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Observing, Photographing, and Collecting Plants

Kenneth R. Robertson

Illinois Natural History Survey Circular 55

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(Continued on Inside Back Cover)

This paper is a contribution from the Section of Botany and Plant Pathology.

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Observing, Photographing, and Collecting Plants

Kenneth R. Robertson

*"Approximately half of the world's families of
ferns, conifers, and flowering plants occur
natively or naturalized in Illinois, and a
number of other families are cultivated."*

—Kenneth R. Robertson

ILLINOIS NATURAL HISTORY SURVEY

Circular 55

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FRONT COVER ILLUSTRATION: Large flowered trillium (*Trillium grandiflorum*)
(Photograph by Kenneth R. Robertson).

Frontispiece — Pitcher plant, *Sarracenia purpurea*, a very specialized flowering plant with pitchers at the base that capture and “digest” insects. In Illinois, this plant is found only in a few bogs in the northern part of the state. (From a colored slide by Elvin Warrick.)

Observing, Photographing, and Collecting Plants

Kenneth R. Robertson

We are living in a remarkable time. Man has set foot on another celestial body and sent unmanned probes to others. The more we learn about other parts of our solar system, the more we realize how special the planet Earth is. As yet, we have found nowhere else with the right combination of environment and chemistry to support life as we know it.

The earth is teeming with life, from deep in the oceans to high in the atmosphere and from the poles to the equator. The number of individual organisms in any given area is tremendous when one takes into account all life forms from microscopic bacteria and fungi to conspicuous plants and animals. Also, the diversity of life on Earth is nearly overwhelming. It is estimated that there are at least one million kinds of animals, of which about three-fourths are insects, and about 400,000 kinds of plants.

We encounter many kinds of plants every day and are dependent on plants for food, fiber, energy, landscaping, and shelter. Many people are interested in learning more about plants as part of their general education, as a pastime, or just to satisfy their curiosity. This booklet has been prepared to introduce such people to the study of plants in the hope that it will stimulate them to look at and observe the plant world around them, in nature, in urban areas, and in their homes.

Obviously, this booklet may not answer all your questions; therefore, at the ends of many of the chapters are selected references, both popular and scientific. They were selected because: (1) they have been useful to the author, (2) they are basic references on the subjects, (3) they are

The text was coordinated and written by Kenneth R. Robertson, Assistant Taxonomist and Curator of the Herbarium of the Illinois Natural History Survey. However, all staff members of the Section of Botany and Plant Pathology contributed material—J. Leland Crane on the groups of lower plants and their collection; Claus Grunwald on the structure of plants; Donald Schoeneweiss on the importance of plants to man; Dan Neely on abnormalities caused by diseases and insect pests; and E. B. Himelick reviewed the section on plant photography. In addition, use was made of material in a previous Survey publication, *Pleasure with Plants* by L. R. Tehon (Illinois Natural History Survey Circular 32, out of print) and of an unpublished manuscript of a revised edition of *Pleasure with Plants* by Robert A. Evers, Natural History Survey Plant Taxonomist Emeritus. Dr. Alfred C. Koelling of the Illinois State Museum kindly reviewed the manuscript and made useful comments. Betty Nelson typed the manuscript. The final editing of the manuscript was done by Shirley McClellan, Assistant Technical Editor, and Robert M. Zewadski, Technical Editor, of the Illinois Natural History Survey.

among the better works directed to the general public, and/or (4) they are generally available in libraries and bookstores.

Professional botanists frequently spend as much time reading about plants as they do studying the plants themselves. If you are strongly interested in plants, we urge you to go to the libraries available to you (municipal, school, college, nature centers, botanical gardens) and browse. Try looking in the library index under "Plants," "Botany," and "Horticulture." Also, you may find it useful to look through local bookstores and at bookstores near college campuses, at nature centers, and at botanical gardens.

ABOUT BOTANY

Botany is the study of plants. What is a plant? The answer is not as simple as you might think. Most familiar plants are green, contain chlorophyll, manufacture their own food through the process of photosynthesis, are immobile and rooted to the ground, have neither a nervous system nor an excretory system, have a cell wall composed largely of cellulose, and can continue to grow almost indefinitely by cell divisions that are localized in certain areas called meristems. However, some plants, including dodder, Indian pipes, beech drops, and cancer root, lack chlorophyll and are parasitic on other plants. Other plants, such as Venus's-flytrap and pitcher plants (*Frontispiece*), trap and "digest" insects. (All of these examples are specialized flowering plants.) Many algae are motile, freely swimming in water, and some have rudimentary nervous and excretory organelles. Fungi lack chlorophyll and are either parasitic on other living organisms or saprophytic on dead ones, and the cell wall is usually composed of chitin instead of cellulose. In spite of these exceptions, algae and fungi are considered plants.

Plants are classified into these major categories: flowering plants, conifers, ferns and the fern allies, mosses and liverworts, algae, fungi, and lichens (Fig. 1). In this booklet, the emphasis is on the flowering plants, since these are the most conspicuous and economically important plants. However, an effort has been made to include brief discussions of the other plant groups.

There are many ways to study plants. The modern science of botany developed out of medicine, beginning with the identification of plants used for medicinal purposes. The need to identify, describe, name, and classify plants, i.e., to catalog them, is basic to botany, because without this, one would not be able to communicate with others about specific kinds of plants. This aspect of botany is called **taxonomy** or **systematics**. The need to study and accurately describe the structure of plants led to the development of the fields of **morphology** and **anatomy**. To understand how plants grow, reproduce, and live in their surroundings, botany has differentiated the disciplines of **cytology**, the study of the structure

and reproduction of plant cells; **physiology**, the study of the chemical and physical processes of plant life, such as photosynthesis, respiration, and differentiation; **ecology**, the study of the relationships between plants and their environment; and **plant geography**, the study of the distribution of plants. **Paleobotany** is the study of fossil plants.

There are other fields of botany specializing in the study of particular plant groups. **Algology** or **phycology** is the study of algae, **mycology** of fungi, **bryology** of mosses and liverworts, and **pteridology** of ferns. Botany is but one of the plant sciences. **Agronomy** is the study of field and pasture crops; **horticulture** of orchard, vegetable, and ornamental plants; **forestry** of forest trees and their management; and **plant pathology** of plant diseases.

Fig. 1 — The kinds of plants. A, morel or sponge-mushroom, *Morchella esculenta*, a fungus and one of the most popular edible wild mushrooms; B, a foliose lichen, *Parmelia* species, growing on a rock; C, two kinds of mosses, haircap moss (top), *Polytrichum commune*, with the spore-bearing capsules at the tips of the long stalks, and peat moss (bottom), *Sphagnum* species, which is found in very wet, acid places; D, ostrich fern, *Matteuccia struthiopteris*, one of our most attractive native ferns; E, Austrian pine, *Pinus nigra*, frequently cultivated in Illinois, visible are pollen-bearing male cones and three stages of female cones — those produced this year, last year, and two years ago; F, trout-lily, *Erythronium albidum*, a monocot and a common early spring woodland wild flower; and G, wild strawberry, *Fragaria virginiana*, a dicot and one of the ancestors of the cultivated strawberry. (Photographs A, C, D, E, F, and G by Kenneth R. Robertson; B by William E. Clark.)

THE IMPORTANCE OF PLANTS TO MAN

In our modern society we are so preoccupied with man-made materials that we tend to forget how man and all other animals are totally dependent on plants for their existence. Plants are not just decorative items in the house or garden and not merely part of nature to be enjoyed if and when we can find the time.

As children we learn that plants make food, but do we realize the importance of this basic process? Plants are the only living organisms that are able to convert light energy into chemical energy. In the process of photosynthesis, carbon dioxide and water, in the presence of light, are made into simple sugars, which are the essential building blocks for all life as we know it and for nearly all sources of fuel energy, such as wood and the fossil fuels, coal, oil, and natural gas. In addition, the energy stored in sugars is the only source of energy to sustain living organisms. Without green plants, all animal life would cease to exist. The most vital question for the 21st century is whether we will be able to produce enough plant material to feed the world's growing population. Yet, food from crops is only one of the many plant products useful to man (Fig. 2).

Before the development of synthetic products such as nylon, orlon, and plastics, man was dependent upon plants for fibers and building materials. Wood products were, and still are, a major source of construction materials. Nearly all of the written and printed matter produced through-

Fig. 2. — Common food plants. What part of a plant do each of these come from? For the answers, turn to page 62. (Photograph by Survey Photographer Leslie Woodrum.)

out history has depended on the use of paper products derived from plant fibers or wood. Fibers from the cotton, flax, and hemp plants and wool from animals grazing on plants, were the major textiles used for cloth. The development of modern synthetics has been so rapid it is difficult to believe that nearly all such products were developed during and after World War II. Even synthetics are in most cases plant products since most are made from petroleum or coal, which are remnants of plants from millions of years ago.

Plants provide much more than the necessities of life. What would our food taste like without spices such as pepper, garlic, nutmeg, mustard, cinnamon, parsley, sage, rosemary, thyme, vanilla, cocoa, and many others, all of which are plant products? How many of us can do without sugar, derived from sugar cane and sugar beets? What about antibiotics, most of which were originally discovered as products of fungi and bacteria, although many are now synthesized in laboratories? Some plant products like alcohol (produced by fermentation of sugar), tobacco, and drugs like heroin from the poppy, cocaine from coca, and marijuana from the hemp plant have often been put to less than desirable uses by man. Many other drugs derived from plants are widely used in medicine. A good example is digitalis from the foxglove plant, often prescribed for patients with heart ailments, and which scientists have not been able to duplicate synthetically. Plants with medicinal properties have been consumed by man for centuries, often with dangerously little knowledge of the possible consequences. Even today, many potentially dangerous plant products can be found in "health food" stores, particularly as "natural" ingredients for teas and broths. Tea made from certain kinds of dried leaves, flowers, or roots can have very serious effects on individuals with allergies or heart problems.

Before synthetic rubber was developed during World War II, the United States and the world rolled on tires made of latex from the sap of the rubber tree. Latex is still widely used for surgical tubing and many other products that require its unique properties.

With the rapid expansion of human populations, plants are coming under more and more pressure and many species have become endangered or their populations badly depleted. Furniture and veneer grade hardwoods like walnut, teak, mahogany and rosewood are in short supply, driving the price of quality furnishings ever higher. Much of the vast food potential of our crop plants, particularly as a source of protein for hungry and undernourished people, has been inefficiently used. Production of meat and poultry in the modern feedlot system does not make best use of plant protein supplies, because more people could be adequately nourished from the grains used to fatten one steer than from the meat itself.

Plants are often mentioned in long-range plans to help mitigate the energy crisis because they are a "renewable resource," unlike the fossil

fuels. Wood was once an important fuel, and still is in some parts of the world. Alcohol, an efficient liquid fuel either when mixed with gasoline to produce gasohol or when used alone, is readily produced from plants, particularly from grains, wood pulp, sugar cane, or corn stubble.

Stop and look around you at all the things that make up your everyday world. How many have been derived from plants or plant products? How desirable would the world be without trees, shrubs, flowers, and grass that color and soften our world and ease the tensions of everyday life? Plants are worth knowing and appreciating for they are indispensable to us in every way. Although man has reached the moon, he has not yet found a substitute for a living plant.

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THE KINDS OF PLANTS

Angiosperms

The **angiosperms** or flowering plants produce flowers and seeds, the latter developing within fruits. Nearly all crop, food, and ornamental plants are angiosperms. There are two major groups of flowering plants, primarily distinguished by the number of seed leaves (cotyledons). The monocotyledons or monocots have a single cotyledon in their seeds while the dicotyledons or dicots have two cotyledons. The leaves of monocots have parallel venation, the flower parts are usually in multiples of three, and monocots do not produce wood in the usual sense. This group of plants includes the grasses, sedges, cat-tails, lilies, orchids, bananas, and palms. The leaves of dicots have net-venation, the flower parts are mostly in multiples of four or five, and wood is produced by long-lived dicots.

