers are usually smaller and the petals generally narrower and more pointed than in those of the other Sections. On some kinds the flowers with their "hairyness" and coloring are as intriguing as the ffowers of some of the species orchids.

Calochortus obispoensis is especially interesting, even though the flower is comparatively small. It grows in a rather limited area in San Luis Obispo County. Strangely enough, the over-all color is slightly greenish in appearance. I have seen it growing on a rocky hillside where the rocks have a greenish-waxy color.

I have very little acquaintance with the members of this Section. They are found more extensively in the northern, southern, and eastern limits of the *Calochortus* range. Chickering says that many of them "domesticate" easily.

Calochortus certainly are worth the effort it takes to grow them in the garden. The necessity for well-drained sandy soil cannot be emphasized too strongly. In fact, many of the species of the genus would be classified ecologically as xerophitic. Not many of them will grow in a region where the relative humidity is very high. Unfortunately I know of no commercial source of these bulbs at the present time. Probably the best way to start a collection is to gather seeds. People who really appreciate the plant rarely dig any wild bulbs, and then only in small quantities. The beauty of the flowers more than repays the special effort it takes to grow them.

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PLANT LIFE LIBRARY

CELL HEREDITY by Ruth Sager and Francis J. Ryan, John Wiley & Sons, Inc., New York, N. Y. 1961. pp. 411. $7.50. Ryan and Sager present an excellent treatment of the tremendous advances made in the field of molecular genetics over the past 20 years and its impact upon other biological disciplines. The authors have aimed their message at, "the curious-minded of all ages from college students to mature scholars in disciplines other than genetics." In the opinion of the reviewer this goal has been attained, although considerable background in biology, with some knowledge of elementary biochemistry will be needed to read the book with maximum profit. The faint-hearted will most likely be deterred by the page-long diagrams of structural formulae of the nucleatides of DNA and RNA, the Delta-helix configuration of a protein, and others. But an understanding of the hereditary determinants, their chemistry, replication, mutation, transmission and above all the system or systems by which they exert control over cellular processes is not calculated to make light reading even for the most avid scholar.

There is an urgent need for a text that brings together in a meaningful synthesis the rapid advances in our knowledge of the genetics of microorganisms with other facets of cell biology. Moreover, a skillful integration of this material should demonstrate centers of weakness in present information, thus suggesting new concepts for testing, and providing for continued progress. The authors have recognized this need, and their informative, clean-cut, well-written book deserves high priority on the reading list of all biologists.

The book is tightly organized into 12 chapters of approximately equal length (about 32 pages), followed by a short terminal chapter of 10 pages. It commences with a chapter on "The chemical basis of heredity," followed by others with such headings as: "The mutable unit of heredity," "Recombination in sexual organisms," "Cytogenetic correlations and crossing over," and "Recombination in viruses and bacteria." Next comes a chapter with the challenging title, "What is a gene," followed in sequence by those on "Chromosome duplication and genetic recombination," "Mutation as a chemical process" and "Nonchromosomal genes." The final three chapters are concerned with, "Mechanisms of gene action," "Genetic control of cell integration" and "Heredity in somatic cells." The last chapter ("The summing up") is a succinct statement of present knowledge with respect to the nature of the hereditary materials, transmission mechanisms, and gene action. In the final section the authors examine and evaluate the few facts and numerous theories about, "Replication and the origin of life."

Among the many fine components of the book are the well-executed figures, tables and graphs. There are also 14 plates, faultlessly reproduced, but it is not clear how they are related to specific material in the text. Most of the plates are electron micrographs of various animal and plant tissues, including a sectioned cell of *Escherichia coli.* There are also several of Rhodes' beautiful photomicrographs of maize chromosomes at meiosis, and one of the salivary gland chromosomes of *Drosophilia.* The bibliographic citations though not numerous are probably adequate for the purposes of the book. They are conveniently assembled at the end of each chapter. There are good indexes, both author and subject, each, unusually accurate. The authors and publishers are to be congratulated upon the pleasing format of the book and the absence of annoying typographical errors. A glossary of technical terms might have added to the value of the book, but this would probably have increased the price ($7.50) which is surprisingly reasonable by present standards.—*Thomes W. Whitaker.*

INTRODUCTION TO SOIL MICROBIOLOGY, by Martin Alexander. John Wiley & Sons, 440 Park Ave., So., New York 16, N. Y. 1961. pp. 472. Illus. This outstanding expository text on soil microbiology was written to satisfy the practical interests of the agronomists and also the theoretical concerns of the microbiologist. The author considers the biological processes that take place in the soil, the nature of the soil microflora, and the biochemical aspects of the field of soil microbiology. After considering the biological habitat, and ecology of the soil microorganisms, the author discusses the carbon, nitrogen and mineral transformations that take place in the soil. This is followed by the consideration of the interrelationships that occur between microorganisms and the plant. This excellent, well-written text is indispensable to the student, teacher, and research worker in soil science, bacteriology, mycology, plant pathology and agronomy. Highly recommended.

[PLANT LIFE LIBRARY, continued on page 4]

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For the roster of the general officers of the Society, the reader is referred to the inside front cover of this volume.

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[AMERICAN AMARYLLIS SOCIETY, continued from page 2.]

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THE PHYLA OF ORGANISMS

By

HAMILTON P. TRAUB

1962

THE AMERICAN PLANT LIFE SOCIETY
Box 150, La Jolla, California

Dedicated to

Michel Adanson (1728–1806), founder of

theoretical systematics

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THE PHYLA OF ORGANISMS

Hamilton P. Traub

1. INTRODUCTION

The classification of organisms presented here is a general summary, down to the phylal level, with some groups carried down to still lower levels, and is published at the request of members of the Society for a comprehensive general grouping for guidance in further study on the basis of a selected bibliography. This will serve until the complete version down to the familial level will be published a little later. This interest by students is an outgrowth of the general reawakening of interest in the sciences in the atomic age. A few have asked for information on the background training needed for a career in biology, including specialization in biosystematics. This is a borderline subject and little success can be expected above the routine level unless a background training of the widest possible extent is obtained. This should include a solid grounding in mathematics, physics, chemistry, geology and biology, not to mention the work in the other sciences and the humanities which are sometimes indirectly concerned, and which are required in all university training. The time has long been passed when biosystematics can be equated with nomenclature, a necessary tool only, and a smattering of only a part of the basic sciences.

The present classification grew out of the writer's insatiable curiosity about all biological matters. In his undergraduate years at the University of Minnesota in the 1910's, the writer was initiated into the fascinating subject of phylogeny of organisms in connection with biology courses, particularly under the guidance of the late F. E. Clements. Although Dr. Clements soon joined the staff of the Carnegie Foundation, his influence has been lasting for the writer had started to make a comprehensive classification of organisms *for his own use* and enjoyment under the inspiration received. The classification was revised periodically during the years—in the 1930's, the 1940's, the 1950's and again recently.

The writer wishes to express his gratitude to the authorities listed in the selected bibliography. It has been a pleasure and an inspiration to study their data and conclusions which have in many cases been deliberately drawn on as indicated by the citations, or may have influenced the presentation indirectly.

2. HYPOTHESES ON THE ORIGIN OF LIFE

The suggested age of the earth is 4.5 billions of years, and life has apparently existed on it for nearly half of this time (see H. N. Andrews, 1961). Life on earth is based on amino acids linked with protein molecules, and it requires a watery environment, and a narrow temperature range. It is not known how life originated. Hypotheses have been proposed to fill this knowledge gap. Contemporary scientists believe that life originated from the inorganic state of matter by natural, material processes. In this connection, Rensch (1960) states that various known levels of organization—(1) macromolecular viruses, (2) organized viruses, and bacteriophages consisting of various chemical compounds; (3) rickettsia, anaplasmids, cysticetes; and (4) bacteria—provide a possible clue to an understanding of the origin of life as a series of successive steps, the first and most important of which was the formation of nucleoproteins capable of reproduction. Rensch (1960), of course, does not claim that this progression can be equated with the actual phylogeny of life, but only that it could be looked on as a model to assist in a discussion of such a possible origin. It should be added that we are a very long way from being able to identify such a model with what really happened.

The 'primary heterotroph' hypothesis is among those proposed (Oparin, 1923, 1938, 1953; Simpson et al, 1957; and others) to account for the origin of life. According to this view, in the absence of scavenging organisms, organic materials were accumulated under the conditions that existed in the early history of the earth. Experiments, such as those of Miller (1953) and others, are cited in possible corroboration. In this organic substrate, life is supposed to have originated as 'primary heterotrophic' (saprophytic) organisms, but before the store of primary organic materials was used up, photoautotrophic' organisms evolved by mutation from the primary dependent feeding organisms ('primary heterotrophs'). Through natural selection, the more efficient photoautotrophs could have displaced the 'primary heterotrophs' and have given rise to 'secondary heterotrophs' (parasites and saprophytes), such as those we know today. This bare outline does not do justice to this hypothesis and the reader should consult the references cited for a more detailed exposition.

Needham (1959) has recently subjected the 'primary heterotroph' hypothesis, which he characterizes as an 'ametabolic' view, to criticism. He proceeds on the assumption that the origination of life was "a spontaneous, natural sequence of 'most probable' events. Survival by natural selection is a particular example of a most probable event, and therefore operated at all stages of the origination. True evolutionary novelties have been most probable responses to new environmental conditions, and may have become rarer as the rate of change of the causal conditions decreased." He explains that "it is more probable that all significant materials and reactions were acquired early, panglobally and in quantity, and that subsequent evolution was restricted (a) to most probable innovations . . . and (b) to less fundamental changes, depending in part on changes in the biological environment itself. In general there has been biological simplification during evolution, rather than the converse." According to Needham (1959), an 'ametabolic' view such as that proposed by Oparin (1923, 1938, 1953) and others "leads to the questionable conclusions that there were originally no autotrophs, no photoactivated endergonic syntheses, no need for solar energy, and no decay, that the initial heterotrophs could feed indefinitely on a limited store of pristine compounds, and that generally reducing conditions prevailed on the early earth. This view fails to recognize that the general level of oxidation is less important than the maintenance of a potential difference in free energy between organism and environment. It also tends to overlook the relative rapidity of the circulation of organic materials through living systems, and the evolutionary implications of this."

Chemoautotrophs.—In the previous discussion, nothing has been said about the origin of the chemoautotrophs. According to one hypothesis, these could have arisen independently of the photoautotrophs in the early history of the earth when conditions were radically different from what they now are. According to Woodruff & Baitsell (1951, p. 50). the chemoautotrophic "process possibly represents the most primitive method of nutrition and the one from which all others have been derived during the evolution of life." In discussing the hydrogen bacteria, Thomas (1956) states that "It is to be noted that free gaseous hydrogen is not present in any environment where existing organisms (hydrogen bacteria) grow. The power to oxidize hydrogen may be a purely accidental biological attribute without any historical significance. But inasmuch as in those primeval epochs when things able to grow and multiply first came into existence, free molecular hydrogen may possibly have been present in the atmosphere, there is scope for speculative argument that the power to consume hydrogen may have had functional significance in some primitive ancestors of the existing hydrogen bacteria."

According to a second hypothesis, the chemoautotrophs originated from the photoautotrophs.

This is not the place to pursue this subject further. Whether primary dependent feeders evolved into independent feeders, which then gave rise to secondary dependent feeders; or whether independent feeders came first and then gave rise to dependent feeders together with chemoautotrophs, really should not delay us in classifying organisms because the hypothetical questions may not be answered in our time. Organisms have to be classified today.

3. THE STATUS OF THE VIRUSES

With the epoch-making discovery by Avery, McLeod & McCarty (1944) in connection with data concerning microorganisms that nucleic acids may possess biological activity, the stage was set for the break-down of the formal lines between cytology, genetics, immunology and virology. As pointed out by Horsfall (1961).

with the discovery that a nucleic acid molecule can reproduce itself in a biological environment, that it is "the chemical basis for heredity and that the biological phenomenon, identified as the gene, is in fact attributable to a specific polynucleotide sequence, molecular biology became a reality, and the long-hoped-for marriage between the biological and the physical sciences commenced." Progress in this field has been fairly rapid so that (Rich, 1961) could write that "It is clear that desoxyribose nucleic acid (DNA) acts as the major carrier of genetic information."

Commenting on this break-through in a recent book, Asimov (1960) took a rather extreme view as shown by such statements as "Modern science has all but wiped out the border-line between life and non-life". Commoner (1961) took him to task and pleaded for a true alliance between biology, on the one hand, and physics and chemistry, on the other. These discussions were later followed by rebuttals. Asimov (1961), for the affirmative, again insisted that "All of the substances of living matter—enzymes and all the others, whose production is catylized by enzymes—depend in the last analysis on DNA." Najarian and Commoner (1961) replied for the negative. The student should read these discussions in full so as to sharpen his ideas about the transformation that biology is undergoing today.

In the light of these events, the debate, first set in motion by the crystallation of viruses by Stanley (1935), as to whether or not viruses are living organisms is apparently meaningless as pointed out by Pirie (1937), Luria (1953) and Zinder (1960). It is clear that viruses cannot be referred to as 'living' in the usual sense of a complete organism, but Rensch (1959) has pointed out that it should not be forgotten that they "display four essential characters which are typical of living beings: (1) their chemical structure, with prevailing protein and nucleoacid; (2) their faculty of identical reproduction (though possibly not always direct), permitting a type of constancy through long chains of 'generations'; (3) their individual cycle . . . and (4) their mutability." He explains that one vital character is still lacking—'energy metabolism'.

Luria (1953), an outstanding authority on the subject, defines viruses as "submicroscopic entities, capable of being introduced into specific living cells and of reproducing inside such cells only." He considers viruses as "truly the stuff of which all life is made", but concludes that "A virus is nothing but part of the cell. We observe and recognize as viruses those parts independent enough to pass from cell to cell, and we compare them with other parts that are more tightly tied up with the whole system."

In the present paper, the viruses which can reproduce only inside the cell of the organism, and thus have to make use of the machinery of the cell for achieving growth and reproduction, are considered as parts of the cell, and not on the same level with cellular organisms. Thus they are outside the scope of the present article.

4. THE HIGHER CATEGORIES

The basic category in biology is the species. From the evolutionary viewpoint as indicated by Meglitsch (1954) and Simpson (1961),—the species "is a lineage (an ancestral-descendant sequence of populations) evolving separately from others and with its own unitary evolutionary role and tendencies." This definition is applicable to uniparental (asexually reproducing) as well as biparental (sexually reproducing) lineages. The species itself may be composed of individuals, or, of two or more subgroups, each of which is composed of individuals. Thus the individual has no standing except as a member of a species, or of a species subgroup. Genetics deals with the origin of the individual; systematics deals with the origin and fate of populations. For convenience in discussion, the remarks will be confined to sexually reproducing species.

Except between species within some genera, and rarely between some species of different but closely related genera as now drawn, within the same family, there is no gene exchange. This is so because evolution is an irreversible process. For instance, once the species of the genera *Lilium* and *Gloriosa,* which are properly drawn and both belong to the family *Liliaceae,* have evolved to their present status, those of the first, as can be shown experimentally, are forever separated from the second as far as gene exchange is concerned. From the standpoint of morphology and functioning, species of these two genera cannot return to the status of the ancestral lineages from which they evolved. Each one is conditioned by the residues from past evolution; each may resemble other lineages in some particulars. but as lineages each will remain distinct. As pointed out by Rensch (1959) and others, the mechanism causing diversity, on which the higher categories (that is above the species level—genus and higher) are based, is the identical mechanism involved in the evolution of the species. As the diversity among species increases with the lapse of time, and large sections of species die out in the course of natural selection, great valleys are left between the mountain peaks of surviving species which are 'united' below by the bond of phylogeny or descent. One or more of such distantly related 'peaks' of surviving species represent the basis of the higher categories.

NUMBER OF HIGHER CATEGORIES.—In systematic practice, one or more presumably related species are grouped together to form a more or less objective group called a genus. These species are presumed to have arisen from a common ancestral stock. One or more of such genera are grouped under a family, and so on, in an ever rising presumably phylogenetic hierarchy as shown in Table 1.

Table 1. The hierarchy of categories in biology.

- **Kingdom** (one or more phyla)
  - **Phylum** (one or more classes)
    - **Class** (one or more orders)
      - **Order** (one or more families)
        - **Family** (one or more genera)
          - **Genus** (one or more species)
            - **Species** (composed of one group of individuals, or two or more of such subspecific groups)

The higher categories listed in Table I represent a bare minimum. In actual practice other categories usually have to be interpolated between those shown. There are those who believe that only a small number are needed by the systematist, but they fail to realize that under such a handicap, the inter-relationships can hardly be adequately indicated, and the so-called classification remains a vaguely delineated system. Others prefer to amplify the number of higher categories so as to indicate with greater exactness the ideas that underlie a proposed system. Unfortunately, the biological societies have not provided a comprehensive uniform series of higher categories, and thus the individual worker has to add those needed to express his ideas about the presumably phylogenetic relationships within the classification. The writer has compiled a comprehensive list (including 32 levels) entirely for his own use (see Table 2), which he has found useful in writing down his comprehensive composite classification of the phyla of organisms summarized in Table 21.

