FLORICULTURE

Fundamentals and Practices

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SECOND EDITION

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FLORICULTURE

PREFACE TO THE SECOND EDITION

Floriculture is not static. Constant changes are occurring in methods of culture brought about largely by the advances made by research workers in the various Federal and state agricultural experiment stations. In particular pest control measures have undergone such great changes that the recommendations made in the previous edition are completely out of date. To a lesser degree advances in the control of moisture in the soil have likewise been striking. As a consequence, a revision of certain chapters in this book was deemed necessary to bring it up to date.

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PREFACE TO THE FIRST EDITION

This book has been prepared primarily as a text for the teaching of a course dealing with ornamental plants. Although many books have been written about individual plants or groups of plants used in the gardens, very few contain precise information dealing with the many crops and phases of ornamental gardening. Many such books, written for the layman, have been compiled by enthusiastic gardeners, dipping into their own personal experiences for their information. As a consequence the practices frequently recommended are based on local conditions and usually on biased hearsay.

The authors have attempted to put together in a brief but accurate form the basic information underlying the many empirical practices and at the same time to provide material that would serve the general coverage of a course intended either for students in horticulture who need it to round out their general course or else to aid those who wish to secure information in compact form for cultural purposes.

The more recent practices and the theories underlying them are presented so as to keep the student and the gardener aware of the newer developments. Among these may be listed the soilless culture of plants, growth-promoting substances, modern methods of pest control, and the latest findings in soils and fertilizers.

Largely because of lack of space and partially because the book is not intended as an appreciation course but one strictly informative in nature, little historical information is presented. Likewise, the review of literature has been omitted, and no specific references are given. However, selected references for more detailed information have been presented wherever possible.

The nomenclature of woody plants is based on the Manual of Cultivated Trees and Shrubs, by Alfred Rehder (2d ed.). All other plant materials are from Hortus by L. H. Bailey (1935 ed.).

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CHAPTER I

HOW PLANTS GROW

Seed-bearing plants are made up of several distinct parts—roots, stems, leaves, flowers, fruits, and seeds. The tissues in these parts serve for support, storage, conduction of sap, and protection and consist of individual cells.

Each cell consists of the living protoplasm surrounded by a cell wall. Protoplasm is composed of proteins, fats, minerals, water, and various other compounds, but this mere mixture of chemical compounds does not indicate its importance. Actually it is the seat of all physiological processes within the plant that are associated with growth. The cell is composed of a nucleus which is separated by a nuclear membrane from the rest of the protoplasm—called *cytoplasm.* The nucleus contains two substances, the nuclear gel and the chromatin. The latter is an important substance aggregating into definite bodies, sometimes rod shaped—called *chromosomes*—which are now properly regarded as the bearers of hereditary characters transmitted from one generation to another. The *cytoplasm* contains the plastids—leucoplasts (transparent bodies which may either develop into chloroplasts or function in the deposit of starch)—and chromoplasts, which contain the colored plastids. The green-bearing chromoplasts are known as *chloroplasts* and contain the green pigment known as *chlorophyll.*

Tissues. A group of cells performing a common function is known as a *tissue.* The basic type of tissue from which the others develop is known as the *parenchyma,* or *ground* tissue, and is composed of thin-walled cells which are not much longer than they are wide. Individual cells may be of various shapes. The cells in an active state of division, particularly in the tips of roots and stems, constitute a meristematic tissue. Parenchyma tissues are found throughout the plant and function in food formation and storage. The outermost layer of cells ensheaths the entire plant body and is known as the *epidermis.*

Collenchyma tissue is composed of elongated cells with thickening occurring on long strips. This tissue is usually underneath the epidermis and functions as a temporary supporting tissue.

Sclerenchyma tissue develops from the parenchyma cells as the cell walls thicken and harden. These function as the supporting tissues and when mature lose their protoplasmic contents.

Xylem and *phloem* constitute the conducting regions of plants, or the vascular strands. The xylem cells are usually woody, elongated, and extremely varied in form. Their chief function is support and the conduction of water. Phloem is composed of various types of cells, but the most characteristic is the sieve tube, which consists of long, thin-walled living cells with large cavities. Their chief function is the conduction of foods and transport of inorganic substances.

Roots. Roots are usually the underground portions of plants serving the functions of anchorage and absorption of water and inorganic salts in solution. Not all roots develop in the soil, however. Exceptions may be noted in the banyan tree, the orchid, *Vitis,* and many other plants where the roots are aerial, either throughout life or in the initial stages of development. Since stems may be found underground, the basis for distinction between the roots and the stems depends on the structural differences. Roots do not produce leaves or flowers directly and have no nodes or internodes. Roots may develop adventitious buds which make possible the vegetative propagation of many horticultural plants. Stem tips do not have such a protective covering as the root cap, and the arrangement of the internal tissues of the primary root is different from that of the primary stem.

The essential difference between the root and the stem in structure is the arrangement of the fundamental, or primary, vascular tissues. In roots the primary xylem and phloem are arranged radially; in the stem they are arranged concentrically. The primary xylem of the root is always exarch (development of cells toward the center), whereas the usual arrangement in the stem is endarch (development of cells toward the outside). After secondary thickening has occurred, the arrangement of the vascular tissue in the root and the stem is similar.

The root characteristically lacks pith, although it may occasionally be found in the roots of some herbaceous dicots or monocots. The pericycle of the root is a more active tissue than that of the stem, where it may be lacking, as in certain woody stems. The pericycle of the root is the tissue from which arise the lateral roots as well as a region contributing to the formation of adventitious shoots. Fibers are sometimes associated with the pericycle in stems. The commercial fibers of hemp and flax are of this type. The endodermis is found in both the root and the stem but may not be so prominent in the stem as in the root. In the stem it may lack the characteristic thickenings of the radial and end walls or the Casparian strip. The cortex of the root is usually a thicker layer in proportion to the axis than in the stem. The tissue is often less dense with more intercellular spaces. Frequently it sloughs off. As secondary thickening occurs, it is replaced by a periderm which is derived from pericycle. The epidermis of the roots is continuous and usually of one layer with a number of root hairs at the tip of the root which are short-lived. In roots of plants with no secondary thickening, as in some monocots and some dicots, it may persist for several years or for the life of the plant. The epidermis of the stem is continuous except for stomatal or lenticellular openings. It may have epidermal projections such as epidermal hairs, prickles, thorns, or other emergences.

Roots may be classified as primary, secondary, and adventitious. The primary root is the first developed by the germinating seed and usually grows downward. From its pericycle tissue which surrounds the woody region of the root, the secondary roots force their way through the surrounding tissue and reach the soil. Adventitious roots may develop from cut ends of stems or near the nodes of prostrate stems. In English ivy and others they may develop all along the stems.

The direction and extent of the growth of roots are influenced by several factors. Of these the most important are gravity, light, temperature, soil texture and structure, soil minerals, soil acidity, soil oxygen, and moisture supply. The downward trend is attributed to gravity or positive geotropism, and light usually has little effect upon the direction or extent. Temperature of the soil plays an important part in the absorption of salts; adequate supplies of oxygen and moisture are extremely important in the extension of the root systems. Improper aeration and poor drainage are the great contributing causes of stunted plant growth provided the nutrient supply and the soil reaction are favorable.

The functions of roots are those of absorption, conduction, anchorage, and storage. Absorption is normally the function of root hairs, which are protrusions of epidermal cells occupying a region a few centimeters long, extending backward from a point about a centimeter behind the tip. The delicate wall of the root hairs molds itself to the soil particles, causing an intimate contact. Root hairs function for a short time and then die off; when they do, the external cortical cells of the root become corky and their power of absorption is lost. In practice, extensive use of roots is made in propagation.

The actual method of absorption of water from the soil is by imbibition (soaking up by hydrophilic colloids, since root hairs consist largely of such), which then makes possible the process of osmosis and the movement of water inside. This occurs because of the presence of a semipermeable membrane and the occurrence of higher concentration inside the cell than out, which produces the movement inward. In simple language, water moves from where it is to where it is not.

The root hairs developing in the soil are surrounded by films of water. The removal of such a film by absorption inside the root hair causes the films from adjacent particles of soil to be drawn on producing an actual movement of water toward the roots. This is not a sucking process but is due to the action of kinetic energy of the molecules of water. (The actual passage of the water from the root hairs into the plant occurs through the direct channel to the xylem by way of the endodermis, in the pericycle which in the root lies next to the xylem.) Upon intake of the water into the root hairs, these become more turgid; and with the greater turgor pressure, passage is assured from one adjoining cell to another. Once the water reaches the xylem elements, which consist of dead cells, it is carried to all parts of the plant largely by physical forces.

The processes involved in the absorption of inorganic salts by root hairs are complicated and not very well determined. Simple diffusion is thought to be responsible for the intake of minerals. The permeability of protoplasmic membrane to certain minerals may cause them to diffuse into the cells independently of the movement of water. The plant has little power of selectivity, and toxic as well as nontoxic substances may enter if the membrane is permeable. It likewise should be understood that dissolved substances move by diffusion only from the regions of high concentration to the lower. Thus, to secure the intake of ammonium sulphate into the plant, its concentration is usually higher in the soil than it is in the cell sap of the root hair. The same principle produces a decreasing concentration gradient from the cell of the root hairs to the xylem and makes for a continued absorption and movement of salts. There is some evidence now which indicates that salts or ions may be taken from a soil where the concentration is very low into a plant where there is actually *more* of the same salt substance or ion.

Stems. The stem is that part of the plant which furnishes a mechanical support for the leaves, flowers, and fruits and provides a path for the passage of foods and water between the tops and the roots. Stems may be erect or prostrate; and although they occur most commonly aboveground, many plants have underground stems. Stems arise from buds; they possess nodes and internodes and usually bear leaves and buds.

Internally at the tips of stems of dicotyledons occur dividing cells called the *apical meristem.* These cells upon differentiation give rise to the epidermis, cortex, phloem, cambium, xylem, and pith in that order from the outside in. They constitute the primary body, which to an extent produces the growth in length and thickness. In the dicotyledons the diameter growth is developed by the secondary tissues, which are derived from the cambium. (These consist of the interfascicular cambium which arises between the vascular bundles and produces the secondary xylem contiguous with the primary xylem and the secondary phloem.) In the cortical region a cork cambium may be differentiated which lays down a layer of cork, or phelloderm.

Monocotyledonous stems have no cambium as a rule, so that secondary growth does not occur. If occasionally traces of cambium are present, they are functionless. Monocotyledons are thus composed of primary tissues differentiated from the tip by meristems and those located in the regions of the nodes and near the bases of the leaves.

The ascent of sap in plants has been ascribed to many factors, such as root pressure, atmospheric pressure, capillarity, and cohesion, but the theories concerning most of these have not been substantiated by facts. The most plausible theory advanced to date is that of cohesion. It is assumed that water is drawn up through the xylem by a pull applied at the top of the water column and that this is transmitted through the cohering water in the vessels and tracheids. During high transpiration this pull is exerted by the evaporation of the water from the leaves. Any deficit of water that occurs in the hydrophilic colloids of the cells near the top of the column may be compensated by exerting a pull on the vessels. Because of the tensile strength of the water itself, such a water column is not broken.

Water and inorganic substances are conducted upward through the xylem and the phloem, and the principal channel for the movement of foods is in the phloem. Proof of this has been demonstrated by chemical analyses of the cells, the structure of the sieve tubes, and girdling tests.

Leaves are important in performing the function of food manufacture, although stems and roots play their part in the process. They usually arise in buds, which are the undeveloped growing points of stems. Complete leaves consist of a blade, a petiole, and stipules, although some are sessile, *i.e.*, possess no petiole; and some have no stipules, or they early abscise. Monocots have an ensheathing leaf base but no petiole. The petiole connects the leaf to the stem and serves as a conducting tissue to the leaf. Likewise, by bending and twisting of the petiole the leaf is brought into favorable positions for the absorption of light rays. The leaf blade is strengthened by veins which are composed of conducting tissue and thus serve to transport water and inorganic materials to the leaf and carry away the manufactured foods.

Each leaf has an outer layer or layers of cells called the *epidermis*, which is covered by a waxy layer called the *cuticle*. Where intense light and heat prevails, several layers of cells compose the epidermis. The tissue between the upper and the lower epidermis is known as the *mesophyll*. Both the lower and the upper epidermis layers may contain openings known as *stomata*, although in most plants they occur in the lower epidermis only. The stomata may be open or closed, depending upon the turgor of their guard cells. This opening and closing regulate the exchange of gases between the interior of the leaf and the outer air and are important in photosynthesis and respiration. Incidental to this gas exchange, water vapor may escape from the leaves entirely independently of the gases. This at times causes excessive water loss.

The structure and the position of leaves make them extremely important in two plant processes—transpiration and photosynthesis.

TRANSPIRATION

The release of water vapor from exposed surfaces of plants is known as *transpiration.* Because of the greater exposure of the leaf area, transpiration rate is greater from the leaves than from any other portion of the plant. Transpiration may be cuticular, *i.e.*, directly through the cuticle of the epidermis, or stomatal, *i.e.*, through the stomata. The former is responsible for only about 10 per cent of the total and therefore is not important. This depends upon the age of leaves—in young leaves, where stomata may not function, cuticular transpiration is important. Stomatal water loss may be exceedingly heavy and at times exceeds water absorption, which results in wilting. Then the turgidity of the stomatal guard cells decreases and causes the openings to close. Transpiration has been likened to evaporation; but it differs in that the living plant controls it, whereas evaporation goes on automatically from a free surface. Thus we find that dead plants may evaporate more water than similar living plants transpire.

The rate of transpiration depends on external and internal factors. The most important of the external factors are radiant energy, humidity, temperature, air circulation, atmospheric pressure, and soil conditions.

The visible rays of light as well as the ultraviolet and the infrared have their effects upon transpiration rate. The visible light causes the stomata to open, which increases the transpiration, and in addition the effect of absorption of radiant energy by the internal cells of the leaves produces heat and vaporizes the water. It is known that the 80 per cent of total radiant energy is absorbed by the leaves but only a small portion of it is used in photosynthesis, the rest being lost in transpiration. The transpiration rate varies with light intensity and is found to be greatest during bright days and particularly high between 1 and 2 P.M. when the light intensity is at its height.

Another factor that governs the transpiration rate is humidity—the amount of water vapor found in the vicinity of the transpiring surfaces. Since transpiration may be regarded as a diffusion process, the passage of vapor is from the concentrated condition of the internal cells to the less moist condition of the atmosphere. Therefore, when the relative humidity of the air approaches 100 per cent, the rate of transpiration decreases appreciably and, if the two concentrations are equal, may cease entirely. Advantage is taken of this situation during extremely hot days in the greenhouses in the summer. Frequent syringing of the leaves with water and maintenance of high humidity reduce transpiration and wilting under such conditions.

Air temperature has its effect upon transpiration. The higher the temperature of the air the higher the temperature in the plant, which causes greater vaporization. Lower temperatures reduce transpiration.

Circulation of air over plants tends at times to increase the transpiration by constantly removing the water vapor that emanates from the leaves and thus creating a greater difference in humidity between the air and the leaves.

Atmospheric pressure influences the rate of vaporization of water and hence influences the rate of transpiration. In general, the higher the pressure the lower the rate of transpiration. In high altitudes the pressure is low and the humidity is low, which increases the transpiration. Because of that fact we frequently find on plants growing in high altitudes special structures that prevent excessive transpiration.

Absorption of water from the soil affects transpiration indirectly. Low soil water content or extremely high soil solution concentration will reduce water intake and lower the transpiration. An amount of water in the soil sufficient for normal growth provides the best conditions for a high transpiration rate.

A number of internal factors exert an important influence over transpiration. Structures that reduce water loss are found on plants that grow in arid regions. Such plants are known as *xerophytes*.

The arrangement and the size of leaves have some effect on transpiration rate. In shady localities leaves are large and thin, whereas under extremely sunny conditions the leaves are small and thick. Spiny leaves in cacti and the needlelike leaves of conifers are modifications that serve to reduce transpiration to the minimum. Broad-leaved evergreens like rhododendrons are protected from strong light during the winter by the rolling of the leaves, thus exposing less surface.

Since the cuticle of the epidermis is effective in reducing water loss, except in young leaves where the cuticle is very thin, greater amounts of it are developed in plants that are evergreen or those which are exposed to extremes of light. All evergreens growing in temperate regions where the ground freezes in the winter and the water supply is limited have a protective covering to slow down transpiration, which goes on regardless of the water intake from the soil. In some cases waxy coverings serve such a purpose. Compact arrangement of cells in the mesophyll is responsible for reduction of transpiration.

The number, the size, and the position of the stomata also influence water loss. Since the velocity of the movement of vapor increases as the size of the opening decreases, the smaller and the more numerous the stomata the greater the loss. Obviously, leaves that contain stomata on both the upper and the lower surfaces transpire at a higher rate. The placement of stomata in depressions reduces transpiration by providing minute pockets of saturated air about these stomata.

An aid in reduction of transpiration comes from the cells that contain hydrophilic colloids (*i.e.*, those which absorb and hold water by imbibition). Such water is bound water and cannot be removed easily. The development of such cells in desert plants is responsible for their survival of droughts, and the same holds true for winter hardiness. Freezing effect is similar to drying, so that the greater the water-holding capacity of cells the hardier the plants. An excellent example of this hardiness is the wintering over of young lawn grasses seeded in the fall.

The age of the plant has an effect on transpiration. Usually the maximum amount occurs about the middle of the maturity period; and if at that time excessive heat occurs without compensating moisture, plants suffer.

Disease and insect injury may cause spots on leaves where the cuticle is destroyed and this will permit of greater transpiration. Clogging of vessels by fungi and bacteria may reduce the water supply, and in a similar manner proliferation and structural changes due to parasites may have a similar effect.

In view of the great losses of water that occur owing to transpiration, much speculation has arisen as to the actual benefit of the process in plant growth. Many theories have been advanced, but the most tenable one argues that transpiration keeps the plant tissues cool by reducing the effect of the energy absorbed from sunlight. This is true, but the actual necessity for transpiration for this purpose may be questioned when the case of the desert plant is considered. Were high transpiration essential under such conditions to maintain lower temperatures in plants, the special structures developed by desert plants to reduce transpiration would become useless. Hence even this theory is not entirely adequate, and further inquiry is necessary before the actual reasons for transpiration are known.

PHOTOSYNTHESIS

The second important function of leaves is the manufacture of foods by a process involving light and called *photosynthesis*. Although true that any green portion of the plant may synthesize foods, the leaves because of area and position are the chief organs for that purpose. However, organic nitrogen and carbohydrates are formed also in roots and stems.

Photosynthesis is a process of storing radiant energy of sunlight and a transformation to the potential energy in the manufactured carbohydrates. Not all the radiant energy is utilized, since only the visible portion of the spectrum is used in photosynthesis, and that forms 37 per cent of the total, the rest being infrared and ultraviolet. Of the visible portion, red gives the greatest absorption, followed by blue-violet, with green being last. Actually a very insignificant percentage of total energy incident to the leaf is utilized by plants in photosynthesis. It amounts to about 1 per cent; and yet in spite of this apparent inefficiency, photosynthesis is important in the extreme, since it is the one process that builds energy.

From the chemical composition of carbohydrates it is evident that there must be a supply of carbon, hydrogen, and oxygen in their synthesis. All these elements are obtained from two compounds—water and carbon dioxide. No other compounds obtained from the air are used in photosynthesis. Ordinarily plants obtain their water from the soil, although some evidence shows that water may be absorbed by leaves. It is absorbed by the roots and conducted from them through the stem to the leaf. The xylem vessels which form the plant's water system are essentially a series of very fine connecting tubes beginning at the roots, ending in the leaves, and containing branches to all parts of the plant, so that every cell is in close proximity to its water supply.

The carbon dioxide enters in gaseous form from the atmosphere, gaining entrance to the leaf through the stomata. Soils ordinarily contain more carbon dioxide than is found in the atmosphere, but it is improbable that any of this carbon dioxide of the soil is absorbed by the roots and used in photosynthesis. Ordinarily carbon dioxide exists in the atmosphere in small quantities, averaging 3 parts in 10,000 parts of air.

The rate at which carbohydrates are made by the plant depends upon the combined action of external and internal factors. The most important external factors are temperature, carbon dioxide supply, the intensity and quality of light, and the water supply. Two internal factors are important—the chlorophyll content and the action of a specific enzyme associated with the process.

In general, as the temperature rises above the minimum, the rate of photosynthesis rises in a geometrical ratio 1.0 for every 10° rise in temperature. The rate of photosynthesis increases 2 to 2.3 times until a temperature of 85 to 95°F. has been reached, beyond which no further increase in the rate occurs; in fact it may decrease.

Probably with the exception of light no other single external factor under natural conditions has a greater influence on the rate of photosynthesis than the carbon dioxide supply of the atmosphere. As previously stated, there is only three-hundredths of 1 per cent of this gas in the air. When it is artificially supplied, many common plants increase in weight until a concentration of about 0.5 to 1 per cent of the air is carbon dioxide. When the fact is borne in mind that this carbon dioxide is the only source of carbon for the plant and that carbon makes up about 50 per cent of the dry weight of the plants, the importance of an ample supply of the gas becomes apparent. The application of additional amounts of carbon dioxide to crop plants has been tried by many investigators, and from 30 to 300 per cent growth increases have been alleged as a result. Our tests in the greenhouses have failed to substantiate such results. Increases in the carbon dioxide content have been noted, but a corresponding increase in growth failed to materialize. Under the artificial conditions of the greenhouse in the winter, additions of carbon dioxide *must be supplemented with light,* which from artificial sources is too costly for practical purposes. In the summer with adequate light the additions of carbon dioxide are apparently nonproductive of results, presumably because of high existing temperatures.