The dicots include roses, carrots, elms, magnolias, buttercups, apples, sunflowers, and many other common plants.

Gymnosperms

The **gymnosperms** or conifers produce “naked” seeds that are not enclosed by fruits but develop on the surface of cone scales. They are woody trees and shrubs, and many species produce aromatic oils and resins, which give their leaves and wood pungent odors. The leaves of most conifers are evergreen, remaining on the plant during winter, but those of a few species, such as bald cypress and tamarack or larch, are deciduous, dropping their leaves in the fall. Conifers thrive particularly in the cooler regions of the temperate zones and make up much of the northern forests of North America and Eurasia. Many conifers are important as ornamentals and for their wood products. Pine, spruce, fir, red and white cedar, yew, ginkgo, cypress, hemlock, redwood, and Douglas fir are gymnosperms.

The Ferns, Horsetails, and Clubmosses

The **ferns**, **horsetails**, and **clubmosses**, collectively called the **pteridophytes**, have true roots, stems, and leaves; however, they lack flowers and seeds, and modern species do not produce wood. They reproduce by tiny spores, and many multiply vegetatively by creeping underground stems. Typical ferns have large, usually compound leaves, a stem that is an underground rhizome, and roots that grow profusely from the rhizome. Ferns are widely distributed in temperate and tropical regions, and since most cannot withstand drought or bright sunlight, they are usually restricted to moist shaded habitats, such as forest floors and ravines. The horsetails, once abundant in past geological ages, are represented today by a single genus, *Equisetum*. They have perennial underground rhizomes and mostly annual above-ground stems or canes that are hollow, ribbed, jointed, and impregnated with silica. Pioneers used the stems to scour pots and pans, and some people call these plants “scouring rushes.” Horsetails are found in wet, often sandy or gravelly soils of damp woods, along the banks of fast-moving rivers and streams, and in standing waters of rivers, ponds, and lakes. Clubmosses are small, evergreen, perennial herbs with upright or trailing stems and small, simple, spirally arranged leaves. They are found mostly in acidic soil of moist, shaded woods and in bogs and are especially abundant in the tropics. Some species are sold commercially for use in Christmas decorations.

Mosses and Liverworts

Mosses and **liverworts**, collectively called the **bryophytes**, are small green plants that lack true roots, leaves, and flowers; they reproduce by spores. Mosses are only a few inches tall and grow in crowded clusters,

tufts, or mats. Their plant bodies are stem-like with leafy scales and stalks bearing tiny capsules, which contain the dust-like spores. Mosses are cosmopolitan in distribution, but tend to prefer harsh habitats, such as exposed rocks, bogs, swamps, tree bark, forest floors, decaying logs, areas around waterfalls, dim caves, cracks in city sidewalks, high altitudes, and the arctic tundra. The most familiar moss product is sphagnum peat moss, which is cut in large blocks from extensive peat deposits that are found at northern latitudes. Peat is used in soil mixtures and, particularly in northern Europe, as a fuel in stoves. Liverworts are of two general kinds. The first grow flat and ribbon-like on wet soil, damp rock, or even on the surface of water, sometimes forming shiny green carpets along streams and ledges. The second kind have distinct stems with leaf-like scales and grow flat or in mats on moist soil, decaying logs, or tree bark.

Algae

The **algae** include both the smallest and simplest of green plants as well as the giant kelps, which are among the largest of plants. Algae can be green, red, brown, yellowish, or purple, depending on the pigments in their cells. The **green algae** are grass green in color, may be one celled, colonial, or filamentous, and are among the most widely distributed of all the algae with species usually inhabiting fresh water and forming large colonies on the surface. They are important as a source of food for fish and other aquatic animals. Sometimes they become so abundant that they pollute waters, give off vile odors, choke streams, and clog filters in water purifying facilities. The **yellow-green** and **golden-brown algae** are found most often in cold brooks, mountain streams, and springs. The related diatoms are important food for fish, and are so abundant in marine waters that they are called the "grass of the sea." The empty, beautifully ornamented siliceous walls of dead diatoms settle in marine waters and often accumulate, forming diatomaceous earth, which is used as a mild abrasive in polishes, cleansers, and toothpaste, and in insulation. The **blue-green algae** have blue and red pigments as well as chlorophyll and are found in a variety of habitats with most species in fresh water, although a few are marine and some thrive in damp and shaded places, such as on the surfaces of soil, rocks, and flower pots. Some blue-green algae have the ability to "fix" atmospheric nitrogen into organic compounds. The **brown algae** which include the giant kelps, have yellow, orange, or brown pigments and are almost entirely marine. They prefer cool water and are especially abundant in the Arctic and Antarctic oceans and along the coasts of the North Atlantic and North Pacific. Brown algae are important food for fish, are used in cattle feed, and are eaten by many people in Asia. Some brown algae are harvested for their abundant gelatinous compounds, which are used in ice cream, laxatives, and cosmetics. The **red algae** have a unique reddish pigment and are mostly marine, although a few species occur in fresh water.

Fungi

The **fungi** are a group of organisms that lack chlorophyll, roots, stems, leaves, and flowers. They reproduce by means of spores, are usually filamentous, have definite cell walls, and live a saprophytic or parasitic existence. As saprophytes they share with bacteria the role of decaying the remains of dead organisms, and as parasites they cause diseases in plants and animals. The large fleshy fungi, such as mushrooms, toadstools, bracket fungi, and puffballs, are familiar to everyone who has walked the Illinois countryside. Other fungi include the morels, truffles, earthstars, and bird's nest fungi. Most fungi are microscopic and not visible to the naked eye, such as molds, mildews, yeasts, rusts, and smuts. **Mushrooms** produce a fruiting body that consists of a stalk surmounted by a broad, umbrella-shaped cap. The reproductive spores are produced on the sides of gills located on the underside of the cap. The mushroom is only one part of the body of the fungus. The remainder consists of an extensive mass of threadlike filaments that grow hidden in the soil or other substrate. Technically, there is no difference between a mushroom and a toadstool. By tradition, the term "mushroom" refers to edible species, some highly prized for their delicious flavors and aromas. The term "toadstool" is used for poisonous species, which produce toxic compounds that can cause illness or death. Since both edible and poisonous species can occur together and can resemble each other, there is great danger of amateurs confusing safe and toxic species. Only people who are thoroughly familiar with the technical identification of mushrooms should collect and eat wild species. The **bracket fungi** resemble mushrooms but differ in having pores instead of gills and are often asymmetrical and hang, bracket-like, on dead or living tree trunks. The **puffballs** produce round or pear-shaped fruiting bodies with a conspicuous outer covering, liberating spores at maturity through a pore or break at the top of the ball. They are found on decomposing wood and bark, decaying leaves, and animal wastes.

Mushrooms can be found throughout most of the year but the largest number appear when the first cooling trend of fall, which usually occurs in September, is accompanied by rains. This diversity will last until temperatures fall below freezing. Warm spring temperatures combined with moist weather brings out the second largest number of fleshy fungi, including many gilled and pore fungi, morels, and puffballs. In late spring and summer, the number of fleshy fungi drop to a low point. A cool spell in August, accompanied by showers, will bring out large numbers of puffballs and pore fungi. However, the return of hot weather will quickly reduce the numbers to a few scattered specimens.

Fungi are of much benefit to man. Many antibiotics, including penicillin, streptomycin, terramycin, aureomycin, and chloromycetin, are produced by fungi. Yeasts carry out the process of fermentation, which makes possible bread, alcoholic beverages, and vinegar. Fungi are also important

in the ripening of certain kinds of cheese, such as Roquefort, Camembert, Brie, and Stilton.

Lichens

A lichen is a unique organism composed of a microscopic green or blue-green alga and a colorless fungus. The alga and fungus live together in a mutually beneficial association termed "symbiosis." The plant body that is formed has no resemblance to either the algal or fungal component. The algal partner provides food energy through photosynthesis and the fungal partner lives on this food, makes up the bulk of the plant body, protects the alga from desiccation, absorbs mineral elements and water, and synthesizes many essential organic compounds. Lichens have a cosmopolitan distribution and are found on a great variety of substrates, such as rock, trees, wood, and soil, from the Arctic (where they are dominant in the tundra) to the Antarctic, from sea level to alpine habitats, in deserts, and freshwater and marine environments. Some lichen communities last for centuries in the Arctic and Antarctic, but if the environment is disturbed, they are eventually replaced by mosses, liverworts, and higher plants. Lichens are very sensitive to air pollution, and different species are affected by different concentrations of specific air pollutants. Thus, it is frequently possible to estimate the level of air pollution in an area by determining the kinds and/or numbers of lichens that are present.

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See high school and college botany textbooks; also see under Plant Identification.

POISONOUS PLANTS

The word "poison" is often used with plants when only the word "caution" is warranted. Quite a number of plants can cause discomfort, pain, or illness, but few are lethal. Three types of injuries are caused by plants: internal poisoning, dermatitis, and allergy.

Internal Poisoning

Although many kinds of mushrooms are perfectly safe to eat, there are some that are extremely toxic, and only a few bites can kill an adult. The dangerous mushrooms often look much like the safe ones. Some flowering plants also are potentially dangerous. The most important ones found in the wild in Illinois include: pokeweed (*Phytolacca americana*), poison hemlock (*Conium maculatum*), water hemlock (*Cicuta maculata*), nightshade (*Solanum* species), and jimson weed (*Datura stramonium*). A few garden plants are also toxic, including: yew (*Taxus* species), lily-of-the-valley (*Convallaria majalis*), daphne (*Daphne mezereum*), the

leaf blades of rhubarb (*Rheum rhaponticum*), and castor bean (*Ricinus communis*).

Children, because of their inquisitive nature and tendency to put things into their mouths, are especially apt to accidentally ingest plant materials. Parents are urged to consult books on poisonous plants to learn to recognize harmful plants that might be growing around their home. If a child is suspected of having ingested plant material that may be poisonous, the parent should immediately contact a poison control center. A physician can advise the location of the nearest center.

Dermatitis

The most frequent cause of plant-induced irritation of the skin is poison-ivy (*Rhus radicans*, also called *Toxicodendron radicans*) (Fig. 3), which is abundant throughout Illinois. A few other plants can cause dermatitis, including poison sumac (*Rhus vernix*), trumpet-creeper (*Campsis radicans*), and some spurges and poinsettia (*Euphorbia* species). Stinging nettle (*Urtica dioica*) and wood nettle (*Laportea cordata*) have stinging hairs that cause immediate, intense pain; one or both of these plants are found nearly throughout Illinois. Some plants cause dermatitis in an indirect manner by making a person hypersensitive to light. In the case of wild parsnip (*Pastinaca sativa*), areas of the skin that come into

Fig. 3. — Poison ivy, *Rhus radicans*. Several other plants have similar leaves, but until you learn how to distinguish them, abide by the old adage, "Leaflets three, let it be." (Photograph by Kenneth R. Robertson.)

contact with the plant which are then exposed to sunlight can develop symptoms similar to poison-ivy. The situation is different with a number of other plants, where hypersensitivity results only when the plant is eaten; this phenomenon is not well understood and, fortunately, few people are affected.

Allergy

A fairly large number of people suffer from allergic reactions to plants. Certain people are allergic to particular plant foods, such as wheat flour, beans, tomatoes, chocolate, nuts, corn, and peanuts. "Hayfever" is an allergic reaction to microscopic airborne pollen and spores. In Illinois, there are three peak seasons for hayfever. In early spring, much pollen is shed by many common trees, such as ash, birch, elm, maple, oak, poplar, and sycamore. Many of the wild, yard, and crop grasses flower in midsummer, causing another peak in pollen count, but the greatest amount occurs in fall when ragweed and a few other weeds shed tremendous quantities of pollen.