According to the Botanical Code (Lanjouw, et al, 1956), the principles of priority do not apply to category names above the rank of order, but it has been said elsewhere that this is really confined to the rank of family. In practice, names of categories above the rank of order are taken from characters indicating the nature of the organisms included, with appropriate endings. Category names above the rank of genus—up to and including the rank of order—are taken from the nomenifer (type) group in each case, with appropriate uniform endings. The Zoological Code (See Schenk & Masters, 1956) does not include provisions as extensive as this.

The status of the viruses is still unsettled in the minds of some, but from our standpoint they belong with organelles—parts of cells, and thus are in the field of the anatomists and physiologists. The nomenclature of the viruses is necessarily tentative until it is possible to adequately categorize them. As has been pointed out in detail above, the subject is extremely technical since it deals with mono- and polymolecular organism-like groups. Accordingly, the nomenclature of the viruses can only be adequately handled by the virologists themselves. Recently, C. H. Andrews, et al (1961) have published a *tentative* classification of the viruses infecting vertebrates based on seven characters—nucleic acid, size ($m\mu$), number of capsomeres, membrane outside the capsid, multiplication, maturation at the cell surface, and ether sensitivity. This will undoubtedly be extended to include the other viruses as more information about these organelles accumulates.

Table 2. List of higher categories, with uniform endings. Categories and endings in **bold face** are authorized in the Botanical and, or Zoological Codes. All others have been supplied by the writer.

	Category endings		
Category designations	**Plantae**	**Heterplantae** *	**Animalia**
Superkingdom	-ae	-ae	-ia
KINGDOM	-ae	-ae	-ia
Subkingdom	-ae	-ae	-ia
Infrakingdom	-ae	-ae	-ia
Superprovince	-iae	-iae	-iae
PROVINCE	-iae	-iae	-iae
Subprovince	-iae	-iae	-iae
Infraprovince	-iae	-iae	-iae
Superphylum	-phytae	-mycotae	-a
PHYLUM	**-phyta**	**-mycota**	-a
Subphylum	**-phytina**	**-mycotina**	-a
Infraphylum	-phytinae	-mycotinae	-a
Superclass	-opsidae	-mycetiae	?
CLASS	**-opsida**	**-mycetes**	?
Subclass	**-idae** **	**-mycetidae**	?
Infraclass	-idinae	-mycetinae	?
Supercohort	-corae	-corae	-corae
COHORT	-coae	-coae	-coae
Subcohort	-cosae	-cosae	-cosae
Infracohort	-conae	-conae	-conae
Superorder	-iales	-iales	?
ORDER	**-ales**	**-ales**	?
Suborder	**-ineae**	**-ineae**	?
Infraorder	-inreae	-inreae	?
Superfamily	-aciae	-aciae	?
FAMILY	**-aceae**	**-aceae**	-idae **
Subfamily	**-oideae**	**-oideae**	-inae ***
Infrafamily	-oidinae	-oidinae	?
Supertribe	-ieae	-ieae	?
TRIBE	**-eae**	**-eae**	?
Subtribe	**-inae** ***	**-inae** ***	?
Infratribe	-inrae	-inrae	?

* See Figs. 1 and 2; and Table 21.

** This ending appears under both **Plantae** and **Animalia**, but in different ranks.

*** This ending appears under **Plantae** and **Heteroplantae** in the same rank, but in a different rank under **Animalia.**

Uniform category endings.—An inspection of Table 2 shows that the higher category endings, which have been taken in part from the biological codes with additions by the writer to fill in some of the gaps, represents a patchwork. Such category endings as have been adopted by the societies from time to time were put forth without any unifying principles for biology as whole. In some cases the same endings appear for different categories under plants and animals. Surely in this atomic age communication between the branches of biology should be such that agreement could be reached to erase these inequalities. Although the category ending represents but a detail in nomenclature, it should receive proper attention. It is helpful to the worker if he *is relieved of the detail* of coining such endings, and is thus able to *devote his entire time* to research.

Simpson (1952) considered the subject of uniform category endings and came out against them, contending that the more or less non-uniform endings used in zoology have been long in use and that it is now too late to make any changes. However, Stenzel (1950) had earlier pointed out that if the same uniform endings were used above the rank of genus, then the reader could recognize at a glance the category itself as well as the degree. With different endings, only the specialist could recognize them. It would be all to the good if a joint committee from the botanical and zoological societies could work toward the end that agreement could be reached on fundamental principles for category endings. Such a committee could also make recommendations for cases where the same endings appear in different categories.

Table 3. Analysis of some uniform category endings from the viewpoint of the criteria discussed in the text.

Kingdom	category rank series	category rank series indicator	category degree indicator suffixes: super	basic	sub	infra	Examples
Plantae	Superphylum	**-phyt-**	**-ac**				Autonitrophytae**
“	Phylum	“		**-a**			Autonitrophyta
“	Subphulym	“			**ina**		Autonitrophytina**
“	Infraphylum	“				**-inae**	Autonitrophytinae**
Heteroplantae*	Superphylum	**-mycot-**	**-ae**				Schizomycotae**
“	Phylum	“		**-a**			Schizomycota
“	Subphylum	“			**-ina**		Schizomycotina**
“	Infraphylum	“				**-inae**	Schizomycotinae**
Plantae	Supercohort	**-co-**	**-rae**				Lilicorae**
“	Cohort	“		**-ae**			Lilicoae**
“	Subcohort	“			**-sae**		Lilicosae**
“	Infracohort	“				**-nae**	Liliconae**
Animalia	Superfamily	**?**	**?**				?
“	Family	**-id-**		**-ae**			Hominidae
“	Subfamily	**-in-**			**-ae**		Homininae
“	Infrafamily	**?**				**?**	?

* See Table 21. ** Not actual taxa recognized by the writer; used only as examples.

As to the endings themselves, those above the phylal level could be very simple and need not show degree, as shown in Table 2. But even here it would be desirable to have distinctive endings if possible.

At the 'phylal' level, or below, the ideal category endings should comply with the following criteria: (1) begin with a consonant; (2) have a first part that serves as a category rank series indicator; (3) possess a final part that serves as a category degree suffix; and (4) be short. A few examples have been analyzed in Table 3.

The examples of the endings at the 'phylal' rank series level, in Table 3, show that the endings, *-phyta* and *-mycota,* meet the requirements, except that possibly they are too long. The example for the ending at the 'cohort' rank series level meets all of the requirements. The example at the 'family' rank series level is incomplete because the Zoological Code provides only for 'family' and 'subfamily' endings. The category rank series indicator is not uniform, and the suffixes are uniform and thus the criteria are not satisfied.

A comprehensive unified handling of this problem could be achieved by adopting a set of short *category rank series indicators* (not necessarily the examples given here)—

province (-vi-), phylum (-phy-), class (-si-), cohort (-co-), order (-do-), family (-mi-) and tribe (-ri-)—

and a uniform set of short *category degree indicator suffixes* which could be applied to the above—

super (-rae), basic (-ae), sub (-sae) and infra (-nae).

One example—cohort (-co-) is included in Tables 2 and 3. Such endings could be uniform for all of biology, or a separate set could be adopted for each of the plant and animal kingdoms.

5. OUTLINE HISTORY OF SYSTEMATIC BIOLOGY

In this very brief article, it will be possible to include only the barest outline of some of the highlights in the history of systematic biology as a branch of Western Culture. The student who is interested in more extensive details is referred to the selected bibliography. Biological science is a unit, and the systematic part is only one of its phases. The development of a part is bound to affect the others. Thus some of the other phases of biology will be referred to in presenting the subject of systematic biology.

(A) SYSTEMATIC BIOLOGY IN THE GRECO-ROMAN PERIOD, TO 476 A. D.

One school of early Greek philosophers working on the problem of the nature of the universe for over two centuries reached the conclusion, in the atomic theory of Leucippus (5th cent. B. C.) and Democritus (C. 460—C. 370 B. C.), that everything in the universe was made up of tiny unseen atoms, all alike, that are united by chance in various ways and numbers. The opposing school believed in a purposeful nature.

As pointed out by Darlington (1937), "It was generally held that evolution of some kind had taken place, though its comprehensive nature was not generally grasped. In regard to its mechanism a wide cleavage of opinion arose between two schools. There were on the one hand those who like Aristotle supposed that a purpose, divine or natural, worked by the inheritance of acquired characters to produce conformity with an imagined harmony of nature. On the other hand there were those who saw no purpose or design in the order of things, and conceived of living organisms as growing and changing according to determinate laws, laws which equally governed non-living things. Such a cleavage still persists today."

The study of organisms for their own sake—the basic science of biology—as distinct from technology (applied biology) began in ancient Greece. Unfortunately, the greater part of the biological work of Aristotle (385(4)—322 B. C.), who is recognized as the father of biology, and zoology in particular, has been lost to us. Works that have survived include,—"On the History of Animals" (10 books), "On the Parts of Animals" (4 books), "On the Reproduction of Animals" (5 books), and "On the Soul" (3 books). Aristotle left his library to his pupil Theophrastus (372(0)—287 B. C.), who is recognized as the father of botany. The work, "Enquiry into Plants", attributed to him, and "The Causes of Plants", have come down to us, but the first may be a compilation from the notes taken down by scholars who attended the lectures of Theophrastus. Thus, what we know about the Aristotelian biology is partly associated with these books. Aristotle recognized only two systematic categories—'kind' and 'group'—and he recognized eight such groups for animals. The classification of animals envisioned by Aristotle was not set down in summary form, and it has been necessary to extract this from his writings. Thus it is natural that there is lack of unanimity as to what it is (Weysse, 1904; Singer, 1931—59; Bodenheimer, 1958, etc.). Such a summary for animals according to Weysse (1904) is given in Table 4.

What we know about Aristotle's views on plants comes down to us mainly through Theophrastus, and apparently the latter made contributions of his own, but he did not formalize any classification of plants. Theophrastus realized the difference between flowerless and flowering plants. He reported detailed observations on the germination of the monocotyledonous and dicotyledonous types of seeds and seedling development, citing the grasses for the former, and leguminous plants for the latter, but did not formalize any system on that basis. Thus the seed was planted that sprouted later into the outlook of Albertus Magnus (before 1256 A. D.) and Ray (1686—1704). Theophrastus also grouped plants from other viewpoints—trees, shrubs, undershrubs and herbs; deciduous and evergreen plants; and cultivated and wild plants. Thus any classification of plants on a formal basis has to be extracted from his writings. One such view is given in Table 4.

Table 4. Summary of classification of plants according to Theophrastus, and animals, according to Aristotle, as extracted from their writings.

Plants* (extracted from Theophrastus' writings)
- Flowerless
- Flowering:
  - [Monocotyledonous type]—germination of grass seeds, and seedling development, cited by Theophrastus.
  - [Dicotyledonous type]—germination of leguminous seeds, and seedling development, cited by Theophrastus.

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* Classification of plants from other viewpoints: trees, shrubs, undershrubs, herbs; deciduous and evergreen; cultivated and wild.

Animals (extracted from Aristotle' writings according to Weysse, 1904)

Animals with blood:
1. viviparous animals (mammals)
2. birds
3. oviparous quadrupeds (our amphibia and reptiles)
4. Fishes

Animals without blood:
5. soft animals (such as Cephalopods)
6. soft animals with shells (such as Crustacea)
7. insects
8. animals with shells (such as Echinodermata and many Mollusca)

The crushing of the Achaean League by the Romans in 146 B. C., marked the end of Greek and Macedonian independence. However, Greek science and culture continued on as a vital influence throughout the time of the Roman Middle and Later Republics and to the end of the Empire in 476 A. D. The Romans, with a practical tradition, carried on mainly as technologists (in applied science).

The first agricultural book in Latin was produced by Cato the Censor (234—149 B. C.). In it 120 cultivated plants were mentioned.

The philosopher, reformer and poet, Lucretius (Titus Lucretius Carus, (99(8)—55 B. C.) in his great poem, "De Rerum Natura", eloquently presented the ideas of his Greek predecessors Democritus (C. 460—370 B. C.) and Epicurus (342—270 B. C.) in order to combat the superstitions of his pagan contemporaries. With reference to biology, he "tells of the existence of monstrous creatures which lived relatively early in the span of earth's history and which eventually proved unsuited to their changing environment and consequently disappeared. The poet pictures all living creatures, including man, as springing originally from the earth, which by his time he believed to have grown old and to have passed her age of greatest fertility (Bennett, 1956)." Although his advanced ideas concerning atomic theory and evolution were scorned by the pagan Romans and later also by the Church fathers, his version of evolutionary philosophy influenced the studies of 18th century A. D. science.

In referring to the disputes between the two schools of evolution in ancient times, Darlington (1937) states that the bases of these "did not rest on the strict experimental evidence that can now be adduced but merely on observations of a world which clearly provides by its ordinary changes the means of testing many fundamental hypotheses as it still does in astronomy and cytology. From such observations emerged one theory which we ought to keep in mind because it agrees in so many respects with the views underlying modern genetics, This was the theory developed with closely reasoned argument by the atomic and materialistic philosophers and preserved for us largely in the great poem of Lucretius. It may be summarized under five heads—(1) Material bodies handed down from one generation to the next determined heredity both of body and mind. Matter being atomic, inheritance was atomic or particulate as we now call it; (2) The offspring were derived from materials of both parents, sometimes more of one than of the other, the two being therefore merely statistically equal; (3) Separation and recombination of these bodies in the course of sexual reproduction was responsible for the separation, recombination and reversion of characters; (4) Evolution occurred in the sense that some species became extinct while others changed. Man for example had developed from brutish ancestors without law or language. There was no all-embracing scheme of evolutionary change and there was equally no conception of species being fixed; (5) New structures arose by chance and survived if they were useful. Nature eliminated unprofitable types. They did not come into being for a purpose or in response to use. Aristotle thought this was leaving too much to chance, an argument that was equally to be used against Darwin."

Gaius Plinius Secundus (23—79 A. D.), commonly known as Pliny, compiled a "Natural History" about A. D. 77. Dioscorides (birth and death dates unknown), produced a "Materia Medica" about 78 A. D. This remained the standard text for students of European botany on through the Middle Ages. The anatomical works of Galen (131—210 A. D.) served as guides in medical schools for twelve centuries.

(B) SYSTEMATIC BIOLOGY DURING THE MIDDLE AGES, 476—1453

With the death of the last Roman Emperor in 476 A. D., the Roman Empire of the West also expired. There followed first a marked decline and then a gradual reawakening of interest in learning in western Europe. This period lasted until about the middle of the 15th century—nearly a millennium. During this whole period, the Aristotelian biological tradition was dominant. The works of Theophrastus, Pliny, Dioscorides, and Galen were standard, and any slight progress was built upon that basis.

Early Middle Ages, 476—1096—With the Mohammedan conquest of large areas in the Middle East, north Africa and Spain, Greek science was gradually adapted to the particular needs of the conquerors in this vast crescent. In time the Arabian and Persian philosophers made notable contributions during a period when the advance of learning in western Europe was in eclipse. Notable contributions were made by Abu Mansur, who composed a pharmacological treatise in Persian during the years 968—977 A. D. Its influence was apparently indirect since it was never translated into Arabic. The Persian, Abu Sina (980—1037), sometimes referred to under a latinized distortion of his name as Avicenna, was a noted mathematician, astronomer, philosopher and poet. His most important biological contribution was his "Canon of Medicine", which ranked not far below Galen's work.

The Age of the Crusades, 1096—1291.—The great natural philosopher Ibn-Rushd (1126—1198), sometimes called Averroes, was born at Cordoba in Spain. He made a notable advance toward a more real conception of nature. With his passing, Arabic philosophy went into decline due to religious intolerance. But Persian and Arabian philosophers had bridged the gap of the Early Middle Ages and the torch was again taken up in western Europe during the Age of the Crusades, which is here under consideration.

The outstanding natural philosopher in the Western tradition during this time was Albertus Magnus (1193—1280). Although the great bulk of his writings are concerned with theology and philosophy, his real interest appears to have been natural science. He upheld the Aristotelian tradition as found in Theophrastus, but he apparently progressed as pointed out by Arber (1938), for the botanical part of his writings, "De vegetabilis" (dating from before 1256 A. D.) reveals that he had in mind a system of classification of his own which he never set down on parchment in summary form. This system has been summarized by modern workers as shown in Table 5.

Table 5: Classification of plants according to Albertus Magnus as extracted from his writings (Arber, 1938). See also Table 4.

1a. Leafless plants [cryptogams in part]
1b. Leafy plants [phanerogams and certain cryptogams]
  2a. Corticate plants [monocotyledons]
  2b. Tunicate plants ("ex ligneis tunicis") [dicotyledons]
    3a. Herbaceous
    3b. Woody

Present day equivalents of the groups are shown in brackets, but it should be realized that he did not recognize the distinction between monocotyledons and dicotyledons to the extent that is shown in Table 5. The influence of the biological work of Albertus Magnus extended over the next two centuries.

Roger Bacon (1214—1294) is to be remembered for his general scientific ideas which stimulated others to perform their work by the inductive scientific method.

Later Middle Ages (1291—1453).—As already intimated, the work of Albertus Magnus eclipsed all the work in Aristotelian biology until the time of Andrea Cesalpino (1519—1603). The manuscript herbals written during the Later Middle Ages were based upon Greek and Latin manuscripts and Arabic commentaries, and thus lacked originality.