The rate of photosynthesis increases as the light increases, up to a maximum point. Plants vary considerably as to this maximum point, but for most of them it is far below the intensity of light at noon. It has been found that poor daylight intensity during the summer can be reduced to one-twelfth its value before any decrease in the rate of photosynthesis occurs. Practically, the reduction of light by means of aster cloth outdoors and whitewashing the greenhouse glass in the summer have resulted in more satisfactory growth than when exposed to the full intensity. Under aster cloth the intensity is reduced by 30 to 40 per cent, or from 10,000 to 6,000 ft.-candles, with very beneficial effects. In some cases, as in *Saintpaulia,* the reduction of intensity to 500 ft.-candles is necessary before satisfactory growth occurs. The same may be said for many shade-loving plants. Since intensity begins to decrease rapidly after Aug. 15, any attempts to reduce light after that period should be done carefully. This is exemplified by the removal of shade on azaleas grown under cloth or lath late in August to ensure proper maturity and satisfactory bud set.

The duration of the light or the length of time that the plant is subjected to light will obviously affect the amount of carbohydrates produced. This factor becomes important during the short days of autumn and winter. It is of considerable practical importance in the production of greenhouse crops in winter.

Deficiency of water will affect the rate of photosynthesis, but this occurs usually when the supply is so low as to cause wilting. Ordinarily the water supply is only partially a limiting factor.

The carbohydrates made by photosynthesis are used in various ways. They are changed to soluble forms and carried to other parts of the plant, oxidized to liberate energy, and used in the making of other foods such as fats and proteins, in the construction of new tissues, and in storage for further use.

MANUFACTURE OF FOODS

The chemical changes that take place in the plant may be of two kinds—constructive and destructive. The first is represented by the process of photosynthesis—the building of carbohydrates and their further elaboration into other foods. The second is represented by the process of respiration—the breaking down of carbohydrates, the release of carbon dioxide, and the development of energy, incidental to that.

As we have noted previously, sugars are formed by photosynthesis in the leaves, but it is thought that the first product of this process is formaldehyde, which is immediately condensed into hexose sugars; and that these, through the action of enzymes, are changed to more complex compounds—carbohydrates—which, as the term indicates, are composed of carbon, hydrogen, and oxygen. These compounds are used as temporary foods to furnish the energy and materials for building plant tissues and as storage products for the future use of the plant.

Other compounds of similar carbohydrate nature, but serving a different purpose, are the gums, the pectins, and the celluloses. These form the structural framework of the plant and are present in cell walls. Another group of compounds produced is the glucosides. These, because of their bitter taste, serve a protective purpose in the bark and immature fruits. The pigment glucosides are responsible for the high coloration of many flowers. The tannins, belonging to the same group, may likewise serve in the protective capacity as agents preventing attacks of parasitic fungi.

Practically all plants contain compounds known as *pigments.* The chlorophylls are green; the carotinoids, flavones, and xanthones are yellow; lycopersicum and anthocyanin are red; anthocyanin derivatives are blue; and brown is characteristic of phycophaein and fucoxanthin. These different pigments play their role in the various metabolic processes that take place within the plants.

Organic acids are widely distributed in plants and are largely responsible for flavors in fruits. Fats form the most important energy supply in plants, whereas waxes are thought to be useful in the regulation of water losses from leaves, stems, and fruits.

In addition to the compounds mentioned above, an extremely important group is the one that contains forms of nitrogen.

These are known as *vegetable bases* and *proteins*. The functions of the vegetable bases are not clear. Some authorities think that they are waste products of protein synthesis. Proteins are very important in the life of the plant. They are a part of the protoplasm; in combination they are a part of the cell nucleus; they predominate in germ cells. Thus it is evident that they are vital to the well-being of the plants. Protein synthesis does not depend directly upon photosynthesis. It is accomplished by certain enzymes that condense amino acids into proteins—which are compounds composed of carbohydrates, nitrogen, sulphur, and phosphorus in varying ratios.

All these processes and changes are dependent largely upon the presence and action of enzymes—catalytic agents of chemical nature, building up synthetic materials and rendering foods soluble for translocation within the plant structure.

RESPIRATION

This important process in the growth of plants is nothing more than the absorption of oxygen and the release of energy, carbon dioxide, and a small amount of heat. Essentially it is the breaking down of foods, and its importance becomes obvious when we realize that accumulated foods have no value unless their energy is released for growth.

Respiration goes on only in living cells, and every cell respires to maintain life, so that respiration is not confined to leaves only but takes place in roots, stems, fruits, and flowers. This process is just the reverse of photosynthesis, where carbon dioxide is taken in and oxygen is given off. It differs from photosynthesis also in the fact that it takes place day and night and in cells containing chlorophyll or devoid of it. During the day the giving off of oxygen by photosynthesis is less than the intake of it by respiration, but at night greater amounts of carbon dioxide are given off owing to lack of photosynthetic activity. In an actively growing green plant, the amount of oxygen liberated by photosynthesis during the 24 hrs. exceeds that absorbed by respiration, and the carbon dioxide contributed by respiration is less than that absorbed by photosynthesis.

The rate of respiration varies with the organs of the plant. Rapidly growing tissues show the greatest activity. The greatest rate occurs in the germination of seeds. In resting, or dormant, buds and bulbs the respiration rate is low but is not entirely lacking. Because of that, stored vegetables, fruits, seeds, bulbs, and other storage parts must have a sufficient supply of oxygen for proper maintenance of the living tissues.

The rate of respiration is influenced by such factors as the destruction of protective tissue which may occur in wounding or bruising, pest or fungous attacks which produce injury to tissues, temperature which when low reduces the rate, and a sufficient supply of oxygen. The latter is extremely important for the respiratory activity of the roots, so that proper aeration of the soil should be provided to secure satisfactory development.

GROWTH

Growth is restricted to living organisms and results from the activities of protoplasm. It involves the formation of new cells and the enlargement of those present. The essential feature of growth is thus cell division, which takes place by the division of the nucleus, the laying down of the new cell wall that separates the new nuclei, the division of the cytoplasm, and the behavior of chromosomes.

The factors that determine growth are both internal and external in nature. The internal factors are many and are not very well understood. Among the more important ones may be listed heredity, the action of hormones and vitamins, the nutrition of the plant, and the relation of plant parts.

Heredity is one of the most important factors affecting growth, since each plant group has certain characters and structures that are transmitted from generation to generation and are rarely modified by environment, although certain latent characteristics may be brought out by a change in conditions. It may be impossible to transform a cabbage into a cauliflower by environmental changes, but the flowering date of the chrysanthemum can be hastened by the reduction of the photoperiod, or a poinsettia may be forced to mature in February instead of December by the use of additional illumination. Usually character changes can be brought about only by hybridization and the combination of characters affected by such means.

Hormones (substances secreted in certain tissues and carried to other tissues whose functional activities they influence) and growth-promoting substances are organic in nature and in recent years have been found to be influential on many of the activities within the plant. The initiation of roots by means of the use of such growth-promoting substances as indolebutyric acid and others, epinasty (a state of curvature due to the more active growth of the dorsal side of an organ) caused by similar compounds, the photoperiodic phenomenon, the stimulation of root growth by nicotinic acid, thiourea, and others are presumably due to plant hormones.

The presence of vitamins, which are likewise organic substances, in plant tissues and their synthesis by plants unquestionably have a profound effect on plant growth. Vitamin B_1 is an example. It occurs in leaves primarily and from thence is transported to roots, causing their extension and development. Synthesized in the laboratories, it has received undue publicity and has commanded enormous sales to laymen. Actually, although essential for plant growth, additions to the soil are usually fruitless because of the presence of sufficient amounts in the plants and the organic residues in the soil. This is particularly true if soils are alkaline and contain organic matter.

Proper balance of nutrients affects growth materially. This has been found to be particularly important in the relationship between carbohydrates and nitrogen wherein high nitrogen and low carbohydrates cause excessive vegetative growth frequently at the expense of flowering and fruiting. Withholding of nitrogen under proper conditions for the manufacture of carbohydrates may likewise result in nonfruitfulness, although the growth may be short and stunted. That is due to high synthesis of carbohydrates without the change over to proteins and other nitrogenous compounds due to lack of inorganic nitrogen. Studies in nutrient medium deficiencies of various elements, particularly such trace elements as boron, zinc, copper, and manganese, have shown that an improper balance or lack of these may cause malnutrition, stunting, and even death. In roses outdoors considerable increases in flower production have occurred where zinc has been added in localities in which deficiencies in the soil occur. Lack of balance in nutrition may likewise be attributed to improper soil reaction.

Relation between plant parts also has its effect upon growth. The removal of one part may have its effect upon the stature and flowering of the rest. For example, the practice of pruning or pinching out of the terminal growth causes branching and changes the form of the plant. Likewise in the case of the chrysanthemum grown under glass, late pinching combined with cold temperatures may result in nonflowering of the shoots. The general effect of the removal of certain organs indicates that some sort of reciprocal influence is present, although a clear explanation is not available at present, with the exception of the action of hormones.

EXTERNAL FACTORS INFLUENCING GROWTH

The external, or environmental, factors that influence plant growth are temperature, light, humidity, soil water, soil aeration, nutrition, and gases in the atmosphere. Of these only temperature, light, and humidity will be discussed, the rest to be covered ni succeeding chapters under their respective heads.

Air and Soil Temperature. Temperature affects the various chemical reactions within the plant and the conditions in the soil. Groups of plants vary in their reactions to the minimum, optimum, and maximum temperatures. The minimum temperature refers to the lowest possible point at which plants will continue to grow without injury; the maximum, to the highest. The optimum temperature is the one in which the most satisfactory growth occurs in the varying stages of the plant cycle. It does not remain constant throughout the life of the plant. For example, rose seeds should be held in a temperature of 41°F. during their afterripening period but require 60 to 62°F. for normal growth and a somewhat lower temperature for the seed-pod ripening. The annual larkspur will not germinate during the high temperatures of the summer but once germinated will grow satisfactorily. Calceolaria will grow profusely in temperatures of 60°F. Lilies will develop a greater number of buds if grown in a temperature of 50°F. but for normal growth require much higher temperatures. Stock, cabbage, celery, and many other crops are affected by temperatures in their flower-bud initiation. Many other examples could be given of the important effects of temperature on growth.

Low temperatures may cause injury. During cold seasons the covering of plants of low-growing habit may result in suffocation due to lack of oxygen. On the other hand, desiccation may set in due to high transpiration rates and to heaving unless mulches are used. Freezing injury may develop due to the mechanical effects of ice formation either within or between the cells. Such a disturbance causes a disruption of the protoplasmic activity. Gradual exposures to low temperatures may, however, produce "hardening"—the withstanding of lower than the normal minimum temperatures—and is used in practice in accustoming such plants as cabbage and carnation to the early spring temperatures. In temperate climates there is a normal variation in the susceptibility of cells to the cold, which explains the living over winter of most of our hardy plants, herbaceous, woody deciduous, or evergreen. The leaves and tissues of these plants are not cold resistant during the summer but pass through a hardened condition in the fall and remain in this state during the winter. In the spring they go through a softening process and lose their cold resistance. The reasons ascribed to cold resistance are low water content of the cells, accumulation of soluble carbohydrates in the cells accompanied by an increase in their osmotic pressure, and an increased proportion of bound water in the tissues.

Heat injury may be caused by high rates of transpiration, which produce desiccation. Likewise, an extreme rise in temperature fails to increase the rate of photosynthesis to keep pace with high respiration; and thus a disproportionate amount of food manufactured is consumed in respiration, and stunting occurs. Direct heat injury to cells is thought to be due to a coagulation of protoplasm, which contains proteins of coagulable nature. Heat resistance is usually due to low water content in the tissues.

Quality and Quantity of Light. Sunlight, being the natural light under which plant life has developed, must necessarily be considered as the ideal until light of different character is shown by proper test procedure to have equal or superior qualities.

Daylight is composed of radiation in a continuous series of increasing wave lengths, from the short wave lengths of ultraviolet radiation, through the visible spectrum from violet to red, to the long infrared radiation. The proportion of energy among these various wave lengths is subject to variation—sky light differs from direct sunlight; north sky, from south sky; cloudy sky, from blue sky. Even the average daylight differs a little with the seasons and with the time of day. Nevertheless, average daylight is recognized as a fairly constant combination of radiation, distinct from that of any artificial illuminant available for plant growth. Daylight that has traversed ordinary window glass differs from outdoor daylight in having a somewhat smaller portion of ultraviolet radiation.

The sun radiates light in the form of waves of various lengths. This radiation in general may be divided into three parts—(1) ultraviolet energy, which is invisible; (2) visible light; and (3) infrared, or heat, waves. The differences between these three forms of radiant energy are merely in the lengths of their waves. The ultraviolet waves are the shortest; visible light waves vary from approximately 40 to 76 millionths of a centimeter in length; infrared waves are the longest.

Visible light is subdivided into the colors of the spectrum by waves of different lengths. All that is necessary in order to separate the different portions of the spectrum is to pass a beam of light through a prism. The infrared region is of no known significance to plants except insofar as it serves to heat the plant. the air, and the soil.

The ultraviolet energy of wave lengths very close to blue light, known as *solar*, or *near ultraviolet*, may be of a slight benefit in the process of photosynthesis. Ultraviolet of shorter wave lengths, known as middle and *far ultraviolet*, not only is unnecessary to plant growth but becomes increasingly injurious as the wave length shortens. We may eliminate, therefore, the ultraviolet and infrared portions of the spectrum and confine our interest to the visible portion of the spectrum, known as *light*.

Of the visible region of light both the red and the blue ends of the spectrum are absolutely essential for normal plant growth. It is probable that the middle portions, *i.e.*, the yellow-green, contribute something toward healthy normal plant growth although much less essential than the red and blue.

Blue light has been found necessary for the production of normal stem and for good chlorophyll development. It prevents excessive elongation. Red light furnishes energy for the process of photosynthesis.

Light is probably the most important single factor in the life of the plant from germination of seed to maturity. It affects the germination of some seeds and has its definite function in the size and form of plants as well as on the flowering and fruiting.

Photoperiodism. Although the first record of the effect of light upon plants dates back to 1686 when John Ray in *Historia Plantarum* observed the differences due to light variation, fully two centuries passed before any comprehensive research along this line was undertaken. Since then, many of the fundamentals have been established. Wiesner, Siemens, Bailey, Rane, Irons, McArthur, Popp, Denny, Gourley, Nightingale, Tincker, Harvey, Gilbert, Adams, and others may well be included in the list of workers who have been responsible for the more recent developments, but the outstanding researches of Garner and Allard have formed the basis of the practical applications discussed herein.

These two workers, after a series of tests, grouped plants into *long-day* and *short-day* classes according to their light-duration and light-intensity responses. The phenomenon was called *photoperiodism*—the effect of daily light duration upon growth. The results were of particular significance. It was found that the lengthening of the duration of the illumination period consistently resulted in initiating or inhibiting the natural, or normal, growth of plants. It was likewise found that the complete exclusion of a portion of daylight during the long days of spring and summer resulted in varying plant reactions. In all cases where positive results were obtained, continuous increase or decrease of light served better than alternate periods of change.

During recent years a large number of experiment stations have been investigating the practical application of supplementary light on plants. Cornell University, Purdue University, Ohio State University, and the U.S. Department of Agriculture have been conducting a large number of experiments dealing with greenhouse crops.

The most outstanding fact that has come out of the research work of the last few years is that many crops will respond to very low light intensities with earlier or increased flowering or both. A 40-watt lamp placed in a suitable reflector 18 to 24 in. above the plant will produce sufficient light for most responsive crops, and for many a 25-watt or even a 15-watt lamp is sufficient.

Four to eight hours of additional light applied at the end of the day or at the beginning has produced equal results. A 5-hr. addition from 5 to 10 P.M. is sufficient for a majority of the crops.

The equipment necessary in the use of additional light is very important. Proper reflectors such as the R.L.M. must be used; or if something cheaper is desired, a homemade reflector can be made out of a 10-cent aluminum cake pan 8 in. square and 2½ to 3 in. deep. A hole is cut in the middle to take the lamp-bulb neck. Reflectors should be deep enough so that only the tip of the lamp extends beyond the outer rim.

Ordinary incandescent Mazda lamps of either clear or inside frosted glass may be used. It was found that nitrogen-filled Mazda lamps were better than mercury, neon, or sun lamps for plant growth on a large number of crops. Ultraviolet light obtained from CX lamps did not show any beneficial effects.

Lamps can be turned on and off manually, but it is more desirable to install time switches, which may be had in a number of types and prices.

The following crops are favorably affected by additional illumination:

Blue laceflower (Didiscus coeruleus)
Boston yellow daisy (Chrysanthemum *sp.*)
Butterfly flower (Schizanthus pinnatus)
Calceolaria (Calceolaria hybrida)
Calendula (Calendula officinalis)
Calla lily (Zantedeschia aethiopica)
Carnation (Dianthus caryophyllus)
China aster (Callistephus chinensis)
Chrysanthemum (Chrysanthemum morifolium var.)
Annual chrysanthemum
Cornflower (Centaurea cyanus)
Corn marigold (Chrysanthemum segetum)
Cineraria (Cineraria *sp.*)
Clarkia (Clarkia elegans)
Coreopsis (Coreopsis *sp.*)
Crown daisy (Chrysanthemum coronarium)
Cyclamen (Cyclamen persicum)
Danlia (Dahlia *sp.*)
Delphinium (Delphinium *sp.*)
Doronicum caucasicum
Feverfew (Matricaria capensis)
Freesia (Freesia hybrida)
Gardenia veitchi
Gaillardia (Gaillardia *sp.*)
Gladiolus (Gladiolus *sp.*)
Gypsophila elegans
Iris (Iris tingitana)
Leptosyne, or sea coreopsis (Leptosyne maritima)
Lily (Lilium *sp.*)
Marigold (Tagetes *sp.*)
Nasturtium (Tropaeolum majus)
Pansy (Viola tricolor)
Primrose (Primula obconica)
Rose (Rosa *sp.*)
Salpiglossis (Salpiglossis sinuata)
Scabiosa (Scabiosa atropurpurea)
Shasta daisy (Chrysanthemum maximum)
Shirley poppy (Papaver rhoeas)
Snapdragon (Antirrhinum majus)
Stock (Matthiola incana)
Sweet pea (Lathyrus odoratus)
Sweet sultan (Centaurea imperialis and Centaurea suaveolens)
Violet (Viola *sp.*)
Yarrow (Achillea millefolium rosea)
Zinnia (Zinnia elegans)

The following plants do not respond to additional **illumination**

Achyranthes brilliantissima
Aquilegia hybrida
Anemone *sp.*
Arctotis grandis
Asparagus plumosus
Asparagus sprengeri
Cosmos bipinnatus
Cynoglossum amabile
Digitalis purpurea
Dimorphotheca aurantiaca
Erlangea tomentosa
Erysimum perofskianum
Felicia amelloides
Hunnemannia fumariaefolia
Hyacinthus orientalis
Iberis umbellata
Ipomopsis elegans
Iresine herbsti
Ixia maculata
Kniphofia pfitzeriana
Muscari botryoides
Narcissus poeticus ornatus
Narcissus pseudonarcissus
Narcissus taxetta
Ornithogalum lacteum
Pelargonium zonale
Pyrethrum hybridum roseum
Ranunculus *sp.*
Statice latifolia
Statice suworowi
Tulipa gesneriana hybrida

The Effect of Reduced Length of Day. Whether or not the use of the short-day method on various crops is of commercial importance is no longer questionable. Many growers are finding it profitable; although others are not. The first commercial application of the reduced day length was made by the senior author in the summer of 1930; from his first tests other leading experiment stations followed, and many improvements have resulted.

The equipment necessary to reduce the length of day is a flexible cover that will keep out most of the light. Black sateen, rubberized cloth, dyed canvas, heavy paper, tar paper, and a number of other materials have been used. Close-woven black sateen (64×104 or closer) has given the best service. Such cloth has given good results after 3 years of ordinary use.

The effectiveness of the cloth depends on the amount of light that is allowed to pass through. The lower the light intensity under the cloth the more effective it is in increasing earliness. It has been shown that chrysanthemums do not form flower buds so long as the light intensity is 2 ft.-candles or more for a period of more than 14 hr. each day.

New cloth should be used for the earlier treatments, and the older cloth for later treatments.

In order to use the short-day treatment successfully it is important to know the normal bud-forming period. Post reports the following for Ithaca, N.Y., conditions:

	Normal Bud-forming Period
Chrysanthenum morifolium	Aug. 15–Sept. 10
Eupatorium coelestinum	July 25–Aug. 10
Piqueria trinervia (stevia)	Sept. 20–27
Kalanchoe blossfeldiana	Sept. 25–Oct. 5
Euphorbia fulgens	Oct. 10–20
Euphorbia pulcherrima	Oct. 10–20
Begonia socotrana Lady Mac	Oct. 10–20
Bougainvillea spectabilis	Sept. 20–Oct. 1

The following plants respond to short-day treatment: azalea, begonia, bouvardia, chrysanthemum, *Eupatorium coelestinum, Euphorbia fulgens, Kalanchoe blossfeldiana*, poinsettia, stevia.

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CHAPTER II

SOILS

For ages the soil has been recognized as the source from which plants draw their sustenance. The beginnings of soil go back to the remote ages when particles of sand or clay split off from the parent rocks and began their movement to the present location, through the agency of water, wind, and glacier. Many of their properties were determined during this wandering process. The mineral particles alone do not constitute the soil. Decaying animal and plant life form an important part of it. The final product is reached after vegetation has sprung up and died, leaving its remains mingled with the mineral parts. While living, the plants build up complex organic matter, but upon death these substances are disintegrated and become a part of the soil medium. The process may be observed readily upon any landslide. After the topsoil has slipped, the virgin soil is exposed, upon which vegetation springs up gradually. This dies and, together with the process of weathering, changes the character of the soil.