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PLANT CLASSIFICATION

With 400,000 kinds of plants, it is necessary to organize this diversity into a classification scheme to be able to communicate with others about plants. There are a variety of ways plants can be classified, such as alphabetically (hibiscus, hickory, hollyhock, hydrangea); by growth habit (herb, shrub, tree, or vine); by habitat (aquatic, terrestrial, aerial); or

by shared characteristics (white flowers, opposite leaves, edible fruits). However, the classification system that has been most useful to botanists is one that groups related plants together into a series of hierarchical categories, so that very closely allied plants are placed together in the system, plants that are somewhat related are grouped near each other, while plants that have very little in common are placed far from each other.

The classification scheme used for plants has the following categories:

Division
Class
Order
Family
Genus
Species
Subspecies
Variety
Form
[Cultivar]

The basic unit of classification is a *species* (spelled the same in both the singular and plural). It is impossible to precisely define a species so that the definition would apply to all plants and be agreed upon by all botanists. In general, however, a species is a population or a series of populations whose individuals are distinct and distinguishable from individuals of other such populations, this distinctiveness is self-perpetuating through succeeding generations, and the population(s) are usually reproductively isolated from populations of other species. To the layman a species is a particular kind of plant or, put another way, all individual plants that look more-or-less alike constitute a species.

We intuitively recognize some species. All human beings constitute a species, and white oak, eastern redbud, flowering dogwood, and white pine are other familiar species. Variation does exist within species, and these variants are sometimes recognized either as **subspecies**, **varieties**, or **forms** (depending on the magnitude of the variations) if they occur in the wild or as **cultivars** or **lines** if they occur only in cultivation.

Related species are grouped together into **genera** (singular, **genus**). Again, the nonbotanist perceives this. For instance all oaks belong to one genus, roses to another, and pines to a third. Some species are so distinctive that they are placed in a genus by themselves, as is the case with the ginkgo.

Related genera, in turn, are placed in the same *family*. This category has no equivalent among laymen, yet it is one of the most useful to botanists. It is relatively easy to learn the identifying characteristics of common plant families in Illinois, and this knowledge is of immense use in quickly identifying unknown plants. Among the common families in

the state are: the grass family, the lily family, the mustard family, the rose family, the legume (or bean) family, the carrot family, the mint family, and the composite (or sunflower) family. Approximately half of the world's families of ferns, conifers, and flowering plants occur natively or naturalized in Illinois, and a number of other families are cultivated. A person with a knowledge of the characteristics of plant families in Illinois can go nearly anywhere in the world and recognize the families of the majority of plants.

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PLANT NAMES

Since ancient time, man has given names to plants that are of special interest, such as food plants, fiber-producing plants, poisonous plants, and ornamental plants. People involved in outdoor activities come into contact with wild plants, and today we encounter more plants than ever before in our homes, gardens, plant shops, and grocery stores. People want to learn the names of these plants.

There are two kinds of names given to plants, common names and scientific names. The two kinds are complementary and each has a definite use. Laymen should not look upon those using scientific names as trying to be pretentious, and botanists should not look with disdain upon those using common names.

Common Names

Common names are the names used by the general population of a given region and are nearly always in the language spoken locally, i.e., English in Illinois, French in Quebec, Spanish in Mexico. Common names are the only names by which most people know familiar plants, since they are usually composed of everyday words. They also are often easy to remember, can accurately depict outstanding characteristics of a plant, and can be precise and stable within limited geographical areas. However, the use of common names has several drawbacks. The same common name may be used for more than one kind of plant, both within one area and from place to place. For example, "mayflower" is used for a member of the lily family (the scientific name of this plant is *Maianthemum canadense*) and also for a member of the heath family (*Epigaea repens*). Nearly everyone in the United States uses the name "corn" for the plant known botanically as *Zea mays*; however, in Europe, "corn" is used for any kind of grain. Also, the same kind of plant may have more than one common name. In addition to being called "mayflower," *Maianthemum canadense* is also called "wild lily-of-the-valley," and *Zea mays* is called "maize," particularly in Europe. As another example, the name "adder's tongue" can refer either to a quaint fern, *Ophioglossum vulgatum*, or to a lovely member of the lily family, *Erythronium albidum*. The latter is also known as "trout-lily," "fawn-lily," or "dog-tooth-violet." When using common names to communicate with others who are knowledgeable about plants, it is very desirable to equate common names to scientific names so that there can be no ambiguity about which particular plants are being discussed.

Scientific Names

The science of botany in Europe, particularly the aspect of identifying and naming plants, reached full development in the 18th century. At that time, educated men in all fields, from law, medicine, philosophy, and religion to science, used Latin as a universal language, which greatly facilitated communication between people of different nationalities speaking many native languages. Thus, it was only natural that Latin was used for plant names in learned circles. At first, plants were given descriptive phrase names such as *Rosa carolina fragrans, foliis medio tenus serratis*. These names were long, confusing, and difficult to remember, and in 1753, the Swedish botanist Carl Linnaeus, applied a system of naming to the entire plant kingdom whereby a plant name consisted of only two words. This binomial system is still used universally by scientists, now following the strict rules of the International Code of Botanical Nomenclature.

The first word of the scientific name is the name of the genus to which the plant is assigned, and the second word is the specific epithet. Thus, from the examples above, *Maianthemum* is the name of the genus and *canadense* is the specific epithet, and together, *Maianthemum*

canadense, they make the scientific name. These names are always in Latin or, if derived from other languages, treated as if they were Latin. Scientific names are italicized in print and underlined when typed or handwritten. The first letter of the generic name is always capitalized; that of the specific epithet may always be left uncapitalized, although it can be capitalized if the name commemorates a person or an old generic name.

The generic name refers to a general kind of plant while the specific epithet indicates a particular kind of plant. Thus, the genus *Rosa* is used for all kinds of roses, while *Rosa setigera* is the prairie rose. When the generic name is frequently repeated, it is customary to abbreviate it by the first letter. Accordingly, *Rosa carolina* is the pasture rose, *R. centifolia* is the cabbage rose, and *R. canina* is the dog rose. These examples show that the use of two words for the name of a particular kind of plant is not restricted to scientific names, but that we frequently do this in English with one word modifying the other.

Following the name of the species is the name of the person who gave the plant that name. This is a bibliographic aid to help locate additional information about the name. Many plants in the eastern United States were first named by Linnaeus, for instance, *Rosa carolina* Linnaeus, the pasture rose. Certain people described so many plants that their name is abbreviated, such as *Rosa carolina* L., *R. canina* L., and *R. setigera* Michx. (for Michaux). Some floras give lists of author abbreviations; see Fernald (under "Floras and Manuals" in references for Plant Identification) for a particularly useful list.

Sometimes a species may have two or more recognizable variants. As previously mentioned, if these are discovered in wild plants, they are called subspecies, varieties, or forms, depending on the magnitude of the variations, and are given an additional Latin name. For example, the pasture rose *R. carolina*, has two variants, one with the leaves smooth and the other with the leaves quite hairy beneath. The first one is called *R. carolina* var. *carolina* and the second, *R. carolina* var. *villosa*. Author citations are used with these names when the name of the variant is different from that of the species, as in *R. carolina* L. var. *villosa* (Best) Rehd. When variants occur only in cultivated plants, they are given "cultivar" names, which may be in languages other than Latin, and they do not carry an author citation with them. The cultivar name is placed in single quotation marks after the specific name, or, in some cases, after the generic name. For example, the name of the Bradford pear is *Pyrus calleryana* 'Bradford.' It is never correct to use so-called trinomial names, such as *Rosa carolina villosa*, that do not indicate the classification rank of the third name.

The names of plant families are based on the name of a genus with the ending changed to "-aceae." Thus, Rosaceae is the name of the rose family and Liliaceae of the lily family. A few very common families may be called either by their traditional name or by the name that is based

on the name of an included genus. Thus, the grass family is Gramineae or Poaceae; the legume or bean family is Leguminosae or Fabaceae; the mustard family is Cruciferae or Brassicaceae; the mint family is Labiatae or Lamiaceae; the carrot family is Umbelliferae or Apiaceae; and the sunflower family is Compositae or Asteraceae.

The application of scientific names to plants is governed today by the International Code of Botanical Nomenclature, the purpose of which is to establish one set of rules by which plants are named. According to these rules, no two kinds of plants can have the same name, and under a given genus, a species can have only one correct name. This correct name is the combination of the earliest correct generic name with the earliest specific epithet.

Some people wonder why one book will use one scientific name for a plant while another will use a different name for the same plant. There are basically two reasons for this. The first is that there has been a **name change** made necessary by the rules of the Code of Botanical Nomenclature. For example, there are two members of the rose family in the eastern United States known as bowman's root and American ipecac. Most floras place these plants in the genus *Gillenia*, which was first described in 1802. However, this name had been used previously for another plant and cannot be used again. The correct generic name for these plants is *Porteranthus*. The second reason is that some groups of plants are more difficult to classify than others, and **different authors may classify them differently**. For instance, the ninebarks (*Physocarpus*) in the eastern United States are extremely variable and some people have distinguished several different species, others only one species with several varieties, and others recognize only one variable species with no varieties.

Pronunciation of Scientific Names

Many people who would use scientific names are afraid to do so because the words seem difficult to pronounce. A number of generic names have become adopted as common names and are familiar to most people — *Chrysanthemum*, *Geranium*, *Rhododendron*, *Magnolia*, *Aster*, *Catalpa*, *Phlox*, *Iris*, *Trillium*, *Delphinium*, *Sassafras*, and *Hydrangea*. There are many common names that are very similar to the scientific names: as lily, *Lilium*; rose, *Rosa*; alder, *Alnus*; spirea, *Spiraea*; violet, *Viola*; gentian, *Gentiana*; elm, *Ulmus*; pine, *Pinus*; poplar, *Populus*; larch, *Larix*; and juniper, *Juniperus*. All of these words are easy for most people to pronounce because they are familiar with them. With a little practice, other scientific names become easy to pronounce. Actually, most Latin or Latinized words are easier to pronounce than unknown English words. Finally, there is no need for someone to be afraid of “mispronouncing” scientific names because there are several different systems for pronouncing Latin — “traditional English” pronunciation as used by most botanists and horticulturalists in English-speaking countries, “re-

formed academic" attempts to approximate the pronunciation of educated Romans, and "Church" Latin as used by the Catholic Church.

In this country most letters of the alphabet are pronounced the same in Latin as in English, including the consonants *b*, *c* (hard and soft), *d*, *f*, *g* (hard and soft), *h*, *k*, *l*, *m*, *n*, *p*, *q*, *r*, *s* (always as in *so*, not like *z*), *t*, *v*, and *z*. The letters *j*, *u*, and *w* were not in the classical Latin alphabet; when they appear in Latinized words, they are usually pronounced as in English except that *j* sometimes has the sound of *y* in *yellow*. The letter *x* at the beginning of a word has the sound of *z*, for example, *Xanthium* is zăn'-thē-ŭm and *Xyris* is zī'-rŭs. Elsewhere, *x* is pronounced as in English, such as *Larix* is lăr-iks and *Oxalis* is ōks-ă'-lis. All vowels may be either long or short, as in English.