(C) SYSTEMATIC BIOLOGY DURING THE MODERN PERIOD, 1453 TO PRESENT TIME

Among the factors that brought about a quickened pace in the reawakening of interest in learning during the early part of this period may be mentioned the invention of printing by movable type in 1440, and the wider dispersal of the ancient Greek manuscripts into western Europe after the fall of the Eastern Roman Empire in 1453.

EARLY MODERN PERIOD, 1453-1757

Following closely in the path of the invention of printing, popularization of knowledge began with the appearance of treatises on various subjects, including biology. In biology, there first appeared a series of herbals, and this was followed later by the appearance of texts devoted to Aristotelian biology, and also biology with a new modern outlook.

"Age of Herbals", 1470—1679.—During the so-called "Age of Herbals", printed herbals were produced in Germany, the Low Countries, Italy, Spain and Portugal, Switzerland, France and England (See Arber, 1938). During this time, the first herbaria were established, and by the 16th century, the making of such collections, including also museum specimens of animals, became a regular part of biological systematics. The herbalists include a long roster of illustrious names such as Brunfels, Fuchs, Carmerarius the Younger, L'Obel, Mattioli, Gesner, Bauhin, and so on. It is not possible to go into detail here about their contributions, except to note that Bauhin (1560—1624) was apparently among the first to fully appreciate the distinction between plant genera and species as shown in his main work, "Pinax theatri botanici" (1623). *He provided the species with descriptions, and named the genera,* but did not characterize the latter

The works of Vesalius (1514(15)—1564?), first published in 1543 (revised edition, 1555) created the modern science of animal anatomy which is basic to systematics.

He was persecuted for his advanced ideas and driven into voluntary exile where he apparently perished. His work was vigorously, and for a long time successfully, opposed by the followers of the outmoded tradition of Galen, but gradually over the next two centuries the contributions of Vesalius were generally accepted .

During the early modern period there was also a revival of Aristotelian biology. In 1552, Wooton (1492—1555) revived the Aristotelian system of animal classification in a modified form. Two of the more important workers in botany may be mentioned. Andreas Cesalpino (1519—1603) in his "De Plantis libri xvi" (1583) insisted on the importance of the reproductive organs in plant classification, and in this he foreshadowed Linnaeus' later artificial system. Adam Zaluziansky von Zaluzian (1558—1613) in his "Methodi herbariae, libri tres" (1592) presented a survey of botany in general and pleaded for the separation of the study of botany from medicine.

The significance of the work of Harvey (1578—1667) on the circulation of blood (1628), and his work, in embryology (1651), basic to systematics, lies in fulfilling the requirements laid down by Francis Bacon (1561—1626) for explaining nature by experience based upon observation and experiment.

END OF AN ERA 1679—1757.—This period in the development of systematic biological tradition begins with the publication of the "Handbook of Botanical Study" ("Isagoge phytoscopica" (1679) of Joachim Jung (1587—1657)) published 22 years after his death by his pupils, which inaugurates the beginning of an accurate terminology and a rigorous descriptive procedure for botany, and indirectly also for biology as a whole—a clear break with the Aristotelian tradition. However, Jung's influence began 18 years earlier as will be explained below. Jung's book contains an exposition of the theory of botany and the characterization of the plant and each of its organs. He used the flower as the basis of his classification and his nomenclature approached a consistent binomial system. This work influenced workers in systematics during the rest of the period, and indirectly also workers up to the present in that all follow a similar modernized procedure. After Jung there is a definite trend in the direction of departing from a slavish adherence to the Aristotelian tradition. Ultimately any of its features are retained only because they can be verified.

Pierre Magnol (1638—1715), first proposed the concept of 'famille', stating that "plants have certain affinity which does not exist in any part considered separately, but only as a whole." However, he did not characterize any families. Joseph Pitton de Tournefort (1656—1708), a pupil of Magnol, *named and adequately described genera* in his "Institutones Rei Herbariae" (1700).

John Ray (1627—1705), who collaborated with Francis Willughby (1635—1672), in zoological research until the latter's death, proposed classifications of plants and animals which are summarized in Table 6.

In 1660, Ray luckily got hold of Jung's manuscripts of "The Handbook of Botanical Study" (1679) and "Doxoscopiae" (1662), three years after the author's death, and 19 years before the first was finally published. This profoundly influenced all of Ray's biological work, and it was through Ray that Linnaeus first came under Jung's influence.

Ray's system for animals was not practical because he used the dichotomous device of branching by two's in the presentation. Ray's largest botanical work is his "Historia Plantarum" (1686—1704). His plant classification is inferior to the conception of Albertus Magnus because Ray divides plants artificially into herbs and trees. But he did confirm Theophrastus' concept of monocotyledons and dicotyledons on the basis of seed leaves. Ray was influenced by the work of Jung with reference to rigorous definitions and terminology, and he cites Cesalpino with reference to the importance of fruits and seeds in classification, but he explains that the form of the leaves and other parts must also be considered. Ray believed in the special creation of an invariable number of species. He characterized each genus with a diagnosis, and gave detailed descriptions of the species. He based his definition of species on reproductive isolation—the unit that breeds true within its own limits.

By early 1700, in some cases, untenable parts of the Aristotelian systematic tradition had been abandoned; some valid Aristotelian concepts had been clarified and conserved; and some new concepts had been adopted. Further developments toward the building of a modern systematic tradition, particularly the general adoption of valid principles of classification, and the recognition of the valid mechanism of evolution, were still in the future.

It is now in order to summarize *some* of the advances made toward the building up of a scientific tradition during the more than two millenia before 1700: (1) A theory of botany had been presented by Jung together with a rigorous terminology and description procedure. (2) A definition of species had been proposed by Ray. (3) Species had been adequately described by Bauhin and Ray. (4) Genera had been adequately described by Ray and Tournefort. (5) The binomial method of naming organisms—genus + specific epithet—had been used by various workers, usually not consistently—Jung, however approached consistency. (6) Theophrastus, Albertus Magnus and Ray had developed the concept of monocotyledons and dicotyledons. (7) Cesalpino had pointed out the importance of considering the characters of the reproductive organs in classification. Jung had based his classification on the flower. (8) Ray had explained that not only the characters of the reproductive organs, but also those of the vegetative parts have to be considered in classification. (9) Vesalius had founded the modern science of animal anatomy, and Harvey had published on animal embryology.

Table 6. Summary of John Ray's classifications of plants and animals. See also Tables 4 and 5.

- Plants:
  - Herbs:
    - Impertectae (mostly algae, fungi, mosses and ferns)
    - Perfectae (seed plants)
      - Monocotyledons
      - Dicotyledons
  - Trees:
    - Monocotyledons
    - Dicotyledons

- Animals:
  - Sanguiferous:
    - Lung breathers:
      - Animals with two heart ventricles:
        - Oviparous (birds)
        - Viviparous:
          - Partly land animals—mammals
          - Partly aquatic animals—whales
      - Animals with one heart ventricle:
        - Oviparous quadrupeds—(frogs, tortoises, lizards and snakes)
    - Gill breathers—fishes
  - Bloodless animals:
    - Small (insects)
    - Large (molluscs, crayfish, crustaceans)
  - Anomalous animals—(hedgehog, mole, shrew-mouse, armadillo, sloth, etc.)

All of this was *part* of the climate in the biological systematic tradition when Linnaeus (1707—1778) came on the scene. The concepts of the Aristotelian tradition were still influential, particularly the theory of design or purpose in nature. The theory of chance in the origin and evolution of organisms as initiated by Leucippus and Democritus, and their followers, and as summarized by Lucretius, was still in eclipse.

Linnaeus was imbued with the thesis that living organisms had been created according to a definite plan by a superior being, and it was to the discovery of this plan that he devoted a life of hard work. Although his metaphysical Aristotelian thesis was far removed from a scientific outlook, it did implant the concept that living organisms are part of an organized whole, and thus it laid to rest finally any idea that nature was chaotic. Linnaeus acknowledged Jung as a forerunner.

Linnaeus (1740, 1751, 1764) attempted to arrange plants according to a natural system by using as the criterion the common agreement existing between all parts of the plant, but he went no farther than to group genera under orders. He never characterized the orders which are equivalent to present day 'families'. He apparently realized that his background and training, and the underdeveloped state of botany, made it impossible for him to complete such a system, but he stated that the completion of it should be the ideal of all botanists in the future. This would explain the unfortunate compromise solution for his day that he adopted. Apparently following the suggestion of Cesalpino, and the example of Jung, he developed the artificial sexual system which he presented in the elaborated form in "Species Plantarum" (1753). An outline of this is shown in Table 7. This was still-born from the standpoint of influencing the future development of systematics, excepting to implant the idea that biology is a unified whole as already suggested, and the incidental introduction into general use of binomial nomenclature which had not been consistently used in the past. However, this system was highly successful as a *practical* device for pigeon-holing the increasing number of newly discovered species. The Linnean method soon degenerated into the dead end street of the uninspired routine of collection and description of species and their arrangement according to the artificial system.

Linnaeus' system of animal classification as presented in "Systema naturae" (1735—58), although inadequate (see Table 7), was in the right direction towards a natural system in contrast with his artificial plant classification. He divided animals into six classes—Quadrupedia, Aves, Amphibia, Pices, Insecta and Vermes. In comparison with Ray's system this does constitute an advance.

Georges Leclerc Buffon (1707—1788) brought out the first part of his "Histoire Naturelle" in 1749, a work concerning animals upon which he was engaged for the remainder of his life. He was a contemporary of Linnaeus, but there the similarity ends. In outlook Linnaeus in a great measure represented the end of an era, but Buffon—a brilliant gadfly—had an intimation of the biology of the future. He pointed out that there is no boundary between the plant and animal kingdoms; that common to both are reproduction and growth, and that thus there was "no question of a common creative origin." He opposed Linnaeus' sexual system of plant classification, and he ridiculed Linnaeus' classification of animals, pointing out obvious inconsistencies and inadequacies.

Table 7. Outline of Linnaeus' classifications of plants and animals.

Kingdom I. Plantae
[Flowering plants]
- Class 1. Monardria (stamens one)
- Class 2. Diandria (stamens two)
- Class 3. Triandria (stamens three)
- Class 4. Tetandria (stamens four)
- Class 5. Pentandria (stamens five)
- Class 6. Hexandria (stamens six)
- Class 7. Heptandria (stamens seven)
- Class 8. Octandria (stamens eight)
- Class 9. Enneandria (stamens nine)
- Class 10. Decandria (stamens ten)
- Class 11. Dodecandria (stamens 11-19)
- Class 12. Icosandria (stamens 20 or more on calyx)
- Class 13. Polyandria (stamens 20 or more on the receptacle)
- Class 14. Didynamia (stamens didynamous—in two pairs of different lengths)
- Class 15. Tetradynamia (stamens tetradynanous — with 4 long and 2 shorter stamens)
- Class 16. Monadelphia (stamens monadelphous—united in one group)
- Class 17. Diadelphia (stamens diadelphous—united in two groups)
- Class 18. Polydelphia (stamens polydelphous—united in 3 or more groups)
- Class 19. Syngenesia (stamens syngenesious — united by their anthers)
- Class 20. Gynandria (stamens united to the gynoecium)
- Class 21. Monoecia (plants monoecious)
- Class 22. Dioecia (plants dioecious)
- Class 23. Polygamia (plants polygamous)

[Flowerless plants]
- Class 24. Cryptogamia (flowerless plants)

Kingdom II. Animalia:

- A. Heart with 1 or 2 ventricles and 2 atria; blood warm and red:
  - (a) Viviparous . . . . Class 1. Quadrupedia
  - (b) Oviparous . . . . Class 2. Aves
- B. Heart with 1 ventricle and 1 or 2 atria; blood cold and red:
  - (a) Breathing by lungs . . . . Class 3. Reptilia
  - (b) Breathing by gills . . . . Class 4. Pices
- C. Heart with one ventricle and no atrium; blood cold and colorless:
  - (a) With antennae . . . . Class 5. Insecta
  - (b) With tentacles . . . . Class 6. Vermes

MIDDLE MODERN PERIOD, 1757—1859 (NATURAL SYSTEMS)

In 1757, the philosopher, scientist and encylopedist Michel Adanson (1728—1806), who is recognized as the father of 'natural' classification, published his "Histoire naturelle du Senegal". In this he first enunciated the principle upon which the 'natural' system of classifying organisms is based. Later he gave a definitive formulation of the principle in his "Familles des Plantes" (1763-64), and systematics as a theoretical science came of age. He was so far ahead of his time that the full significance of his contribution to theoretical systematics was not appreciated until the lapse of two centuries when Sneath applied the Adansonian multivariate method to the classification of bacteria, including the use of electronic computers (Sneath, 1957a & 1957b). See also Michener & Sokal (1957) and D. J. Rogers (1961).

Adanson proposed that every feature of the organism be given equal weight in arriving at valid taxonomic groupings as contrasted with Linnaeus' use of one or a few selected sexual characters in making his artificial sexual system. By his method Adanson would achieve some measure of overall similarity, an idea first suggested in embryo by Magnol in the 'famille' concept; followed by Ray's suggestion that not only the sexual but also the vegetative characters are to be used in classification; and Linnaeus' similar suggestion that any natural system should be based on the common agreement existing between various parts of the plant. In 1757, the situation was similar to that which existed with reference to the theory of evolution later. Some pre-Darwinians from ancient times onward believed in a theory of evolution, but Darwin discovered the all important mechanism of evolution. Some pre-Adansonians had sensed that a group of characters should be used in classification, but it was the genius of the philosopher and scientist Adanson which first perceived the multivariate principle in arriving at 'natural' groups.

Adanson's multivariate principle for the classification of organisms was not fully understood in his time, and his important contribution to theoretical systematics was not utilized to its fullest extent. The workers who believed in the 'natural' system, including his contemporaries and those who came after him, tried to use both sexual and vegetative characters in classification, and thus they were in a measure Adansonian systematists.

In his "Familles des Plantes" (1763-64), Adanson applied his method in the grouping of plants into families which gave a very stable nomenclature. In this work he described 58 plant families *for the first time.* An estimate of the validity of his method may be gauged by noting in Table 8, that of Adanson's families of flowering plants, 34 are still recognized under the names he gave them, and that others are valid but are now parading under different names. It is to be noted that Bauhin and Ray first described species, Tournefort and Ray first described genera, and Adanson described families for the first time.

Adanson did not attempt to apply his method to the forming of groups above the familial level and this confused most of his contemporaries and also later workers who equated progress with the presentation of some sort of system, any system. What he did do was to provide a valid guiding principle for the grouping on all levels of the hierarchy from the lowest to the highest. It is regrettable that many of his contemporaries and later workers did not understand Adanson and his work, and allowed his memory to lapse into semi-obscurity.

It is a sad commentary on human nature that it is necessary to note that Adanson was the victim of deliberate persecution, and that he was never given the opportunity of fully developing his vast talents; and that during the Revolution he almost starved to death (see Chevalier. 1934; Glass, 1959). This recalls a somewhat similar fate suffered by Vesalius and some other pioneers in science.

A. L. de Jussieu (1748—1836), in his "Genera Plantarum" (1789), appropriated most of the families *first described by Adanson* without giving due credit, calling them "orders", but he did increase the number to 100, using an abbreviated Adansonian principle in doing so. Many of Jussieu's added "orders" (= families) have endured. Unfortunately, Jussieu, who succeeded to his post at the Jardin des Plantes in Paris by nepotism (see Chevalier, 1934, Glass, 1959)—a post that rightfully belonged to Adanson—was not intellectually honest. He deliberately suppressed the truth about Adanson's contributions toward the first description of

Table 8. Families of flowering plants **first described** by Adanson (1763) and still recognized by Gunderson (1950) and/or Hutchinson (1959). Arranged in the order in which they appear in Adanson's work. Endings according to Art. 18, Int. Code (Lanjouw et al, 1956).

Palmae Adans.
Gramineae Adans.
Liliaceae Adans.
Zingiberaceae Adans.
Orchidaceae Adans.
Aristolochiaceae Adans.
Eleagnaceae Adans.
Onagaraceae Adans.
Myrtaceae Adans.
Umbelliferae Adans.
Compositae Adans.
Campanulaceae Adans.
Caprifoliaceae Adans.
Vacciniaceae Adans.
Apocynaceae Adans.
Boraginaeae Adans.
Labiatae Adans.
Verbenaceae Adans.
Solanaceae Adans.
Portulacaceae Adans.
Amaranthaceae Adans.
Thymelacaceae Adans.
Rosaceae Adans.
Leguminosae Adans.
Annonaceae Adans.
Tiliaceae Adans.
Geraniaceae Adans.
Malvaceae Adans.
Cappariaceae Adans.
Cruciferae Adans.
Papaveraceae Adans.
Cistiaceae Adans.
Ranunculaceae Adans.
Araceae Adans.

plant families, and during the rest of his life attempted to downgrade the outstanding achievements of Adanson. In this sinister plan Jussieu succeeded only too well—many who read these lines have been kept from knowing the facts even to the year 1962.*

Jussieu's major taxonomic groups are Acotyledones, Monocotyledones and Dicotyledones, which apparently were borrowed from Ray's "Historia Plantarum" (1686—1704), and which he improved by eliminating the grouping under herbs and trees as shown in Table 9.