In our discussion of soil for garden and greenhouse purposes we refer to the superficial layer of earth in which plants can grow and from which they obtain water and nutrients. The layer below this is the subsoil, which may differ materially from the topsoil. The topsoil usually contains more organic matter and a greater supply of microorganisms; it may be coarser because of the finer particles being washed below; and it contains more available nutrients. This occurs largely because of more favorable environmental conditions. The soil depends for its value upon the original material from which it was derived, its texture and structure, and the extent of decomposition and leaching of the essential elements.

The physical properties of good soil are firmness, mellowness, ability to hold moisture and retain heat, and a porous structure to permit of proper air circulation.

Soil texture refers to the size of the individual particles, and according to their texture soils are classified as sandy, silt, clay, and loam, the last being an intermediate between the others.

Sandy soils contain less than 20 per cent of silt and clay particles and usually are not suitable for proper growth because they permit of rapid runoff of water, contain too much air which causes rapid decomposition of organic matter, absorb too much heat, and lose available elements too rapidly. Extremely sandy soils may be improved by the incorporation of silt or clay and the addition of organic matter.

Clay soils contain 30 per cent or more of fine-textured particles. They hold water, are deficient in needed oxygen, become compact and sticky, harden after rains, become "puddled" if worked when wet. They are the very opposite of sandy soils and because of the extremes are not suitable for the best growth of plants. Additions of sand, cinders, or organic matter help clay soils materially.

Silt and loam soils are the intermediates between sandy soils and clay soils. Therefore they possess the proper requisites of fineness of particles, porosity, and water-holding capacity most suitable for plant growth.

Soil structure refers to the arrangement of the particles. The best arrangement is the crumb structure where the soil is granulated by several particles being held together by colloidal material. To determine a good structure a trowel or a spade may be used. A good loam when lifted will fall apart into small crumbs. Sandy soils break up into individual particles; clay soils will break apart only by force and then into clods. Soil crumb structure is influenced by alternate drying and wetting, by alternate freezing and thawing, by cultivation, by the action of roots, and by organic matter which tends to hold particles together.

Soil Composition. The inorganic constituents of soils are approximately as given in the table on page 26.

The organic constituents of soils consist of animal and plant remains in various stages of decomposition, such as green manures, stable manures, peat, muck, leaf mold, and the decomposed matter called humus.

Humus is a complex substance, dark brown in color, originated during the decomposition of plant and animal remains. This decomposition is produced by soil organisms in the presence or the absence of air.

The functions of humus are largely threefold: (1) physical—modifying the soil color, texture, structure, water-holding capacity, and aeration—(2) chemical—influencing the solubility of certain soil minerals, forming compounds with such elements as iron, thus making them more available to plants and increasing the buffering properties of soil, *i.e.*, making the soil a safe medium for plant growth—(3) biological—serving as a source of energy

INORGANIC CONSTITUENTS OF SOILS

Element	Per cent	Forms present in
Oxygen	47.0	
Silicon	28.0	Silicon dioxide (silica)
Aluminum	9.0	Silicate, oxide, phosphate
Iron	4.5	Oxide, hydroxide, sulphate sulphide
Calcium	3.5	Carbonate, sulphate, phosphate, nitrate
Magnesium	2.5	Carbonate, sulphate, phosphate, nitrate, chloride
Sodium	2.5	Carbonate, sulphate, phosphate, nitrate, chloride
Potassium	2.5	Carbonate, sulphate, phosphate, nitrate, chloride
Sulphur, phosphorus, and others	1.75	Sulphate or sulphide

for the organisms and supplying a continuous flow of nutrients to plant life.

Manures are sources of humus but not until they become decomposed to the proper stage. A comparison of the composition of sheep, horse, and cow manure will show that the soluble organic matter is highest in sheep, followed by cow, and last horse. That is the reason why sheep manure is more active than the other two. Horse manure is the slowest, although it may do damage from quick release of ammonium. It should be remembered that no two manures will act the same, largely because of the difference in the food given the animals and the variation in bedding used. The composition of manures also determines their rate of decomposition, so that it is difficult to make a general rule of how quickly a breakdown may be expected.

When stable manure is placed in a compost that is kept under favorable conditions of moisture and aeration, the various organic constituents become attacked by a variety of organisms, which, however, do not act equally. Therefore the rapidity and nature of the decomposition will vary greatly. When fresh manure is added to the soil, only the water-soluble forms of nitrogen become readily available to the growth of higher plants, whereas the more complex organic compounds, which comprise about half the total nitrogen in manure, are not available. This is due to the fact that as fast as the organic matter is broken down, the organisms use it for sources of energy, and likewise part of the nitrogen combines with such materials as lignin and becomes unavailable. Only after complete decomposition occurs is the nitrogen in available form.

Practically, this means that except for a portion of the manure, the nitrogen in fresh manure is slowly available; hence it is much more advisable to use either partially decomposed or well-rotted manure, particularly since the need for nitrogen can be supplied through the use of inorganic fertilizers.

The phosphorus and the potassium of manure are about as readily available as those in artificial manure, whereas the nitrogen is from one-third to one-half as available as that in inorganic fertilizers. Thus, for nutritional purposes manures are not so quick acting as commercial fertilizers, but their effect is more lasting and carries over for a period of years. *Manures should be used in all soils, irrespective of the commercial fertilizers applied.*

Organic fertilizers such as peat, guano, dried blood, bone meal, fish meal, tankage, hoof meal, bean meal, cottonseed meal are used partially because of their high nitrogen content and partially because of their slower availability than that in inorganic fertilizers. The latter is due to the fact that decomposition must first occur before absorption by plants can take place. Organic fertilizers add a certain amount of humus to the soil, and the lower their content of nitrogen the greater the amount of humus produced. This means that low-grade organic fertilizers will carry over a much longer time but are extremely slow in their initial effect.

The use of green manures in the preparation of soil for the greenhouse is based on (1) the increase of the supply of the total nitrogen in the soil, (2) the conservation of nutrient elements in the soil and the prevention of leaching of nitrates, (3) the increase of humus or organic supply of the soil. The more mature the green manure when plowed under the slower will be its decomposition and the greater the danger of its nitrogen being removed by organisms; hence plowing under in a somewhat green state is recommended.

Action of Organic Matter. Humus increases the power of the soil to hold water and the soluble materials in water. Its colloidal properties permit absorption of gases and their retention. These same colloidal properties improve the structure, making it granular. In clay soils the stickiness is reduced, water is distributed more evenly, aeration is improved, and root development is stimulated. In sandy soils, the particles are bound together, excessive porosity and aeration is reduced, moisture-holding capacity is increased, leaching of elements is lessened, and erosion is reduced.

Humus aids in the absorption and the retention of soil heat. It also makes potassium and phosphorus compounds more available through the acids that are formed in the process of decomposition. Soil nitrogen normally is derived from the decomposition of humus and is helpful in the growth of organisms needed in the soil.

The loss of organic matter occurs when air is too abundant, accompanied by high temperatures and moderate amounts of moisture. This causes greater activity of microorganisms and quick decomposition. Abundance of bases such as calcium carbonate and calcium hydroxide causes neutralization of organic acids and increases bacterial activity. Because of these factors, too frequent cultivation and additions of lime when not needed produce unnecessary losses of organic matter.

Soil Aeration. In addition to requiring nutrients, the plant must have adequate aeration and moisture in order to carry on its growth activities. Lack of sufficient aeration often becomes a limiting factor in plant production. The growing root of the plant takes in water, oxygen, and nutrients through its roots and gives off carbon dioxide. The root cannot grow unless it can carry on its normal respiration activities. It is seen, therefore, that a lack of water or of oxygen or an abundance of carbon dioxide will hinder normal respiration. The passage of carbon dioxide from this zone to the atmosphere takes place through the process of diffusion through the soil pore space.

The replenishment of oxygen from the atmospheric air likewise takes place through these same pores. Consequently, any reduction in total pore space, and particularly in the content of the large pores, will result in a decreased air capacity and a much slower rate of exchange between atmosphere and soil air. This will result in an accumulation of carbon dioxide and a deficiency of oxygen in the root zone of the plant. In consequence of this lack of aeration, the root will not develop extensively, and the volume of soil from which the plant can extract water and nutrients is considerably diminished.

It is a well-established fact that plant roots get moisture as they come in contact with water films. Capillary movement of water is too slow to be of significant value to the plant after the moisture content of the soil has been reduced below the field capacity.

Moreover, recent developments indicate that the plant gets its nutrients by coming in contact with the soil particles. In light of these facts it is seen that a well-developed plant depends upon a well-developed root system. A well-developed root system depends upon, among other factors, an adequate supply of oxygen. Therefore, soil porosity is one of the keys to the satisfactory growth of crops, when the plant is growing in soils.

Well-granulated soils and coarse-textured soils are sufficiently aerated for the growth of most plants. Poorly granulated soils and especially heavy clay soils lack satisfactory aeration. It behooves the floriculturist, who is attempting to grow high-quality plants on soils within a greenhouse, the field, or the garden, to pay particular attention to keeping the soil open. It must be well aerated and have a sufficient supply of moisture in order that the plant roots may develop extensively to make use of the nutrients and moisture within the soil.

Practically, soil aeration may be secured by the addition of organic matter such as manures, peats, leaf mold, or green manures. Besides, the incorporation of fine cinders and sand with clay soil is beneficial, provided organic matter is likewise present.

Soil Water. Water exists in soils as free, capillary, and hygroscopic.

Free or ground water saturates the soil and fills the spaces between soil particles and by gravity moves downward until it reaches the level where the pore spaces are already full. This level of free water is known as the *water table,* and it varies in depth depending on location. Free water is useful to plants when its level is below that of the roots so that it may rise by capillarity and be available as the water in the upper regions is removed by plants or evaporation. When the water table is so high that the roots are enclosed in the water constantly, growth is reduced because of exclusion of oxygen, slowing up of organic-matter decomposition, increase of nitrites, and decrease of nitrates. Water plants and others like rice and cranberry have roots adapted to such conditions and cannot grow unless the roots are immersed in water.

Capillary water surrounds the soil particles, is held by colloidal matter, and furnishes the important supply of available water to plants. The amount of capillary water depends upon the size of soil particles, their structure, and the colloidal content. The finer the particles, as in clays, the larger the capillary water content. In sand, however, the water capacity is low. The distance that capillary water can move depends upon the arrangement of soil particles and pores. In clays, cultivation and additions of organic matter increase the rate of capillary movement and the water-holding capacity. In sands, cultivation has the opposite effect.

Hygroscopic water is held by the colloidal matter in the soil and is not available to plants.

The loss of soil water occurs through percolation, by evaporation, and through intake by plants.

Percolation is the downward movement of water to the water table. It is slow in clays and rapid in sands, its movement depending upon the size of the pores and the colloidal matter. Abundance of roots near the surface likewise reduces the speed of percolation. Heavy rains and forcible watering cause quicker percolation and greater losses of water. Hence in practice it is important that though heavy watering may be preferred, the application should be made gradually.

Loss by evaporation depends upon the temperature, the humidity of the air, and air movements. Greatest losses occur during hot, dry, windy periods and particularly when the structure of the soil is loose and lacking in organic matter.

Losses by plants are due to transpiration which is checked only when the relative humidity of the air is high.

Control of Moisture. The objective in the control of moisture in the soil is the prevention of its loss and is done by proper tillage, mulching, organic matter, and fertilization.

Tillage includes the various operations in the preparation and care of soils for plant growth. Plowing or spading constitutes one of these operations. As a rule, clay soils should be spaded deeper than sandy soils, which, however, may be worked deep if well supplied with organic matter. Fall spading or plowing is usually preferred to spring in regions where fall and winter rainfall is light. In that way more of the available moisture is absorbed than if the soil remained unworked. Early spring spading, if followed by cultivation, is satisfactory. The texture of the soil should be considered when plowing or spading wet soils. No particular harm will accrue to sandy soils if spaded when wet, but such a procedure in clay soils will result in the development of clods that will be difficult to break up.

Harrowing or raking and rolling follow the plowing or spading in order to pulverize the soil to a satisfactory structure. Rolling decreases the percolation but increases evaporation.

Cultivation controls weeds and at the same time tends to keep the soil in a good physical condition by increasing granulation and aeration.

Mulching is the process of covering the topsoil to reduce evaporation. Various organic materials are used for the purpose and include corncobs, straw, manures, peat, cottonseed hulls, alfalfa chaff, leaves, and similar substances. For most purposes, because of their water-holding capacity and pleasing appearance, peat and corncobs give the most satisfactory results. Mulching with paper is likewise a satisfactory method but is not particularly desirable for garden purposes where appearance is an essential. Cultivation to provide a soil mulch is an old-time practice, but it is questionable if such a mulch under usual conditions lessens the evaporation to any appreciable extent. Frequently the cultivation of the soil brings more moist soil in contact with air and brings about greater drying.

The value of organic matter in the conservation of moisture has been discussed previously, except insofar as peat is concerned.

The use of peat as a source of organic matter for improving the physical condition of mineral soils is becoming of increasing importance. Numerous publications have described such use and have shown, particularly in the growth of greenhouse crops and lawns, that definite benefits may be obtained when peat is mixed with certain soils. Peat improves the structure of clay and loose sandy soils, and presumably the benefits derived from its use result largely from improved physical conditions in the soil medium.

It is frequently stated by writers, in connection with soil-improvement work, that peat greatly increases the water-holding capacity of the soil with which it is mixed and thereby increases the available moisture supply. For example, it is known that a sphagnum-moss peat may absorb from 1,000 to 3,000 per cent of water, whereas a mineral soil may absorb only 30 to 40 per cent under the same conditions. On this basis the assumption has been made that the apparent increased moisture-holding capacity resulting from the admixture of peat to a mineral soil is of considerable value in supplying water to plants over a period of drought.

The work of I. C. Feustel and H. G. Byers of the Bureau of Chemistry and Soils, U.S. Department of Agriculture, has shown that in clay loams little or no advantage in moisture economy results from the admixture of peat in quantities as large as equal proportions by volume. The types of peat used ranged from raw fibrous-moss peat to well-decomposed reed muck. Such mixtures with soil were capable of absorbing from 40 to 50 per cent more moisture than the soil alone, but the increased evaporation rate and the greater content of moisture at the wilting point largely counteracted the initially higher moisture-holding capacity. Lawn grasses on field plots appeared to suffer to the same extent during dry periods, whether growing on soil alone or on peat mixtures. A greenhouse experiment with peat on similar mixtures showed no advantage of peat regarding retentiveness of available moisture, with a possible exception of decomposed reed peat. The choice of a particular variety of peat to be used for soil-improvement purposes with clay loam soil need not be concerned with relative moisture-holding percentages but should be governed by other desirable physical or chemical characteristics not considered in this study.

Improved moisture conditions may, however, be expected from the incorporation of peat with a sand. This was shown by the experiment with growing wheat, in which peat mixtures with quartz sand supported plants after those on the sand alone were dead from lack of moisture. The fibrous type of peat was less effective in this respect than the more decomposed material. As a result of incorporation of peat, the moisture-holding capacity of sand or of a sandy soil was increased to a greater extent than that of a clay soil. This increase amounted to as much as 80 per cent in the case of quartz sand. Peat mixtures with sand were found to be more retentive of moisture relative to the sand alone than were corresponding clay-loam mixtures, and therefore greater value is obtained with sand in regard to moisture-supplying ability.

More favorable effects might possibly have been obtained by the use of peat in proportions greater than equal parts by volume, but such amounts are not considered practical or economical for general use as soil amendments.

Peats by themselves were superior to any mixture of peat with soil, not only in moisture-absorbing ability but also in the retention of available moisture against evaporation loss. The relative order of evaporation rate of the peats, as well as of the respective mixtures, was always the same. Decomposed reed peat had the lowest rate, and fibrous-moss peat the highest, with partly decomposed sedge peat intermediate.

Moss peat is somewhat comparable to a sponge. It can more readily transfer internal moisture by capillarity to the surface where evaporation is most rapid. Reed peat is more granular, and its structure such that the capillary continuity is broken and hence tends to have an insulating effect on moisture immediately below the surface. These inherent characteristics were apparent even in the respective mixtures with both soil types and with quartz sand. The moisture contents of the peats at the wilting point were in the reverse order of magnitude to their respective evaporation rates.

The higher wilting point of soil, which resulted from the incorporation of peat, was proportional to the quantity of peat added and to the amount of unavailable moisture held by the particular peat over and above that held by the soil before mixing. In the event that a soil had a higher wilting point than that of a peat, the result would undoubtedly be a lowering of the unavailable moisture content of the soil.

Moisture relationships of various types of peat and soil were determined with particular reference to the effect of incorporation of peat with soil in varying proportions.

The maximum moisture-holding capacity of peat is more than twice that of soil, compared on a basis of equal volumes of material. Mixtures of peat with soil in equal proportions by volume absorbed from 40 to 50 per cent more moisture than the untreated soil in the case of a clay loam and as much as 80 per cent more in the case of pure quartz sand. Values for a loamy fine sand soil were intermediate.

Evaporation rates from initially saturated soils and peat mixtures were similar during the first part of the evaporation period, but later the presence of peat resulted in a definite increase in the evaporation rate. Fibrous-moss peat lost moisture at a greater rate than the more decomposed and granular reed peat. This was characteristic also of the respective mixtures with soil. When the materials had a lower but identical initial moisture content, peat caused a reduction in the evaporation rate of soil, except in the case of moss peat with clay-loam soil. Reed peat reduced evaporation to the greatest extent, whereas sedge peat was intermediate in its effects. Mixtures of peat with sand retained more moisture relative to the sand alone than did the corresponding clay-loam soil mixtures.

Observations in connection with field plots and greenhouse plots indicated little or no advantage in the use of any variety of peat with clay-loam soil with regard to the supply of moisture available to plants during a dry period, with the possible exception of decomposed reed peat. Beneficial effects in moisture economy, however, were obtained on quartz sand and to a lesser degree on loamy fine sand soil. Reed peat was more effective than moss peat.

Wilting-point determinations, using dwarf sunflowers (*Helianthus annuus* var. *nanus*) as indicator plants, showed that a decomposed type of peat had a considerably greater content of unavailable moisture than fibrous varieties. Moss peat had a content only slightly greater than clay-loam soil.

Addition of peat to soil increased the wilting moisture content by an amount proportional to the quantity of peat used and to the magnitude of unavailable moisture, as compared with that of the soil before mixing.

Wilting percentages of peat and of mixtures of peat with soil were found to be in general qualitative agreement with values calculated from the moisture equivalent by the Briggs and Shantz formula. The use of peat as a soil amendment for the sole purpose of conserving a supply of available moisture is not recommended, except possibly in the case of a decomposed type of peat with a sand or a very sandy soil. The textural and other physical or chemical effects have not been considered in this study. They must be evaluated, however, in judging the benefit that may be realized from the addition of peat to soil.

Mulching with Ground Corncobs. The scarcity of manure and the high price of peat have raised the question of what can be used in their place for a mulch. Ground corncobs have been used for several years and have given striking results, especially on roses.

Size of Cob Particles. Pieces of cob that range between ¼ and ¾ in. in size appear to be the best, although the presence of finer particles is not objectionable. If particles are too fine, however, difficulty will be experienced in getting water through.

Sources. In many sections of the United States where corn is a major crop, there should be no difficulty in finding a feed mill that will grind cobs. Where corn is not grown extensively, it will be necessary to have it shipped in.

Amount to Apply. On *roses* the ground corncobs are applied to a depth of 2 to 4 in. This amounts to 1 ton per 1,000 sq. ft., or 2 lb. per plant. This may seen to be an excessive amount, but longer stems and more of them have resulted from such heavy applications.

On young plants the mulch is applied 3 months after benching. On older plants it is applied at any time of year. More corncobs must be added periodically to maintain the desired depth, because they decompose and settle. When the roses are discarded, the cobs are mixed with the soil and steamed.

On *carnations* a deep mulch would cause stem rot, and a 1-in. layer is recommended. It will be necessary to add to this periodically, especially in spring, when loss of water by evaporation from the soil is high.

There is no reason why *chrysanthemums, snapdragons,* and *other crops* could not be mulched with ground corncobs. Cut flowers grown either *outside* or *under cloth* will be benefited. We have spread ground cobs in a frame to a depth of 2 in. and set pot plants on them. The cobs prevent clogging of the drainage in the pots and help to maintain humidity.

What a Corncob Mulch Does.

1. CONSERVES WATER. Like any other mulch it prevents undue loss of water from soil by evaporation.

2. PREVENTS SOIL COMPACTION. Where no breakers or Ohio State University watering methods are used, the force of water striking the soil tends to pack it down. The ground corncob particles are irregular in shape and are not disturbed when the bench is watered, and they break up the force of the water and thus prevent soil compaction.

3. ADDS ORGANIC MATTER. When organic matter of any type is used as a mulch, the soil underneath gradually increases in organic content. The table below shows results of mulching with wheat straw in an orchard, and it is expected that ground corncobs would be similar.

PER CENT OF ORGANIC MATTER IN SOIL AT VARIOUS DEPTHS
(Gourley and Havis)

Depth, in.	Mulched	Cultivated
0–2	4.30	1.87
2–4	2.34	1.64
4–6	1.61	1.45
6–8	0.98	0.94

The main effect on organic content is within the upper 4 in. of soil. Since soil in rose benches is seldom over 6 in. deep, it is expected that the organic matter content would be increased throughout the entire depth if ground corncobs were used.