A Latin word has as many syllables as it has vowels or diphthongs (two vowels pronounced as one sound). The diphthongs commonly used in botanical names, and their pronunciations, are: *ae* (ē as *ea* in *meat*), *au* (as *aw* in *awful*), and *eu* (as in *neutral* and as *oo* in *tool*). Some examples are: *Actaea* (ăk-tē'-ă), *laevis* (lē'-vis), *Aureolaria* (ăw-rē-ō-lăr'-i-ă), *caudatus* (kăw-dă'-tŭs), *Eleusine* (ěl-ōō'-sĭ-nē), and *Deutzia* (dōot'-zē-ă).

Every vowel or diphthong is pronounced, and there are no silent letters at the end of a word. Thus, *Ribes* is rī'-bēs, not rĭbs or rĭbs; *Androsace* is ăn-drō-să'-sē; *Leucothoë* is lōō-cō'-thō-ē; *gerardii* is jēr-ăr'-dē-i; *illinoense* is il-li-nō-in'-sē; *Rosaceae* is rōs-ă'-sē-ē; *Liatris* is li-ă'-trĭs; *Iliama* is il-lē-ă'-mă; and *Aloe* is ă-lō'-ē, not ăl-ō.

When a word begins with any of the following combinations of two consonants, the first letter is silent: *cn*, *gn*, *mn*, *ps*, and *pt*. Thus, *Cnicus* is nĭ'-kŭs; *Gnaphalium* is nă-fă'-lē-ŭm; *Mnium* is nĭ-ŭm; *Psoralea* is sō-ră'-lē-ă; and *Pteridium* is tē-rĭ'-dē-ŭm.

Those who wish to learn more about the pronunciation of scientific names are urged to read: A. W. Smith, J. E. Smith, Jr., and Radford *et al.* (the latter two listed in the references for Plant Classification).

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PLANT IDENTIFICATION

Plant identification is basic to the study of plants, because once a plant is identified, you have a name for the plant. By using this name, you can communicate with others about the plant and you can gather more information about it. Obviously, it is extremely important to identify the plant correctly, for if it is misidentified, then any information you learn or pass on about the plant may be misapplied. As an extreme example, mistaking a destroying angel mushroom for a morel would likely be fatal.

There are several ways to identify a plant. The simplest, and often the best, is to ask some knowledgeable person. Another way to identify a plant is to compare it with photographs, drawings, or descriptions in guidebooks or floras, which need not require much technical knowledge, but which can be time consuming. If one has access to a herbarium collection, unknown plants can be compared to already named specimens. Lastly, plants can be identified with the use of "keys" for identification that are found in nearly all floras or botanical manuals.

Because of the large number of plants, there is no single book that can be used to identify all plants. Rather, different books are used for different kinds of plants. In the references at the end of this chapter, the books are grouped into the following categories in order to make them more useful:

1. **Food plants and edible wild plants.** Usually well illustrated and often containing information on how to prepare edible wild plants.
2. **Floras and manuals.** Generally include all species of flowering plants, conifers, and ferns for particular geographical areas; nearly all contain keys, some are illustrated.
3. **Wild flowers.** Contain the most common species that occur in particular geographical areas; nearly always well illustrated with drawings and/or photographs, rarely with keys.
4. **Weeds.** Like wild flower books, but for weeds.
5. **Woody plants.** Contain means to identify native and/or cultivated trees, shrubs, and woody vines; some with keys, some with illustrations or photographs, some with neither.
6. **Cultivated plants.** Like the preceding, but for garden flowers, house plants, and other cultivated plants.
7. **Special habitats.** A few books deal with plants in particular habitats, such as prairies and aquatic situations.
8. **Specific plant groups.** Separate guidebooks are available for: grasses, orchids, and the lower plants such as ferns, mosses, liverworts, lichens, fungi, and algae.

Professional taxonomic botanists usually have a number of books for identifying plants, and botanical libraries contain thousands of such books. However, a student or layman is usually only interested in a few categories of plants, such as wild flowers or trees, and can identify most plants with a few titles. Most public, school, and university libraries have a number of the different identification books.

Keys

By the use of keys, plants that have particular structural features are separated from all plants that lack such features, and the process of identification is made simpler. A key consists of a series of paired contrasting or contradictory statements: each pair of statements is called a couplet. The first couplet of a key is compared with the plant to be identified. One of the statements **will not** apply to the plant while the other one **will** and leads to another set of couplets. This process of choosing one statement of a couplet and rejecting the other is repeated until only one possibility remains, which gives the name of the plant. This process is called "keying out" a plant. Most books have a number of separate keys. One key is used to determine the plant family (if it is not known), another to identify the plant to genus, and a third key to identify the species. With experience, common families and genera are readily recognized, which makes the identification to species much more rapid. Often, however, all is not so simple, and the user may not have all the information needed to select the proper statement or the choices are not clear-cut. Nevertheless, time has proven the usefulness of keys. With experience, keys become relatively easy to use, and you will be able to take pride in your ability to use them.

Hints for the Use of Keys

1. Examine the unknown plant in a general way to see its basic morphological features, such as habit, leaf type and arrangement, flower color and structure, and fruit type. This will save time when using the key; certain other features will have to be checked more thoroughly while using a key.

2. Select a suitable key. This is very important. Don't try to identify a tree with a wild flower guide. Also, use a key that is as specific as possible. For instance, if trying to identify a plant from a pond in Illinois, it would be best to use a book dealing with aquatic plants of Illinois; a flora of Illinois or a manual on aquatic plants in general would be next best; while a flora of the entire eastern United States would be considerably more difficult.

3. Look carefully at the key to determine its arrangement and read any instructions on the use of the key.

4. Always begin at the very first couplet; sometimes it is tempting to jump to the middle of a familiar key.

5. Read carefully both statements of a couplet before selecting one.

6. Use a glossary for any terms you don't understand; remember that the same term may mean different things to different authors.

7. When measurements are called for, make them carefully and don't guess. Measurements should be made from several samples.

8. Use a hand lens when the key asks about minute structures.

9. Remember that there is variation within a species; most keys apply to the usual situation and may not include extremes.

10. When it is not clear which statement of a couplet to select, choose the one that *best* suits the unknown plant; it is not always possible to write keys that perfectly fit every plant to which the statement is supposed to apply.

11. When it is seemingly impossible to select one statement over another, or not enough information is at hand, arbitrarily select one statement and proceed for several other couplets, then go back and try the other troublesome statement and follow it for a few additional couplets. Usually, it will become obvious which of the two statements is the correct choice.

12. Once a tentative identification is made with a key, check the identification with detailed descriptions, illustrations, photographs, and if possible, with accurately identified herbarium specimens.

13. Check the geographical and habitat descriptions to make sure the plant being identified occurs in the same region and habitat as the species to which it has been tentatively identified.

A Simplified Yoked Key to Separate Certain Genera of Common Trees

1. Leaves alternate.
 2. Leaves simple.
 3. Leaves fan-shaped with a notch at the tip.....*Ginkgo*.
 3. Leaves not fan-shaped, lacking a notch at the tip.
 4. Leaves entire.....*Magnolia*.
 4. Leaves lobed or toothed.
 5. Leaves lobed.....*Quercus*.
 5. Leaves toothed.....*Ulmus*.
 2. Leaves compound.
 6. Leaflets small.....*Gleditsia*.
 6. Leaflets large.....*Cladrastis*.
1. Leaves opposite or whorled.
 7. Leaves whorled.....*Catalpa*.
 7. Leaves opposite.
 8. Leaves simple.
 9. Leaves palmately lobed.....*Acer*.
 9. Leaves entire.....*Cornus*.
 8. Leaves compound.
 10. Leaves palmately compound.....*Aesculus*.
 10. Leaves pinnately compound.....*Fraxinus*.

A Simplified Bracketed Key to Separate Certain Genera of Common Trees

1. Leaves alternate.....	2.
1. Leaves opposite or whorled.....	7.
2. Leaves simple.....	3.
2. Leaves compound.....	6.
3. Leaves fan-shaped with a notch at the tip.....	<i>Ginkgo</i> .
3. Leaves not fan-shaped, lacking a notch at the tip.....	4.
4. Leaves entire.....	<i>Magnolia</i> .
4. Leaves lobed or toothed.....	5.
5. Leaves lobed.....	<i>Quercus</i> .
5. Leaves toothed.....	<i>Ulmus</i> .
6. Leaflets small.....	<i>Gleditsia</i> .
6. Leaflets large.....	<i>Cladrastis</i> .
7. Leaves whorled.....	<i>Catalpa</i> .
7. Leaves opposite.....	8.
8. Leaves simple.....	9.
8. Leaves compound.....	10.
9. Leaves palmately lobed.....	<i>Acer</i> .
9. Leaves entire.....	<i>Cornus</i> .
10. Leaves palmately compound.....	<i>Aesculus</i> .
10. Leaves pinnately compound.....	<i>Fraxinus</i> .

Examining Plants

To obtain an accurate identification of many plants, it is necessary to examine details of leaf edges, plant hairs, flowers, and fruits. Often flowers must be dissected (cut apart by pieces), and accurate measurements are required. The following items (Fig. 4) will help in these tasks. (1) A **ruler** about 6" long marked in both metric and English units is essential. (2) To examine minute parts, a small 10X (enlarges 10 times) **hand lens** is needed. When using a hand lens, hold the lens close to the eye and then move the specimen toward the lens until it is in sharp focus (Fig. 5). Reading type magnifiers are of little use for studying plants; also, avoid magnifiers with plastic lenses. (3) **Cutting tools** are needed to slice apart small parts, mostly flowers and fruits. In the field, a small, very sharp pocket knife (a pruning knife is best) is essential. Indoors, razor blades and/or hobby knives may be used. Sharpen or replace blades frequently, as dull blades tear delicate plant tissues. (4) It is helpful to have different types of pointed forceps (tweezers) to hold small plant parts while making dissections. Inexpensive chrome-plated ones are adequate for most tasks, although stainless-steel forceps are needed for fine, delicate work. (5) **Dissecting needles** are used for "teasing" apart small structures. These can be made by forcing the eye of a large sewing needle into one end of a short length of ¼" wooden dowel. (6) When examining plants indoors, it is convenient to have a small

Fig. 4. — Items useful for examining plants. Shown are hand lenses, forceps, dissecting needles, a hobby knife, a pruning knife, a razor blade, and a ruler. (Photograph by Survey Photographer Leslie Woodrum.)

glass plate on which to dissect the specimens. A good **light** is essential; a high-intensity reading light is ideal. (7) When making dissections of dried herbarium material (see below), it is necessary to soften the material by gently heating or soaking it in water to which a **softening agent**, such as Kodak Photo-Flo, has been added.

Most of the items mentioned above are available at hobby shops, college bookstores, hardware stores, and specialty tool companies.

When examining plants, you should be aware that abnormalities occur and that some of these are due to disease and pests. The same groups of organisms (fungi, bacteria, viruses) that cause diseases in man and in animals also cause diseases in plants. Fortunately, none of the species that affect plants affect man. Many disease symptoms are readily apparent, the most frequent being leaf spots (localized dead tissue), leaf rust (bright yellow or orange leaf spots), powdery mildew (a white powdery or mealy covering on the leaf or young stem), and tumors (an abnormal enlarged growth on the stem often near the ground line).

Many insects feed on plant tissues and they also disrupt plant functions or appearance. When plant specimens are examined closely, insects can often be observed. Insect pests can be grouped into five categories depending upon how they feed. Sucking insects take sap from the plant and frequently leave a sticky "honeydew" on the leaves; one small group

Fig. 5.—How to use a hand lens.
(Drawing by Survey Illustrator Lloyd LeMere.)

of sucking insects are found inside galls on leaves. Rasping insects give the leaves a “silvery” appearance due to the collapse of some surface cells. Chewing insects devour tissues of the leaf and may or may not leave the veins and midrib. Mining insects eat the inner leaf tissues, leaving the upper and lower leaf layers intact. Boring insects feed in tunnels in the bark or wood.