Table 9. Abbreviated classification of plants according to Jussieu (1789), with indication of probable derivation of the major taxonomic groups. See also Table 4.

Jussieu (1789)	Albertus Magnus (before 1256 A. D.) See Table 5.	Ray (1686-1704) See Table 6.
Acotyledones (fungi, Algae, Musci)	I. Leafless plants	I. Imperfactae
————	II. Leafy plants	II. Perfactae (herbs & trees)
Monocotyledones	'Corticate Plants'	Two groups (herbs & trees) of monocotyledons
Dicotyledones	'Tunicate Plants' "ex ligneis tunicis"	Two groups (herbs & trees) of dicotyledons

Under the three major headings he recognized a total of 15 classes. Under the classes he grouped the orders (= families). The classification within the framework between the three major groups and the orders (families) is highly artificial

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* The Bicentenary of the publication of Adanson's "Familles des Plantes" (1763-64) will be celebrated in 1963-64. An evaluation of Adanson's contributions to science will be included in an "Adanson Memorial" volume.

There is a new movemest afoot to by-pass the rightful claims of Adanson in the attempt to designate Jussieu's "Genera Plantarum" (1789) as the sole starting point of plant families. However, the only just and decent procedure is to designate Adanson's "Familles des Plantes" and Jussieu's "Genera Plantarum" jointly as the starting points of plant families, and thus avoid a gross injustice. The Adanson and Jussieu family names that are in general use could remain standard, and later names by others superceding Adanson and Jussieu family names, and in general use, could be conserved. One index showing that Adanson's genius is finally widely appreciated is revealed in the recent purchase by the Hunt Botanical Library, Pittsburgh, Penna., of the residue of the Adanson papers formerly housed at the family home at Baleine in France. In their new home they will be available to students.

and not in harmony with the tradition of any 'natural' system. The workers during the next half century greatly modified Jussieu's system for the better so that they became in fact new systems, retaining only the ancient conceptions of acotyledons, monocotyledons and dicotyledons in new relationships. Jussieu's lasting contribution is therefore in connection with natural families of plants, an honor which he has to share jointly as a junior partner with Adanson who first described many of those which Jussieu appropriated without giving credit to the source.

Robert Brown (1773—1858), who had adopted the natural system in presenting his work, "Botany of Terra Australia" in 1814, set the general trend toward ignoring the artificial Linnean system which was carried on by faithful followers for a considerable time into the 19th century. Thus the Linnean system was doomed to a lingering decline and death. Robert Brown is also to be credited with the first recognition of the gymnosperms.

The most celebrated systematists of the first half of the 19th century were the Candolles. Pyrame de Candolle (1778—1841) is noted for the publication of his "Theorie elementaire" (1813) in which he detailed his concepts about plant classification, and for initiating the great work, "Prodomus systematis naturelle regni vegetabilis". He had adopted the natural system (see Table 10), and it was his object to describe and classify all species of plants. During his lifetime he published seven volumes starting in 1824. The work was continued by his son, Alphonse de Candolle (1806—1893), in collaboration with others, and an additional 10 volumes were published, the last in 1873. Various other systems were proposed during the first half of the 19th century, but the Candolle system was supreme on into the early years of the next period.

The outstanding "Genera Plantarum" (1836—40) of Endlicher (1805—1849) is to be noted. He grouped the plant Kingdom into "Thallophytes" (algae, lichens and fungi) and "Cormophytes" (mosses, ferns and seed plants), a notable advance over previous systems.

Brongniart (1770—1847), the founder of paleobotany, divided dicotyledons into gymnosperms and angiosperms. This feature was adopted by Lindley (1799—1865) in his "natural System of Botany" (1830). It is also to be noted that Alexander Braun (1805—1877) subordinated monocotyledons and dicotyledons under angiosperms.

Table 10. An outline of the Candolle system as of 1819.

I. Vasculares (vascular plants, with cotyledons)
    Class 1. Exogenae (vascular bundles in a ring: dicotyledons)
        [artificial classification under this head]
    Class 2. Endogenae (vascular bundles scattered: monocotyledons, etc.)
        A. Phanerogamae (flowers present), Lilaceae, etc.
        B. Cryptogamae (flowers absent, hidden, or unknown), ferns, etc.
II. Cellulares (plants without vascular bundles or cotyledons)
    Class 1. Foliaceae (mosses, liverworts)
    Class 2. Aphyllae (not leafy; sexuality unknown), algae, fungi, lichens.

The Chevalier de Lamarck (1744—1829) was entirely self taught and a hack writer until he took up the study of zoology by accident after he reached the age of fifty years. He was a thinker in his own right and was chiefly influenced by Buffon, Bonnet (1720—1793) and Cuvier (1769—1832), the founder of modern comparative zoology. By sheer genius he made outstanding contributions in zoology. His most important publications are "Philosophie zoologique" (1809) and

Table 11. An outline of Lamarck's classification of animals as of 1815-1822.

I. Vertebrates:
    1. Vertebrata
II. Invertebrates:
    2. Mollusca
    3. Cirripedia
    4. Annelida
    5. Crustacea

Invertebrates (continued)
    6. Arachinda
    7. Insecta
    8. Vermes
    9. Radiata
    10. Polypi
    11. Infusoria

"Histoire naturelle des animaux sans vertèbres" (1815—1822). He proposed his well-known theory of evolution by means of acquired characters, and elaborated a system of animal classification that represented an extraordinary advance over that of Linnaeus. Lamarck recognized eleven 'natural' groups in contrast with the six of Linnaeus as shown in Table 11. It will be noted that he divided animals into vertebrates and invertebrates.

Malthus (1766—1834) had published his essay on population as early as 1803. The great popularizer Robert Chambers (1802—1870) had published his "Vestiges of the Natural History of Creation" anonymously in 1844, summarizing circumstantial evidence, which was often downright erroneous, for a belief in organic evolution. But the mechanism for the evolutionary process was lacking. Thus the ground was prepared for the next great advance in the development of biology.

On July 1, 1858, in the best tradition of scientific integrity, a joint paper by Charles Darwin and Alfred Russell Wallace was read before the Linnean Society in London. The paper was on the subject of the evolution of species by means of natural selection, and was read in the absence of the authors. Darwin had worked on the problem for many years but had delayed publication of his conclusions. When Wallace independently, in a flash, reached similar conclusions, and had communicated them to Darwin, it was arranged by mutual friends to communicate the views of both scientists jointly. This leads directly to the beginning of the Later Modern Period with the publication of Darwin's monumental book on the same subject.

LATER MODERN PERIOD, 1859 TO PRESENT TIME—PHYLOGENETIC SYSTEMS

Charles Darwin (1809—1892) published his "Origin of Species by Means of Natural Selection" in 1859. Although the thesis as indicated in the title was not generally accepted at once, prominent scientists in England and elsewhere soon declared their adherence to it, including J. D. Hooker (1817—1911), Thomas Henry Huxley (1825—1895), Asa Gray (1810—1888), Ernst Heinrich Haeckel (1834—1919), and others. Although Gregor Mendel (1822—1884), the father of the science of genetics, and Charles Darwin were contemporaries, the faulty communication then existing between scientists prevented the latter from making use of Mendel's particulate theory of inheritance (Mendel, 1866) in later editions of the "Origin of Species". By this regrettable accident, Darwin had to fall back on an untenable device in the Lamarckian tradition to explain the mechanics of mutation. It was not until after 1900 that Mendel's contributions and those subsequently built on this base were integrated into a more complete theory of organic evolution (see Hardin, 1959; Strauss, 1960).

It is obvious that the theory of organic evolution by means of natural selection is not in conflict with the 'natural' method of plant classification, but is rather complementary to it. Now it was possible to explain on a phylogenetic basis how the natural groups originated. It was easy therefore to make a gradual transition from the 'natural' to the 'phylogenetic' systems.

The Candolle natural system was the one most widely accepted at the beginning of this period, but Bentham & Hooker published their "Genera Plantarum" from 1862 to 1883. This system was patterned on the Candolle system.

In the year that the last parts of the Bentham & Hooker system were published, the outstanding system of August Wilhelm Eichler (1839—1887) was proposed. This is summarized in Table 12.

The Eichler system recognized thallophyte, bryophyte, pteridophyte, gymnosperm and angiosperm groups. Through various transformations this is the basis of most of the systems proposed since 1883. The well-known "Natuerlichen Pflanzenfamilien" of Engler (1844—1930) is based on the Eichler system. The Engler classification is most widely used at the present time, not because it is the most desirable, but for the reason that it is the one most nearly completed. Once a system has been adopted by any institution, it is difficult to make a change. The first edition of the Engler system, 24 volumes, was completed from 1887 to 1915; the second edition, started in 1924, has not been completed.

A number of other systems have been proposed, but in this brief paper which is becoming far too long already, it is possible only to mention the names of some of those who have made notable contributions in this field—Charles Edwin Bessey (1845—1915). Richard von Wettstein (1862—1931), Hans Hallier (1868—1932), John Hutchinson (1884—), and Carl Scottsberg (1888—).

Table 12. Outline of plant classification according to Eichler (1883)

- A. Cryptogamae
  - Division I. Thallophyta
    - Class 1. Algae (Cyanophyceae, Chlorophyceae, Phaeophyceae, Rhodophyceae)
    - Class 2. Fungi
  - Division II. Bryophyta
    - Class 1. Hepaticae
    - Class 2. Musci
  - Division III. Pterophyta
    - Class 1. Equisetineae
    - Class 2. Lycopodineae
    - Class 3. Filicineae
- B. Phanerogamae
  - Division I. Gymnospermae
  - Division II. Angiospermae
    - Class 1. Monocotyleae
    - Class 2. Sympetalae

One of the workers in the field of zoology who was inspired by Darwinism was Haeckel, already mentioned. He was the authority on Radiolaria, sponges and Medusae. He declared his adherence to Darwinism early (Haeckel, 1862). He was dominated by the monistic philosophy which had its roots in the Neo-Platonic stream of thought developed in the Middle Ages (Wulf, 1922; Nordenskiold 1949) as contrasted with the scholastic tradition that developed into the modern Western tradition. In spite of his "fuzzy" outlook due to monism, which invalidated much of his work, Haeckel did make lasting contributions. He coined terms that we all use today: 'ontogeny', the individual's development; 'phylogeny', the race's development, and 'oecology' (ecology), the relation of organisms to their environment. In his systematic work, Haeckel (1894) proposed a four-kingdom system in contrast with the usual two-kingdom systems proposed before Darwin,—Kingdom I Protophyta, Kingdom II. Protozoa, Kingdom IV. Metaphyta, and Kingdom IV. Metazoa.

It now remains to summarize briefly, the systems actually taught in the schools and colleges at the turn of the century, and the most recent developments in the classification of organisms.

When the writer came on the scene, systems similar to the ones summarized in Table 13 were presented to the student. It should be noted that the example shown for plants resembles the Eichler system of 1883. The system for animals represents a marked improvement over that of Lamarck in 1815—1822.

Haeckel's 1894 four-kingdom system has already been noted. More recently four- three- two- and one-kingdom systems have been offered. The student should not take the increase in kingdoms in a single system too seriously because the naming of more kingdoms does not change the actual relationships among organisms. Those who make more kingdoms are honestly convinced that this change will express the relationships more accurately.

Copeland (1938; 1956) Barkley (1939) and Rothmaler (1948) have proposed four-kingdom systems. Three-kingdom systems have been suggested or proposed by D. P. Rogers (1948), Simpson et al (1957), Whittaker (1959), and others. Two-kingdom systems, with details for plants only, have been proposed by Pascher (1931), Tippo (1942), Cronquist (1960), and others. One-kingdom systems have been proposed by Walton (1930) and Dillon (1957). Two examples of each of three- and two-kingdom systems will be briefly considered here.

The Simpson et al. (1957) three-kingdom system (Table 16) is based on the premise that the *Protista* cannot be classified definitely with either plants or animals, and the organisms included may be considered as plant-like or as animal-like depending on what part of their structure, or what phase of their functioning, one may be considering. If one accepts this premise, then this type of system is in order. It is all in the point of view.

D. P. Rogers (1948), on the basis of evolutionary tendencies in plants, fungi and animals, suggested that each be recognized as a kingdom, but he did not elaborate any system.

Table 13. Outline of typical classifications of the phyla (divisions) of organisms as presented in high schools and colleges at the end of the 19th century. Plantae according to Bergen & Davis (1906) and Animalia according to Thomson (1895).

Kingdom I. Plantae (according to Bergen & Davis, 1906)
- Division I. Thallophyta:
  - Series of the Algae:
    - Class 1. Cyanophyceae
    - Class 2. Chlorophyceae
    - Class 3. Phaeophyceae
    - Class 4. Rhodophyceae
  - Series of the Fungi:
    - Class 5. Schizomycetes (bacteria)
    - Class 6. Saccharomycetes (yeasts)
    - Class 7. Phycomycetes (alga-like fungi)
    - Class 8. Ascomycetes (sac fungi)
    - Class 9. Basidiomycetes (basidia fungi)
- Division II. Bryophyta:
  - Class 1. Hepaticae (liverworts)
  - Class 2. Musci (mosses)
- Division III. Pteridophyta (ferns and their allies, or pteridophytes):
  - Class 1. Filicineae
  - Class 2. Equisetineae
  - Class 3. Lycopodineae
- Division IV. Spermophyta (seed plants, or spermatophytes):
  - Subdivision 1. Gymnospermae (gymnosperms)
  - Subdivision 2. Angiospermae (angiosperms):
    - Class 1. Monocotyledoneae
    - Class 2. Dicotyledoneae

Kingdom II. Animalia (according to Thomson, 1895)
- Subkingdom I. Protozoae
  - Phylum 1. Protozoa
- Subkingdom II. Metazoae
  - Phylum 2. Porifera
  - Phylum 3. Coelenterata
  - Phylum 4. Annelida
  - Phylum 5. Brachiopoda
  - Phylum 6. Nematoda
  - Phylum 7. Platyhelminthes
  - Phylum 8. Echinodermata
  - Phylum 9. Arthropoda
  - Phylum 10. Mollusca
  - Phylum 11. Chordata

The examples (Tables 14 and 15) of the two-kingdom systems chosen for comment represent two extremes. In both the animal kingdom part is not elaborated.

Pascher (1931) and Tippo (1942) have proposed somewhat similar systems. The composite system of Tippo (1942), presented in outline form, is based on the presentation of non-vascular plants by G. M. Smith (1938) plus the *Schizomycota;* and the contributions of A. J. Eames (1936) on vascular plants. This system has much to commend it, particularly in the grouping under embryophytes where only two phyla are recognized—*Bryophyta and Tracheophyta.* On the premise that the phylum is a rather elevated rank just below the kingdom, the present writer agrees that the number of phyla under the vascular embryophytes should be greatly restricted, and that certain groups sometimes recognized as phyla could be given lower ranks without doing violence to the basic facts. Thus this solution is in the right direction. However, continuing research in paleobotany will undoubtedly affect the placement of the sub-groups (see H. N. Andrews, 1962). The student should realize that the classification of organisms will never lead to an entirely static system. It is true that certain parts of it will have general acceptance in time, but other parts will always remain subject to change on the basis of continuing research and experiment.

In contrast to the Tippo (1942) system, that of Cronquist (1960) recognizes eight coordinate phyla (divisions) under *Embryophytae.* This represents the other extreme. The student should note these two schools of thought when considering other systems, always recognizing that the phylum represents a really major group, and that it should not be used for lesser taxa.

It should be noted that all of these systems (Tables 13, 14, 15 & 16) follow the lead of the Eichler system of 1883 (see Table 12) and later systems, and do not measure up to the criterion set forth at the beginning of this section—that any arrangement of the phyla of organisms should reveal, on the phylal level, *all of the major kinds* of organisms. The student who is confronted with such systems will receive no inkling of two great groups of organisms—the chemoautotrophs and the bacterial photoautotrophs which are hidden in some other major group, usually in the catch-all group of the *Schizomycota.* Such a catch-all includes bacterial photoautotrophs, chemoautotrophs, and heterotrophs and is surely not a phylogenetic

Table 14. Classification of organisms—two-kingdom system summarized from Tippo (1942).

[Kingdom I. PLANTAE]
  Subkingdom I. THALLOPHYTA
    Phylum 1. EUGLENOPHYTA
    Phylum 2. CYANOPHYTA (blue-green algae)
    Phylum 3. CHLOROPHYTA (green algae)
    Phylum 4. CHRYSOPHYTA (yellow-green and golden brown algae, and diatomes)
    Phylum 5. PHAEOPHYTA (brown algae)
    Phylum 6. RHODOPHYTA (red algae)
    Phylum 7. PYRROPHYTA (cryptomonads and dinoflagellates)
    Phylum 8. SCHIZOMYCOPHYTA (bacteria)
    Phylum 9. MYXOMYCOPHYTA (slime molds)
    Phylum 10. EUMYCOPHYTA (true fungi)

[Kingdom I. PLANTAE]—continued
  Subkingdom II. EMBRYOPHYTA
    Phylum 11. BRYOPHYTA (mosses and liverworts)
    Phylum 12. TRACHEOPHYTA (Tracheata)
      Subphylum 1. Psilopsida
      Subphylum 2. Lycopsida
      Subphylum 3. Spenopsida (Equisetopsida)
      Subphylum 4. Pteropsida
        Class 1. Filicinae (ferns)
        Class 2. Gymnospermae
          Subclass 1. Cycadophytae
          Subclass 2. Coniferophytae
        Class 3. Angiospermae
          Subclass 1. Dicotyledoneae
          Subclass 2. Monocotyledoneae
[Kingdom II. ANIMALIA]—not elaborated.