An analysis of well-prepared soil used for garden roses, grown for 3 years, showed 20 per cent organic matter under ground corncobs and only 8.5 per cent where cultivation was practiced. This shows the beneficial effect of ground corncobs on organic matter.

4. DECREASES NITROGEN. When ground corncobs are used as a mulch, the millions of microorganisms in the soil begin to decompose them. In so doing, the microorganisms grow and develop rapidly, and since they are actually small plants, they

take the nitrogen from the soil for their growth. The result of this is that the growing plants will *very quickly* become starved for nitrogen unless nitrogenous fertilizer is added to keep up the nutrient level.

It is advisable to use both inorganic and organic nitrogenous materials—the inorganic for quick effect and the organic for its lasting quality. In case of doubt the soil should be tested.

Fresh corncobs should not be mixed with the soil as this mass of raw organic matter is so great that it is almost impossible to add enough nitrogen to the soil to take care of the demand by the microorganisms and at the same time not injure the growing plant.

5. Granulates the Soil. This is probably the most important effect of ground corncobs. By granulation is meant the grouping or gathering together of individual particles of soil (clay, silt, or sand) into a granule or lump. When this happens, water is held within the granule, but between granules the spaces are so large that water drains away, and here is where the air is present.

Just how mulching with corncobs causes granulation is not entirely clear, but there are some clues. Tests at Ohio Agricultural Experiment Station by Havis have shown that the addition of *sugar* to the soil caused an almost miraculous increase in granulation. It is thought that the sugar stimulated the growth of microorganisms and that they gave off a material which actually cements individual particles of soil together into granules. It is not very practical to apply sugar to soil because it is too expensive and the effect is not long lasting, but it is of interest to note that corncobs contain 6.8 per cent sugars. Therefore, when ground cobs are used as a mulch the effect is similar to the addition of sugar. This is shown in the following table.

Effect of Ground Corncobs on Granulation and Porosity

Treatment	Per cent granulation	Average diameter of granules in millimeters	Total porosity	Per cent of non-capillary (air-holding) pore space
No mulch	27.5	0.90	59.1	25.3
Old corncobs	28.8	0.97	59.7	24.4
Fresh corncobs	37.5	2.26	63.6	30.5

It should be noted that beneficial effects are obtained from corncobs that have not been exposed to weathering, presumably rain or snow. The loss of the sugar, which would wash out quite easily, could account for the less beneficial effect produced by the old corncobs. This same effect of old versus fresh material holds true for straw and other materials tested at Ohio Argicultural Experiment Station.

Effect of Fertilizers on Water in the Soil. It is interesting to note that well-fertilized soil reduces the water requirement of plants. The explanation is simple. If a soil is poor, some mineral element may be lacking; and as the supply of such an element nears exhaustion, growth practically ceases but transpiration continues, thus requiring more water for the plant in proportion. It may be argued that more moisture is lost from a plant growing in fertile soil than from a similar one growing in poor soil, owing to the fact that more foliage is produced in the rich soil. Yet actually, per unit of growth, less water is needed. All this emphasizes is the importance of maintaining fertility of the soil.

Drainage. The object of drainage is to remove excess water from the regions where roots grow. This is necessary to provide good crumb structure, increase the air supply, raise the temperature in the spring so as to extend the growing season, and promote chemical and biological activities, which in turn affect the availability of soil elements. Although the total amount of water is diminished by drainage, the supply as a whole, available to plants, is increased. In fine-textured soils the effect of drainage on their structure enables them to hold moisture longer. In well-drained soils deeper and more extensive root growth develops which provides greater area for the securing of nutrients and moisture and thus makes for greater drought resistance.

The Practice of Watering. At present watering is still an art and not a science. The devices proposed for measuring soil moisture are becoming of use in the laboratory and under field conditions, but most of these (some are called *tensiometers*) to be of value require involved calculations. Furthermore, the measurement of the moisture is confined to the particular spot where the instrument is placed. Because of these objections accuracy in determining the moisture content of the entire soil in a given bench or house cannot be secured without having the instruments placed at close intervals.

To determine soil moisture without too much guesswork and personal opinion, use a clean trowel. If insertion is hard, the soil is too dry. If the soil feels gritty, it is on the dry side and should be watered. If upon removal no moisture is present on the trowel and no soil particles cling, it is time to water. If the soil is too wet for additional water, the trowel will show particles of soil and moisture clinging to it.

Heavy watering at infrequent intervals is to be preferred to surface sprinkling, since the latter has the tendency to restrict the root area to the top and may cause damage from abnormal heat and drying. Water applied through a hose should have a "breaker" on the end of the hose to spread the stream and reduce its force so that packing of the surface does not occur.

Usually, to provide uniformity of watering, sprinklers or irrigation lines are more reliable than hose watering in the impatient hands of the average gardener. Various systems are available for this purpose and depend for their effectiveness on the uniform spread of water, falling gently upon the soil for a sufficient period of time to soak the soil thoroughly.

Ooze hose may be substituted for irrigation lines or sprinklers, but it does not give a wide spread of water and is useless on slopes, since its action is dependent upon a slow flow of water through the canvas hose and its oozing out as the canvas becomes saturated.

The notion that no watering should be done while the sun is shining has no foundation on fact, although it is true that greater penetration in a shorter time is possible during cloudy days or at night. Burning of foliage frequently attributed to watering during sunny weather may be due to the practice of surface sprinkling rather than the action of the sun. The mere observation of a heavy shower followed by full sunlight with no subsequent burning should convince the thinking gardener.

Methods of Watering Greenhouse Plants. There are several methods of watering both cut flowers and pot plants, either by hand or automatically. The advantage of automatic systems lies in the savings in labor.

Water is applied to either cut-flower benches or pot plants through a hose in the conventional manner. The volume should be great enough to complete the job without a waste of time, yet slow enough to avoid washing the soil or splashing the plants unduly. Breakers are suggested. The disadvantage of this method of watering is that it is very costly from the standpoint of the labor required.

There are several systems that apply water automatically overhead.

The Skinner System. On outside installations permanent pipes equipped with special nozzles and covering a large area may be used. They are especially valuable for pot plants under lath, cloth, or outside beds, and may be used for some cut flowers outside. Large areas in the greenhouse devoted to propagation may be watered by means of short-throw Skinner nozzles. The Skinner Irrigation Company, Troy, Ohio, supplies the nozzles and pipes.

Portable Pipe System. Especially valuable for watering gladiolus fields and other plants grown outside or under lath on a considerable scale is the portable pipe made by the Skinner Irrigation Company, Troy, Ohio, and The Armco Drainage and Metal Products, Inc., Berkeley, Calif. Thin steel pipe 3 to 4 in. in diameter is laid on the soil in the field. Risers 3 to 10 ft. high may be installed in the main line, and rotating sprinklers placed at the top of the risers will cover a considerable area under high water pressure. Connections between lengths of pipe and fittings, such as tees and elbows, are of the snap-on or quick-change type which enable the operator to set up the watering system quickly. The equipment is light in weight and can be rapidly taken apart and reassembled in another location with a minimum of labor.

The Revere System. Any nonwatertight bench, either level or sloping, wood or concrete, may be used for this method of watering. The soil is placed in the bench up to 1 in. of the top of the sideboard. The plants are benched, and 1 in. of very fine sand is placed on top of the soil. For a 4-ft. bench, two lines of ½- or ⅜-in. copper pipe with holes (0.039 in. in diameter) drilled every 2 ft. are placed on top of the sand about 2 ft. apart, running lengthwise of the bench. The sections of copper pipe are not welded together, but the ends are slipped inside a short piece of greenhouse hose as the low water pressure required (1 to 3 lb.) will not break the connection. For even distribution of water in the pipe on long runs, the two ends may be connected together or several inlets for water in the system may be installed. The holes in the pipe should be straight up for roses; for carnations, where foliage must be kept dry, the pipes may be turned to a 30- or 45-deg. angle from the surface of the sand. The pipes are connected to a water line, and when turned on, the water streams from the holes should shoot up no more than 8 in. Only a few pounds of water pressure are necessary for operating this system. The water spreads rapidly in the sand by capillarity until the sand is saturated, and then the water moves downward through the soil. A tensiometer is a useful guide for determining the time of watering. Without a tensiometer, on raised benches, the water is allowed to run until it drips through the bottom of the bench, then it is shut off. On ground beds, without a tensiometer, a trowel is used to determine when it is wet to a sufficient depth. By timing, one can determine how long the system should be run to wet the soil to the desired depth.

Fertilizer should be applied on the sand as uniformly as possible, and the streams of water will carry the soluble portion into the soil below. No attempt should be made to wash fertilizer in with a hose unless the sand is not disturbed. A light watering overhead with a flaring rose on the end of the hose is recommended as it does not disturb the sand. Mixing the sand with the soil by watering in fertilizer with a hose or any other means will destroy the fast capillarity of the sand, and the system will not work. Water-soluble fertilizer can be applied by means of a Hozon nozzle or a sprayer or sump pump with a flaring rose to break the stream.

The Revere system is merely an automatic method of overhead watering cut-flower crops. On roses that are changed every 4 years the mixing of the sand with the soil when the plants are removed could be overcome by changing the soil and would not be too serious. On short crops, like chrysanthemums, snapdragons, stocks, and others, it would probably be necessary to remove half the soil at the end of each crop and replace with fresh soil to prevent building up a soil very sandy in nature. Fresh sand would be needed for each change of crops.

The copper pipe with holes drilled every 2 ft. may be obtained from the Revere Copper & Brass, Inc., Rome, N.Y.

Ohio State System. Any type of bench may be watered by this method. The soil is placed in the bench in the usual way, and the plants are benched. A ¾- or 1-in. pipe drilled every 12 in. for the Ohio State special nozzle is placed in the center of the bench on top of the soil and is connected to a water line with a valve for hand control. The nozzles are so designed that the water spreads uniformly over the surface of the soil without moistening the foliage excessively (Fig. 1). On benches over 4 ft. in width, two lines of pipe may be necessary to secure uniform distribution of water. The pipe and nozzles may be obtained from the Nelson Manufacturing Company and the Skinner Irriga-

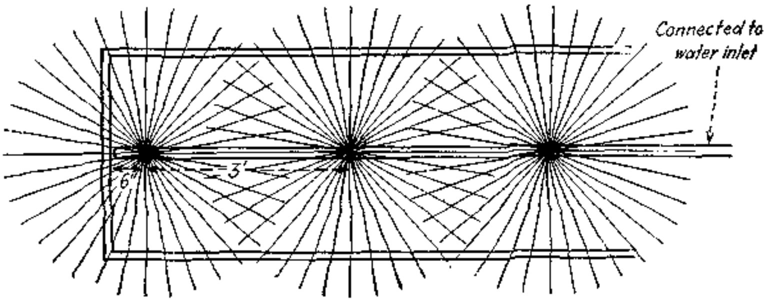

FIG. 1.—Ohio system of watering, showing water spread of nozzles spaced 3 ft apart.

tion Company, both of Troy, Ohio. An improved nozzle, which throws a full circle of water, is available from these companies.

Fertilizer is applied in the conventional manner and watered in by turning on the watering system. Considerably less water is used compared to the normal method of watering soil overhead by means of a hose. This is the cheapest and most satisfactory of all the systems of overhead automatic watering of cut-flower benches.

SUBIRRIGATION

This method of applying water is not a new idea as in 1895 the Ohio Agricultural Experiment Station issued *Bulletin* 61 which gave detailed instructions on the use of subirrigation for lettuce and other crops. Recently several modifications have been suggested by Post of Cornell University which have proved to be very satisfactory and practical.

For any system of automatic watering that requires a watertight bench, some type of gravel is used to fill the bottom of the bench. If the gravel used is calcareous (lime-bearing), it may cause the pH of the soil to become very alkaline. To counteract this, superphosphate broadcast on the gravel at 10 lb. per 100 sq.

ft. will reduce the danger of alkalinity. If silica gravel (acid) is used, the superphosphate may be omitted.

Hand. A level, watertight bench with a V bottom, equipped with half tile for a channel to allow the uniform spread of water, is necessary. The bench is filled with gravel to the top of the V and then filled with soil and plants benched in the usual way. In spring, summer, and early fall the soil may be watered by flooding the bench to the soil surface and then draining the excess water from the bench. Filling the bench with water to within 1½ or 3 in. from the soil surface requires less water and may be used, but the excess water should be drained. In winter many soils remain too wet too long when subirrigated, and plant growth is checked.

Pot plants may be subirrigated by hand, but the method has several drawbacks. A watertight bench with a 1-in. layer of gravel on the bottom is necessary. The water level is raised to one-third or one-half the height of the pot and allowed to remain for several hours, and then the excess water is drained away. Considerably more water is used by hand subirrigating than by watering overhead in the usual manner. Heavy soils are unsuited and growth of the plants will be poor owing to the lack of development of a good root system. It is often the case to find no roots in the lower one-third to one-half of the pot, as the soil is waterlogged and roots will not grow. Addition of sand to the potting mixture partly alleviates this trouble. Differences in firmness of potting by individuals and the absence of a completely uniform soil mixture cause trouble as some pots dry out before others. This necessitates spot watering, and the advantages of subirrigation are lost. Furthermore, only one size of pot and one type of plant may be placed in a bench watered by hand subirrigation, because of the differences in the time of watering various pot sizes and various plants.

Automatic Injection. This system requires a level, watertight bench with a time clock, relay switch, solenoid valve, tensiometer, and other electrical equipment. It is quite complicated to install for proper operation, and since there are so many gadgets needed, it has not been accepted enthusiastically by the growers.

Constant Level for Cut Flowers. As one of the newer developments in the practice of watering, constant level appears to be a very satisfactory means of watering cut-flower crops, provided benches can be maintained in a watertight condition for many years.

A level, watertight, V-bottom bench, with half tile or some other channel to facilitate the movement of water, is necessary (Fig. 2). The bench is filled with pea gravel placed level 1 in. above the top of the V. On top of the gravel a 1-in. layer of common sand is leveled and 4 to 6 in. of well-prepared soil are placed on top of the sand. A small tank with a float valve placed in or on the side of the bench is connected to the bottom of the bench by means of pipe or hose, the purpose of which is to maintain a constant level of water in the bench. To aid in observing the water level in the bench, a short length of 3-in. tile or a 4-in. flower pot may be placed in the bench at the time of filling.

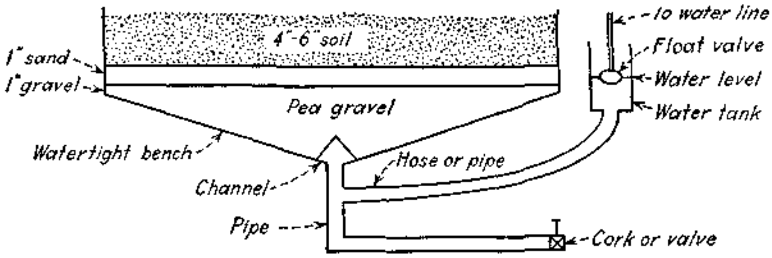

FIG. 2.—Cross section of V-type bench for constant-level watering for cut flowers.

The plants should be benched in the usual fashion and watered thoroughly overhead in the usual manner to wet the soil and establish capillarity. Immediately after watering, the float valve should be adjusted so that the water level is maintained in the lower ½ in. of sand. Provided the system is connected properly and good capillarity is established, no further attention need be given the bench as far as watering is concerned. A number of benches all on the same level may be watered from one tank and float valve.

To fertilize the plants, drain out the water, apply the dry fertilizer on the soil, water it in thoroughly, and when dripping stops, start the float valve in action again. Indications are that less fertilizer per application is needed as none of it leaves the soil except that which the plant absorbs. This, however, may be true only if precautionary overhead leaching is not given at regular intervals.

Selenium may be applied the same as fertilizer, either dry or liquid. The constant evaporation of water from the soil surface will cause a gradual accumulation of fertilizer or soluble salts in the upper layer of soil. Since there are few roots in this area, the presence of high soluble salts at the soil surface usually causes no damage. If soluble salts become high throughout the entire soil, they should be reduced by leaching. The float-valve mechanism should be disconnected, and the bench should be drained. From 3 to 5 gal. of water applied per square foot will wash out considerable excess fertilizer, and when dripping ceases, the float valve is placed in operation. Selenium tends to rise in soil watered by the constant-level method, and a light watering overhead each month will wash it down into the area occupied by the roots. When this is practiced, the excess water must be allowed to drain. In the case of roses that may be syringed for red spider control, the excess water that drips from the plants should be drained out of the bench.

The water level should not be maintained in the soil proper. If the soil becomes too dry, the water level may be raised up in the sand ¼ in. or so, but never so high as to touch the soil. The purpose of the sand is to prevent free water from touching the soil. If water does touch the soil, it will keep the soil too wet and will kill most of the roots. Marsh gas will form from decomposition of roots and other organic matter in the absence of air and is easily recognized by its objectionable odor. What will happen to the arrangement of the gravel, sand, and soil layers when the soil is spaded or rototilled remains to be seen.

On the face of it, the extremely wet condition of the soil in constant level makes it appear undesirable. The question is asked: How can plants continue to grow in that mud? The explanation is simple. When soil is watered thoroughly overhead, some of the water runs through and drips out the bottom of the bench. There are some pores too large (noncapillary) to hold this water, and it runs through, but there are other pores (capillary) which are small and hold the water. When water is applied below the soil, it rises like ink in a blotter through the small pores, and fills them completely with water. The large, noncapillary pores are too large, water cannot rise in them, and so they remain filled with air. Even though water can be squeezed from soil watered by the constant-level method, it still has air in it because of these large pores which cannot take up water.

If soil were watered overhead to keep it as moist as soil watered from below (probably once or twice every day), the large pores would be filled with water, there would be very little oxygen in the soil, and the plant roots would die.

Constant Level for Pot Plants. Although many points need further research, this system of watering is good enough to try on a small scale. It will save a tremendous amount of labor which is the bane of all pot-plant growers (Fig. 3).

A level, watertight, V-bottom bench, with half tile or some other channel to facilitate the movement of water, is necessary.

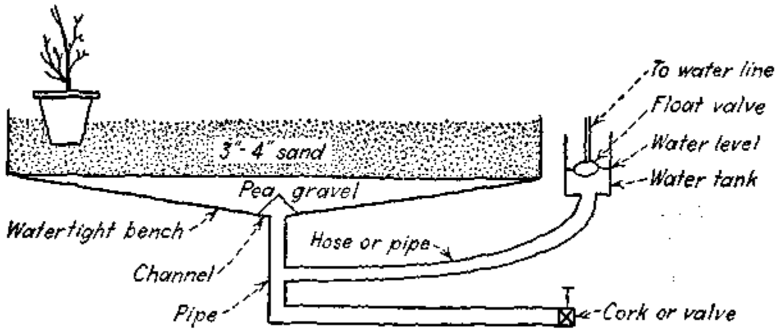

FIG. 3.—Cross section of V-type bench for constant-level watering of pot plants.

The bench should be filled with pea gravel to the top of the V. On top of the gravel is placed 3 to 4 in. of sand which should be leveled. The bottom of the bench is connected at one point with pipe or hose to a tank equipped with a float valve. The plants are potted as usual, but the piece of broken pot is omitted. The pots should be set on the sand very firmly, watered overhead thoroughly, and the float valve put into operation. If for any reason some pots dry out because of failure to establish capillarity with the water in the sand, they should be watered overhead and given a turn deeper into the sand to provide better contact between the pot and the moist sand.

The points that have not been determined are where to maintain the water level on various plants, and whether the system will work on large pots unless they are partly plunged in sand. During the winter, maintaining the level about 1 in. below the bottom of the pot works well. In summer with hot weather, it is necessary to raise the level. The water level should not be maintained so high that it touches the pot, as this keeps the soil too wet and the roots die. It may be necessary to plunge the pots in sand (keeps them clean on the outside) during the summer with the water level about 1 in. below the pot. There also may be some pot plants that may not grow in constant level.

Fertilizer may be applied in dry or liquid form, but dry fertilizer must be watered in overhead. In either case, the float valve should be disconnected and the bench allowed to drain during the watering so that the water level can be readjusted to the desired point.

Marsh gas will develop within the pot if the soil is kept too moist. This is common if the water level is maintained too close to the bottom of the pot. When the plant is knocked out of the pot, all or a part of the root system may be dead, and a very objectionable odor can be readily detected. Lowering the water level or making a poor contact between the sand and pot by setting the pot on the sand lightly is the means of preventing this.

Breakers. Benches are watered overhead by directing the water onto the soil surface with a hose. When high-pressure water from 60 to 100 lb. is used, some method of counteracting the packing effect of the water on the soil must be employed. Breakers are ideally suited for this. The Advance breaker is well adapted to use on roses. At the widest portion of the bell or bulb there is a metal plate crosswise to the direction of flow of the water. This plate breaks the force of the water, and a large volume may be applied without packing the soil. The long type of breaker consists of several screens which reduce the force of the water without appreciably affecting the volume. A breaker composed of soft rubber tubing fitted with a female coupling placed over a spiraled rose stake is satisfactory.

Tensiometers. Recently the use of tensiometers has been suggested by Post of Cornell University as an indication of the time to water. The device consists of a special porous clay cup placed in the soil; attached to it is a vacuum gauge. The entire system is filled with water, and as the soil dries out, water diffuses from the porous cup into the soil. As this occurs, there is tension exerted on the water in the system; this causes the hand on the vacuum gauge to move, indicating that the soil is drying. Such an instrument would be very useful to the commercial florist in eliminating guesswork in watering. It would be necessary to determine at what point on the vacuum gauge the soil was dry enough to water, and in the future each time the hand on the gauge reached that point, water could be applied. There is a possibility that the system could be made automatic by installing proper electrical equipment on subirrigated benches (Fig. 4).