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SENDING PLANTS FOR EXPERT IDENTIFICATION

Sometimes it is necessary to send a plant to an expert for identification or for confirmation of your tentative identification. To do this, collect a sample that includes enough of the plant for identification. For most herbaceous plants, send the whole plant; for woody plants, send a piece at least 12 inches long. All specimens should have leaves and flowers or fruits. Professional botanists have a very limited amount of time to spend on identifications; so don't send scrappy specimens or many samples at one time. Press the sample flat and dry it thoroughly, because samples not dried will mold in the mail. Pack the sample between pieces of stiff cardboard. Enclose information about the plant, including whether the plant is wild or cultivated, where you collected it, when it was collected, flower or fruit color, the height of the plant, and the type of habitat it came from. Send the sample to: (a) the botany department at the nearest state university; (b) the Illinois Natural History Survey, Section of Botany and Plant Pathology, 172 Natural Resources Building, Urbana, Illinois 61801; (c) the Illinois State Museum, Botany Section/Herbarium, Springfield, Illinois 62706; or (d) a local botanical garden or arboretum.

THE STRUCTURE OF FLOWERING PLANTS

Flowering plants are complex organisms and show a wealth of diversity. To describe the distinguishing characteristics of plant species, a large vocabulary of descriptive terms has been developed. Some of these terms are technical and often have a Latin base. Fortunately, it is not necessary for the layman to learn much of this jargon to identify the more common plants, but a few terms are essential.

Plants may be either **woody** or **herbaceous**. Those that are woody may be **trees**, **shrubs**, or **woody vines**, and the leaves may be **evergreen**, persisting for more than 1 year, or **deciduous**, dropping in autumn. Those that are herbaceous may be **annual**, growing from seed to maturity and then dying in 1 year; **biennial**, living for 2 years and generally producing flowers only in the second year; or **perennial**, producing above ground stems and leaves and flowering repeatedly over a number of years.

A complete plant is composed of four basic organs, each with a different function. **Roots** anchor a plant to the soil and absorb water and minerals. The **stem** is the main support of a plant, bearing the leaves and flowers and containing conductive tissue for transferring water, carbohydrates, and nutrients from one organ to another. **Leaves** are the principal photosynthetic organs of a plant and have special tissue where energy from sunlight is used to make sugars and starch from carbon dioxide and water. The stems and leaves collectively are called the **shoot**. **Flowers** are the reproductive part of a plant and mature into **fruits** that contain seed.

Roots

There are two general types of roots—**primary**, which develop from the primary root of the seedling into either a taproot or a fibrous root system, and **adventitious**, which arise superficially from stems and which are usually fibrous in nature. Sometimes roots are greatly enlarged to store food for the next growing season; examples are carrots, beets, sweet potatoes, and dahlias.

Stems

Stems are composed of several parts. The place where a leaf is or was attached is called a **node**, and the area between two nodes is the **internode**. The upper angle formed by a leaf and a stem is the **leaf axil**, and usually one or more **axillary buds**, which are capable of developing into lateral branches, are found in each leaf axil. Many stems are terminated by a **terminal bud**. Stems that trail along the surface of the soil, sending up new erect stems at intervals, are called **stolons** or **runners**. **Rhizomes** are creeping, usually subterranean, horizontal stems that produce new upright stems at their tips. Some stems are also modified for the storage of food material. **Tubers** are fleshy, thickened, subterranean stems covered with a thick skin, such as the potato. **Corms**, such as those produced by the crocus and gladiolus, are underground, very short, erect, swollen stem bases covered by dry leaf bases. True **bulbs**, such as onions and tulips, are miniature erect stems surrounded by swollen, fleshy bud-scales, which are modified leaves and which, in turn, are enclosed by a dry, paper-like tunic, which is also made of modified leaves.

Leaves

Leaves are composed of three parts. The **petiole** is the supporting stalk of the leaf; the **blade** is the expanded, flat part; and many leaves also have **stipules**, which are appendages at the base of the petiole. Leaves are either **simple**, with the blade all in one piece, or **compound**, with the blade composed of several to numerous individual **leaflets** arranged in either a palmate or pinnate fashion (Fig. 6). The general outline is referred to as leaf shape, and some of the diverse kinds are shown in Fig. 6. There is also an abundance of different kinds of leaf margins, tips, and bases as illustrated in Fig. 7. Leaves occur on the stems in **alternate**, **opposite**, or **whorled** arrangements (Fig. 6).

Flowers

Flowers are arranged together into **inflorescences**, some types of which are shown in Fig. 8. Flowers are composed of several parts (Fig. 9). The **sepals** are the outermost part of a flower and are commonly green and rather leaflike in texture, although in some species they are colored and petal-like. Collectively, the sepals are called the **calyx**.

Fig. 6. — Leaf arrangements: A, alternate; B, opposite; and C, whorled. Leaf types: A, simple; B, ternately compound; C, pinnately compound; D, palmately compound; and E, twice-pinnately compound. Leaf shapes: A, linear; B, lanceolate; C, ovate; D, elliptic; E, narrowly elliptic; F, obovate; G, spatulate; H, deltoid; I, rhomboid; J, reniform; and K, orbicular.

Fig. 7.—Leaf margins: A, entire; B, crenate; C, serrate; D, incised; E, pectinate; F, pinnately lobed; and G, palmately lobed. Leaf tips: A, aristate; B, acuminate; C, acute; D, mucronate; E, obtuse; F, retuse; and G, emarginate. Leaf bases: A, attenuate; B, cuneate; C, rounded; D, truncate; E, oblique; F, cordate; G, sagittate; H, perfoliate; I, hastate; J, peltate; and K, sheathing.

Fig. 8. — Inflorescences: A, simple cyme; B, compound cyme; C, panicle; D, raceme; E, spike; F, corymb; G, simple umbel; H, compound umbel; and I, head.

The **petals** are positioned inward from the sepals and are commonly colored and delicate in texture. Collectively, the petals are called the **corolla**, and the sepals and petals together are called the **perianth**. In some plants, the sepals and petals cannot be told apart, and the perianth parts are then called **tepals**.

The **stamens** are inward from the petals and are the “male” reproductive parts of the flower. A stamen usually consists of the **anther**, which contains the **pollen**, and a stalk called the **filament**. Collectively, the stamens are called the **androecium**.

The **pistil** occupies the central position in a flower and is the “female” reproductive part of a flower. It consists of a terminal **stigma**, which is often sticky, the function of which is to receive the pollen; a

Fig. 9. — The parts of a flower. The open circles below the pistil represent scars where one filament and two petals were removed. (Drawing by Survey Illustrator Lloyd LeMere.)

style; and, at the base, an **ovary**, which contains one or more **ovules**. Collectively, all the pistils in one flower are called the **gynoecium**.

Fruits

A **fruit** is the ripened ovary of a flower, and a **seed** is the matured ovule. Fruits are highly diverse (some of this diversity is illustrated in Fig. 2 and 21), but can be classified by the number of ovaries involved in their formation and by their consistency, structure, and whether they are **dehiscent** (splitting open at maturity) or **indehiscent** (remaining entire at maturity).

Simple fruits, such as grapes, cherries, and tomatoes, develop from a single ovary. **Aggregate fruits**, such as strawberries and raspberries, are produced from a number of separate ovaries contained within a single flower. **Multiple fruits**, such as pineapples, mulberries, and figs, result when the mature ovaries of several flowers coalesce into one mass.

The two most common kinds of dehiscent fruits are the **follicle**, a dry fruit derived from a simple pistil and opening by one slit, and the **capsule**, also a dry fruit, but derived from a compound pistil and usually with several areas of dehiscence. The basic kinds of indehiscent fruits are the **berry**, which is fleshy throughout; the **drupe**, which is fleshy but with a stone or pit inside; the **achene**, a dry, one-seeded fruit with the seed attached at one point to the fruit wall; the **grain**, a dry, one-seeded fruit with the seed coat fused to the fruit wall; and the **nut**, a dry, one-seeded fruit with a hard shell. Many of these fruit types are shown in Fig. 2.

REFERENCES:

See references under Plant Classification; many of the references under Plant Identification also have material on plant structure.

WHERE TO STUDY PLANTS

People often begin to study plants by having their curiosity aroused by the many plants around them. Those in urban areas can find interesting plants in vacant lots and in parks, while those in rural areas look in farmyards, woodlots, fallow fields, and roadsides. Both city and country dwellers find a wealth of plant life in yards, vegetable and flower gardens, and along railroad right-of-ways (Fig. 10).

Those interested in plants tend to study either wild plants or plants in cultivation. However, all plants have much to teach us, and it is hoped that you will not ignore a plant because it is a weed, is wild, or is in a garden. People who primarily seek plants in nature can learn much from looking at exotic plants in cultivation, and those who study cultivated plants can greatly enjoy a back-to-nature hike in the country.

Fig. 10. — A railroad prairie remnant in central Illinois. On one September day, about 40 different species of plants, excluding grasses, belonging to 30 genera and 15 families were seen here. (Photograph by Kenneth R. Robertson.)

Natural Areas

Illinois is a very long state from north to south and is blessed with a number of different habitats for plants, with sand beaches and dunes along Lake Michigan; acidic bogs (Fig. 11), alkaline fens, prairies, and various forests in northern Illinois; a variety of prairie types plus some forests in central and western Illinois; and rich forests and swamps in southern Illinois (Fig. 12). (See the publication by Schwegman in the reference section for detailed descriptions of the natural divisions in Illinois.)

Man's activities, however, have altered much of the landscape in the state. Most of the black-soil prairie (Fig. 13) has been plowed for farmland, much of the forests have been logged, and many natural areas have been lost to urban development, particularly in large metropolitan areas. However, Illinois still has many natural areas, such as state parks, state forests, and a fine series of nature preserves. (Lists of these areas are available from the Illinois Department of Conservation.) There are a number of trails through the thousands of acres in the Shawnee National Forest in southern Illinois. Many county forest preserve districts have areas devoted to nature conservation; the Cook and Lake county districts are particularly noteworthy. Some cities and soil conservation districts also own natural areas. Significant natural areas are owned by public and private universities and colleges in the state (Fig. 14).

Fig. 11. — Volo Bog, Lake County, Illinois. (Photograph by Kenneth R. Robertson.)

Fig. 12. — Bald cypress and tupelo growing in the water of Horseshoe Lake, Alexander County. Primrose-willow also grows in the water here (foreground).

Fig. 13. — A diverse, black-soil prairie in central Illinois. The plant in the foreground is pale cone-flower, *Echinacea pallida*. (Photograph by Kenneth R. Robertson.)

Fig. 14. — LaRue-Pine Hills Ecological Area, Union County—a view of the swamp from the adjacent bluff. (Photograph by Wilmer Zehr.)

In addition to these largely publicly owned areas, there are a multitude of privately owned places where one can enjoy nature, such as prairie remnants, woodlots, aquatic situations along rivers and lakes, and privately owned “nature preserves.” (The publication by Evers & Page discusses selected natural areas in Illinois; single copies of this publication are available from the Illinois Natural History Survey.) **ALWAYS OBTAIN PERMISSION FROM THE OWNER BEFORE ENTERING PRIVATE PROPERTY.**

Gardens, Arboreta, Greenhouses, and Nurseries

The greatest varieties of plants in cultivation are found in large botanical gardens and arboreta (specialized gardens that grow only woody plants). Two gardens are in the Chicago region, the Botanical Garden of the Chicago Horticultural Society (at the junction of Lake-Cook Road and Interstate 94) and the Morton Arboretum in Lisle. Just across the river from Illinois is the Missouri Botanical Garden (Shaw’s Garden) in St. Louis. There are several smaller botanical gardens in Illinois, including the Lincoln Memorial Garden just south of Springfield and the Botanical Garden of the Champaign County Forest Preserve District. In

addition, certain city and county parks are worth visiting for their collections and displays of cultivated plants. Many of the state and private colleges and universities have a variety of woody ornamentals and beds of herbaceous plants on their campuses; some also have greenhouses for growing tropical plants. For example, the University of Illinois at Urbana-Champaign has a fine collection of woody ornamentals, is famous for its Trial Garden of Annuals and Bedding Plants (Fig. 15), and maintains nearby Allerton Park.