Table 15. Classification of organisms—two-kingdom system summarized from Cronquist (1960).

- **[Kingdom I. PLANTAE]**
  - Subkingdom I. THALLOPHYTA
    - *Division 1. SCHIZOPHYTA (bacteria and Cyanophyceae
    - Division 2. RHODOPHYTA
    - Division 3. CHLOROPHYTA
    - Division 4. EUGLENOPHYTA
    - Division 5. PYRROPHYTA
    - Division 6. CHRYSOPHYTA
    - Division 7. PHAEOPHYTA
    - Division 8. FUNGI
      - Subdivision 1. Myxomycotina
      - Subdivision 2. Eumycotina
- **[Kingdom I. PLANTAE]**—continued
  - Subkingdom II. EMBRYOPHYTA
    - Division 9. BRYOPHYTA
    - Division 10. PSILOPHYTA
    - Division 11. LEPIDOPHYTA (Lycopodiae)
    - Division 12. CALAMOPHYTA (Equisetae)
    - Division 13. FILICOPHYTA
    - Division 14. CONIFEROPHYTA
    - Division 15. CYCADOPHYTA
    - Division 16. ANTHOPHYTA
      - Class 1. Dicotyledonae
      - Class 2. Monocotyledonae
- **[Kingdom 2. ANIMALIA]** —not elaborated

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* 'Division' is equivalent to 'Phylum' as used in other tables.

group. The time has surely arrived when this problem has to be faced squarely, and it will be discussed in the final part of this paper.

With reference to the animal phyla, the more recent monumental work of Hyman (1940-59), on which the grouping in Table 21 is based in part, and the presentation of Simpson et al. (1957), outline shown in Table 16, are to be noted. These show a remarkable improvement over the system of Lamarck (1817-22), and the one shown in Table 13, with which the student at the turn of the century had to be satisfied.

CONTEMPORARY ERA.—Beginning in the early 1940's the climate apparently was favorable for new developments in systematics. This movement culminated in the organization of The Society for the Study of Evolution in March of 1946 for the integration of the various fields of science concerned with evolution. Under its influence, a new systematics, based on the latest basic research—for biology as a whole—is emerging in the procedural tradition of the geneticists, ecologists, virologists, etc., in their respective fields. Specialization by the workers is necessarily the basis of such a procedure, but through the new agency the workers are kept informed on what the other specialists are accomplishing in one comprehensive science of systematics. This new outlook is reflected in the outstanding reports and treatises that have appeared since 1940. A partial selection of these is included in the selected bibliography at the end of this article.

6. THE PHYLA OF ORGANISMS

It now remains to present a summary of the classification of organisms started in the 1910's for the writer's own use and revised over the years when time permitted. An attempt has been made to account for the origin of the kinds of heterotrophs on a theoretical basis; to resolve the inconsistency in the usual classifications with respect to the criteron of habits of nutrition; to characterize the major kinds of life on the phylal level; to give enough detail to show something about the writer's basic ideas about the postulated phylogenetic relationships, and to consider life as a whole so as to present a balanced system.

ORIGIN OF HETEROTROPHIC LINEAGES

Lineages of organisms, unless they are extinct, do not stand still but are continually subject to evolution by natural selection. In accordance with the principle of irreversibility in evolution, all future evolution is built on the base of residues of past evolution. A corollary of this principle may be expressed as the 'decreasing plasticity principle':

> The plasticity of lineages of organisms for the capacity of giving rise to new lineages by mutation with uniqueness, relatively unencumbered by the residues of past evolution, decreases markedly with time once distinctive patterns in structure and functioning have evolved.

Table 16. Classification of organisms—three-kingdom system summarized from Simpson et al (1957).

Kingdom I. PROTISTA (protists)
- Phylum 1. SCHIZOMYCETES (bacteria)
- Phylum 2. MASTIGOPHORA (flagellates)
- Phylum 3. SARCODINA (rhizopods)
- Phylum 4. SPOROZOA **(Plasmodium)**
- Phylum 5. CILIOPHORA (Classes—Ciliata and Suctoria)
- Phylum 6. MYXOMYCETES (slime molds)

Kingdom II. PLANTAE (plants)
- Phylum 7. MYXOPHYTA (blue-green algae)
- Phylum 8. CHLOROPHYTA (green algae)
- Phylum 9. CHRYSOPHYTA (yellow-green and golden-green algae)
- Phylum 10. PHAEOPHYTA (brown algae)
- Phylum 11. RHODOPHYTA (red algae)
- Phylum 12. MYCOPHYTA (fungi)
- Phylum 13. BRYOPHYTA (liverworts, hornworts and mosses)
- Phylum 14. TRACHEOPHYTA (vascular plants)

Kingdom III. ANIMALIA (animals)
- Phylum 15. PORIFERA (sponges)
- Phylum 16. COELENTERATA (coelenterates)
- *Phylum 17. GRAPTOLITHINA (graptolites)
- Phylum 18. CTENOPHORA (comb jellies)
- Phylum 19. PLATYHELMINTHES (flatworms)
- Phylum 20. MESOZOA **(Rhopalura)**
- Phylum 21. NEMERTEA (ribbon worms)
- Phylum 22. NEMATODA (round worms)
- Phylum 23. NEMATOMORPHA (horsehair worms)
- Phylum 24. ACANTHOCEPHALA (spiny-headed worms)
- Phylum 25. KINORHYNCHA (Echinoderes)
- Phylum 26. TROCHELMINTHES (Classes—Rotifera and Gastrotricha)
- Phylum 27. BRYOZOA (sea mosses or moss animals
- Phylum 28. BRACHIOPODA (brachipods and lampshells)
- Phylum 29. PHORONIDEA **(Phoronis)**
- Phylum 30. CHAETOGNATHA (arrow worms)
- Phylum 31. MOLLUSCA (mollusks)
- Phylum 32. ANNELIDA (segmented worms)
- Phylum 33. ARTHROPODA (arthropods)
- Phylum 34. ECHINODERMATA (echinoderms)
- Phylum 35. CHORDATA (chordates)

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* Extinct phylum

This principle is important in considering the foundation of any classification of organisms. Since there is no fossil record of very early organisms, it is necessary to rely on theory based on the functioning of the evolutionary process in later times to account for the kinds of heterotrophic organisms evolved during this period. It is reasonable to assume that the mechanism of evolution has been similar throughout the time that it has been and is operative now. It is only on this basis that we may have any reasonable explanation of divergence during the early and intermediate stages in the history of life.

The 'decreasing plasticity principle' can explain on a theoretical basis how animals, plants and intermediate lineages of organisms may have evolved from the same initial ancestral stock. Figure 1 shows a generalized diagram to illustrate the origin of the kinds of evolving heterotrophic lineages, in different time frames, from the evolving autotrophic lineages .

The ancestral autotrophic stock is indicated at A, in Fig. 1 (see also Fig. 2). The lineages fanning out from it in the triangle ABC represent an indefinite number of evolving autotrophic lineages terminating in the surviving autotrophic groups along the horizontal line BC. See autotrophic phyla 1—16, Fig. 2; and Table 21.

Apparently the first animal-like (heterotrophic) lineage or lineages originated from primitive, relatively undifferentiated autotrophic lineages (D, in Fig. 1.) early in the history of life before distinctive patterns in structure and functioning, other than the primitive autotrophic nutrition, had evolved. Secondary heterotrophic lineages fanned out from this beginning and continued to evolve. These are now recognized as the animal phyla—DEF in Fig. 1 (see also Fig. 2; and Table 21). The initial autotrophic lineages (at D, in Fig. 1) were apparently relatively unencumbered by residues from past evolution and thus were more plastic. This made it possible for one or more unique animal-like (heterotrophic) lineages to make their appearance by mutation. By natural selection among the secondary heterotrophic lineages the unicellular animal-like, and multicellular animal lineages (DEF, in Fig. 1) evolved, with surviving groups represented in the horizontal line EF. These *early appearing* heterotrophs may appropriately be named 'archiheterotrophs Phyla 20—43 in Fig. 2, and Table 21.

Evolution is a continuous process and heterotrophic lineages originate during the entire history of the autotrophic lineages, but as the residues from past evolution increase with time, future autotrophic lineages become less and less plastic from the standpoint of capability of giving rise to relatively unique patterns by mutation, uncolored by past evolution. Thus, during an early intermediate (not a middle) period, still in the relatively early history of life, heterotrophic lineages originating from the autotrophic lineages would be slightly conditioned by residues accumulated through evolution toward the characteristic plant-like lineages. These could contribute some plant-like patterns of anatomy and/or functioning which could be colored by animal-like mutations (essentially dependent feeding, including food ingestion) and thus the intermediate phyla might have originated, GHI in Fig. 1. Such organisms having both plant-like and animal-like characteristics might explain the origin of the phyla in the Kingdom *Heteroplantae* (other feeding plants), phyla 17—19, in Fig. 2, and Table 21. These intermediate lineages may be named 'mesoheterotrophs'. Some of these are practically unknown to the general reader—most heterotrophic bacteria and the slime molds—but some of the larger local fungi are better known.

Returning to the ancestral autotrophic lineages as indicated by ABC in Fig. 1, it is to be noted that there are five series (Fig. 2 and Table 21) when considered on the basis of the development of the plant body which is one index of residues from past evolution: (1) the microscopic unicellular *Chemoautotrophae;* (2) the phyla *Chromobiophyta, Chlorobiophyta, Cyanophyta, Euglenophyta, Chrysophyta* and *Pyrrophyta* which show no marked development of the plant body; (3) the phyla *Phaeophyta* and *Rhodophyta* with marked development of the plant body along unique lines; (4) the phylum *Chlorophyta* with some development of the plant body; and (5) the *Embryophytae* with usually marked development of the plant body. In addition to such residues from past evolution, there are various other kinds of residues—morphological and functional patterns—in each of the five series.

It is among these autotrophic lineages that the evolution of a third kind of heterotrophic lineages is to be noted. After the period when the mesoheterotrophic lineages evolved, and continuing on to the present time, when the plant-like structural and functioning patterns have been well-established, heterotrophic lineages (JKL, in Fig. 1) have and are still evolving. These are so conditioned by the rigid patterns of the autotrophic lineages at these stages as briefly indicated above, that the mutant heterotrophic lineages resemble the autotrophs in all except the dependent feeding habit. At this stage the 'decreasing plasticity principle' can be verified experimentally. For instance, *Astasia longa* is identical with a colorless strain of *Euglena gracilis* that appeared in cultural experiments and has been renamed *E. gracilis* forma *hyalina* (Pringsheim, 1948). It is like the autotrophic lineage from which it evolved in all characters excepting the dependent (heterotrophic) feeding habit. From the phylogenetic standpoint such lineages do belong with or near the autotrophic lineages from which they originated, and they are in practice correctly classed with them—Phyla 1—16, see Fig. 2; and Table 21. These *late appearing* heterotrophs may be called 'neoheterotrophs'. The mutant *Euglena gracilis* forma *hyalina* is in fact one example of such neoheterotrophs. Some of the others are familiar to most readers—the neoheterotrophic parasitic dicotyledons—Dodder (*Cuscuta*), Mistletoe (*Viscum*), *Monotropa,* etc. Others are relatively unknown—the neopheterotrophic (saprophytic) iron bacterium *Siderobacter;* the neophotoheterotrophic (saprophytic) *Rhodomicrobium,* etc.

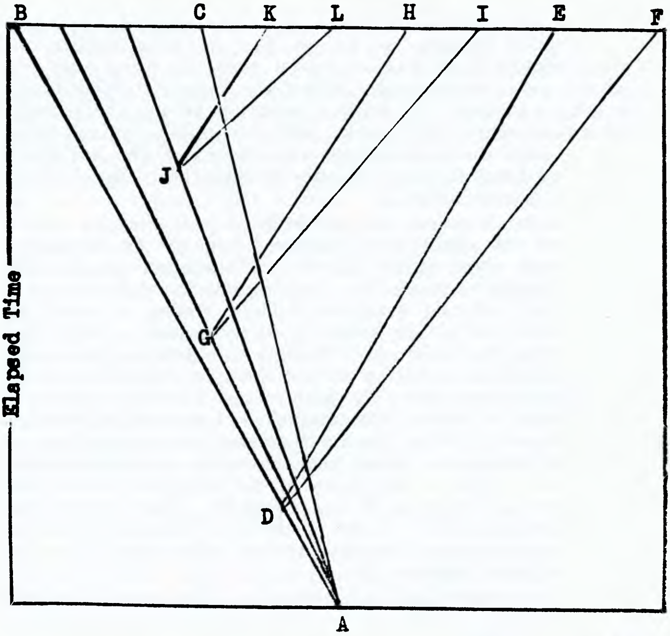

Fig. 1. A generalized diagram showing evolving lineages plotted against elapsed time, to illustrate the origin by mutation and subsequent natural selection of 'early', 'intermediate' and 'late' evolving heterotrophic lineages from evolving autotrophic ancestral lineages, in accordance with the 'decreasing plasticity principle'. The evolving lineages in each case are characterized by the increasing accumulation of residues from past evolution. Compare with Fig. 2, for application of the principle.

A—origin of life; the lineages fanning out from it in the triangle ABC represent an indefinite number of evolving autotrophic ancestral lineages terminating in the surviving autotrophic groups along the horizontal line BC. See autotrophic phyla 1—16, Fig. 2 and Table 21; and text discussion.

DEF—represents an indefinite number of mutant evolving heterotrophic lineages that appeared *early* in the history of life before few if any diversities had accumulated from past evolution (*archiheterotrophs*). See archiheterotrophic phyla 20—43, Fig. 2; and Table 21; and text discussion.

GHI—represents an indefinite number of mutant evolving heterotrophic lineages that appeared at an *intermediate* period in the history of life when some diversities had accumulated from past evolution (*mesoheterotrophs*). See mesoheterotrophic phyla 17—19, Fig. 2, and Table 21; and text discussion.

JKL—represents an indefinite number of mutant evolving heterotrophic lineages that appeared *late* in the history of life after marked diversification had appeared from residues of past evolution (*neoheterotrophs*). Neoheterotrophs are classified with the autotrophs—phyla 1—16, Fig. 2, and Table 21—from which they originated and which they resemble in structure.

EF, HI, and KL represent an indefinite number of archi-, meso- and neoheterotrophic lineages respectively surviving to the present time.

It should be noted that the 'decreasing plasticity principle' is especially useful in explaining the origin of the intermediate phyla between the typical plants and animals. It might help to correct the untenable views that appear in even the most recent classifications of organisms that would show evolution of living (surviving) phyla from other living ones, particularly the *Schizomycota.* The living *Schizomycota,* although they are extremely small and may appear superficially simple in structure and in functioning, are really nothing of the kind. They are very complex due to millions of years of evolution and apparently have not given rise to other existing phyla of organisms. The *Schizomycota* and other phyla may have evolved in the very distant past from certain common ancestral lineages (see Fig. 2) but this is an entirely different matter. These relationships should be reflected in phylogenetic diagrams that are offered.

Some critics may wish to raise the possibility of a lineage remaining relatively unchanged (primitive) until the present day. There is hardly any such possibility since evolution by natural selection has been going on under the changing climatic conditions since life first originated. They may be primitive in some characters but that again is a different matter. Thus it should be emphasized that groups that do seem to be relatively primitive superficially, such as the *Schizomycota,* have evolved during the ages and are rather complex on their particular level as will be indicated later on.

INDEPENDENT AND DEPENDENT FEEDERS

The inspection of existing classifications (Tables 14, 15, 16) shows that the main divisions are based on the habits of nutrition, *but not consistently.* Whittaker (1959) recognizes photoautotrophs (independent feeders), and absorbers and ingestors (dependent feeders). However, there is basically only one type of dependent feeding (absorption of elaborated food). Ingestors are also absorbers that ingest the materials from which absorption takes place in a digestive pouch or tube. The division of organisms according to feeding habits is usually followed for algae and higher plants (independent feeders) and animals (dependent feeders), but such division somehow breaks down when the intermediate phyla, including photo- and chemoautotrophs and heterotrophs, are classified as has already been indicated. Such a scheme is outlined in Table 17.

Table 17. Showing inconsistency in applying the criteria for habits of feeding in current classifications.