FIG. 4.—Tensiometer (with attachment for automatic watering).

Outdoor Watering. In the garden the same methods of determining the time to water may be used as described for the greenhouse, keeping in mind that outdoor plants generally will not be injured by becoming somewhat drier, provided they do not wilt.

Water is applied by means of rotary or stationary sprinklers, overhead lines, canvas hose, or by spraying with a nozzle attached to a hose. No matter which method is used, thoroughness of application is essential. Frequent light waterings encourage a shallow root system which will be injured in hot, dry weather. The soil should be watered to a depth of approximately 6 in. before moving to another location. The average person has neither the time nor the patience to water properly with a nozzle on the end of a hose as it should be directed on one area for a period of 2 to 4 hr. Canvas hose waters the area directly underneath it as lateral movement of water in the soil is negligible.

In both the greenhouse and the garden, fertilizer should never be applied to dry soil as burning of the roots is apt to occur. If dry soil is fertilized and then watered, the concentrated solution of fertilizer moves down and usually causes burning. If the soil is moist, the fertilizer solution will be constantly diluted as it moves downward and no burning will occur.

Microorganisms in the Soil. The soil literally teems with minute organisms which are extremely important in the changes of chemical nature that take place. The most important of these are the bacteria, actinomyces, and fungi representing plant life and protozoa which form the simplest type of animal life.

Bacteria are the simplest form of plant life, consisting of single cells of varying shapes which reproduce by simple division at an exceedingly rapid rate if proper environmental conditions are available. The changes attributed to bacteria are caused by chemical substances produced by bacteria known as *enzymes.* These substances act upon various insoluble materials, making them usable as nutrients for bacteria, which further change these into sugars, acids, alcohols, and various soluble nitrogenous compounds.

For proper development bacterial growth is affected by the nutrient supply, temperature, oxygen, light, and reaction of the oil.

The usual supply of *nutrients,* for bacteria, comes from the rganic matter of the soil, so that the greater the supply of such ıaterials, particularly of easily decomposable nature as manures nd green manures, the greater the bacterial activity. Soluble ompounds of nitrogen, carbon, hydrogen, sulphur, oxygen, hosphorus, potassium, magnesium, and others form the integral art of the nutrient supply.

The best range of temperature for soil bacteria is from 60 to 0°F. At 32°F. all activity ceases, though death usually does ot occur. Many bacteria are killed at 130 to 140°F., but in ıany cases the spores remain alive even at 212°F. This is the ase where steam sterilization is used—many of the beneficial pores remaining alive and producing new generations as the heat s reduced.

Oxygen is necessary for many kinds of bacteria to oxidize rganic matter and produce rapid decomposition and nitrification. Bacteria that require oxygen are called *aerobic;* those which erish in its presence are known as *anaerobic.* The latter are articularly important in the decomposition of celluloses. As he aerobic bacteria remove oxygen for their needs, the anaerobic inds are enabled to flourish, thus making the growth of both inds possible under such conditions as manure piles and compost ıeaps.

Moisture is absolutely necessary for bacterial activity; and when it drops below 25 per cent, action may cease or death occur. *ight* has a tendency to destroy bacteria. *Slightly alkaline or* *neutral reactions* are favorable for most bacterial growth. Since bacteria produce acids, frequently such an accumulation occurs as to produce an extremely acid reaction in the soil. Sufficient amounts of calcium carbonate neutralize this effect and make for a continuance of bacterial development.

Bacteria are effective in such processes of decomposition as ammonification, nitrification, denitrification, and sulphofication.

Ammonification is the process of conversion of proteins into ammonium. The bacteria causing this are present in abundance in the air, rain water, manure, and surface of soils. The process is important in that some plants use ammonium as such but largely because the production of ammonium leads to the formation of nitrate nitrogen in the soil. The ammonium produced usually combines with carbon dioxide and water to form ammonium carbonate.

Nitrification is the process of conversion of organic matter into nitrate nitrogen—the form most used by plants. Ammonium is the form of nitrogen directly used in nitrification. Two distinct steps are involved in the process. Bacteria known as *Nitrosomanas* and *Nitrosococcus* change the ammonium into nitrous acid or nitrite nitrogen by oxidation. The *nitrobacter group* then changes the nitrite nitrogen into nitric acid or nitrate nitrogen, again by oxidation. The final product—a free acid—combines with calcium, potassium, magnesium, or sodium to form such salt as calcium nitrate, potassium nitrate, magnesium nitrate, or sodium nitrate.

Nitrification goes on most successfully in the upper layers of soil because of the presence of proper temperatures, sufficient moisture, oxygen, and nutrient supply. Acidity of the soil has to be counteracted to produce the most satisfactory effects. Ordinarily in the presence of too much moisture and exclusion of oxygen, nitrites are formed that may be extremely deleterious to plant growth. Such may be the case when soils are steam sterilized and remain too wet for a period of time.

Denitrification is a reduction process consisting of the removal of oxygen from nitric acid to form nitrous acid and then its removal to form ammonium or nitrogen gas. Another form of denitrification is the conversion of nitrate nitrogen into insoluble protein compounds. The process of denitrification is dependent upon lack of oxygen and high amounts of soluble organic matter.

Denitrifying bacteria require oxygen; and when sufficient quantities are not present in soils, removal from nitrates results. Hence we note the process occurring in saturated and poorly drained soils. Any condition that promotes soil aeration diminishes the danger from denitrification. Likewise application of nitrates to soils lacking in air may cause their conversion to free nitrogen. Presence of large amounts of carbohydrates causes greater denitrification. Practically, heavy applications of nitrates and *fresh green manures* may produce denitrification.

Denitrification into insoluble proteins may be useful in holding such compounds in soils so as to avoid losses by leaching.

Nitrogen Fixation. Some forms of bacteria are able to add nitrogen to the soil, and such a process is called *nitrogen fixation.* This may be done by nonsymbiotic organisms which live in the *soil independently of plants; or it may occur through the action* of plant-dependent, or symbiotic, bacteria. The former belong to the *azotibacter* group which are able to utilize the atmospheric nitrogen in the soil and combine it with other elements in their cells. The most favorable conditions for such an effect are a large supply of carbohydrates; low nitrates; the presence of soluble compounds of calcium, phosphorus, potassium, sulphur, iron, and manganese; and an acid reaction.

The symbiotic bacteria (*Bacillus radicicola*) gain entrance largely into leguminous plant roots through the cell walls of root hairs; and as they multiply, the cells proliferate and develop nodules. Upon maturity these nodules decay, and nitrogen is added to the soil. The soil conditions that favor general nitrification are likewise suitable for the nitrogen fixation, except that only a minimum amount of available nitrogen must be present.

Practically use of the nitrogen-fixation process is helpful in crop rotations and in substitution of green-manure crops for the application of commercial fertilizers. Where nitrogen-fixing bacteria are lacking, they may be supplied by the addition of pure cultures or by inoculation with soils containing the bacteria. Inoculation fails to produce results where soils are strongly acid, the supply of potassium and phosphorus is inadequate, the nitrogen supply is high, and aeration and drainage are lacking.

Sulphofication is the process of conversion of organic-matter sulphur compounds into hydrogen, sulphide, and free sulphur and later by oxidation into sulphurous and sulphuric acids. The latter combines with other compounds to form sulphates of calcium, magnesium, potassium, etc.

Effect upon Inorganic Constituents of Soil. In addition to the effect upon organic matter, the bacteria through the action of their products cause extensive chemical changes in the inorganic constituents of soils and also in the fertilizers applied to soils. The acids formed by bacterial action such as nitrous, nitric, sulphuric, and various organic acids as well as carbon dioxide gas are effective in this process of chemical change, making insoluble calcium, phosphorus, potassium, and other minerals available to plants.

Other Organisms. Actinomyces resemble both bacteria and fungi. They are abundant and effective in the decomposition of various organic compounds and particularly on resistant materials like lignin.

Fungi, or molds, are effective in the early stages of decomposition of organic matter. They function well in acid soils, converting insoluble nitrogenous compounds into proteins incorporated in their cells, which, however, are returned to the soil upon death of the organisms. Carbohydrates and cellulose are broken down readily by fungi.

Soil Acidity and Alkalinity. The soil reaction is of importance because it affects the activity of the microorganisms in the soil and the growth of plants. Alkalinity results from accumulations of salts of calcium, magnesium, sodium, and others, so as to produce an overabundance of hydroxyl ions (OH) over the hydrogen ions (H) in the soil solution. Such concentrations of soluble salts frequently occur in dry regions. In humid regions, on the other hand, the removal of calcium and magnesium may take place to such an extent as to cause a high concentration of hydrogen ions, which results in soil acidity. This is usually due to the generation of carbon dioxide from organic matter and the development of carbonic acid.

The actual removal of calcium or magnesium occurs through the leaching processes, their place being taken by hydrogen. Any manipulation of the soil that decreases magnesium and calcium tends toward acidity. Actually, additions of ammonium sulphate, aluminum sulphate, iron sulphate, or sulphur increase acidity, whereas sodium nitrate, calcium nitrate, and the various calcium compounds decrease it.

ACIDITY CHART

Low pH 5.5 and lower	Medium pH 6.0–6.5	High pH 6.5–7.5
Azalea	Hydrangea	Rose (winter)
Rhododendron	Gardenia (winter) 6.5	Carnation
Gardenia (summer)	Rose (summer)	Calendula
	Chrysanthemum	Sweet pea
	Snapdragon	Gerbera
	Carnation	Bouvardia
	Calendula	Stock
	Bouvardia	Delphinium
	Stock	Primrose
	Calceolaria	Geranium
	Cineraria	Genista
	Poinsettia	Buddleia
	Cyclamen	Swainsonia
	Lily	Boston yellow daisy
	Buddleia	Didiscus
	Marigold	Feverfew
	Myosotis	Pansy
	Zinnia	Zinnia
	Pansy	Fern
	Fern	Saintpaulia
	Saintpaulia	Yellow calla
	Yellow calla	Begonia
	Begonia	Calla
	Calla	Pelargonium
	Astilbe	
	Euphorbia	
	Fuchsia	
	Lantana	
	Petunia	
	Solanum	
	Pelargonium	

Soil reaction is usually expressed in terms of pH which is the garithm of the reciprocal of the hydrogen ion concentration and expressed by a mathematical formula—pH $= \log \frac{1}{(H+)}$. he pH scale is 0 to 14, with 7 being the neutral point. All ›ints below 7 indicate acidity; all points above show alkalinity. he change is geometric so that the units between pH 6 and 7 ›uld be 10, those between pH 5 and 6 would be 100, those ›tween pH 4 and 5 would be 1,000, etc.

Soil reaction affects plants through its influence on the physical condition of the soil, the availability of essential elements, the activity of microorganisms, and the solubility of toxic substances.

The physical condition of clay soils is affected by an acid reaction because of lack of calcium carbonate which would keep the particles coagulated, thus developing a suitable crumb structure. In sandy soils the same material acts as a binder.

The availability of the essential elements depends on the soil reaction. Phosphorus becomes less available as the pH drops below 6.5. Potassium presumably is more available in somewhat acid soils. Calcium and magnesium become less available as the acidity increases. Iron, manganese, copper, zinc, and boron are less available in neutral or in alkaline soils. In general, however, slightly acid, approaching pH 6.5, gives the highest availability of most elements. The availability of nitrogen and sulphur, both dependent upon bacterial activity, is reduced by acidity, since many of the bacteria are sensitive to acid reactions, but even for this purpose slight acidity of pH 6.5 is to be preferred to an alkaline condition.

Extremely high acidity may be responsible for the toxic effects of free iron and aluminum and may frequently be corrected by additions of phosphorus to produce insoluble phosphates of iron or aluminum.

The response of plants to the soil reaction varies considerably. The table on page 53 indicates, approximately, the most suitable range for many flowering plants.

SOIL TESTING

The methods used at present for testing soil acidity are either (1) colorimetric, where the soil is treated directly with an indicator solution and the resulting color compared with a standard chart, or (2) electrometric, by means of a glass electrode. The latter is the more accurate of the two, but for quick tests the colorimetric method is sufficiently accurate, provided the operator has good eyesight and uses proper precautions.

Rapid Chemical Soil Tests

Relation of Soil Tests to Other Growth Factors. Soil tests are designed to indicate the capacity of a soil to supply nutrients

The presence or the absence of nutritional material is only one of the factors affecting plant growth. Soil tests give no information regarding the effect of important physical factors such as water supply, drainage, system of cultivation, and seasonal variation of temperature and light upon crop response. Hence, to be of value, the results of soil tests must be interpreted in relation to the other factors. Some of the more important are listed here.

Previous Fertilizer Practices. The results of a soil test will be more significant if they are considered in connection with previous rates and frequencies of applications of fertilizer materials, for these records will serve as a check as to the validity of the information obtained by testing. For example, at the time of planting, only a moderate amount of nitrate fertilizer is applied to a soil known to have a low organic-matter content. A short time afterward, a test on a sample of this soil shows that its nitrate content is very high. Since the records show that the soil has a low organic-matter content, the only source of potential nitrate accessible to the soil, and that only a moderate amount of nitrate fertilizer has been applied to the soil, it may be safely concluded that an error has been made in carrying out the test. This error may have been caused by (1) contamination from unclean apparatus or (2) defective reagents.

The pH Requirement of the Crop. Generally speaking, most crops grow best in a pH range of 5.5 to 7.0, because the elements essential for plant nutrition are most generally available in this pH range. If the soil reaction is above or below this range, poor plant growth may result from any one or a combination of the following factors: a deficiency of a necessary element may occur because (1) it leaches readily from the soil or (2) it is combined with other elements in forms in which it is not available to the plant; an element may become toxic because it is present in a free state at a very high concentration.

In a soil with a pH below 5, toxicity is most frequently caused by high concentrations of free iron and aluminum. Free sulphate and manganese are also toxic on highly acid soils.

Deficiencies of base elements such as potassium, calcium, and magnesium also occur readily on soils whose reaction is below pH 5, for these elements leach readily in strongly acid soils. Nitrogen deficiency is also of common occurrence on strongly acid soils because (1) nitrates leach readily from strongly acid soils and (2) even though the total nitrogen content is high, very little nitrate will be formed, since a low pH hinders the activity of nitrifying bacteria. Phosphorus deficiency is of common occurrence on soils whose reaction is below pH 5, because at this pH it is made unavailable to the plants by being transformed into insoluble aluminum and ferric phosphates by combining with the free aluminum and iron that are usually present in high concentrations in highly acid soils.

If the crop being grown requires a strongly acid soil, iron and aluminum toxicity can be overcome by adding enough superphosphate to exceed the reverting power of the soil and establish an available range of phosphorus of 2.5 to 5 p.p.m. Subsequent additions of phosphate fertilizers should be enough to maintain this range of availability.

To maintain a sufficient available nitrate supply in a strongly acid soil the most satisfactory procedure would probably be to supplement the applications of manure with small but frequent applications of ammonium sulphate, urea, or other nitrogenous fertilizer that would not interfere with the maintenance of an acid reaction.

An ample available potassium supply could probably be maintained by the use of wood ashes or potassium chloride.

If calcium or magnesium deficiencies appeared on the plants growing in a soil that was maintained at pH 5, either could probably be corrected by applications of calcium nitrate, calcium sulphate, magnesium nitrate, or magnesium sulphate, respectively.

In soils with a reaction above pH 7.0, toxicity is most frequently caused by free aluminum or by the accumulation of salts which is indicated by high tests for both sodium and chlorine.

In soils whose reaction is above pH 7.5, calcium and phosphorus deficiencies are likely to occur; for in medium to strongly alkaline soils, calcium and phosphorus are made unavailable by being precipitated out of the soil solution or soil colloids as calcium phosphate. Phosphorus may also become unavailable in very alkaline soils by being precipitated out as insoluble aluminum phosphate.

The Nature of the Root System. In interpreting chemical tests in respect to plant growth or response of crops to fertilization or other soil treatments, the extent of the root system and the time of occupation of the land or the bench by the crop are important matters. Many cultivated crop plants obtain their mineral nutrients from the upper layers of the soil because of their shallow root system; other plants extend their roots into the ground to a depth of several feet. A deep-rooted crop that occupies the land or bench for a full growing season or longer can draw nutrients from a much larger volume of soil for a longer period of time than can a shallow-rooted, short-season crop; hence the former kind of crop can obtain its nutrients from a lower nutrient concentration in the soil.

The appearance of the crop is a valuable aid in interpreting the chemical test results obtained from the soil. If the soil test reads *blank* or *low* and the plants are stunted and have a poor color, it is quite safe to say that the plants need nutrients. In all cases, however, one must be sure that an unhealthy or a discolored appearance of the plants is not due to disease or insects before attempting to diagnose soil deficiencies or troubles by this means.

When the crop is making a good growth and the plants appear healthy, but the soil tests read low, the probable explanation is that no acute deficiency exists but that the plant is using up the nutrients as fast as they become available. Under these conditions the plant is receiving enough nutrients to make satisfactory growth, but no reserve of readily available nutrients is being built up by the soil. A moderate application of fertilizer should prove advantageous in a case such as this.

To maintain a check on the accuracy of the soil tests, a coordinate test on the plant tissue should be made. A low or blank reading on a test of tissue from poorly growing plants indicates that the poor growth is more likely a result of nutrient deficiency of the element found lacking in the soil than the result of toxicity of another soil constituent. A test on a plant that is making good growth on a soil that tests low would probably read low or blank, indicating that the absorbed nutrients are used almost immediately.

A medium test in association with satisfactory growth indicates that the plant is receiving sufficient nutrients and that the soil is maintaining a significant reserve of nutrients.

When plant growth is good and the soil tests *high*, it may be said with considerable certainty that soil conditions and fertilizer practices are such that an abundant reserve of available nutrients is being maintained.

High tests in association with poor plant growth may be interpreted in a number of ways, depending upon the environmental conditions under which the plant is growing:

1. High tests and poor plant growth may indicate that available nutrients are present in such high concentrations that they are toxic to the plants. If the plant tissue gives a high test, it may be concluded with a reasonable degree of certainty that poor growth is a result of toxicity. In the greenhouse this is often the case when heavy fertilizer applications are made during the dark days of winter or prior to a prolonged cloudy spell.

2. High tests coupled with (*a*) a wet soil; (*b*) a very compact soil, either or both of which would interfere with soil aeration; (*c*) low soil temperature; or (*d*) any combination of these factors would seem to indicate that the poor growth was a result of nutrient deficiency, not because ample nutrients are not present in the soil but because the environmental conditions interfere with proper root action and hence with the absorption of sufficient nutrients to maintain a good growth.

THE INTERPRETATION OF SOIL TESTS

Although the results obtained with these rapid chemical soil tests are only semiquantitative, they are fairly accurately representative of the portion of the soil minerals that are available to the plant as nutrients. In most soil tests a very dilute solution of a weak acid is used in extracting the soil sample. Since in some cases the presence of the acid in the extract leads to results that are apparently erroneous, a further interpretation and evaluation of individual tests will now be attempted. The discussion will be limited to seven nutrients, *viz.*, nitrate, ammonia, nitrite, phosphorus, potassium, calcium, and iron.

Nitrates. 1. As nitrates are soluble in water, the test gives practically the total quantity of nitrate in the soil.

2. From the preceding statement and from what has been said about the relation of low pH to nitrate retention and nitrate formation, it may be seen that a low nitrate test in a soil of pH 5 or lower indicates a true nitrate deficiency.

3. Low nitrate in the soil, either before or after the crop is planted or while the plants are small, especially if the plants have a yellow-green color and show a slow rate of growth, indicates nitrate deficiency.

4. Medium-nitrate tests indicate a normal nitrate supply.

5. High-nitrate tests indicate 100 to 150 p.p.m.

Ammonia. 1. Low ammonia with low-nitrate tests indicates a low supply of nitrogen in the soil.

2. High ammonia with low nitrate may indicate that a harmful soil condition is interfering with nitrate formation.

Nitrite. 1. Nitrite test results of 2 to 5 p.p.m. indicate toxicity due to nitrites.

2. The chief use of the nitrite test is to determine if sterilization of the soil formed nitrites and also when the nitrite content becomes low enough for safe planting.

Phosphorus. On strongly acid soils a low-phosphorus test usually indicates a lack of available phosphorus, for on very acid soils (below pH 5) the reverting power for phosphorus is high because of the presence of high concentrations of free aluminum and free iron.

On alkaline soils (pH above 7.5) a high-phosphorus test does not necessarily indicate a high concentration of available phosphorus, especially if the calcium content is high, because at reactions above pH 7 in soils high in calcium, phosphorus is not too readily available, since a large portion of it may be combined as insoluble calcium phosphate. A relatively high-phosphorus test is obtained because the acid in the extracting solution liberates a considerable quantity of it from the calcium phosphate. In a crop grown on a medium to strongly alkaline soil, poor growth, late maturity, and shrunken seed may be indicative of phosphorus deficiency even though the test for phosphorus is high.

For forced plant growth, as in a greenhouse, a continuous supply of 2.5 to 5 p.p.m. of phosphorus is suitable.

Potassium. 1. A low or a blank test for active potassium indicates the need of potash fertilization for intensive crop production or for forced crops.

2. A continuous supply of about 10 to 20 p.p.m. is suitable for forced crop growth.

3. The excess range of potassium in soils begins at about 50 p.p.m.

4. The potassium test is not reliable in the presence of 50 p.p.m. or more of ammonia.

Calcium. 1. A low test for calcium, about 40 p.p.m., indicates a low available supply and, if the soil is acid, also emphasizes the need for liming to grow "high-lime" crops.