Interesting plants can also be seen at flower shows, from those of a local garden club to the Chicago Flower Show in McCormick Place. You can also explore plant shops, nurseries, garden supply stores, greenhouses, and florists. Even grocery stores, health food shops, and specialty or ethnic food stores are fascinating from a botanical point of view (many botany instructors obtain material for their classes from such stores).

While museums do not have collections of living plants, they do have very interesting and educational exhibits of various aspects of plants and plant products. Particularly noteworthy in Illinois are the Field Museum of Natural History in Chicago and the Illinois State Museum in Springfield.

Fig. 15. — Marigolds in the Trial Garden of Annuals and Bedding Plants at the University of Illinois. Such gardens contain many fascinating plants belonging to a number of genera and families, many of which do not occur wild in Illinois. (Photograph by Survey Photographer Leslie Woodrum.)

Vacation Areas

Keep in mind your interest in plants when traveling. Some of the plants found in Illinois can be found many other places, but the farther one travels from the state the more different will be the plants. Tropical areas are especially interesting for their abundance of colorful "exotic" plants. When traveling, begin to look for wild plants in state and national parks and for cultivated plants in botanical gardens.

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PLANT PHOTOGRAPHY

Plants have an innate beauty, with striking to subtle contrasts of texture, form, and color, and they have long been favorite subjects of photographers. Plant photographs are made for a variety of reasons: to record the occurrence of plants in particular locations or habitats, to use for future identifications, to communicate certain information about the subject to the viewer, and as an art medium through which impressions of the photographer are passed on to the viewer. Many enjoy searching for that elusive, rare species and "capturing" it on film.

Everyone wants to take "good" photographs, but what is "good?" Simply, a good photograph is one that pleases you. Many people are interested only in snapshots that help them later to recall pleasant moments and places. Serious photographers are more critical of their work and find that, while good photographs sometimes are produced by accident or by following "cookbook" guidelines, they come about more consistently when the photographer knows how to manipulate equipment and situations. The beginner will have to make numerous cautious, deliberate

decisions, but the motions of composing and taking photographs will largely become automatic as he gains experience by taking many pictures, analyzing them, and comparing them to photographs in books and magazines.

Equipment and Materials

Cameras

Almost any kind of camera can be used for plant photography. However, simple pocket, box, or "instant" cameras have limitations, and the single-lens reflex camera (SLR) has a number of attributes that make it particularly well suited for plant photography. In a SLR, a mirror behind the lens reflects the image through a prism into the eyepiece, and the photographer composes and focuses on an image that is exactly what will appear in the photograph. This feature is especially useful for close-ups and when using wide-angle or telephoto lenses. A photograph can only be as good as the lens that takes it, and nearly all SLR's have lenses of much better quality than those in simpler cameras. Most SLR's also have interchangeable lenses that allow for the control of perspective, built-in exposure meters that make accurate exposure determination dependable or even automatic, and adjustable shutter speeds and lens diaphragms for controlling exposures. SLR cameras that use 35mm film are by far the most popular, since they are small and easy to carry but yield high-quality photographs.

Films

The selection of the proper film suitable for your purposes is essential. The beginner can be overwhelmed by the variety of films, but they are of three basic types. Black and white film gives a negative from which black and white prints are made. Color negative film produces an orange-tinted negative from which color prints are made. Color slide film yields a positive color slide or transparency that is usually viewed with a slide projector. Films in each category are available in different film sizes and with different film speeds, which in the United States are rated as ASA numbers. A film with an ASA rating of 25 to 32 is, in relative terms, not very sensitive to light and is called a slow film. Films with an ASA of 64 to 125 are more sensitive to light and are medium-speed films. Films with an ASA of 400 or more are called fast. A film with an ASA of 25 requires twice the exposure (twice as much light to reach the film) of an ASA 50 film; the ASA 50 film requires twice that of an ASA 100 film, and so forth. Films with different speeds are made primarily to suit different light conditions, with slow films normally used in very bright situations and fast films in dim areas. Slow films have finer grain, can resolve more detail, and, for color films, have better color rendition than fast films.

Photographic film is perishable and should be used before the expiration date marked on the package. High temperatures can damage

film; so on hot days never leave film (or cameras) unprotected in an enclosed car. Instead, keep it in a small styrofoam cooler. Film that will not be used for several months should be stored in unopened containers in a refrigerator. There is some evidence that the X-ray machines used to inspect luggage at airports can damage film, and many photographers have their camera cases hand inspected.

Processing

Film should be processed as soon after exposure as possible. Color film can be sent to processing laboratories in prepaid mailers, which is especially convenient when traveling. When you take photographs with care, make sure they are carefully processed. All commercial processing is NOT of the same quality. Acceptable color processing is available from some film manufacturers and from laboratories that process work for professional photographers. If you need help finding reputable processors in your area, try asking operators of camera shops or professionals. Few photographic laboratories do quality processing of black and white materials, and most photographers develop and print their own.

Lenses

Most cameras come with a **normal lens** that has a picture angle and perspective similar to those of the human eye, and it is the most versatile lens for all-around shooting. Normal lenses have their limitations, and a camera that accepts interchangeable lenses allows for a great deal of creative flexibility.

There are several types of lenses. **Wide-angle lenses** have a wider angle of view than normal lenses, enabling you to get more into a picture. They are good for working in cramped quarters and for landscape and habitat photographs. A broad, panoramic perspective is produced by wide-angle lenses because they make objects in the foreground appear larger and those in the background smaller. Wide-angle lenses also have greater apparent depth of field (see below) than normal lenses.

Telephoto lenses have a narrower angle of view than normal lenses and are used to bring distant objects nearer. Because of their shallow depth of field, telephoto lenses are particularly useful in isolating a subject from the surrounding environment. The image produced by telephoto lenses has a foreshortened effect and gives the impression of flattening objects and compressing them together.

Macro lenses focus to within a few inches of an object and, unlike normal lenses, are designed to yield incredibly sharp images at close range. **Zoom lenses** incorporate a mechanism that changes the angle of view, and one zoom lens can replace the function of several nonzoom lenses. The usual range of zoom lenses is from wide-angle to normal or from short telephoto to medium-long telephoto, although there are other ranges. Of special interest to plant photographers are those zoom lenses that also feature close-up or macro capabilities.

Filters

Pieces of optical glass called filters come in a multitude of colors and mount in front of the lens to modify the color of the light that reaches the film. Haze, ultraviolet, and skylight filters are nearly colorless, but they remove ultraviolet light, to which film is sensitive, and many people use such a filter at all times to protect expensive lenses. A bluish filter can be used in early morning or late evening to correct for the excessive reddish color of light, and a reddish filter can be used to add warmth on cloudy days or in dense shade. Polarizing filters are quite useful, since they increase color saturation and contrast, which can result in striking deep blue skies, and they also reduce reflections from water and glossy leaves. When using black and white film to photograph plants, a light green filter should be used so that green foliage is rendered properly; without such a filter, green is sometimes rendered too dark.

Techniques

Imagine for a moment that you are in the middle of a prairie one day in May. The day is warm, the wind is brisk, the sun is shining in a brilliant blue sky, birds are singing, and the prairie is alive with colorful wild flowers and fascinating insects. Taken in by the whole scene, you hold a camera to your eye and press the shutter. When the film is processed, you are disappointed that the picture did not capture the prairie as you remember it. What happened? You have just learned that there are fundamental differences between what the eye sees and what the camera records. A photograph is two-dimensional and is arbitrarily framed by four straight lines. It will not include what your peripheral vision saw, the whole scene in perfect focus, or what your other senses perceived. It will not emphasize any of the points that fascinated you and will suppress none that you ignored. By learning how to visualize a picture while looking through the viewfinder, a photographer can select the camera position, kind of lens, and camera settings that will produce a photograph that conveys the photographer's impressions to the viewer.

Composition

Successful pictures display the visual information desired by the photographer clearly and succinctly. Every part of the picture will affect the viewer, and if the wrong elements are included or if the subject is presented in a confusing manner, the photographer's ideas may not be communicated. The material that is included should be arranged within the limits of the picture borders in such a way that the whole effect is pleasing.

Most plant photographs should be made without moving or disturbing the plants. When getting ready to take the picture, walk around the plant to find the best angle, distance, and height at which to place the camera. By carefully choosing the camera position, one can have much control over what will appear in the picture and how it will be arranged.

The use of wide-angle, normal, or telephoto lenses allows the photographer to control perspective and alter the relative sizes of near and distant objects.

Backgrounds

Be very careful to look at the background when composing the photograph. Is it cluttered, or does it have distracting reflections, crisscrossing lines, or visual elements that distract from or confuse the subject? If you want to isolate the subject against a uniform light background, try holding the camera so that the sky is behind the subject. For dark backgrounds, position the camera so that a deep shadow falls behind the subject. Grass and water make good backgrounds when they are out of focus. Plants generally look best when photographed in their natural surroundings, since this contributes much to the character and ambience of a photograph. Colored cardboard or cloth can be used as artificial backgrounds in some situations, but they should be used discretely.

Lighting

The intensity, color, evenness, direction, and degree of diffusion of light have great influence on how a scene is rendered in a photograph. Sunlight on a cloudless day is very harsh and contrasty, which gives sharp, crisp outlines and textures along with prominent shadows. On overcast days, the overall contrast is low, the lighting is very even, and there are essentially no shadows; many plant photographers prefer such lighting although the dim light may cause problems in making the exposure.

The direction of the light has a major influence on the depiction of depth and space in a photograph. To most people, most of the time, a semidiffuse light source that is above and to one side of the camera gives the most "natural" light. However, other types of lighting are better in some situations. Direct frontal lighting makes the subject appear flat, subdues form and texture, casts no shadows, and gives very even illumination. Sidelighting dramatically emphasizes the shape and surface texture of the subject and casts a prominent shadow on one side of the subject. Backlighting minimizes texture and the three-dimensional shape of a subject but emphasizes its outline; very dramatic photographs can result when backlighting gives a translucent glow to thin leaves and petals.

Daylight, when properly used, gives excellent photographs, and some use it exclusively. It is variable, however, and others prefer to use flash for many of their photographs, which solves several problems: there is always enough light for all but distant scenes, the color of the light is constant, exposures can be standardized, and the short duration of the flash "freezes" the motion of plants on a windy day. Disposable flash bulbs work well but are expensive to use; so most serious photographers use electronic flash units, of which there are many kinds. Perhaps

the best for plant photographers are those that have automatic exposure sensors and a variable light output, allowing the use of different f-stops to control depth of field.

Wind

One of the greatest problems for plant photographers is wind. Just when everything is set and adjusted, along comes a gust of wind and messes it up! There is no easy solution to this problem except patience. The air is quietest in early morning and late afternoon, but the light is poorest at these times. A sheet of clear plastic can be stretched between the plant and the wind. Very fast shutter speeds stop motion at the expense of depth of field (see Fig. 16). The use of electronic flash "freezes" most movement although plants constantly in motion are difficult to keep in focus. If the camera is mounted on a tripod and carefully positioned and focused, there will usually be occasional seconds when the wind dies down and the shutter can be released. It is often not worth the effort to photograph on extremely windy days.