Kingdom 1. Plantae
    (a) Algae and higher green plants (independent feeders)
    (b) Intermediate phyla, including **Schizomycota** (independent and dependent feeders), and **Myxomycota** and **Eumycota** (dependent feeders)
Kingdom 2. Animalia (dependent feeders)

The *Schizomycota* as now constituted are of ancient and very obscure origins, and are a heterogeneous assemblage containing chemoautotrophs, photoautotrophs and heterotrophs and this is hardly an acceptable phylogenetic grouping. Copeland

(1958) is to be credited with keen insight when he removed the photoautotrophic bacteria, containing bacterial chlorophyll, from the *Schizomycota* and placed them in the *Cyanophyta* (blue-green algae), containing plants with α-cholorophyll and other pigments. He stated that the criterion of size was not cogent because there are organisms of similar size already in the latter group. This was a step in the right direction, but such a taxon, containing organisms with bacterial cholorophyll and the other characters associated with it, is sufficiently distinct from a taxon, containing organisms with α-chlorophyll and other characters associated with it, and should not be placed in the same group. Thus in the present paper, the bacteria containing bacterial chlorophyll are given coordinate rank with the plants containing α-chlorophyll as the chief photosynthetic pigment.

Yet another kind of autotrophic organisms lies buried in the *Schizomycota* as now constituted. These are the chemoautotrophs—no one has considered them objectively from the standpoint of according appropriate rank to these organisms. Under the discussion of the origin of life, it was indicated that it is not known at present whether these originated independently of the photoautotrophs or evolved from the latter. For our purposes the question of their origin does not matter because we are confronted with organisms that have solved the problem of independent feeding in different ways from that of the photoautotrophs, and as such are entitled to cooordinate rank with the latter in any classification. They have achieved different habits of fixing carbon based on chemical energy sources as contrasted with light energy in the photoautotrophs. The problem posed here may be solved by applying the criterion of habits of nutrition consistently, as shown in Table 18.

Table 18. Consistent outline classification of organisms on the basis of independent and dependent feeding.

- Superkingdom I **Autotrophae** (independent feeders*)
  - Kingdom I. **Plantae** (autotrophic plants*)
    - Subkingdom I. **Chemoautotrophae** (phyla using chemical energy sources in fixing carbon)
    - Subkingdom II. **Photoautotrophae** (phyla using light energy in fixing carbon):
      - Infrakingdom I. **Thallophytae** (non-embryo-bearing plants)
        - Province I. **Bactochlorophylliae** (containing bacterial chlorophyll)
        - Province II. **Alphachlorophylliae** (containing a-chlorophyll: algae)
      - Infrakingdom II. **Embryophytae** (embryo-bearing plants; containing a-chlorophyll: **Bryophyta** and **Tracheophyta**)
- Superkingdom II. **Heterotrophae** (dependent feeders)
  - Kingdom II. **Heteroplantae** (other feeding plants; mesoheterotrophs; see Fig. 1; **Schizomycota, Myxomycota** and **Eumycota**)
  - Kingdom III. **Animalia** (archiheterotrophs; see Fig. 1)

* Including also neoheterotrophs. See text discussion and Fig. 1.

It should be noted that although on a theoretical basis this is a three-kingdom system, in actual practice it is really a two-kingdom system.—*Plantae* (typical autotrophs and neoheterotrophs and *Heteroplantae* (mesoheterotrophs) are in the province of the botanist; and *Animalia* (archiheterotrophs) in the province of the zoologist. The objective is to resolve the problem posed by the mixture of organisms included in the old *Schizomycota*. The new phylum *Schizomycota* includes only mesoheterotrophs. The system outlined in Table 18 will be elaborated in the remainder of the paper. It is clear by this time that life should be considered as a whole, and the higher taxa such as "superkingdoms" and "kingdoms" should be interpreted as representing *parts of a whole.* In the past these have too often been regarded as representing separate disciplines.

KINGDOM I. PLANTAE

As already indicated, the organisms assigned here are obligate and facultative autotrophs, and neoheterotrophs, which are phylogenetically related to the former and are therefore classed with the former from which they originated. The organisms are subdivided on the basis of habits of nutrition—chemoautotrophs and photoautotrophs—and the other characters correlated with these according to the Adansonian principle (Adanson, 1763-64).

SUBKINGDOM I. CHEMOAUTOTROPHAE

Even after the lapse of more than eighty years since Winogradsky (1887, 1880, 1890, 1891) pioneered in the field of the chemoautotrophic organisms, the subject has not been intensively explored, and the true autotrophic nature of some of those reported is still in doubt. Although the autotrophic nature of others has been definitely established, much research is needed to adequately cultivate the entire field. It is hoped that the recognition of the *Chemoautotrophae* as coordinate with the *Photoautotrophae* will call attention to the need for research, and that doctorate theses and other research projects will be undertaken oftener from now on in the field of these fascinating microscopic organisms.

The chemoautotrophic habits of nutrition are unique among microscopic organisms. These habits are limited to a relatively few species, but the number of individuals involved may sometimes be enormous. According to Alexander (1961) the number of ammonia oxidizers (Class *Nitrosopsida,* see Table 21) may vary from zero to one million per gram of soil, but the larger counts are found only for soils of pH greater than 6.0. Those working with the higher plants may overlook such enormous population statistics. The chemoautotrophic bacteria are functional in helping to maintain the balance of nature, and have great economic importance, particularly with reference to cultivated plants. It is true that utility has no weight whatever in assigning rank to these organisms in any system of classification and reliance has to be placed on their unique position in having the ability of obtaining energy from the transformation of inorganic materials, and to utilize CO_2 for their entire carbon requirements. On that basis they are entitled to a coordinate rank with the photoautotrophs that obtain their energy from light and also utilize CO_2 for their entire carbon needs.

Those species capable of oxidizing only inorganic materials for their energy needs are known as 'obligate' or strict chemoautotrophs. In contrast, some species have evolved in the direction of heterotrophy and may obtain their energy from the oxidation of either inorganic materials or organic carbon, and these are known as 'facultative' chemoautotrophs. These organisms are intermediate between the obligate chemoautotrophs and those that have evolved to a completely heterotrophic habit of nutrition. The complete heterotrophs in this case are 'neoheterotrophs' as explained in Fig. 1, and the text discussion above. They are similiar in structure to the chemoautotrophs but differ in habit of nutrition, and are placed with autotrophs from which they evolved late in the history of life. This principle is of assistance in coping with the vexing problem of classifying certain types of bacteria. In practice such neoheterotrophs should be placed with the related chemoautotrophs as indicated because they belong there on the phylogenetic basis.

The autotrophic nature of the important nitrogen bacteria—*Nitrosomonas* and *Nitrobacter*—is definitely known. This is also true of some species of *Thiobacillus* and *Ferrobacillus.* Others are known to have facultative autotrophic nutrition. The classification of the five phyla adopted here (Table 21) is based on those species whose autotrophic nature is definitely established and any neoheterotrophic species (Fig. 1) related to them. The existence of selenium (Brenner, 1916, Lipman & Waksman, 1923) and manganese (Satory & Meyer, 1947; Prave, 1957) autotrophy is in doubt, and these reports remain to be verified. It is considered best to leave in the *Schizomycota* any that are in doubt. Should any others be found to be definitely autotrophic by later research, or should new autotrophic species be discovered, then it is time enough to transfer them to the subkingdom *Chemoautotrophae.*

As here interpreted, the subkingdom *Chemoautotrophae* is polyphyletic as shown in Fig. 2. Theoretically each group having a different habit of nutrition is coordinate with other similar groups, and on that basis each should be recognized as belonging to a separate kingdom, coordinate with the *Photoautotrophae.* As already indicated relatively few organisms have as yet been discovered that exhibit chemoautotrophy, and it would be inconvenient to recognize any large number of kingdoms. The logical compromise is to group all of the photoautotrophs in one subkingdom and all chemoautotrophs in another, with subdivisions under these for further distinctions (see Table 21). The student should note that such compromises often have to be made in systematic work, always recognizing the apparently true, or lack of, phylogenetic relationships between the groups concerned, as a footnote.

There is need for a comprehensive summary of the knowledge of the *Chemoautotrophae.*

SUBKINGDOM II. PHOTOAUTOTROPHAE

The organisms in this subkingdom have the common bond of photoautotrophic nutrition, ranging from the anaerobic photosynthetic bacteria to the aerobic nutrition of the higher green plants. With the exception of two phyla containing bacterial chlorophyll, all of the rest contain α-chlorophyll as the chief photosynthetic pigment. As explained under Fig. 1, any neoheterotrophs related to the photoautotrophs are placed here also.

Kamen & Newton (1959)* have recently summarized the information concerning the photosynthetic particles found in these organisms, and this is reproduced here for the student.—

"These particles range in size from those encountered in bacteria and some blue-green algae—so-called 'chromatophores' in bacteria and 'grana' in the algae—to relatively enormous chloroplasts in some green plants. Chromatophores are spherical or semispherical bodies which can be as small as 30—40 millimicrons in diameter, while chloroplasts are variegated and often up to two orders of magnitude greater in linear dimensions. Grana are usually disc-shaped and intermediate in size between chromatophores and chloroplasts. They can occur as components or as individual entities.

"Considerable work has been done on the structure of chloroplasts and grana. Chloroplasts in higher plants are generally ellipsoid, typical dimensions in unicellular algae being 4—6 microns in diameter and 0.5—1 micron thick. They can exhibit a variety of forms. Usually a laminer pattern is seen in grana, indicating a structure consisting of 20—30 thin disc-shaped plates in a stack. These platelets are probably protein discs about 10 millimicrons thick which can carry one or more complete layers of chlorophyll intermixed with other componets of the photo-active system such as carotinoids, pyridine nucleotides, heme proteins, etc. Generally, the grana are embedded in unpigmented lipoproteins—so-called 'stroma'—which are probably the locus for enzymes involved in secondary functions such as CO_2 assimilation, phosphate transfer, protein and lipid synthesis, etc.

"Nothing is known about the fine structure of bacterial chromatophores but it is reasonable to suppose they are similar to small grana such as those found in blue-green algae. In fact, if we neglect the specification of a nucleus, a cell like the anerobic sulfur bacterium *Chromatium* can be considered as analogous to a chloroplast, the chromatophores filling the role of grana and the extrachromatophore material that of the stroma. Recently, electron microscope pictures of *Chromatium* have been published which suggest strongly that this analogy is not far-fetched (Vatter and Wolfe, 1958).

"These considerations lead to the expectation that a varied pattern of enzymatic composition should be found in all of these subcellular photo-active particles, depending on their degree of fragmentation. 'Whole' chloroplasts such as those isolated from *Spirogyra* (Thomas & Haans, 1955) or spinach (Arnon, et al, 1954) appear to contain a great number of enzymes, sufficient in fact to enable the chloroplast to function as a complete photosynthetic unit (Allen, et al, 1955). Fragmented chloroplasts, grana and chromatophores show fewer enzymatic activities, a number of soluble enzymes being recovered in the supernatant fluid from broken particles (Frenkel, 1956; Geller, 1959; Allen, et al, 1957; Newton & Kamen, 1957). However, all of these particles, fragmented or not, exhibit a general reaction initiated by light absorption and presumably intimately connected with the photochemical act. This reaction is the light-activated esterification of adenosine diphosphate (ADP) by inorganic phosphate (P_i) to form adenosine triphosphate

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*The passages in quotation marks on this and the following page are excerpted from—

Martin D. Kamen and Jack W. Newton, "Particles in Photosynthetic Phosphorylation" in "Subcellular Particles," edited by Teru Hayashi. The Ronald Press Company, 1959.

(ATP); e. g. ADP + P_i + light—)ATP. The characteristics of this reaction, called 'photophosphorylation', are quite similar in all the different particles encountered, regardless of structural complexity, and can be described adequately by considering any one of the many systems which have been studied . . . The similarities which exist between the bacterial chromatophores and the green plant chloroplasts are such as to indicate that the same general mechanism is operative in photometabolism in both types of systems. It appears that the only essential difference between green plant and bacterial photosynthesis—namely, the lack of an oxygen evolution system in the latter case—is also the only essential difference found between bacterial chromatophores and green plant chloroplasts. It is likely that both systems function identically, or very similarly, in effecting photophosphorylation. . . . The electron transport chain coupled to the chloroplast system may span this whole range so that photophosphorylation efficiency is maximal for each electron transferred. On the other hand, the bacterial photo-oxidant may be generated at a considerably lower electro-chemical potential, particularly in the strict anerobes, so that a much smaller potential span is available in bacterial photosynthesis. Hence, the photophosphorylation efficiency in the bacteria may be significantly less. This may be correlated with the fact that although green plants dissipate most of their photo-oxidant as molecular oxygen, they still make enough ATP by photophosphorylation to satisfy all requirements for carbon dioxide assimilation. On the other hand, the bacteria with a less efficient system may require all their photo-oxidant to be reduced through the electron transport system."

The subkingdom *Photoautotrophae* as interpreted here on the basis of the analysis of photosynthetic nutrition (Kamen & Newton, 1959; Arnon et al, 1961) is apparently phylogenetic with two offshoots from a common ancestral lineage that may have had a more primitive type of photosynthesis (see Fig. 2) which has been superceded. One two-branched offshoot contains plants with the less efficient type of photosynthesis based on bacterial chlorophyll, and the other multi-branched offshoot contains plants with the more efficient type of photosynthesis based, chiefly on α-chlorophyll. On this basis the photoautotrophae should be grouped as indicated in Table 19.

Table 19. Classification of the Photoautotrophae on the basis of type of photosynthesis.

Infrakingdom 1. "Bactochlorophyllae"
Infrakingdom 2. "Alphachlorophyllae"
  Province 1. "Thallophytiae"
  Province 2. "Embryophytiae"

But such a division would omit the "Bactochlorophyllae" from the thallophytes. The latter is a useful taxon, and apparently a compromise has to be made to preserve this concept although it runs counter to a strict phylogenetic system. In the future the divisions shown in Table 19 may be adopted, but for the present the customary grouping will be used as shown in Table 20.

Table 20. Compromise classification of the Photoautrophae on the basis of structure (thallophytes and embryophytes). See also Tables 18 and 21.

Infrakingdom 1. **Thallophytae**
  Province 1. **Bactochlorophylliae**
  Province 2. **Alphachlorophylliae**
Infrakingdom 2. **Embryophytae** (also contain a-chlorophyll)

This disposition cuts across the line of the plants containing α-chlorophyll, but it emphasizes the importance of the evolution from the non-embryophytes to the embryophytes. The student should note the above as another compromise.

As shown in Tables 20 and 21, there are two comprehensive groups under *Thallophytae*. Province 1. *Bactochlorophylliae* to accomodate organisms containing bacterial chlorophyll, which is new, and Province 2, *Alphachlorophylliae,* to accomodate the algal phyla.

Under *Bactochlorophylliae,* Phylum 6. *Chromobiophyta* accomodiates the red, purple and brown photoautotrophic bacteria, and Phylum 7. *Chlorobiophyta* includes the green photoautotrophic bacteria. As indicated earlier, Copeland (1958) had transferred the organisms now included in the two phyla from the *Schizomycota* to the *Cyanophyta.* However, it is clear from the description of the photosynthetic particles (Kamen & Newton; Arnon, et al, 1961) that the photoautotrophic bacteria deserve a coordinate rank with the photoautrophic organisms containing α-chlorophyll. The new Province *Bactochlorophylliae* is therefore fully justified.

The Province *Alphachlorophylliae* is divided into two major taxa, superphylum *Chromophytae,* to accomodate the five phyla of variously colored algae as distinguished from the grass-green algae, and superphylum *Chlorophytae,* to include the two phyla of grass-green algae. These seven phyla are recognized essentially as delimited by G. M. Smith (1955). The Cryptomonads (*Cryptomonas, Chilomonas*), and Chloromonads (*Coelomonas*) are considered as algal groups of uncertain taxonomic position.

In Infrakingdom 2. *Embryophytae,* only two phyla are recognized—Phylum 15. *Bryophyta,* including non-vascular embryophytes, and Phylum 16. *Tracheo*phyta, the vascular embryophytes. Although this summary is on the whole confined to the phylal level, additional sub-taxa are included for the information of the student, and to supplement the discussion.

Some authorities (Bold, 1957, and others) divide *Bryophyta* into more than one phylum, and they may be correct, but for the present the traditional one phylum is recognized here.

There is considerable controversy about the status of the phylum *Tracheophyta.* One group, including Tippo (1942), and others, including also the writer, maintain that only one phylum is required for all of the plants having a vascular structure. This phylum is analogous to the phylum *Chordata* under *Animalia* (see Table 21). A second group ,including Bold (1957), Cronquist (1960), and others, maintains that there should be a number of phyla to accomodate the various evolutionary lineages. Fundamentally these two schools of thought are not far apart—the difference between them concerns *relative* rank of taxa. As indicated earlier in this paper, the meaning of the relative ranks in the hierarchy of higher categories should be considered very carefully. It is not necessary to elevate the various lineages under *Embryophytae* to phylal rank when the same purpose can be fulfilled by using the subphylum rank as shown in the scheme proposed by Tippo (1942). In the present system (see Table 21), under Phylum *Tracheophyta,* two subphyla are recognized, one—Pteroidophytina—to include the fern-like plants and the ferns, and the other—Spermophytina—to include the seed plants. Under these the various lineages are grouped into infraphyla, superclasses and/or classes as shown in Table 21. This preserves the 'pteridophyte' and 'spermatophyte' concepts as subphyla, and other concepts, including 'gymnosperm' and 'angiosperm', either as infraphyla or superclasses. All of these are useful in presenting the subject. If a long list of phyla, or even subphyla are employed, then no such distinctions are apparent.