2. For most plants 100 to 150 p.p.m. of calcium may be considered good. Since at soil reactions above pH 7 calcium in the presence of high amounts of phosphorus may be present in large quantities as insoluble calcium phosphate, a high-calcium test does not necessarily mean that a large amount of calcium is available. A high test is obtained because considerable calcium is liberated from the calcium phosphate by the acid in the extracting solution.

Sometimes very high calcium tests are obtained when the soil reaction is as low as pH 6.0. In such a case the high test indicates that large amounts of calcium are present in insoluble form.

In strongly alkaline soils calcium and phosphorus can be made more available by lowering the pH by incorporating an acidifying material such as sulphur, ferrous sulphate, or aluminum sulphate into the soil or by the use of fertilizers leaving an acid residue such as ammonium sulphate. The same procedure can be used for making calcium more available on slightly acid soils.

Iron. Most soils give low tests for soluble iron. Chlorotic plants on an alkaline soil may indicate iron deficiency. If this condition is suspected, the recommended provisional tests for reserve iron should be made. A low reserve iron supply emphasizes the possibility of iron deficiency.

Excessively high tests for iron in a strongly acid soil indicate iron toxicity. The high-iron test will be accompanied, usually, by a high test for sulphates, nitrates, or chlorides.

OTHER USES OF RAPID CHEMICAL SOIL-TESTING REAGENTS

The reagents used in soil testing may be used in a number of other ways that aid plant culture besides (1) estimating the amount of available nutrients present in soils and (2) verifying suspected cases of nutrient deficiency or nutrient abnormality by chemical examination of the plant itself:

1. A rough picture of the relative amounts of various soluble chemical constituents in the drainage waters from soils or in the waters of springs or streams may be obtained by the application of these tests to such waters.
2. The reaction and the approximate concentration of nutrients in nutrient solutions may also be determined by means of these rapid chemical tests.

SUMMARY

1. Rapid chemical soil tests are designed to indicate the capacity of a soil to supply available nutrients. The results of these soil tests are only semiqualitative.

2. The soil tests give no information regarding the effect of important physical factors such as water supply, drainage, system of cultivation, and temperature and seasonal variations upon crop response.

3. Plant tests show the relative nutrient supply as compared with the other possible limiting factors. The results apply only to the conditions under which the plants have grown.

4. A coordinated system of soil testing that gives a rather complete picture of the nutrient status of both soil and plant is much more valuable than a single test for any one nutrient.

5. In practical interpretations, full consideration should be given to other plant growth factors. The appearance of the plant is often of much assistance. Soil type, water supply, and other physical factors that influence fertilizer efficiency and potential productivity must be considered.

6. The tests serve as good indicators of the type of fertilizer that can be profitably used, *i.e.*, whether it should be high in nitrogen, phosphorus, or potassium or in a combination of these nutrients. For a definite recommendation these findings should be coupled with the general knowledge as to the amount of fertilizer and time and method of application that have been found profitable for different crops and soil.

7. In general, with soil tests and plant tests, very low results for any nutrient indicate a definite need for all crops under practically all conditions, and very high tests an adequate supply. Intermediate tests may not be so easily and so definitely interpreted. Except in extreme cases, no crop-production factor should be considered alone but only in its relation to other factors.

SOIL STERILIZATION

Soil pests (insects, disease organisms, and animal life) are readily controlled by proper sterilization methods. Sterilization can be accomplished by chemicals, heat, or a combination of the two.

Chemicals

Formaldehyde. This is a powerful liquid disinfectant useful in frames or areas where steam is not available. Loosen the soil, and soak with a solution of 1 gal. (4 qt.) of commercial formalin to 50 gal. (200 qt.) of water. Use ½ to 1 gal. of this solution per square foot of soil area. Cover with airtight material such as paper, tarpaulin, canvas, or Sisalkraft for 24 hr. Black shading cloth is not sufficiently airtight and is unsuited for covering. Allow 10 to 14 days for drying and airing, but do not plant until all odor of formaldehyde has disappeared from the soil.

The soil may become puddled from the drenching, which is undesirable. Waiting for the soil to dry and air out is costly. Do not use this method in a greenhouse where other plants are growing, as damage may occur. It is very satisfactory on outdoor soils.

Cuprocide 54Y (**Red Copper Oxide**). Its chief use is sterilization of seed flats to prevent or control damping-off fungi. Dissolve ½ oz. of the dust in 1 gal. of water, and apply at the rate of 1 pt. per square foot of area. This material is of no value to sterilize soil in the bench.

Dichlorethyl Ether. This heavy liquid may prove valuable in controlling symphilids (garden centipedes). Make an emulsion by mixing 66 cc. dichlorethyl ether, 1 cc. Areskalene (Monsanto Chemical Company, St. Louis, Mo.), and 33 cc. water. Use at the rate of 6 to 10 cc. of the emulsion per gallon of water, which will cover a 10 to 12 sq. ft. area. It has been used directly on soil in which plants are growing at the lower concentration. Since this material is as yet in the experimental stage, it is safest to try it on a small scale.

Chloropicrin (Tear Gas or Larvacide). This liquid evaporates as a gas and is a new material that may be used in frames, in compost heaps, or in a greenhouse bench. *It cannot be used in a greenhouse where other plants are growing—damage or death results.* For a greenhouse bench where soil is about 6 in. deep use 4 to 6 cc. (cubic centimeters) per square foot. For frames and compost heaps use 6 to 8 cc. per sq. foot. The material is best applied with an applicator made by Innis Speiden Company, New York, which can be adjusted to deliver the required number of cubic centimeters. If no applicator is available, punch holes with a crowbar or a pipe 1 ft. apart each way and 4 to 8 in. deep. Pour the required amount of liquid in the hole, and cover with soil.

Success depends on several factors. The soil must be only moderately moist—just hold its shape when compressed in the hand. Loosening it before application is desirable. The temperature must be 60 to 65°F., or satisfactory results may not be obtained. The soil must be covered for 3 to 4 days with an air-tight seal.

Sprinkling with water to moisten only the top inch is satisfactory but difficult to accomplish. Too much water results in poor penetration of the gas, and not enough allows its escape. Impervious paper or a tarpaulin fastened securely at all edges is good. Remove the cover after 3 days, and air the soil thoroughly before planting. The effects of chloropicrin in the soil are similar to steam in many respects. Other soil fumigants are discussed under Pest Control.

Heat

Sterilization of soil by heat is generally practical on benches where chemicals are usually not.

Electricity. Although useful where power is cheap, the effects of electricity on the soil are not so satisfactory as steam. Two general methods prevail: (1) heating the soil with cables or (2) inserting plates in the soil that allow it to conduct a current; being quite resistant, the soil rises in temperature. Neither of the methods has been used generally in greenhouses; but both offer possibilities, especially the former. The latter method with plates is dangerous, as touching the soil or plates results in severe shock or death.

Hot Water. Steam is mixed with water so that the temperature of the water is 180 to 200°F. This is applied through a pipe which is forced into the soil at various depths over the area to be sterilized. The soil quickly cools the water, and large amounts of water must be applied so that a temperature of 160 to 170°F. is reached in the soil. It is necessary to allow the soil to dry before planting, this often requiring considerable time in winter. Soils may become puddled, and unsatisfactory results may be obtained because of insufficient or nonuniform heating.

Steam. Sterilization of soil with steam is the easiest, most economical, and most effective method of combating soil-borne insects, diseases, and animal pests. Several methods of using steam are given below.

Steam Rake or Harrow. A framework of pipe is made to fit the bench or the bed, and into this pipe framework are screwed teeth made of small-size pipe. The teeth are 6 in. long, spaced 6 in. apart each direction on the frame, and closed at the end by flattening. Either $\frac{1}{8}$- or $\frac{3}{16}$-in. holes are drilled near the flattened end of the teeth for the passage of steam. Small valves fitted in them to close when the teeth are forced in the soil and open when the steam is applied prevent clogging of the openings with soil. The steam is supplied by a hose and circulates through the framework into the teeth, which are buried in the soil. Only small sections of benches can be sterilized with such an outfit.

Buried Pipe. Perforated pipe made by drilling two lines of $\frac{1}{8}$- or $\frac{3}{16}$-in. holes on opposite sides of the pipe about 8 to 12 in. apart is buried 3 to 6 in. deep in the soil. Two lines spaced 18 to 24 in. apart are sufficient for a 4-ft. bench. The soil is covered with a tarpaulin, canvas, or newspaper and steamed. Labor required to fit the pipes is great, but operators have widened one end of the pipes and narrowed the other end so that a tight fit between pipes is obtained by hitting the end of the pipes with a hammer.

Buried Downspouting. This is similar in all respects to the buried pipe system, but 2- or $2\frac{1}{2}$-in. galvanized spouting is used. It is easier and faster to move from bench to bench because of light weight.

Inverted Pan. A pan made to fit the width of the beds is constructed of 14 to 20 gauge metal about 6 to 9 in. deep and is inverted over the soil. Steam enters through a coupling at the top or may be generated from within by electric cables under a tray of water. Only small sections can be sterilized, and it is not practical on raised benches.

Buried Tile. Three- or four-inch agricultural tile are laid end to end 1 in. from the bottom of the bench or 3 to 6 in. deep in a ground bed. In ground beds the tile may be placed 9 to 12 in. deep and serve as drainage—constituting a permanent tile system. With temporary systems the tile is removed following sterilization.

The effects of steam sterilization on the soil are marked. Direct changes are on (1) soil structure, (2) organic matter, and (3) biological activity. Heat causes the soil particles to clump together in granules, making the soil more friable and permitting greater aeration. Eventually the soil returns to the original state of structure, but the initial push given to a crop in its early stages by the improved aeration is of value. Organic-matter decomposition is hastened by steaming. This improves the structure and promotes activity of the many microorganisms in the soil. Biological changes are of great importance, although we cannot see them. The heat kills many, but not all, of the various organisms in the soil. Bacteria that liberate nitrates are readily killed, whereas those liberating ammonia are quite resistant to heat. Molds and actinomyces are killed easily with short periods of sterilization. Indirect changes are on the fertilizer, or nutrient, content of the soil. As a result of the changes in bacterial population, nitrates drop for 2 to 3 weeks and then rise rapidly until a peak is reached about 6 weeks after steaming. Under conditions of poor aeration (wet soil and poor drainage) nitrites accumulate that inhibit plant growth. Ammonia accumulates as the nitrates drop and decreases as the nitrates increase. At the end of 4 to 6 weeks little ammonia is present in the soil. Soluble salts are not increased to the danger point unless the fertilizer content of the soil is high at the start. Leaching heavily (3 to 4 gal. per square foot) overcomes this difficulty.

Pointers on Steam Sterilization. 1. Apply manure before sterilization to hasten its decomposition by action of heat.

2. Have the soil moderately moist so that it forms a crumbly ball when firmed with the hand.

3. Two lines of tile or pipe to a 4-ft. bench and three lines for wider benches are necessary.

4. Fifty to seventy-five feet each way from the header is the maximum efficient length for tile or pipe lines.

5. Carry at least 15 lb. steam pressure. Sterilization will be accomplished more quickly.

6. Allow the soil to reach 160°F., and leave the steam on for at least 20 to 30 min. Place a dairy thermometer at a point where the soil will be coolest (farthest from tile). Also, place a potato in the soil; and when it is baked, the soil is sterilized.

7. Cover the soil with tarpaulin, canvas, or other airtight material to retain the heat.

8. Place the covering over the ends and sides of the bench. This sterilizes the bench as well as the soil.

9. Turn on the steam slowly in concrete benches to prevent cracking of the bench. Be sure that the sides and the ends are covered to permit uniform heating.

10. Remove the cover immediately after sterilization and the tile or the pipe whenever cool enough to handle.

11. Clumping of particles results in better aeration; hence the soil in the bench dries out more rapidly.

12. Nematodes can be easily controlled in raised benches by allowing the steam to remain on for 60 min. after reaching 160°F.

13. The cost of sterilizing is less than changing the soil. Changing soil costs 2.5 to 3.5 cents per square foot area, and steam sterilization from 0.6 to 1.5 cents per square foot, which includes all costs (labor for laying and removing tile and covering, water, coal, etc.).

Combinations

Steam and formaldehyde have been used successfully with an inverted pan. Less time is required, but additional equipment to vaporize the water and formaldehyde is necessary. As yet, this is not practical on large-scale operations.

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CHAPTER III

FERTILIZERS

A fertilizer is any material that when added to the soil increases its fertility and produces better crops. Fertilizers may be classed as organic or inorganic, depending on whether the origin is from plant or animal residues or from materials of natural mineral deposits and synthetic combination of various elements. The term "plant food" commonly ascribed to fertilizers is a misnomer, since plants manufacture their food from the nutrients secured from the soil in combination with carbon, hydrogen, and oxygen derived from air and soil.

The elements used as nutrients for plants are nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, sulphur, boron, zinc, copper, and many others in minute quantities. Insofar as is known and conjectured, these play certain specific roles in plant nutrition.

Nitrogen. Nitrogen encourages vegetative growth, improves green color in the foliage, and increases size of flowers and plumpness of seeds. It tends to govern the utilization of potassium, phosphorus, and other elements and plays an important role in protein development within the plants. Succulence of growth is an aftermath of its sufficiency and as such is used where foliage development is essential. On the other hand, it has some detrimental effects—delay of maturity, weakness of stems, lowered quality, and increased susceptibility to disease.

The selection of the material to use depends upon its cheapness and the speed with which it becomes available. Vegetable and animal organic materials are less quickly available because the proteins in them have to be decomposed before they are usable by plants. The synthetic organic and the inorganic materials are available more quickly. Because of this quicker availability, greater caution should be used in the application of inorganic fertilizers than those of organic nature. The solubility of inorganic and synthetic organic fertilizers makes them usable in liquid form. Usually the materials containing 15 to 20 per cent nitrogen are dissolved at the rate of 1 oz. to 2 gal. of water. Others should be used proportionally.

NITROGENOUS FERTILIZERS

Kind	Nitrogen, per cent	Other elements, per cent	Rate of application, lb. per 100 sq. ft
Inorganic:			
Sodium nitrate	15	....	1
Potassium nitrate	13	41% potassium	1
Calcium nitrate	15	20% calcium	1
Ammonium nitrate	35	....	½
Ammonium sulphate	20	....	1
Organic (synthetic):			
Calcium cyanamid	21	25% calcium	1
Urea	46	....	¼
Calurea (mixture urea and calcium nitrate)	34	....	½
Organic (vegetable):			
Cottonseed meal	7	3% phosphorus 2% potassium	2–3
Soybean meal	6.5	6% phosphorus 1% potassium	2–3
Tobacco	3	10% potassium	5–10
Organic (animal):			
Dried blood	6–12	....	2–3
Tankage	8	10% phosphorus	2–3
Fish tankage	8	6% phosphorus	2–3
Garbage tankage	3	....	5–10
Activated sludge	5	3% phosphorus	4–6
Hoof meal	10	2% phosphorus	2

Nitrogen-deficiency Symptoms. These are exhibited by a severe dwarfing of the plant and a uniform yellowing of all the leaves. The *yellowing starts on the old growth and soon spreads to the* young leaves as well. The affected leaves dry slowly but remain on the plant. This yellowing of the foliage may be caused by excessive moisture at the roots accompanied by poor drainage, but in such cases leaves drop rapidly. Frequently overdoses of nitrogen may also cause yellowing.

Overdoses of nitrogen are accompanied by short internodes and small leaves and flowers. The leaves first brown at the margins and then turn yellow. At first the foliage may turn extremely dark green. Wilting may follow excess applications of nitrogen, and in some instances leaves become crinkled.

Phosphorus. Phosphorus plays an important part in cell division and in the formation of fats and albumen. The changing of starches to sugars is done in the presence of phosphorus. In general, phosphorus hastens maturity, encourages root development, strengthens stems, and is present in high amounts in seeds. Its affect upon plant growth is especially valuable, since it counteracts some of the detrimental effects of nitrogen by hastening maturity, increasing the root systems of plants, and playing its role in flowering.

Phosphorus is sold either as superphosphate (20 per cent phosphorus); treble phosphate (45 per cent phosphorus); ammonium phosphate (11–48–0); and bone meal, raw or steamed.

Bone meal should be finely pulverized for best results. This is feasible only if the bones were subjected to steaming so as to remove the fatty substances in them. Steamed bone meal contains about 1 to 1½ per cent nitrogen, whereas the raw bone may carry as high as 3 per cent. Which to use becomes a question; the greater amount of nitrogen in raw bone is balanced by the better availability of phosphorus in the steamed bone meal. Bone meal is not soluble in water but becomes soluble as the organic acids in the soil act on it. The phosphorus in bone meal is its least soluble form—tricalcium phosphate—requiring considerable time to change over to the soluble forms. In general, however, the phosphorus in bone may be considered slightly less soluble than in the superphosphate. In acid soils bone meal may have a better effect than superphosphate; but where adequate amounts of calcium are present, superphosphate is more satisfactory than bone in spite of its content of nitrogen as an added factor of value. Bone meal has a definite alkaline effect on the soil; however, its use for such a purpose is not economical.

Superphosphates are soluble in water and hence provide quicker action than bone meal. This is particularly true of the treble phosphate. Additions of lime cause the reversion of the soluble monocalcium and dicalcium forms (as found in superphosphate) to change to tricalcium form, but even under such circumstances the phosphorus is still as quickly available as in the form of bone meal. The chief disadvantage is the fact that under very acid conditions superphosphates are not so satisfactory as bone meal.

The differences in price between the materials should be given consideration when purchased—the superphosphates being much cheaper even when the nitrogen of bone is considered.

Ammonium phosphate is the most soluble form of phosphorus and, where both nitrogen and phosphorus are desired, makes the most satisfactory material of all the phosphates. In the form of ammophos (11–48–0) or in the complete fertilizer ammophoska (15–30–15) it is exceptionally satisfactory.

Monocalcium phosphate (food grade), which contains 55 per cent phosphoric acid and is being used in gravel culture solutions, is too expensive for average soil application. It is quite highly soluble in water.

Availability of Phosphorus. Fineness of grinding is important in such phosphorus fertilizers as bone to permit each individual particle being in contact on all sides with soil and later with root hairs. Such fineness is not desirable in the soluble phosphates, even though they may change over to a somewhat insoluble form upon contact with soil moisture. This form becomes soluble through the action of various organic acids in the soil, so that at least a portion may be used by the plant.

Phosphorus is utilized by the bacteria and the fungi of the soil and may be tied up for a period but later is released for plant use. As in the case of nitrogen when straw mulch is applied, the loss is only temporary. The spread of roots through the soil causes phosphorus availability, as certain solvents are released by the roots in contact with particles of phosphorus. Hence it is very important that phosphorus in the form of bone or superphosphate be mixed thoroughly with the soil and particularly in the areas where roots abound. The solubility of ammonium phosphate will force its passage to a greater depth than other forms of phosphorus. The rate of phosphorus penetration through the soil is only about ½ in. in depth per year; hence any surface applications are of little value. It should be mixed with soil whenever possible.

Granulated Phosphates. As pointed out previously, superphosphate should not be used in fine form, and this is also true of ammonium phosphate. Granular materials permit of less care in application. They have much less tendency to stick together. Likewise, the granules expose less surface to the surrounding soil, thereby reducing the amount of fixation (insolubility) of phosphoric acid by the soil.

Applications. Superphosphate (20 per cent) and bone meal may be used at the rate of 5 lb. per 100 sq. ft. preferably as mixtures in the soil. If applied to the top, they should be worked in. The beneficial effect from surface applications of bone meal is due to the nitrogen content which, however, is quickly dissipated. If an organic nitrogen fertilizer is desired, tankage is the preferable form. Ammonium phosphate could be used as a top dressing at the rate of 2 lb. per 100 sq. ft., and ammophoska at the rate of 1 to 1½ lb. per 100 sq. ft.

Phosphorus deficiency is indicated by dwarfing of plants caused by a small root system. The color of the foliage is very dark purplish green at first with marginal yellowing developing later and followed by dropping of the leaves.

Overdoses of phosphorus occur only at extremely high concentrations. The first symptoms show a browning of the older leaves, usually at tips and margins. Later, complete shriveling may occur, or the leaves may become puffed.

Potassium. Potassium tends to balance both nitrogen and phosphorus by encouraging longer root systems and delaying maturity. It is essential in starch formation and its translocation. It is needed in chlorophyll formation and is helpful in assimilation of carbon dioxide so that in the greenhouse in the winter when light intensity is low, additions of potassium tend to compensate for that lack. In general, potassium seems to add tone and vigor to plants and reduces susceptibility to disease. Dahlia and other root crops benefit by its presence, and the coloration of flowers is sometimes intensified through its application.

Many of our cultivated soils, particularly sands and peats, are lacking in sufficient quantities of potassium for the needs. Even in clay and silt soils continual use without the compensating additions of manures or leguminous cover crops will cause potash depletion, which will result in unsatisfactory growth.

Because potassium is held by soil particles and thus is not readily leached, large quantities would apparently be available to the plant. Yet actually a comparatively small percentage is available. As a consequence it has been found that to maintain a high level of this element, frequent applications are necessary.

Thus, if our nitrogen–phosphorus–potash–calcium relationship is maintained at 25 to 50 p.p.m. (nitrogen)–10 p.p.m. (phosphorus)–40 to 80 p.p.m. (potash)–150 p.p.m. (calcium), it would be necessary to add potash at more frequent intervals than nitrogen which becomes more readily available. In the majority of our soils that is frequently necessary.