Exposure

Many cameras have built-in light meters that set the exposure automatically or allow the photographer to obtain the correct exposure by matching a needle or indicator light. These meters work well in many circumstances, but creative plant photography requires that the photographer have a basic understanding of how to regulate the exposure.

The amount of light needed to produce the proper exposure is determined by the intensity of light falling on (and reflected to the camera by) the subject and by the speed of the film. There are two camera adjustments that control the amount of light reaching the film — shutter speed and lens diaphragm opening (aperture). The shutter speed is simply the duration of time that the shutter is open. This is usually a small fraction of a second: $1/2$, $1/4$, $1/8$, $1/15$, $1/30$, $1/60$, $1/125$, $1/250$, $1/500$, or $1/1000$. A shutter speed of $1/30$ of a second lets in twice as much light as a speed of $1/60$, $1/60$ essentially twice as much as $1/125$, and so forth. The lens diaphragm numbers, called f-stops, are not as easy to understand. Their sequence is: 1, 1.4, 2, 2.8, 4, 5.6, 8, 11, 16, 22, 32, and 45. Numerically low f-stops ($f/1.4$, $f/2$) are called wide apertures and let in more light than numerically high numbers ($f/11$, $f/16$, etc.), which are called small apertures. Adjacent f-stops let in half or twice as much light; for example, $f/2.8$ lets twice as much light through the lens as $f/4$ and half as much as $f/2$.

The shutter speed and f-stop work together to control the exposure. Suppose that the light meter in a camera says that the correct exposure can be obtained in a certain situation by setting the shutter speed at $1/125$ and the f-stop at $f/11$. The following combinations will also give this same exposure:

1/30 @ f/22
1/60 @ f/16
1/250 @ f/8
1/500 @ f/5.6
1/1000 @ f/4

In this example, one could use a fast shutter speed and a wide aperture or a slow shutter speed and a small aperture, but not a fast shutter speed and a small aperture. What difference does this make? Fast shutter speeds can stop motion, such as flowers in a breeze, while slow shutter speeds cannot. Wide apertures produce a shallow depth of field, while small ones produce a deep depth of field. Pictures made at the two extremes are quite different (Fig. 16).

Depth of Field

Understanding and learning to control depth of field is a great aid in producing good plant photographs. When a lens is focused on a point a certain distance from the camera, other points in front of and behind the central point will also be in focus, while still other points farther in front of and behind the central point are not (Fig. 16). The zone in which everything appears to be in focus is called the depth of field. The depth of this zone is dependent on several factors. It is great when the camera is some distance from the subject and progressively decreases as the camera is moved toward the subject, becoming very small indeed in extreme close-ups. The size of the aperture also affects depth of field, with a wide f-stop, such as f/2, producing a much shallower depth of field than a small f-stop, such as f/22. Also, wide-angle lenses have an apparent depth of field that is greater than normal lenses, while telephoto lenses have a shallower depth of field.

Habit Photographs

The purpose of a habit photograph is to make a portrait of a whole plant, or large parts of it, and frequently to include something of its surroundings as well. There are two basic, somewhat contradictory, requirements in such photographs. The first is obtaining enough depth of field to include in focus all of the structures of the plant that need to be shown. Secondly, the plant must be photographed so that it stands out from the background. It can be quite a problem to satisfy both requirements. In some instances, careful selection of the f-stop will allow the plant to be in focus while the background is not. The use of a telephoto lens, with its shallow depth of field, can also help to isolate the subject. In a few rather special situations, excellent habit photographs can be obtained by using a wide-angle lens and moving the camera rather close to emphasize the subject while the background is rendered only slightly out of focus. The selection of the proper lighting can also help to isolate the plant; for example, having the subject in bright light while a shadow falls on the background.

Fig. 16. — Depth of field. A, $f/4$ @ $1/1000$ second — the depth of field is very shallow and not enough to include all of the subject in sharp focus; B, $f/8$ @ $1/250$ second — the depth of field is enough for all of the subject to be in focus, while the background is out of focus; C, $f/16$ @ $1/60$ second — the depth of field is so great that much of the background is in focus, which distracts from the subject; and D, $f/32$ @ $1/15$ second — the slow shutter speed is not fast enough to “freeze” the slight movement of the subject. All photographs were taken from the same location of the same plant using ASA 125 film on a bright cloudy day. (Photographs by Kenneth R. Robertson.)

Close-ups

Simple cameras generally focus to about 5 feet from an object and 35mm SLR's to about 18 inches. Special techniques are required to focus closer, and then a whole new world of plants is revealed. It becomes possible to fill a whole picture with small subjects such as beautiful but tiny flowers, colorful fruits, and Lilliputian mosses. The discussion here is limited to techniques used with SLR cameras; information on taking close-ups with simple cameras is available in the references.

There are several ways to obtain close-ups. The simplest and least expensive way is with supplementary close-up or portrait lenses that attach to the front of normal lenses. These are often sold in sets of three different strengths and allow focusing down to about 9 inches and an image that is approximately one-quarter life size. Special high-quality macro lenses that focus continuously to produce an image one-half life size or even life size are made by most lens manufacturers, and professional botanists consider such lenses standard equipment. To get even closer and produce images larger than life size, extension tubes or bellows are inserted between the lens and the camera body. Special devices called teleconverters are not, strictly speaking, made to produce close-ups; rather they are optical lenses that convert normal lenses into short telephotos. However, when used with small lens apertures and an electronic flash, a teleconverter and a normal lens can be very effective for close-ups.

There are several inherent difficulties in close-up photography. Depth of field is very shallow, even at small apertures, and careful focusing and composing are critical. Any movement of the camera or subject is amplified in close-ups, and it is often necessary to use a tripod. Lighting is sometimes difficult; a fairly high intensity is usually needed, yet the camera is so close to the subject that it interferes with natural light. Some people routinely use a bracket that holds two small electronic flash units, one on either side of the camera, for close-ups.

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WILD PLANT CONSERVATION

Increasing awareness of the environment combined with urban spread and expanding agricultural use of land in Illinois have created a paradox—there are fewer and fewer natural areas where plants grow wild, but at the same time, there are more people who want to “get back to nature.” Many species of plants that were once common in Illinois are now quite rare or even no longer found in the state. People who study plants in nature must be aware of this situation, respect rare plants, and assure that these plants will remain in Illinois for future generations to enjoy. Similar practices are followed by people who return from African safaris only with photographs of live animals.

People who want to grow native plants, especially wild flowers, in their gardens should not remove any from the wild but the most common species. Remember that plants may NOT be removed from state parks, state forests, nature preserves, and certain other areas. However, a number of commercial nurseries in Illinois specialize in growing and selling wild flowers.

Some species of plants are legally protected by the Illinois Endangered Species Act, the Federal Endangered Species Act, and the Convention on International Trade in Endangered Species of Wild Fauna and Flora. For information on endangered species in Illinois, contact Endangered Species Program, Department of Conservation, Springfield, Illinois 62701.

COLLECTING PLANTS

Throughout this booklet, thus far, the emphasis has been on observing plants without disturbing them. However, it would be absurd flatly to say “Don’t Pick the Flowers!” There are situations where it is possible and necessary to make plant collections, both in nature and in gardens.

Again, no plant collections of any kind may be made without permission in state and national parks, nature preserves, botanical gardens, arboreta, private property, and certain other areas.

Plants are collected for a variety of reasons:

- 1) To make small samples for later identification and discarding. Such

samples can usually be made without harm, where it is legal to do so, except for rare plants. If you see only a few individuals of a species, do not disturb them.

- 2) To make pressed and dried herbarium specimens for school projects or to add to local or personal collections. This was once commonly done, but is less frequent today due to the few areas remaining in Illinois where collections can be made and due to a change in the study of botany from emphasizing identification to understanding the whole plant, including its chemical processes. Rare plant species usually should NOT be collected for such purposes, and underground parts of perennial plants should be left in place.
- 3) To make herbarium specimens for research collections. Several of the large universities in the state as well as the Illinois Natural History Survey, the Illinois State Museum, the Field Museum of Natural History, the Morton Arboretum, and in St. Louis, the Missouri Botanical Garden have research herbaria containing from 100,000 to several million specimens. Because of their research nature, these collections are not normally open to the public, although some can be visited by special arrangement. Plant collections for such herbaria are nearly always made by professional botanists or dedicated and experienced amateurs.

Herbarium Specimens and Herbaria

A herbarium specimen is a pressed and dried plant, or part of a plant, fastened to a sheet of heavy paper and accompanied by a label that gives information on what the plant is, who collected it, and where and when it was found (see Fig. 18, 0). It is a permanent record of a particular plant growing in a particular place at a particular time. Such a collection of plant specimens is a herbarium (plural, herbaria).

The method of making herbarium specimens originated in Italy around 1530, and some specimens dating from the 16th century are still in existence and are remarkably preserved. Shown in Fig. 17 is a photograph of a specimen in the herbarium of the Missouri Botanical Garden that was collected by Banks and Solander in 1768 on Captain Cook's first circumglobal voyage. Thus, in human measures of time, properly cared for herbarium specimens are permanent. The earliest herbarium specimens were bound together into books, and some amateurs still like to do this today. However, it was soon discovered that if the individual sheets are left separate, with only one collection of one species on each sheet of paper, then the specimens are much easier to study and can be arranged so that all specimens of a species are grouped together regardless of the time of their collection. Today, all specimens of a species are placed in one or more manila folders, which in institutional herbaria are housed in special metal cases (see Fig. 20). All species of a given genus are filed sequentially, and usually, all genera of a family are also filed

Fig. 17. — A herbarium specimen collected in 1768 by Banks and Solander on Captain Cook's first voyage around the world; this specimen is in the herbarium of the Missouri Botanical Garden.

sequentially. The families, in turn, are arranged either alphabetically or according to a classification scheme.

At first glance, a dried, often brownish, two-dimensional herbarium specimen bears little resemblance to the living, colorful, three-dimensional plant that it once was. Nevertheless, much useful information is preserved in herbarium specimens, such as leaf, floral, and fruiting characteristics. Most research on the identification, naming, and classification of plants, as well as the compilation of floras, is based on the study of herbarium specimens. In the herbarium, plants that originally grew in many different localities at different times can be examined and compared simultaneously. For example, when studying the yellow-wood tree (*Cladrastis lutea*) recently, I was able to examine at one time herbarium specimens from eleven states (plus China and Japan for the Asiatic species) collected from the early 1800's to the present at all stages from flower, fruit, and foliage to winter twigs and buds.

How to Make Herbarium Specimens

The basic idea in making a herbarium specimen is to collect a live plant, press it flat, dry it to prevent decay, prepare its label, and mount the specimen and label onto a sheet of paper. There are many variations of each of these steps. A basic technique for ferns, conifers, and flowering plants is given below; more detailed information is available in the references. Brief discussions on the collection of the lower plants is given at the end of this unit.

Vascular Plants

It is essential to collect plants at the proper stage for identification. All specimens, except those made for special purposes, should have flowers and/or fruits in addition to stems and leaves. Frequently, you must know something about the plant group before good collections can be made. For small herbs, collect the whole plant: if the plants are tiny, collect enough to cover about three-fourths of the newsprint in which the plants are pressed. For herbs that are too large to fit onto the newsprint, select parts representing the inflorescences, upper leaves, and lower leaves. For woody plants, collect enough of the plant to fit onto the newsprint; again, include flowers and/or fruits with the leaves. To prevent wilting, the plants must be IMMEDIATELY either pressed in the field or placed in a moisture-retaining container, such as a heavy plastic bag. If one is going to collect only a few specimens at a time, a large-sized magazine can work as a substitute for a field press. Field observations for each specimen should be recorded in a small notebook or on field labels. Details to be noted include flower color and scent, height and habit of plants too large to fit whole into the plant press, habitat, names of some of the other plants in the same habitat, locality as precisely as possible (so that another person could find the site again), date of collection, relative abundance

of the species, and any other information not obvious on the dried specimen. Give each collection a collection number.