KINGDOM 2. HETEROPLANTAE (PLANT-LIKE ORGANISMS)

The plant-like organisms (see Fig. 1 and text discussions above) under the Kingdom *Heteroplantae* were formerly usually placed under *Thallophyta,* and included heterotrophic as well as chemo- and photoautotrophic organisms. The latter two have been removed to the Kingdom *Plantae* as indicated in the previous discussion. Thus we are dealing only with mesoheterotrophs (see Fig. 2 and Table 21). All are predominantly plant-like, although the slime molds do have an animal-like plasmodium phase when they move and ingest food during part of the year, but later this movement ceases and spore sacs and spores are produced much like those of the higher fungi. This latter habit definitely places them with plant-like organisms. The plant-like organisms have been variously classified in the past, but this phase will not be discussed in detail here, but some recent suggestions for the solution of the problem are noted.

D. P. Rogers (1948) suggested on the basis of evolutionary tendencies in plants, fungi and animals that each of these should be recognized as a kingdom.

Under fungi he includes *Myxo- Phyco- Asco-* and *Basidiomycetes,* but he does not discuss the *Myxomycetes,* and leaves out the *Plasmodiomycetes* and *Acrasimycetes* which are included here also in the *Myxomycota* (see Table 21). He says nothing about the Schizomycota which also are included in the *Heteroplantae* in the present classification.

G. M. Smith (1955), who does not include the *Schizomycota* under *Thallophyta,* or even in the plant kingdom, is of the opinion that none of the fungi evolved from the algae, and states that "if, as appears to be the case, the divisions of a fungal nature have evolved from the protozoa, they have no phylogenetic connection with the divisions in the plant kingdom." He believes that they evolved independently of one another.

Cronquist (1960) is of the opinion that bacteria are apparently the most primitive groups of living organisms from which all other kinds of organisms evolved, and that the origin of the bacteria is obscure. According to his view, the bacteria branched in two directions. One branch gave rise to the blue-green algae (*Cyanophyta*) which in turn gave rise to the *Rhodophyta.* Lineages from the other branch evolved into all other plants. Among these other plants, the fungi (the *Phycomycetes-Ascomycetes-Basidiomycetes,* and *Myxomycetes* lines) originated as algal offshoots. He believes that new evidence on the phylogeny of the fungi "lies in the structure of the flagella" in *Myxomycetes* and *Phycomycetes.* The student should note that there is no essential difference between the specialized parts of the cell known as cilia and flagella—when they are less numerous they are called flagella.

In contrast to these views, the Kingdom *Herteroplantae,* or dependent-feeding plant-like organisms, as here interpreted, includes very ancient exclusively *mesoheterotrophic* lineages which originated from autotrophic lineages at an intermediate period in the history of life as previously explained (see Fig. 1, and the text discussion above). According to this view, such ancient lineages cannot be definitely connected with any existing algal phyla on the basis of the available evidence. It is more likely that both the photoautotrophic algae, and the phyla of the *Heteroplantae,* are separate offshoots from ancient autotrophic lineages, and thus are not strictly related phylogenetically among themselves, or with the phyla of algae as shown in Fig. 2. However, there is the possibility that they might retain some similar anatomical characters such as certain types of flagella in some algae on the one hand, and *Myxomycetes* and *Phycomycetes* on the other, as indicated by Cronquist (1960) and others. However, flagella and flagella-like relicts are of such widespread occurrence in organisms (Porter, 1957, Satir, 1961, Ehret, 1960) that even the sensory elements of the vertebrate eye have evolved from flagella. Thus this kind of evidence has to be discounted. The widespread occurrence of flagella and flagella-like relicts in *Plantae, Heteroplantae* and *Animalia* apparently is evidence that all living organisms have evolved from a common ancestral stock.

With further reference to any relationship between the phyla of the *Heteroplantae* to each other, it should be realized that they do not constitute a phylogenetic taxon on the kingdom level as already intimated. Thus there are two courses open to the worker—either each may be given coordinate rank as a kingdom, with an undue increase in the number of such taxa; or all three groups may be grouped together as one kingdom for convenience in classification. This latter course is justified so long as the apparently true status of each is realized, and this solution is adopted here.

Three phyla of *Heteroplantae—Schizomycota, Myxomycota* and *Eumycota*—are recognized (see Fig. 2 and Table 21). As previously explained, all of the autotrophs have been removed from the *Schizomycota,* and the Kingdom is composed exclusively of mesoheterotrophs.

Phylum 17. *Schizomycota,* mesoheterotrophic bacteria, includes six classes—*Eubacterimycetes, Actinomycetes, Chlamydobacteriomycetes, Myxobacterimycetes, Spirochaemycetes* and *Rickettsimycetes.*

Phylum 18. *Myxomycota,* the slime molds, includes three classes—*Myxomycetes, Plasmodiomycetes* and *Acsasimycetes.*

Phylum 19. *Eumycota,* the true fungi ,includes three classes—Phycomycetes (algal fungi), *Ascomycetes* (cup fungi), *Basidiomycetes* (club fungi).

The so-called "Deuteromycetes" (fungi imperfecti) do not constitute a phylogenetic taxon, but are in fact an artificial collection of imperfectly known fungi. As sufficient information becomes available about any of these, then each is referred to the appropriate class under the phyla listed above.

The lichens, included in some classifications, represent a symbiotic relationship between an alga and a fungus in each case, and are out of place here. They belong in the field of the ecologist.

KINGDOM III. ANIMALIA

As interpreted here the Kingdom *Animalia* includes archiheterotrophic lineages that had their origin early in the history of life before the autotrophic ancestral stock from which they originated had diversified to any extent toward the typical plants (see Figs. 1 & 2, Table 21, and the text discussions above). The classification here adopted is based in part on Hyman (1940-59), and Simpson, et al, (1957).

Two subkingdom are recognized—*Protozoae* and *Metazoae.* Subkingdom 1. *Protozoae* includes unicellular organisms that are definitely animal-like—archiheterotrophic ingestors. All plant-like organisms are excluded. The *Protozoae* are sometimes represented as being primitive, but this is hardly the case because the evolutionary process has been active over millions of years. They are, as in the case of the *Schizomycota,* ancient lineages, and although they may appear to be realtively primitive in structure, they are at any rate complex on a functional basis. The *Protozoae* are divided into two infraphyla: Infraphylum 1. *Plasmodromae,* in which the locomotor organelles are either pseudopodia or flagella, accomodates three phyla—20. *Zoomastigophora**, including animal-like flagellates; 21. *Sarcodina,* the rhizopods; and 22. *Sporozoa,—Plasmodium,* etc. Infraphylum 2. *Ciliophorae,* in which the locomotor organelles are cilia, accomodates Phylum 23. *Ciliophora,—Paramecium, Stentor,* etc. As shown in Fig. 2. these lineages apparently branched out from a common ancestral stock early in the history of life.

Subkingdom 2. *Metazoae* includes multicellular animals. There are two distinct evolutionary lines—Infrakingdom 1. *Parazoae,* with incipient tissue formation, represents a lineage distinct from that of Infrakingdom 2. *Eumetazoae,* with tissues and organ-system construction. Under *Parazoae,* Phylum 24. *Porifera* (sponges) is recognized, with interior cells of several kinds, without organs, digestive tract or mouth.

Infrakingdom 2. *Eumetazoae* is divided into two groups—Superprovince 1. *Radiatiae,* with primary radial symmetry, digestive cavity the sole body space, and with no anus; and Superprovince 2. *Bilateriae,* with bilateral symmetry or secondary radial symmetry; mostly also with body spaces in addition to the digestive cavity, and with anus usually present.

Under Superprovince. 1. *Radiatiae,* two phyla are recognized, Phylum 25. *Coelenterata,* the coelenterates, and Phylum 26. *Ctenophora,* the comb jellies. Under the latter is included the extinct animal lineage sometimes recognized as Phylum *Graptolithina.* This extinct lineage has sometimes been grouped with the Phylum *Chordata* on the basis of unreliable evidence.

Superprovince 2. *Bilateriae* is divided into three provinces on the basis of evolutionary trends.

In Province 1. *Acoelomatiae,* the region between the digestive tract and the body wall is filled with mesenchyme, the excretory system is composed of protonephridia which are provided with flame bulbs; the organisms are unsegmented or if segmented, the youngest segments are nearest the head; the anus may be absent or present. Three phyla are recognized—Phylum 27. *Platyhelminthes,* the flatworms. Phylum 28. *Mezozoa,* (Rhopalura), a group characterized by parasitic degeneration, which is given the rank of a subfamily by Hyman (1940). As here interpreted

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* The unicellular organisms included under **Zoomastigophora** are restricted to the four distinctly animal-like orders **Protomondina, Polymastigina, Hypermastigina,** and **Rhizomastigina.** The other six orders of plant-like organisms containing a-chlorophyll, and related neoheterotrophs which Hyman (1940) included under **Protozoae** are referred to the Province **Alphachlorophylliae** (the algae), under Subkingdom 2. **Photoautotrophae** (Table 21).

they are organisms of the general type of the flatworms with a degenerated structure as a result of the parasitic mode of life. The third group. Phylum 29. *Nemertinea,* includes the nemertine or ribbon worms.

In Province 2. *Pseudocoelmatiae,* there is a space present between the digestive tract and the body wall, but this space is a pseudocoel and not a coelom; protonephridia and flame bulbs may or may not be present; the anus is present. Five phyla are recognized—Phylum 30. *Nematoda,* the round worms; Phylum 31. *Nematomorpha,* the horsehair worms; Phylum 32. *Acanthocephala,* the spiny-headed worms; Phylum 33. *Kinorhyncha,—Enchinoderes,* and Phylum 34. *Trochelminthes,—Rotifera* (wheel animalcules), and *Gastrotricha.*

In Province 3. *Eucoelmatiae,* there is a true coelom, and usually there is a well-developed entomesoderm; excretory organs are protonephridia with solenocytes, or metanephridia with or without nephrostomes; the anus is present. There are two subprovinces.

Under Subprovince 1. *Schizocoeliae,* there are two subgroups: (a) Infraprovince 1. *Lopophoriae,* with a circular or crescentric or double spirally coiled ridge, the lopophore, bearing ciliated tentacles; the intestines are looped, bringing mouth near the anus; the coelom is various. There are three phyla—Phylum 35. *Bryozoa,* the moss animals; Phylum 36. *Brachiopoda,* the brachiopoda or lamp shells; and Phylum 37. *Phoronidea, Phoronis.* (b) Infraprovince 2. *Anneloidiae,* without a lopophore, with a schizocoel; unsegmented or segmented. Three phyla are recognized—Phylum 38. *Mollusca,* mollusks: chitons:; snails, etc; scaphopods; clams, mussels; cephalopods, squids, octopuses; Phylum 39. *Annelida,* segmented worms; and Phylum 40. *Arthropoda,* the arthrodpods, crustaceans, arachnids, centipedes, millipedes, insects, etc.

The members of Subprovince 2. *Entercoeliae,* are without a lopophore; and the coelom is an entercoel. Three phyla are recognized—Phylum 41. *Chaetognatha,* the arrow worms; Phylum 42. *Echinodermata,* the echinoderms; and Phylum 43. *Chordata,* tongue worms, tunicates; ascidians; lancelets; and vertebrates—fishes, amphibians, reptiles, birds, mammals.

A WORD TO THE STUDENT

This brief summary is all too short to cover adequately the large subject for the ordering of diversity among living organisms. It should be considered as an outline for further study on the basis of the selected bibliography, and the examples of organisms cited for each of the 43 phyla.

It is hoped that the student will carry away with him a dynamic historical view that reveals what really matters are basic advances—the rigorous procedure for description of the organism, the multivariate principle in classification, the mechanism of evolution, particulate inheritance, etc.—and not static systems of classification, no matter how practical these may be for the hour.

Thus, it should be realized that the classification of organisms will never be completed because there is so much that is still unknown about them. One can expect that areas of disagreement may decrease and areas of agreement increase, with time as new facts become known, but there will still be unknown areas. Thus the student should not expect rigidity in any classification. A science that does not change is a dead science.

The student who may not have had the advantage of a thorough course in biology, including classification, should not give up hope. In many cases he may obtain materials for study locally. In cases where such materials are not available locally, he may in most instances obtain them from a biological supply house. This is particularly true of microscopic organisms such as the chemo- and photoautotrophic bacteria, and the heterotrophic bacteria. Although a knowledge of one or more examples of each of the 43 phyla cannot be equated with an adequate knowledge of biology, it can go a long way toward awakening an interest that may lead to further study of not only the structural but also the functional diversity. Today there are many opportunities for adult study in local high schools and colleges and the interested beginning or adult student should make a start as the opportunity is offered. He should remember also that most excellent texts are now available, such as that of Simpson et al (1957). Their kind was unknown in the writer's student

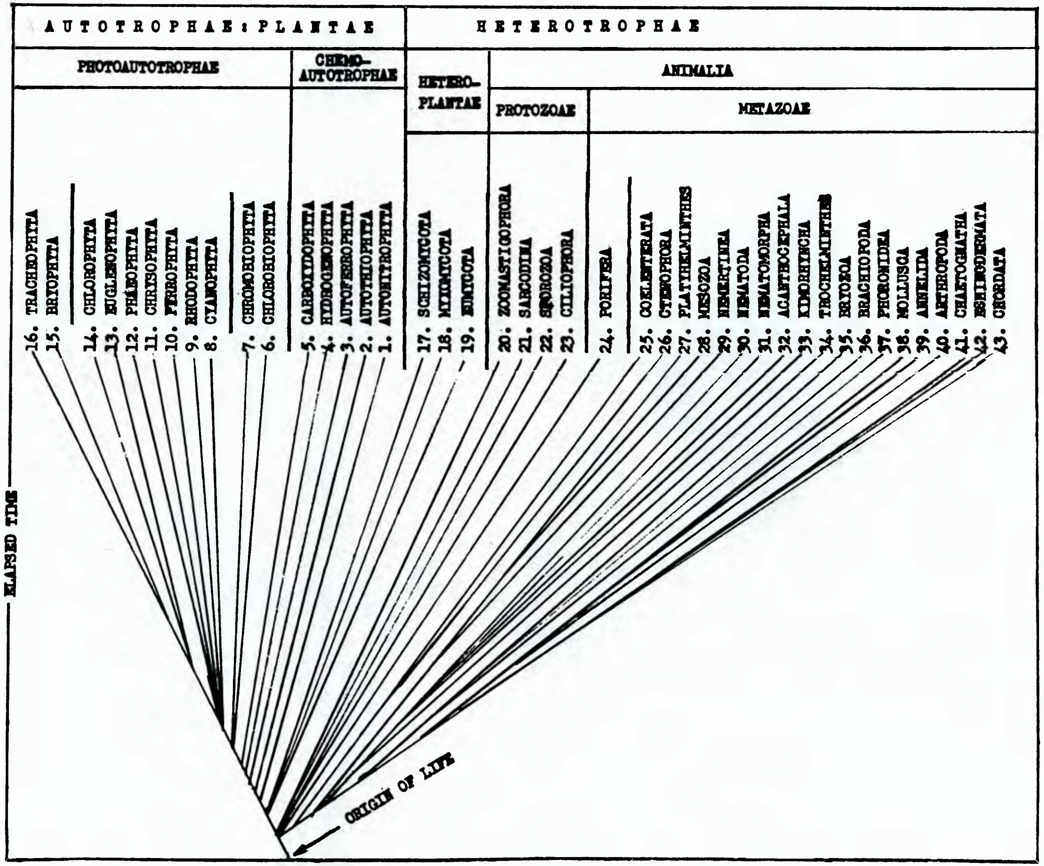

Fig. 2. A generalized diagram to illustrate a postulated phylogeny of the 43 phyla of living organisms with lineages plotted against elapsed time—**AUTOTROPHAE** (nos. 1—16, **PLANTAE**), and **HETEROTROPHAE** (nos. 17—19, **HETEROPLANTAE**; and nos. 20—43, **ANIMALIA**). See Fig. 1, text discussions, and Table 21.

days. The student in this atomic age is thus in a most enviable position and should make the most of his enlarged opportunities.

TABLE 21. THE PHYLA OF ORGANISMS

Superkingdom I. **AUTOTROPHAE** (Obligate or facultative chemo- and photoautotrophs that utilize either inorganic compounds or light as energy sources; and CO2, as the sole source of carbon; and related neoheterotrophs).

Kingdom I. **PLANTAE** (same as above)

Subkingdom 1. **CHEMOAUTOTROPHAE** (Obligate or facultative chemoautotrophs that utilize inorganic compounds as energy sources, and CO_2 as the sole source of carbon; and related neoheterotrophs)

Phylum 1. AUTONITROPHYTA (Obligate chemoautotrophs that utilize inorganic nitrogen compounds as energy sources, and CO_2 as the sole source of carbon; and related neoheterotrophs)

- Class 1. Nitrosopsida (energy obtained from the oxidation of ammonia to nitrite)
  - Order 1. Nitrosomonales
    - Family 1. Nitrosomonaceae **(Nitrosomonas, Nitrosococcus, Nitrosospira, Nitrosocystis, Nitrosogloea)**
- Class 2. Nitrobacteropsida (energy obtained from the oxidation of nitrite to nitrate)
  - Order 1. Nitrobacterales
    - Family 1. Nitrobacteraceae **(Nitrobacter, Nitrocystis)**

Phylum 2. AUTOTHIOPHYTA (obligate or facultative chemoautotrophs uitilizing elemental sulfur or inorganic sulfur compounds for energy; and related neoheterotrophs)

- Class 1. Thiobacillopsida
  - Order 1. Thiobacillales
    - Family 1. Thiobacillaceae (**Thiobacillus**—9 species. Note.— **T. ferrooxidans** appears to be a link with the next phylum because it has the capacity to use energy from the oxidation of either ferrous or sulfur salts; the two phyla will apparently have to be reduced to subphyla under the Phylum **HALENERGEIOPHYTA** in the next revision).