It is interesting to note that a soil high in colloidal matter (fine particles of soil of gel-like nature to which the property of adsorption is attributed) may come to such a shortage of potassium necessary for its maintenance that when potash is added, little or no effect is produced because of competition between the soil colloidal matter and the plants. Thus, frequently a heavier application of potash may be required on clay soil than on sand, this in spite of the fact that clay soils are usually considered to have more potash than the sandy types. Considering all these matters, the use of potash cannot be overlooked. Likewise, it must be borne in mind that growers of by-gone days did not seem to need to apply potash—they were content with the use of manures and bone meal. And therein lay the story. (1) The soils themselves—more virgin than now—contained enough potash; (2) manure supplies potash in high amounts; and (3) the calcium in bone as well as its nitrogen had and have a capacity to liberate potassium. Thus, frequently, when we apply lime or nitrate of soda, we liberate potash; but a limit is eventually reached, and replacements must be made.

One of the best sources of potassium is unleached wood ashes containing 3 to 10 per cent. However, since about 50 per cent of the ashes is in the form of lime, on neutral or alkaline soils wood ashes may become detrimental.

Other usable sources are tobacco stems or dust (3 to 5 per cent), flue dust from cement industry (10 per cent), flue dust from iron blast furnaces (16 per cent), waste from sugar-beet factories (16 per cent), seaweed (28 per cent), wool washings from the wool industry (10 to 14 per cent). The usual forms, however, are potassium chloride (muriate of potash) and potassium sulphate and occasionally in combination with nitrogen as potassium nitrate.

Potassium chloride is the form usually preferred, although potassium sulphate may likewise be used. Either one is used ordinarily at the rate of 1 to 2 lb. per 100 sq. ft. of bench. Where magnesium is lacking in the soil, potassium magnesium sulphate may be substituted. Since the first two mentioned contain about 50 per cent potassium, other materials bearing potash may be used in proportion. As an example, hardwood ashes containing 10 per cent potash could be used at the rate of 5 to 6 lb. per 100 sq. ft., and tobacco could be used in even greater amounts, except for its tendency to hold moisture when used too heavily and likewise because of its nitrogen content.

Potassium deficiency is readily recognized by an initial mottling of the foliage, followed by marginal browning and dying of the lower leaves. This occurs because of the mobility of potassium and its translocation to the younger leaves when a deficiency occurs.

Excess of potassium is evidenced by plants of dwarf nature with short internodes. Yellowing of the foliage begins at the bottom and progresses upward. The yellow leaves turn brown and finally shrivel. Extreme overdoses will cause a complete collapse of the plant in a short time.

MINOR OR TRACE ELEMENTS

Much study has been given of late to the functions of the so-called "minor elements" in the soil and their effect upon plant growth. In many instances they are present in sufficient quantities in the average soil or else are furnished by the use of fertilizers that contain these as impurities. The minor elements include calcium, sulphur, iron, magnesium, boron, manganese, aluminum, sodium, chlorine, copper, zinc, selenium, iodine, barium, arsenic, titanium, etc.

These elements are needed in minute quantities and affect plants in a number of ways. They may act as catalysts (aids), may depress some injurious reactions to plant growth, may make certain elements more available, may help maintain certain specific ratios between elements, may help in maintaining greater resistance to disease. In view of these facts it is well to note just how some of them affect plant growth, *but at the same time it does not necessarily mean that additions should be made unless proved that such elements are lacking to a damaging extent.*

Calcium. Calcium is needed for cell-wall formation, formation of protoplasm and proteins, and development of roots. It is usually considered a necessary agent in reducing the acidity of soils. Calcium is applied to the soil in the form of calcium carbonate (limestone), calcium hydroxide (slaked lime), or calcium sulphate (land plaster). The last named provides the calcium without changing the soil reaction. To avoid raising of the pH of the soil, calcium should be used with caution, although it should be maintained to a level of at least 150 p.p.m.

Calcium Deficiency. Nearly all the feeding roots die within 2 to 4 weeks. Death of the terminal bud follows. Severe stunting of the plant results, and finally the plant dies entirely.

Magnesium. Magnesium is needed in chlorophyll formation; otherwise chlorosis develops, characterized by yellowing of margins and between veins. Magnesium has an effect upon the availability of phosphorus and although needed in small quantities is quite important. Approximately 5 p.p.m. is a desirable amount in the soil. Preliminary tests with *roses* have shown indications that a sufficiency of magnesium *has some effect on the development of bottom breaks,* possibly because of increased root action due to greater phosphorus mobility within the plant. It should be applied to soils as magnesium sulphate at the approximate rate of 1 lb. per 100 sq. ft. If calcium is low, magnesium applications may cause damage.

Magnesium Deficiency. The earliest symptom is a greatly reduced rate of growth. A chlorosis appears on the lower part of the plant. The yellowing comes between the veins, and the veins remain normally green. Petioles are short, and the entire plant becomes severely stunted. Frequently necrotic areas appear very suddenly (within 24 hr.) between the veins. On some types, puckering of leaves is evident. Leaf abscission is prevalent with some plants. Roots are few in number. Blooming is delayed, and flower color is poor.

Manganese. Manganese is important in the making of chlorophyll and the formation of sugars in plants. In addition, it apparently has an effect in regulating the solubility of iron. In strongly acid soils concentrations of manganese are injurious, whereas in alkaline soils the material is unavailable. Soils testing above 5 p.p.m., if acid, may cause damage. If manganese is lacking in alkaline soils, their acidification may release it. The best pH is between 6 to 6.5; and if any additions are made, the rate of ½ lb. per 100 sq. ft. is sufficient (manganese sulphate).

Manganese Deficiency. The top leaves become chlorotic between the veins. This type of chlorosis can be distinguished from iron chlorosis in several ways. First, manganese deficiency is usually not so severe as iron deficiency. Second, necrotic areas due to manganese deficiency are smaller in size and are located in the middle of the leaf. Third, even the most minute veins remain green in manganese deficiency, and the leaf has a very netted appearance.

Iron. Iron is necessary for chlorophyll formation, in the making of carbohydrates and proteins. Its lack is evidenced by chlorosis and may be controlled by the application of ferric sulphate if the pH is about 5 to 5.5 or ferrous sulphate if the pH is about 6 to 6.5. The amounts used are: 1 lb. per 100 sq. ft., or 4 oz. to 5 gal. of water.

Iron Deficiency. The first symptom is a chlorosis between the veins of the top leaves of the plant. On some plants this chlorosis becomes so severe that necrotic areas appear on the leaf. These necrotic areas are usually larger than those due to manganese deficiency and appear more generally on the margins and tip of the leaf.

Boron. Boron has an effect in reducing internal disorders in the plant. In small quantities its presence is essential for the development of terminal shoots, elimination of extreme brittleness of stem, the upkeep of tissues, and maintenance of actively growing roots. In alkaline soils and with extremely high calcium content, boron becomes inactive and deficiency symptoms occur, particularly cracking and corking of stems. It is likewise thought to be useful in regulation of water and carbohydrate transportation within the plant. If used as borax or boric acid, extremely small amounts are applied—10 to 15 lb. per acre. When applied, a concentration of 1 p.p.m. is sufficient.

Boron Deficiency. Death of the terminal bud is characteristic. This causes the development of the lateral buds. The leaves on the top of the plant become thick and brittle and tend to roll in a half circle from the tip toward the base.

Sulphur. Sulphur is a component of proteins and is thus important. It likewise promotes an increased root system and has an indirect effect on the chlorophyll. It is usually present in most of the fertilizers applied so that additions are useless unless needed for acidification purposes.

Sulphur Deficiency. As a general rule, the veins of sulphur-deficient leaves are lighter than the rest of the leaf. This condition is exactly opposite to that found in all other deficiencies. Plants have a much slower rate of growth. The top leaves of the plant are affected first.

MINOR ELEMENTS IN FERTILIZERS

Frequently the use of certain mixed fertilizers is advocated because of the supposed additions of certain minor elements of plant growth that may be lacking in the soil, such as iron, manganese, magnesium, boron, sulphur, and others. Theoretically such an assumption is correct; but practically even if the soils are deficient in these materials, the crude fertilizers that we apply separately or that form the component parts of mixtures contain many of these "impurities" or minor elements in sufficient quantities. Let us examine some of these.

Ammonium sulphate contains, besides the ammonium, some *sulphur, fluorine, lead,* and *arsenic.*

Nitrate of soda contains nitrogen, silicon, iron, aluminum, magnesium, sulphur, iodine, manganese, calcium, boron, chlorine, and potassium.

Potassium chloride contains potassium, chlorine, sulphur, sodium, magnesium, manganese, calcium, and, from some sources, boron and iodine.

Calcium nitrate contains nitrogen, calcium, aluminum, iron, magnesium, sodium, chlorine, and sulphur.

Superphosphate contains phosphorus, arsenic, calcium, magnesium, iron, aluminum, potassium, sulphur, manganese, copper, zinc, boron, and lead.

COMPLETE FERTILIZERS

In the majority of cases soils become depleted of the major elements such as nitrogen, phosphorus, and potassium. To make sure that these are supplied in adequate amounts, so-called "complete" fertilizers are sold. Many different formulas have been computed for various crops, but in general for garden purposes the standard is a 4–12–4 formula, meaning 4 per cent nitrogen, 12 per cent phosphorus, and 4 per cent potassium. It is usually applied at the rate of 2 to 4 lb. per 100 sq. ft. For ecific purposes such as tree fertilization the 10–6–4 formula is ed; for dahlia and peony a 2–10–10 formula is advocated.

Many trade-marked complete fertilizers are based on the -12–4 formula. They differ from the cheaper form fertilizers the same ratio because of better mixing; the breaking of the trogen component into organic and inorganic parts to give nger availability; the additions of trace elements such as iron, anganese, sulphur, and others; the elimination of fillers and at mes preparing them in such a way that a residual acid reaction left.

Manure. Manure from cows, horses, pigs, sheep, hens, and bbits is an important source of organic matter in the soil. In ldition to its nutrient contents, manure is valuable for its addion of microorganisms to the soil, its betterment of the waterlding capacity of the soil, its aid in the structural changes in e soil, and perhaps its hormone content.

Manure is both solid and liquid, with about one-half the trogen, two-thirds of its potassium, and all its phosphorus found the solid form. The available portions in the liquid form make at likewise a valuable part and one that needs to be conserved possible.

In general, manure may be said to contain 0.5 per cent nitrogen, 25 per cent phosphoric acid, and 0.5 per cent potassium. However, there is considerable variation, depending partially on the pe of food used by the animals and partially upon the animal om which the excrement is secured.

PERCENTAGE OF NITROGEN, PHOSPHORUS, AND POTASSIUM IN VARIOUS MANURES

Kind	Nitrogen	Phosphorus	Potassium
Horse	0.70	0.25	0.55
Cow	0.60	0.15	0.45
Pig	0.50	0.35	0.40
Sheep	0.95	0.35	1.00
Hen	1.00	0.80	0.40

It will be noted that manure is thus a low-grade fertilizer when compared with the usual formulas used. However, the high amounts of manure used in comparison with commercial fertilizers provide sufficiently large portions of nutrients. A common application to gardens is about 20 tons per acre which supplies 200 lb. of nitrogen, 100 lb. of phosphoric acid, and 200 lb. of potassium. This will equal about 1,200 lb. of nitrate of soda, 600 lb. of superphosphate, and 400 lb. of potassium chloride, which makes a rather heavy application per acre. It should be borne in mind that these total amounts are not readily available, so that actually per ton we might expect the immediate availability of only 5 lb. of nitrogen, 1 lb. of phosphoric acid, and 5 lb. of potassium.

Because of the low amount of phosphoric acid available the average manure is considered an unbalanced fertilizer, and usually additions of phosphorus are necessary. It should be noted that although manure is supposed to be especially valuable for its nitrogen, actually greater amounts of potassium are usable because of the tendency for the nitrogen to be leached or escape by fermentation. Hence the potassic value of manure should not be overlooked.

For garden purposes fresh manures are to be used when they are spaded in or plowed under some time previous to planting. Well-rotted manures may be used at any time; and since additional nutrients needed may be supplied by commercial fertilizers, as a matter of safety such manures are to be preferred to fresh manures. The residual effect of manures has been found to be of long duration, and part of their value lies in that effect.

The use of shredded and dried manures is of doubtful value when their high cost is considered. They cannot be used in such quantities as are recommended for stable manures, so that the comparatively small amount of organic matter that they add is not compensated for by the price paid. Sheep manure in particular is highly overrated for garden or greenhouse purposes It would be much better to incorporate stable manure or other humus material for their organic-matter content and supplement with commercial fertilizers.

Artificial Manures. Such manures are made by the use of straw, hay, leaves, and other vegetable matter to which fertilizing materials are added. The usual procedure is to stack a pile of straw in layers about 12 in. deep and spread commercial fertilizers on top of each layer until a height of 4 or 5 ft. is reached. The fertilizers used may be any complete fertilizer of 4–12–4 ratio at the rate of about 150 lb. per ton of straw or a combination of

60 lb. of ammonium sulphate, 25 lb. of superphosphate, 30 lb. of potassium chloride, and 50 lb of agricultural lime. Likewise, 100 to 150 lb of calcium cyanamid may be used as a substitute for the ammonium sulphate and limestone.

As the layers are made, a proportionate amount of the fertilizer should be scattered over the top and watered in thoroughly. The top of the entire stack should be dished to permit water to collect and penetrate through the pile. The success of such a procedure depends on the amount of water applied and the season of the year. If done late in the spring and properly watered, a ton pile of straw will make about 2½ tons of well-rotted manure in 6 to 8 weeks. Such a manure will be as satisfactory as stable manure and in addition will be more balanced, ordorless, and comparatively free of weed seeds. Its cost in comparison to stable manure is higher and depends upon the price of straw or other vegetable matter used. Where stable manure is difficult to obtain, artificial manure is very desirable.

Green Manures. Green manures constitute the cheapest and best method of preparing soil. They furnish additional organic matter, better the physical condition of the soil and add nutrients. The average crop of green manure adds 5 to 10 tons of material to the soil, of which three-fourths usually is in the form of water. A large proportion of the dry matter consists of carbon, hydrogen, and oxygen, the mineral parts having come from the soil originally. However, as these return, they are in intimate contact with organic materials and are thus made quickly available by decomposition.

Green manures should be disked in when in a partially mature stage rather than when ripe, because the content of carbohydrates increases with maturity, while the nitrogen and the minerals decrease.

The amount of nitrogen added to the soil by a green-manure crop will depend upon the crop chosen, the yield, the maturity, and various other factors. Leguminous crops will add more nitrogen than nonlegumes. A leguminous crop well grown and plowed under at the right time may add as much as 100 to 150 lb. or more of nitrogen per acre. This would be equivalent to an application of 10 to 15 tons of average farm manure or 500 to 750 lb. of ammonium sulphate.

Subsoils may be greatly improved through the growth of green-manure crops, especially legumes. Such crops should not be judged by the amount of material produced above the ground alone. Tests have shown that at certain periods as much as 33½ per cent of the total plant of alfalfa or red clover is in the roots. Sweet clover, vetch, and soybeans run 26½, 17, and 12 per cent, respectively, while rye has only about 5 per cent of the total plant in the roots. Of equal importance is the fact that with cereals approximately one-half of the total root system is in the first 10 in. of soil while with alfalfa and probably other legumes, as much as 40 per cent of the root system is below 30 in.

This deep penetration of roots may be of considerable importance in the distribution of fertilizers, especially phosphorus. When applied to the surface of the soil, the penetration of this element is very slow. Deep-rooting legumes may act in taking some of this element from near the surface to the lower root zones.

The extent of growth of green-manure crops will depend largely upon the tilth and richness of the soil. For legumes especially, the soil should be in fine tilth and should contain enough nutrients to start a quick active growth. On poor soils where a crop like soybeans follows directly the removal of other crops, it will be well to add a complete fertilizer, low in nitrogen, at the rate of 400 to 600 lb. per acre. For the crops that thrive only in slightly acid or alkaline soils (pH 6.5 to 8.0), it will be well to add lime if the soil is naturally highly acid. The additions of lime should be based upon actual tests to determine its necessity. The green-manure crops listed will grow readily in soils between the minimum pH given in the table and pH 7.5 to 8.0. If leguminous crops are used on a field for the first time, inoculation may be advisable or necessary.

In the decomposition of organic material, considerable nitrogen is used by the bacteria doing the work. If the amount of nitrogen in the crop is less than 2 per cent at the time it is plowed under, it will be used in the decay of the organic matter and leave little available for the following crop. Because of this it may pay, with crops such as rye that are low in nitrogen, to add some inorganic nitrogen to the soil.

The table on page 81 gives suggested green-manure and cover crops for soil improvement in the field.

Sod crops are those which remain on the land for a period of more than a year. There are several mixtures which may be

Crop	Duration	Minimum soil acidity for favorable growth	Approximate per cent of nitrogen in tops and roots at time plowed under	Amount of seed per acre	Planting season	Time to plow under	Notes
Sudan grass. .	Annual	pH 6.0	2.25	20–30 lb.	May 20–June 20	Aug. 1–20	In mixture, use ¾ soybeans, ¼ sudan grass
Soybeans.	Annual	pH 6.0	2.65	1½–2 bu.	May 15–June 15	When beans in pods are ½ to ⅔ grown	Use varieties Earlyana, Richland, or Lincoln. Seed should be inoculated before sown
Rye*.	Winter annual	pH 5.5	1.75	1½–2 bu.	Sept. 1–15	When 9–10 in. high, about mid-April	Percentage of nitrogen reduces rapidly if plowed under later
Hairy vetch. .	Winter annual	pH 6.5	3.75	3–4 pk.	Aug. 1–Sept. 15	Early to mid-May	Sandy, well-drained soil best. When plowed under as recommended, tops have about 4 per cent nitrogen, and roots 2 per cent. Soil should be inoculated
Rye grass. . . .	Perennial	pH 5.5	2.00	20 lb.	Sept. 1–15	Apr. 15–May 15	Suggested for trial in place of rye
Oats.	Annual	pH 6.0	. . . .	50–60 lb.	Late August	. . . .	Used as winter cover in small evergreens. Cultivate into the soil in the spring

* A mixture of rye and vetch may be used as a winter cover crop. Use a mixture of 60 lb. of rye and 20 lb. of vetch and seed early in September at the rate of 5 pk. per acre. Plow under about May 15 to 30.

used, and seed should be sown shallow in March or April, but not later than June for best results. The seed mixtures suggested below are sufficient for 1 acre.

	Pounds		Pounds
1. Timothy	4	3. Timothy	6
Orchard grass	5	Red clover or alfalfa	10
Alfalfa	5	Ladino clover	1
Red clover	5	4. Brome grass	10
Ladino clover	1	Alfalfa or red clover	10
2. Timothy	4		
Bluegrass	4		
Red clover	5		
Alfalfa	5		
Ladino clover	1		

Seed mixtures are used for these sod crops because of the adaptability of the different grasses, because of the amounts of organic matter and nitrogen added, and because of the variation in root growth. The sod crop should remain for 2 to 4 years before it is plowed down. Although these sod grasses can be hayed, greater soil improvement will be derived from them if the grass is not cut or if mowed once a year, about July 1, and left on the ground.

Peat. Peat is partially decomposed organic residue of sphagnum moss or various reeds, sedges, and grasses, produced by the laying down of many generations of plants growing in standing water. Under such conditions the exclusion of air retards the processes of decomposition. Peats are usually acid in reaction, although the presence of marl deposits frequently brings the reaction to the neutral point. The nitrogen content may range from 1 to 4 per cent, but it is usually slowly available. However, when mixed with small amounts of manure, more rapid decomposition may be expected due to the introduction of cellulose- and lignin-decomposing organisms. The phosphorus and potassium contents are low, so that peat, if used as a fertilizer, is even more unbalanced than manure.

Most of our domestic peats are from sedge deposits and are higher in nitrogen content than the foreign peats of sphagnum-moss origin. There are sphagnum-peat deposits in Maine and other parts of the country which are being exploited now. The imported peats are lower in moisture content and do not decompose so readily as the domestic kinds.

Mucks are the advanced stages of peat decay and are found closer to the surface. Their value as organic-matter addition to soils is not so great as that of peats.

Peats are very useful as mulches and for soil mixtures, particularly for plants that thrive under acid conditions. Azalea, rhododendron, kalmia, and others of the same character thrive when large admixtures of acid peats are made to soils.

Leaf mold is the partially decomposed residue of leaves and twigs that accumulate on the forest floor. Its value lies in the organic matter that it contains, and it is thus a help in the physical structure of soils. The burning of leaves in the fall is to be deplored, since a compost may be made readily in a manner similar to the making of artificial manure. Such a compost is extremely useful for mixing with soils and as a mulch.

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CHAPTER IV

HORTICULTURAL TAXONOMY

Gardening calls for the knowledge and the use of plant materials, and they in turn call for a system of names. To be authentic and international in use the names must be standardized. Since this has never been done to common names of plants except in this country alone, it will be necessary to use the botanical names which, because of their Latin and Greek roots, are world wide in their use. The value of botany, especially taxonomy dealing with the naming and classification of plants, is all too little appreciated by the home gardener, the commercial florist, and nurseryman. Yet an understanding of some of the more common botanical terms and the meanings of botanical names is helpful in learning plants. The next step beyond this is knowing something of the relationship of plants to one another. With this in mind the following list of plant families with their more common genera has been prepared.

If this will be looked upon not as a tedious list but an animated series of plant relationships, its value may be perceived. Beginners will find but limited use for it; but as experience and knowledge of plants develop, it will become of increasing value. No attempt has been made to give detailed botanical descriptions of the various families; but where a few simple characteristics apply to the entire family, they are given. All this material is adapted from L. H. Bailey's Manual of Cultivated Plants.

Much of the material in this chapter is included for its cultural value rather than its practical use. For a simple but complete presentation of the whole subject of plant families read The World of Plant Life, by C. J. Hylander; followed by The World Was My Garden, by David Fairchild. From these books will be obtained a broad conception of the cultivated plants of the world.