To press the specimens (this process is illustrated in Fig. 18), take one frame end of a plant press and place it on your work surface. Put one cardboard ventilator on it, a blotter on the ventilator, and an opened sheet of newsprint on the blotter.

Place a plant specimen on the newsprint and arrange it carefully, since little can be changed once the specimen is dry. Large herbs must be folded one or more times to fit onto the newsprint. Thick roots, tubers, bulbs, and fleshy fruits should be cut in half to facilitate drying. Be sure to turn over a few leaves to show both upper and lower surfaces and avoid too much overlapping — all plant parts should be visible. Remember that the specimen will eventually be mounted on paper and only one side will then be visible. Place the field label in the newsprint folder or write the collection number on the outside of the newsprint. When the specimen is arranged to your satisfaction, carefully fold the open half of the newsprint over the specimen.

Place a blotter on the newsprint and a cardboard ventilator on the blotter. Press down firmly to compress the specimen. You are now ready to proceed with the next specimen by placing a blotter on the ventilator and repeating the sequence: ventilator, blotter, newsprint and specimen, blotter, ventilator, blotter, and so forth. When all the specimens have been pressed or the stack is high enough to fill the plant press, place a ventilator and the other frame end on top of the stack. Run the straps around the whole unit and draw the straps as tight as you can get them.

Plants left in a plant press without further attention will rapidly mold and begin to decay. To prevent this, they must be dried. Open the plant press about 12 hours after the plants were put in it and replace the wet blotters with dry ones. This process is repeated once a day until the plants are dry, usually about a week. Excellent specimens can be obtained in this way, but the procedure is very time consuming, and the wet blotters must be dried before reuse. The drying of specimens is greatly speeded by causing warm air to flow through the plant press. Many ingenious methods can be devised to do this, such as placing the plant press on its side over a hot air register, tying it to the roof of a moving car (except in rainy areas), or suspending the press over a source of heat. If you will be doing quite a bit of collecting, it is worthwhile constructing a simple apparatus for drying plants (Fig. 19).

When using artificial heat for drying plants, remember that only WARM air is necessary — too much heat can discolor the plants and can be DANGEROUS as well, since the plant press is flammable — and that the warm air must flow THROUGH the plant press to remove moisture. Heating the plants without ventilation, such as by placing them in an oven, cooks and discolors the plants without drying them.

The dried specimens are ready to be mounted onto sheets of paper,

Fig. 18.—How to make a herbarium specimen. A, the living plant; B, collecting the plant; C, folding the plant to fit into the newsprint; D, folding the newsprint over the plant; E, tightening the straps on the plant press; F, the plant press on a plant drier frame; G, the dried specimen; H, coating a cookie sheet with white glue; I, pressing lightly on the specimen to make sure that glue is transferred to it; J, placing the specimen onto a sheet of mounting paper; K, gluing the label onto the mounting paper; L, covering the glued specimen with a sheet of waxed paper; M, putting the specimen, enclosed in a newsprint sheet, into a plant press for the glue to dry; N, reinforcing stems with straps of household cement; and O, the finished herbarium specimen. (Photographs by Kenneth R. Robertson.)

Fig. 19. — Making a plant drier. A frame (A) is made of plywood or sheet metal about 18½ inches wide, 18-24 inches tall, and 18 inches or more long. A strip of wood or metal is placed around the inside of the frame about 2 inches from the top to hold the plant press (B). A cardboard piece (C) is used to cover any space between the press and the end of the frame. Any one of the following can be used as a heat source: 1. light bulbs (D) attached to the floor of the frame (be sure to cut holes (E) in the sides of the frame to allow air to enter the frame); 2. an electric space heater with a fan (F) or a hair drier (G) mounted to an opening in the side of the frame (holes are *not* needed in the sides of the frame for additional ventilation with a blower); or 3. a small kerosene lamp (H) placed on a fireproof base on the bottom of the frame (ventilation holes in the sides of the frame are needed when using a kerosene lamp). **WARNING:** Construct and use any type of plant drier very carefully, since the materials in the plant press and, if wood is used, the plant drier itself are highly flammable. (Drawing by Survey Illustrator Lloyd LeMere.)

which should be 11½ by 16½ inches, quite heavy in weight and stiff, of 100-percent rag content, and vellum or mat surfaced. The most readily available, suitable adhesives are white glues (water-polyvinyl or water-aliphatic emulsions) and certain household, all-purpose cements (soluble resin in a quick-evaporating solvent); NEVER use transparent cellulose tape, rubber cements, contact cements, spray-can adhesives, or acidic library pastes.

To mount a specimen (Fig. 18), pour some diluted white glue on a hard, waterproof surface (cookie sheet, glass, plastic) at least 12 x 17 inches and coat it with a thin layer of the glue. Lay out the plant speci-

men on the mounting paper to determine the best way to fit it on the sheet (leave space in the lower-right corner for the label), pick it up and put it on the glue-coated sheet, press it lightly to make sure that glue is transferred to the back of the plant specimen, and then put the specimen back on the paper in its predetermined position. Pressure must be applied to hold the specimen against the paper until the glue dries. One way to do this is to cover the specimen with a sheet of waxed paper, place it within a newsprint sheet, put it in the plant press, tighten the straps moderately, and leave it overnight. If, after drying, some parts of the specimen need reinforcement, apply some all-purpose, household cement in straps across the specimen.

A permanent label should be placed on the lower right-hand corner of the herbarium specimen sheet. The paper used for the labels should be 100-percent rag content, 20-pound stock, cut approximately $2\frac{3}{4}$ by $4\frac{1}{4}$ inches. The scientific name of the plant is spaced by itself in the upper quarter of the label. Then comes the following information: the precise locality of collection (state, county, and distance and direction from the nearest municipality); habitat; notes from the field label or notebook on habit, flower color, etc.; whether the plant is cultivated or not, date of collection; name of collector(s); and collection number. The label is fastened to the mounting paper with white glue.

Mounted herbarium specimens should be properly stored to prevent physical damage. The specimen sheets can be placed in heavy manila folders. In a small plant collection, all species of a genus may be placed in one folder. As the collection grows, each species may need its own folder(s). Herbarium cases can be made in a home or school workshop (plans are available from the Section of Botany and Plant Pathology of the Illinois Natural History Survey). However, most amateurs keep their specimens in cardboard boxes. All herbarium specimens are susceptible to attack by certain insects, particularly the tobacco or cigarette beetle. To prevent damage, it is usually necessary to use an insect repellent or insecticide. The most commonly used chemicals are paradichlorobenzene or naphthalene (moth balls). Recently, segments of No-pest or Vapona strips have been used. All of these materials are **DANGEROUS**; so read and follow the directions carefully. If your specimens are stored in cardboard boxes, they should first be placed in large plastic bags (trash-can size) with some of the chemical added to the bags before they are sealed.

Mosses and Liverworts

These plants are collected by simply cutting or pulling a sample from the substrate on which it occurs. Capsules are generally needed for identification. When collecting, make careful, specific notes on the substrate (for example, limestone ledge, wet sandy soil, decaying oak log, bark of juniper tree). The samples can be put in paper bags, which are set in a sunny or airy place until the samples are dry. Do NOT leave

specimens in plastic bags, since they will mold. The specimens can also be placed in a plant press, but use very gentle pressure. The dried collections are placed in individual packets made from high-quality typing paper and folded to approximately 4 x 6 inches. A label containing the same basic information as for flowering plants is glued on the front of the packet. Most amateurs find shoe boxes or metal card file cabinets good containers for the storage of the packets. Since mosses and liverworts are so small, a hand lens and fine dissecting tools are essential, and stereo and compound microscopes are often required for positive identification.

Algae

Nearly any body of water will contain some algae. Filamentous algae can be collected by hand from masses, and the samples are placed in vials or collecting jars. Many of the less conspicuous filamentous forms are found as films on aquatic plants, and the plant parts containing the algae may be placed in vials. Submerged glass, shells, and pieces of pottery and wood also serve as substrates for many algae. Blue-green and rare freshwater red algae may be collected from the rims of dams or the edges of stones in flowing water. Marine species of red and brown algae may be found on beaches, in tidal waters, and on rocks and other substrates along beaches in marine waters. Microscopic algal species in open waters are best taken with a plankton net; these are commercially available from most biological supply houses. Most algal samples are poured into shallow trays of water for sorting and examination. Many algal species will remain viable for varying periods of time if kept in a refrigerator. Some collectors prefer to preserve their large algal samples as herbarium specimens. This may be done by floating the algae onto cards or stiff paper. These specimens are allowed to dry, and they may then be filed in the herbarium. Algal samples may be preserved indefinitely in vials of preservative prepared with 6 parts water, 3 parts 95-percent alcohol, and 1 part commercial formalin. A compound microscope is usually necessary for the study of freshwater algae. However, a simple hand lens or a stereo microscope may be adequate for study of the larger marine species.

Fungi

To collect fleshy fungi, use a sharp knife to cut all visible parts away from the substrate. Handle fungi very carefully and place the specimens in individual paper bags or small boxes, which in turn, are best carried in an ample basket. Make copious notes on the habitat and substrate and on the color, shape, size, and consistency of the fungus, since these change upon drying. Dry the specimens in opened paper bags or on screens that have been placed over plant driers. When dry, the specimens are stored either in packets like those used for mosses or in small boxes. The label is glued to the packet or box. Most fleshy fungi can be identified without any special equipment.

Lichens

Lichens are usually collected by using a knife to cut or scrape the plant body from its substrate; to remove lichens growing on rock, a hammer and chisel may be necessary. Specimens should be large enough to show the characters of the species, and large, entire samples are better than numerous small fragments. Some lichens that are dry and brittle can be collected more easily if they are first moistened. Specimens are normally collected in paper bags; never leave them in plastic bags, as they will discolor and mold. Many lichens do not need to be dried, while others can be air dried in paper bags or placed under *gentle* pressure in a plant press. The dry specimens are stored in packets like mosses. Many lichens can be identified without any special equipment except a hand lens, but precise technical identification often requires the use of simple chemical tests.

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Fig. 20. — Part of a herbarium case in the Illinois Natural History Survey, showing how the specimens are filed in manilla folders and housed in metal cases. (Photograph by Kenneth R. Robertson.)

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Fig. 21. — ANSWERS TO FIG. 2 ON PAGE 4.

A, asparagus (young stems); B, lettuce (leaves); C, tomatoes (fruit, a berry); D, artichoke (young inflorescence with bracts); E, apple (fruit); F, pineapple (multiple fruit); G, turnips (taproot); H, potatoes (tuber); I, sweet potatoes (swollen root); J, celery (leaf petioles); K, cabbage (leaves); L, Jerusalem artichoke (tuber); M, carrots (taproot); N, green beans (fruit); O, assorted dry beans (seeds); P, corn-on-the-cob (inflorescence with grains); Q, radishes (taproot); R, peanuts (fruit with edible seeds); S, onions (bulb); T, plums (fruit, a drupe); U, peas in the pod (fruit with edible seeds); V, hazelnuts (fruit, a nut); W, broccoli (inflorescences); X, bananas (fruit); Y, orange (fruit); Z, wheat (fruit, a grain); AA, bell pepper (fruit); BB, strawberries (aggregate fruit); and CC, beet (taproot). (Drawing by Survey Illustrator Lloyd LeMere.)

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Big blue stem (*Andropogon gerardii*) (Photograph by Kenneth R. Robertson).

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