Phylum 3. AUTOFERROPHYTA (obligate or facultative chemoautotrophs oxidizing ferrous iron to the ferric state for energy; and related neoheterotrophs. See note under Phylum 2, above)

- Class 1. Ferrobacillopsida
  - Order 1. Ferrobacillales
    - Family 1. Ferrobacillaceae **(Ferrobacillus, Siderobacter, Siderococcus)**
  - Order 2. Gallionellales
    - Family 1. Gallionellaceae **(Gallionella, Siderophacus)**
  - Order 3. Leptothringales
    - Family 1. Leptothringscese **(Leptothrix, Sphaerotilus, Toxothrix)**

Phylum 4. HYDROGENOPHYTA (facultative chemoautotrophs utilizing energy from oxidation of either H_2 or short chain fatty acids and simple alochols; and related neoheterotrophs)

- Class 1. Hydrogenopsida (hydrogen bacteria)
  - Order 1. Hydrogenomonales
    - Family 1. Hydrogenomonaceae **(Hydrogenomonas)**
- Class 2. Methanopsida (methane forming hydrogen bacteria)
  - Order 1. Methanobacteriales
    - Family 1. Methanobacteriaceae Barker, 1956 **(Methanobacterium, Methanobacillus, Methanosarcina, Methanococcus)**

Phylum 5. CARBOXYDOPHYTA (facultative chemoautotrophs using energy from the oxidation of carbon monoxide to carbon dioxide)

Class 1. Carboxydopsida
  Order 1. Carboxydomonales
    Family 1. Carboxydomonaceae **(Carboxydomonas)**

Subkingdom 2. **PHOTOAUTOTROPHAE** (obligate and facultative photoautotrophs that utilize light as the source of energy, and CO_2 as the sole source of carbon; and related neoheterotrophs)
Infrakingdom. 1. **THALLOPHYTAE** (non-embryo-bearing photoautotrophs and related neoheterotrophs)
Province 1. **BACTOCHLOROPHYLLIAE** (photoautotrophic bacteria—obligate or facultative photoautotrophs containing bacterial chlorophyll; and related neoheterotrophs)
Phylum 6. CHROMOBIOPHYTA (red, purple and brown Bactochlorophylliae)

Class 1. Chromatiopsida
  Order 1. Chromatiales
    Family 1. Chromatiaceae **(Chromatium)**
Class 2. Rhodobacteriopsida
  Order 1. Rhodobacteriales
    Family 1 Rhodobacteriaceae **(Rhodobacterium** Molisch)
Class 3. Rhodomicrobiopsida (photoheterotrophs containing teriochlorophyll, using acetone, etc. as source of Hydrogen)
  Order 1. Rhodomicrobiales
    Family 1. Rhodomicrobiaceae **(Rhodomicrobium)**

Phylum 7. CHLOROBIOPHYTA (obligate and facultative photoautotrophic green sulfur bacteria)

Class 1. Chlorobiopsida
  Order 1. Chlorobiales
    Family 1. Chlorobiaceae **(Chlorobium)**

Province 2. **ALPHACHLORAPHYLLIAE** (the algae—obligate or facultative photoautotrophs containing α-chlorophyll; and related neoheterotrophs). The Cryptomonads (**Cryptomonas, Chilomonas,**) and Chloromonads (**Coelomonas**) are considered as algal groups of uncertain taxonomic position.
Superphylum 1. **CHROMOPHYTAE** (containing other colored pigments in association with α-chlorophyll)
Phylum 8. CYANOPHYTA blue-green algae; **Cholorcoccus, Oscillatoria, Nostoc,** etc.
Phylum 9. RHODOPHYTA red algae: **Porphyra, Cumagloia, Nelamion,** etc.
Phylum 10. PYRROPHYTA (greenish-tan and golden-brown algae: **Oxyrrhis, Exuviaella,** etc.)
Phylum 11. PHAEOPHYTA (brown algae: **Macrocystis, Echocarpus, Cutleria,** etc.)
Phylum 12. CHRYSOPHYTA (yellowish-green algae: **Triboema, Vaucheria, Melosira,** etc.)
Superphylum 2. **CHLOROPHYTAE** (green-algae: euglenoids and grass-green algae)
Phylum 13. EUGLENOPHYTA (Euglenoids: **Euglena, Astasia, Colacium,** etc.)
Phylum 14. CHLOROPHYTA (grass-green algae: **Volvox, Spirogyra,** etc.)
Infrakingdom 2. **EMBRYOPHYTAE** (embryo-bearing plants with a α-chlorophyll as the chief photosynthetic pigment; and related neoherotrophs

Phylum 15. BRYOPHYTA (non-vascular embryophytes; general similarity in life cycle—all have a dominant sexual phase and a much smaller sporophyte phase that is either partially or wholly dependent on the former)

Class 1. Hepatiopsida (liverworts: **Spaerocarpus, Marchantia, Riccardia, Calobryum,** etc.)
Class 2. Anthoceropsida (hornworts: **Anthoceros, Notothylas,** etc.)
Class 3. Musciopsida (mosses: **Funaria, Sphagnum, Andreaea,** etc.)

Phylum 16. TRACHEOPHYTA (vascular embryophytes; all have a dominant sporophyte phase and a much smaller sexual phase)

Subphylum 1. **Pteroidophytina** (fern-like plants and ferns: both the gametophytes and the sporophyte are independent plants at maturity)

Infraphylum 1. **Psilophytinae** (**Psilotum**)
Infraphylum 2. **Lycopodophytinae** (lycopods and club-mosses: **Lycopodium, Selaginella,** etc.)
Infraphylum 3. **Arthrophytinae** (articulates: **Equisetum**)
Infraphylum 4. **Pterophytinae** (ferns)

Class 1. Archipteropsida (early ferns—sporangia borne on pedicels, forming panicles and clusters: **†Protopteridium, †Svalbardia,** etc.—all extinct)
Class 2. Eusporopsida (sporangium developed from a group of initial cells, jacket layer more than one cell in thickness: **Ophioglossum, Marattia,** etc.)
Class 3. Leptosporopsida (sporangium developed from a single initial cell, jacket layer one cell in thickness: **Osmunda, Schizaea,** etc.)

Subphylum 2. **Spermophytina** (seed plants: permanent retention of female gametophyte within tissues of sporophyte; production of seeds, and temporary cessation of growth at a certain stage in development of embryonic sporophyte)

Infraphylum 1. **Gymnospermophytinae** (naked-seeded plants)

Superclass 1. **Archispermopsidae** (early seed plants: growth fern-like; seeds form in various ways on fronds, sometimes partially enclosed in a cupule: †**Lyginopteris,** †**Crossotheca,** etc.—all extinct)
Suberclass 2. **Gnetopsidae** (**Gnetum, Ephedra, Welwitschia,**
Superclass 3. **Ginkgopsidae** (**Ginkgo**)
Superclass 4. **Coniferopsidae** (cordaites and conifers: †**Cordaites, Pinus, Podocarpus,** etc.)
Superclass 5. **Cycadopsidae** (cycads: †**Cycadeooidea, Cycas, Zamia,** etc.)

Infraphylum 2. **Anthophytinae** (flowering plants; seeds hidden in the fruit.)

Superclass 1. **Dicotyopsidae** (**Wintera, Magnolia, Ranunculus,** etc.)
Superclass 2. **Monocotyopsidae** (**Alisma, Commelina, Orchis, Triticum,** etc.

Superkingdom II. **HETEROTROPHAE** (mesoheterotrophs and archiheterotrophs—other feeding organisms: parasites and saprophytes, including plant-like organisms, and animals)

Kingdom II. **HETEROPLANTAE** (mesoheterotrophs—unicellular and multicellular plant-like parasites and saprophytes)

Phylum 17. SCHIZOMYCOTA (heterotrophic bacteria)

Class 1. Eubacterimycetes (**Pseudomonas, Acetobacter, Streptococcus, Lactobacillus,** etc.)
Class 2. Actinomycetes (**Mycobacterium, Actinomyces,** etc.
Class 3. Chlamydobacterimycetes (**Leptothrix, Crenothrix, Beggiatoa,** etc.)
Class 4. Myxobacterimycetes (**Cryptophaga,** Chondromyces, Polyangium, **Myxococcus,** etc.)

Class 5. Spirochaemycetes (**Borrelia, Treponema, Spirochaeta,** etc.)
Class 6. Rickettsimycetes (**Rickettsia**)

Phylum 18. MYXOMYCOTA (Slime molds)

Class 1. Myxomycetes
Subclass 1. Eusporomycetidae
Order 1. Liceales
Family 1. Licaceae Rost. Versuch. 4. 1873 (**Licea**)
Family 2. Reticulariaceae Rost. Versuch. 6. 1873 (**Reticularia, Tubifera, Lycogala, Dictydiaethalium**)
Family 3. Cribriariaceae (**Cribriaria**)
Subclass 2. Exporomycetidae
Order 1. Ceratiomyxales
Family 1. Ceratiomyxaceae Schroeter, in EP. 1889. (**Ceratiomyxa** Schroeter—syn-**Ceratium** Albertini & Schwintz, 1805, non Schrank, 1793)
Class 2. Plasmodiomycetes
Order 1. Plasmodiophorales
Family 1. Plasmodiophoraceae (**Plasmodiophora**)
Class 3. Acrasimycetes
Order 1. Acrasiales
Family 1. Sappiniaceae (**Sappinia**)
Family 2. Guttulinaceae (**Guttulinopsis, Guttulina**)
Family 3. Acrasiaceae (**Acrasis, Dictyostelium, Coenonia, Polysphondylium**)

Phylum 19. EUMYCOTA (true fungi)

Class 1. Phycomycetes (algal fungi—**Olpidium, Allomyces, Pythium, Rhizopus,** etc.)
Class 2. Ascomycetes (cup fungi—**Pyronema, Eremascus, Penecillium, Neurospora, Sacchromyces,** etc.)
Class 3. Basidiomycetes (Club fungi—**Agaricus, Corticium, Stereum, Psalliota, Phallus, Puccinia, Ustilago,** etc.)
"Deuteromycetes" (fungi imperfecti)—an artificial group—**Colletotchricum lindemuthianum** (bean anthracnose); **Alternaria solani** (early potato blight); species of **Epidermophyton,** and **Trichophyton** (athlete's foot), etc.)

Kingdom III. **ANIMALIA** (animals—archiheterotrophs, usually ingesting materials from which elaborated food is absorbed)
Subkingdom 1. **PROTOZOAE** (unicellular animals)
Infrakingdom 1. **PLASMODROMAE** (locomotor organelles either with pseudopodia or flagella; sexual reproduction by complete fusion of gametes)

Phylum 20. ZOOMASTIGOPHORA (animal flagellates)
Class 1. Protomonadina (**Oicomonas, Rhizomastix,** etc.; and the trypanosomes — **Leishmania, Trypanosoma,** etc.)
Class 2. Polymastigina (**Chilomastix, Tetramitus, Trichomonas,** etc.)
Class 3. Hypermastigina (**Lophomonas, Barbulonympha,** etc.)
Class 4. Rhizomastigina (**Magistamoeba, Mastigina, Mastigella,** etc.

Phylum 21. SARCODINA (the rhizopods—**Amoeba, Pelomyxa,** etc.)
Phylum 22. SPOROZOA (internal parasites—**Gregarina, Monocystis, Adelea, Plasmodium,** etc.)
Infrakingdom 2. **CILIOPHORAE** (animals having locomotor organelles in the form of cilia throughout or in young stages)
Phylum 23. CILIOPHORA (same as above)

Class 1. Ciliata (**Frontonia, Paramecium, Didinium,** etc.)
Class 2. Suctoria (**Podophyra, Acineta, Ephelota,** etc.)

Subkingdom 2. **METAZOAE** (multicellular animals; composed of cells which may lose their boundaries in the adult state)

Infrakingdom 1. **PARAZOAE** (Incipient tissue formation, interior cells of several kinds; without organs, digestive tract, or mouth)
  Phylum 24. PORIFERA (sponges—**Archecyathus, Scypha, Hyalonema**, etc.)
Infrakingdom 2. **EUMETAZOAE** (Tissues and organ-system construction, with mouth and digestive tract, except when lost by parasitic degeration; interior cells reproductive only in part)
 Superprovince 1. **RADIATIAE** (with primary radial symmetry; digestive cavity the sole body space; anus absent)
  Phylum 25. COELENTERATA (coelenterates—**Hydra, Clathrodictyon, Aurelia, Astrangia**, etc.)
  Phylum 26. CTENOPHORA (comb jellies—**Cestum**, etc.)
 Superprovince 2. **BILATERIAE** (with bilateral symmetry or secondary radial symmetry; mostly also with body spaces in addition to the digestive cavity; anus usually present)
  Province 1. **ACOELOMATIAE** (Region between digestive tract and body wall filled with mesenchyme, excretory system of protonephrida with flame bulbs; unsegmented, or if segmented, then youngest segments nearest the head; anus absent in phyla 27 and 28, present in phylum 29)
   Phylum 27. PLATYHELMINTHES (flatworms—**Dugesia, Fasciola, Taenia**, etc.)
   Phylum 28. MESOZOA (degerate parasites—**Dicyema, Pseudicyema, Rhopalura**, etc.)
   Phylum 29. NEMERTINEA (nemertime or ribbon worms—**Lineus**, etc.)
  Province 2. **PSEUDOCOELMATIAE** (space present between digestive tract and body wall but this space is a pseudocoel and not a coelom; with or without protonephridia, flame bulbs present or absent; anus present;)
   Phylum 30. NEMATODA (roundworms — **Ascaris, Trichina**, etc.)
   Phylum 31. NEMATOMORPHA (horsehair worms—**Paragordius**, etc.)
   Phylum 32. ACANTHOCEPHALA (spinyheaded worms—**Gigantorhynchus**, etc.)
   Phylum 33. KINORHYNCHA (Enchinoderes)
   Phylum 34. TROCHELMINTHES (Rotifera—**Asplancha**; Gastrotricha—**Chaetonotus**)
  Province 3. **EUCOELOMATIAE** with a true coelom, and usually well-developed entomesoderm; excretory organs are protonephridia with solenocytes, or metanephridia with or without nephrostomes; anus present)
   Subprovince 1. **SCHIZOCOELIAE** (coelom a schizocoel)
    Infraprovince 1. **LOPHOPHORIAE** (with a circular or crescentric or double spirally coiled ridge, the lophophore, bearing ciliated tentacles; intestines looped, bringing mouth near anus; coelom various)
     Phylum 35. BRYOZOA (moss animals—Endoprocta: **Urnatella**, etc; Ecotprocta: **Plumatella, Bugula**, etc.)
     Phylum 36. BRACHIOPODA (lampshells—Inarticulata; **Lingula**, etc.; Articulata: **Laqueus, Terebratulina**, etc.)
     Phylum 37. PHORONIDIA (**Phoronis**, etc.)
    Infraprovince 2. **ANNELOIDIAE** (without a lophophore; coelom a schizocoel; unsegmented or segmented)
     Phylum 38. MOLLUSCA (mollusks—chitons: **Chiton**; snails etc.; **Helix, Buccinum, Arion, Patella, Archidoris, Tethys, Dentalium**; clams and mussels: **Venus, Anodonta, Phoas, Solen**, etc.; squids, octopuses and nautilus: **Loligo, Octopus, Nautilus**)

Phylum 39. ANNELIDA (segmented worms—**Neanthes, Nereis, Lumbricus, Polygordius, Hirndo, Sipunculus,** etc.)
Phylum 40. ARTHROPODA (arthropods—crustaceans, arachnids, centipedes, millepedes, insects)
Subprovince 2. **ENTERCOELIAE** (without a lopophore; coelom an entercoel)
Phylum 41. CHAETOGNATHA (arrow worms—**Sagitta,** etc.)
Phylum 42. ECHINODERMATA (echinoderms—starfishes, etc. —**Antedon, Asterias, Ophiura, Strongylocentrotus, Cucumaria,** etc.)
Phylum 43. CHORDATA (tongue worms—**Balanoglossus,** etc.; tunicates—**Ciona;** Lancelets—**Branchiostoma;** vertebrates—fishes: **Petromyzon, Squalus, Acipenser,** etc.; tetrapods—amphibians: frogs, **Rana,** etc.; reptiles: **Aromochelys, Gerrhonotus, Thamnophis, Crocodilus,** etc.; birds—**Columba,** etc.; mammals: marsupials—**Didelphis,** etc.; Placentals—**Cebus, Homo,** etc.)

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