A BRIEF SYNOPSIS OF MORE COMMON PLANT STRUCTURES USED IN PLANT IDENTIFICATION

Flower Structure. *Parts of the Flower.* The outer row of parts is the calyx, made up of sepals. The latter may be separate (polysepalous) or partially or completely joined to each other (gamosepalous). They may be green or any other color. They

FLOWER STRUCTURE

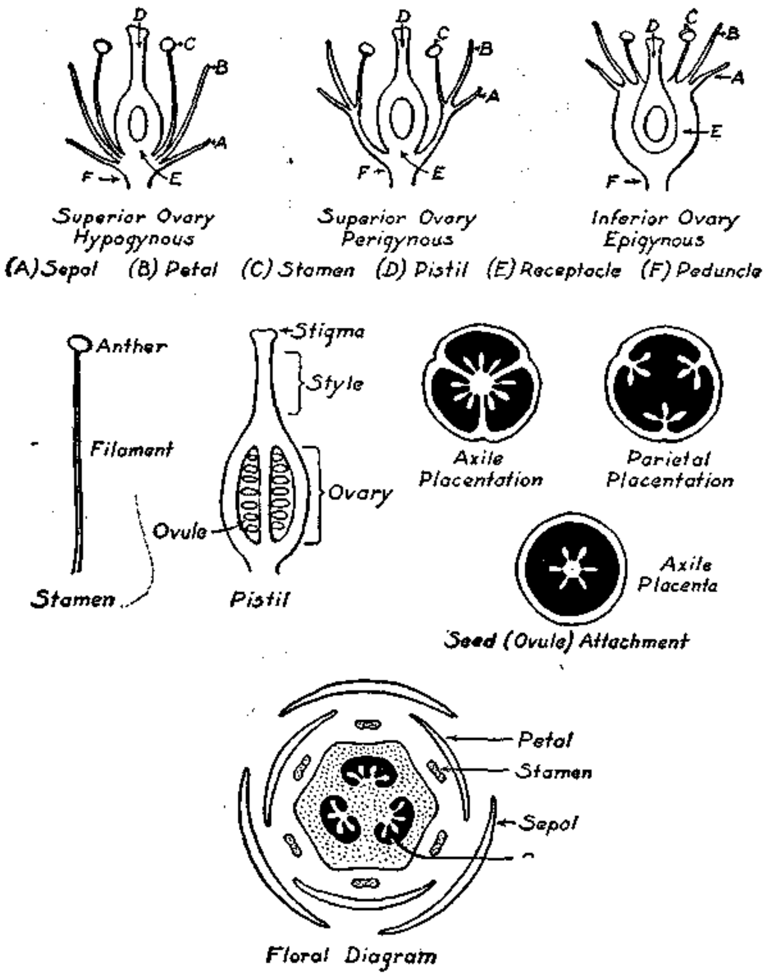

FIG. 5.

may be similar to the petals. Their number is constant for any one species, although they may be lacking entirely.

The inner set of parts of the perianth is the corolla or petals, always of a definite number in any one species, from none (apetalous) to many. They may be all alike as in the petunia (regular flower) or different as in the pansy and snapdragon (irregular flower). They may be separate as in the rose (polypetalous) or united as in the morning glory (gamopetalous). All parts of the flower are attached to the broadened end of the stem or receptacle. This varies as indicated in Fig. 5, giving a superior or an inferior ovary.

The reproductive parts of the flower are the stamen (male) and the pistil (female). They may both be present in a flower, in which case it is said to be *perfect*. If but one sex is present, it is *imperfect*. If both sexes are on one plant but in separate flowers, it is *monoecious* as in *Pinus*, *Salix*, and *Alnus*. If on separate plants, *dioecious* as in *Ilex*, *Myrica*, *Rhus*, and *Celastrus*.

The stamens consist of the anther (pollen sac) and filament. They may be independently attached to the receptacle or fused with the perianth (adnate). They may be separate or joined in a tube (monadelphous) as in the mallow family, or they may be fused in two groups (diadelphous) as in *Lathyrus* and *Citrus*. The filaments may be separate but the anthers joined as in the composite family. The number of stamens, the place of attachment and length of the filaments, and the nature of the anther are all constant characteristics used in flower identification. Stamens may be changed in appearance to resemble petals as in many double flowers. The pistil, likewise, has constant characteristics. Each is made up of ovary, style, and stigma. There may be one or more pistils, each one composed of one cell (carpel) each or of two or more. When two or more pistils are more or less united, each unit is a carpel. Within each ovary the seeds or ovules may vary from one to many in any one family. The method of attachment of the seeds to the placenta (placentation) is another constant character. The nature and number of styles of the pistils are likewise important.

POINTS TO CONSIDER IN ANALYZING FLOWERS FOR IDENTIFICATION

- Perianth
  - *Sepals*—Calyx
    - Number
    - Separate or united
    - Surface—glabrous or otherwise
    - Where attached
  - *Petals*—Corolla
    - Number
    - Separate or united
    - Regular or irregular
    - Where attached

- Essential parts
  - *Stamens*
    - Number
    - Separate or united
    - Attached at base of pistil or united with petals
  - *Pistil*
    - Inferior or superior
    - Simple (1 carpel) or compound (2 or more carpels)
    - Number of cells (carpels)
    - Ovules (how attached, number)
    - Stigma (number, kind)
- *Fruit*
  - Is the ovary containing the ovules or seeds
  - Kind—method of opening if a dry fruit

Tabulate or diagram the foregoing data in a floral plan. Note that in this plan in Fig. 5 the relation of point of attachment of sepals, petals, and stamens is indicated whether they be alternate with each other or opposite. This method should be used far more than it is. If done before attempting to use a key, there is less likelihood of making the floral parts fit the specifications of the key, and therefore a more accurate diagnosis is obtained.

The Inflorescence. Just as the individual flower has a definite structure and arrangement of parts, so a cluster of flowers has a pattern, or arrangement, on an axis. This schematic plan of flowers on the stem or axis is termed an *inflorescence.*

1. *Solitary Flowers.* Flowers may occur singly in either a terminal or an axillary position, in which cases they are said to be *solitary*. This is seen in the fruit plants of quince and peach, the former terminal and the latter axillary. The flower may be borne at the terminus of a stalk arising at the ground in a number of herbaceous plants (as with bulbs and corms). The stalk bearing the flower in this case is termed a *scape,* although it is really a peduncle as with any solitary flower. Such a case is familiar in the tulip, crocus, and violet. Since the term inflorescence implies more than one flower in a cluster, this case may be considered apart from the other two categories.

2. *The Racemose Inflorescence.* This is the most common situation in flower clusters and consists of an axis of unlimited growth bearing the oldest flowers at the base and the younger ones progressively upward to the tip. The arrangement is familiar in such plants as hollyhock, lily-of-the-valley, and snapdragon. There are various modifications of this racemose inflorescence, but the general scheme is the same. The more usual ones are as follows:

a. Raceme. The individual flowers of the main axis or peduncle have little stems known as *pedicels*, and they are of equal length. Examples are lily-of-the-valley, snapdragon, gladiolus.

b. Spike. A spike is similar to the raceme except that the flowers are sessile; *i.e.*, the pedicel is absent, as in buddleia. Commonly, the flowers are numerous, completely covering a portion of the peduncle as in plantain. In some cases they are in whorls with conspicuous intervals between the whorls as in salvia.

c. Catkin or Ament. This is a spike or raceme with a slender rachis bearing many unisexual, apetalous flowers, which falls as a whole when mature. Examples are ornamental amaranthus, birch, willow, alder.

d. Umbel. This is a short rachis bearing long-pedicellate flowers of about equal length, spreading umbrellalike as in Queen Anne's lace, ivy, cowslip, onion.

e. Corymb. The main axis is elongated, and the pedicels are of unequal length. The lower ones are longest; and the upper, or central, ones are shortest, resulting in the flowers lying in a plane. As in all racemose types the lowest ones reach anthesis first, and the maturing of the flowers proceeds upward until the last one to open is at the apex or what appears to be the center. Candytuft is an example.

f. Spadix. This is a spike with a fleshy axis (rachis). It is sometimes surrounded or overarched by a very large bract—the spathe—as in calla lily, Jack-in-the-pulpit, monstera.

g. Head or Capitulum. Numerous small flowers without pedicels are crowded together on a very short rachis called a disk. Osage orange, sycamore, sweetgum, and members of the Compositae, including dandelion and chrysanthemum, are examples.

3. *The Cymose Inflorescence*. At the growing point a flower bud is produced so that no further elongation of the axis can occur. The other flower buds of the cluster are produced below this point and hence are progressively younger from the tip of the axis toward the base. This gives a situation called *determinate growth*. The solitary flower is, in a sense, cymose. This situation is seen in the begonia, kalanchoe, exacum, hydrangea, viburnum, carnation.

Compound Inflorescences. Not infrequently some of the preceding types are compound as in the panicle (lilac), compound spike (wheat), and compound umbel (parsnip).

LEAF CHARACTERISTICS FOR PLANT IDENTIFICATION

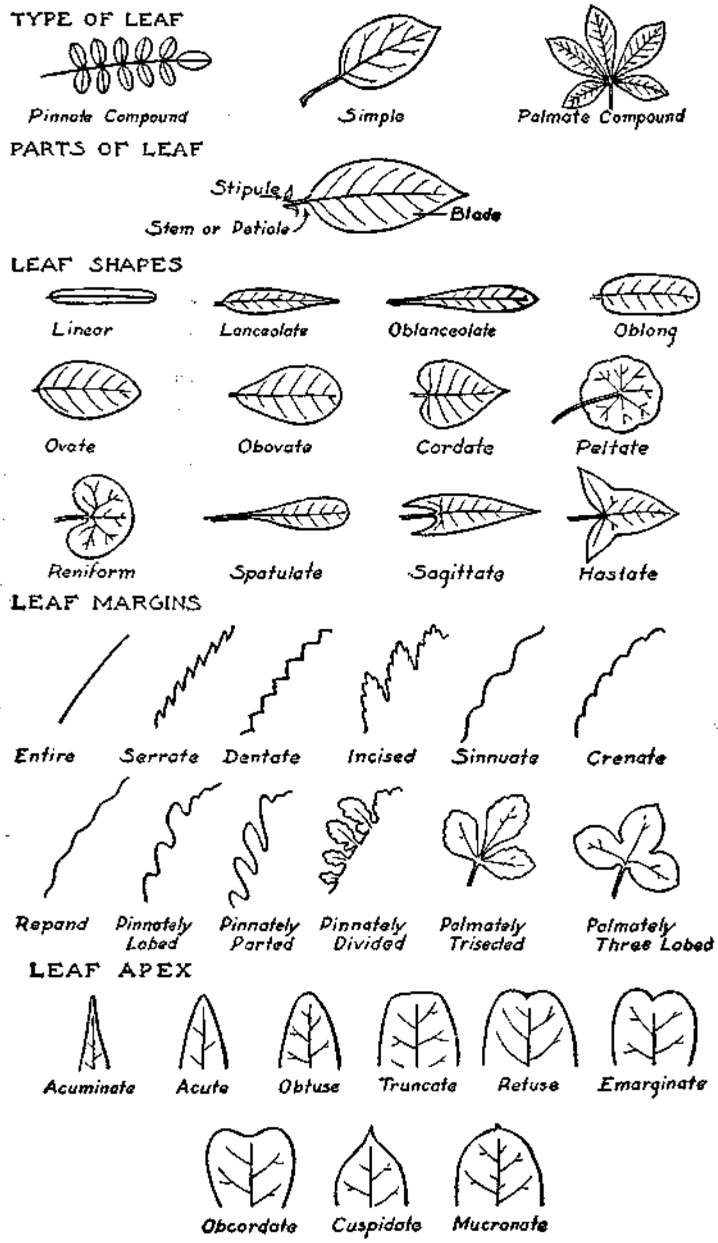

FIG. 6.

Anomalous Types of Inflorescence. It is not surprising to find flower arrangements that do not fit into the conventional types as described above. These may be called *anomalous* types. For instance in *Campanula americana,* or bellwort, the terminal flower opens first, which suggests a cyme, but then the basal one or ones open next, which suggests a racemose type.

Thyrse. This is a mixed inflorescence, the main axis of which is indeterminate and the secondary axes cymose as in privet.

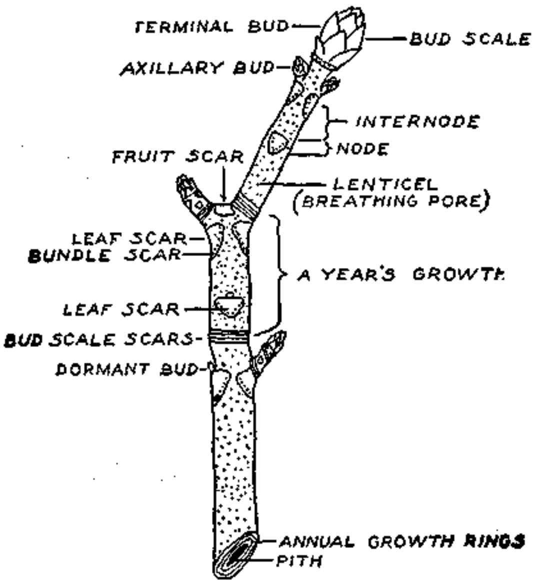

Fig. 7. —Winter-twig characters.

Oblique Inflorescence. A spike, raceme, or cyme may have the flowers developed on one side of axis only. Such clusters are known as *oblique* inflorescences or *scorpoid* spikes, racemes, or cymes. Gladiolus, freesia, and Solomonseal show this characteristic.

A practical application of the use of plant families is found in the following key to the more common families of garden flowers. It will serve to emphasize the major distinguishing characteristics among these families. In Bailey's Manual of Cultivated Plants will be found additional keys to the genera and often species within each family.

KEY TO COMMON GARDEN FLOWER FAMILIES

Adapted from L. H. Bailey's Manual of Cultivated Plants

A. Leaves mostly parallel veined; flower parts mostly threes or sixes, never fives. Woody fibers scattered through stem, no distinct pith. *Monocotyledons.*

AA. Leaves usually netted veined, flower parts prevailing in fives. Distinct bark, wood, and pith. *Dicotyledons.*

MONOCOTYLEDONS

A. Stamen or stamens and pistil grown together, flowers extremely irregular. *Orchid family.*

AA. Stamens and pistil not grown together.

B. Flowers irregular with 3 or 6 perfect stamens, ovary superior *Spiderwort family.*

BB. Flowers regular or nearly so. 3, 4, or 6 perfect stamens.

C. Ovary superior. *Lily family.*

CC. Ovary inferior.

D. Stamens 6 or, if 3, opposite inner petals. *Amaryllis family.*

DD. Stamens 3, opposite outer petals. *Iris family.*

BBB. Flowers usually irregular, 1 or 5 perfect stamens, 1 or more imperfect stamens.

C. One stamen, 2-celled anther. *Ginger family.*

CC. One stamen, 1-celled anther. *Canna family.*

DICOTYLEDONS

Group I. Petals wanting or, if present, not united. See Group II, page 93.

A. Corolla lacking, calyx present or absent, sometimes resembling corolla.

B. Ovules only 1 or 2 in each cell or ovary.

C. Pistils or distinct carpels more than 1.

D. Sepals colored and petal-like. *Crowfoot family.*

DD. Sepals not colored or petal-like. *Rose family.*

CC. Pistil 1, simple or compound.

D. Ovary superior, leaves opposite. *Pink family.*

DD. Ovary inferior, flowers calyxlike bracts. *Four-o'clock family.*

BB. Cells of ovary 3, many ovules, ovary superior.

C. Pistils 2 or more and separate. *Crowfoot family.*

CC. Pistil 1.

D. Ovary 1-celled. *Crowfoot family.*

DD. Ovary 2 and many cells. *Loosestrife family.*

AA. Corolla and calyx present.

B. Plant floating. *Water lily family.*

BB. Plant not floating.

C. Stamens more than 10.

D. Ovary inferior or apparently so.

E. Flowers unisexual. *Begonia family.*

EE. Flowers bisexual. Sepal or calyx lobes 2. ***Purslane famil***
DD. Ovary superior.
E. Pistil 1 (may be 2 or more united carpels).
F. Ovary 1-celled.
G. Ovules 2.
H. Leaves alternate. *Rose family.*
HH. Leaves opposite. *Rockrose family.*
GG. Ovules more than 2.
H. Sepals 2.
I. Juice milky or colored. *Poppy family.*
II. Juice not milky or colored.
J. Flowers regular. *Purslane family.*
JJ. Flowers irregular. *Fumitory family.*
HH. Sepals 3, 4, or 5.
I. Leaves compound. *Crowfoot family.*
II. Leaves not compound. *Rockrose family.*
FF. Ovary 2-celled or more. *Mallow family.*
EE. Pistils few to many, distinct or united at base.
F. Plants climbing. *Clematis.*
FF. Plants not climbing.
G. Stamen filaments united in tube. *Mallow family.*
GG. Stamen filaments not united in tube.
H. Stamens inserted on calyx. *Rose family.*
HH. Stamens not inserted on calyx. *Mignonette family.*
CC. Stamens definite, usually 5 to 10, or not more than twice number of petals.
D. Ovary inferior.
E. Ovules 1, in each cell of ovary.
F. Stamens 5 to 10. *Parsley family.*
FF. Stamens, 2, 4, or 8. *Evening-primrose family.*
EE. Ovules more than 1 per cell.
F. Ovary 1-celled.
G. Sepals or calyx lobes 2. *Purslane family.*
GG. Sepals or calyx lobes more than 2. *Saxifrage*
FF. Ovary 2-celled or more.
G. Styles 1. *Evening-primrose family.*
GG. Styles 2. *Saxifrage family.*
DD. Ovary superior.
E. Pistils 2 or more (may be united at base).
F. Stamens fastened to calyx tube.
G. Plant fleshy. *Orpine family.*
GG. Plant not fleshy.
H. Stipules none. *Saxifrage family.*
HH. Stipules present. *Rose family.*
FF. Stamens not fastened to calyx tube.
G. Leaves with transparent dots. *Rue family.*
GG. Leaves not as above.
H. Plant fleshy. *Orpine family.*

HH. Plant not fleshy.
I. Ovaries with styles or stigmas separate. *Crowfoot family.*
II. Ovaries separate or joined, one style. *Geranium family.*
EE. Pistil 1 (may be more than 1 carpel).
F. Ovary 1-celled.
G. Stigmas 2 or more, petals 4, ovary 1 ovule. *Mustard family.*
GG. Stigma 1, pistil 1 carpel, petals 5. *Legume family.*
GGG. Stigma 1 or more, ovules 2 or more (more than 1 carpel).
H. Corolla irregular.
I. Petals and stamens 6. *Fumitory family.*
II. Petals and stamens 5. *Violet family.*
HH. Corolla regular or nearly so.
I. Ovules not attached to outer walls of ovary.
J. Stamens free, not attached to corolla.
K. Stamens attached to calyx tube. *Loosestrife family.*
KK. Stamens not attached to calyx tube. *Pink family.*
JJ. Stamens attached to corolla. *Plumbago family.*
II. Ovules attached to outside wall of ovary.
J. Stamens 6. *Mustard family.*
JJ. Stamens otherwise.
K. Stamens numerous. *Rockrose family.*
KK. Stamens same or twice as many as sepals. *Saxifrage family.*
FF. Ovary 2-celled or more.
G. Corolla very irregular.
H. Calyx not tubular. 1 long spur.
I. Carpels 1 ovule. *Nasturtium family.*
II. Carpels several ovules. *Balsam family.*
HH. Calyx tubular. *Loosestrife family.*
GG. Corolla regular or nearly so.
H. Petals 4, stamens 5, with 2 shorter. *Mustard family.*
HH. Petals and stamens otherwise.
I. Flowers unisexual, juice milky. *Spurge family.*
II. Flowers bisexual.
J. Leaves digitate. *Oxalis family.*
JJ. Leaves pinnate. *Saxifrage family.*
JJJ. Leaves simple, may be lobed.
K. Carpels joined by styles. *Geranium family.*
KK. Carpels not joined by styles.
L. Leaves opposite or verticillate.
M. Petals not fastened to calyx. *Pink family.*
MM. Petals on calyx. *Loosestrife family.*
LL. Leaves alternate. *Flax family.*

Group II. Corolla in one piece, petals more or less united.
A. Ovary superior.
B. Stamen not attached to corolla. *Nolana.*
BB. Stamen attached to corolla. Twice or more as many as corolla lobes, or if same number opposite lobes. *Primrose family.*

BBB. **Stamens** attached to corolla, not more than lobes of **corolla, alternate** with them.

C. Ovaries 2, distinct, each 1-celled.

D. Stamens distinct, styles united. *Dogbane family.*

DD. Stamens usually united. styles separate. *Milkweed family.*

CC. Ovary 1, 1-celled.

D. Style 1.

E. Stamens as many as lobes of corolla. *Gentian family.*

EE. Stamens fewer, 2 or 4. *Gesneria family.*

DD. Style 2. *Waterleaf family.*

CCC. Ovary deeply lobes around style. Parts separating as **nutlets.**

D. Leaves alternate. *Borage family.*

DD. Leaves opposite. *Mint family.*

CCCC. Ovary 1 but compound, *i.e.*, 2-celled or more.

D. Fruit 4 nutlets.

E. Leaves opposite. *Verbena family.*

EE. Leaves alternate. *Borage family.*

DD. Fruit not as above.

E. Stamens fewer than lobes of corolla, usually **2 to 4.**

F. Leaves opposite. *Acanthus family.*

FF. Leaves alternate.

G. Fruit a berry or capsule. *Nightshade family.*

GG. Fruit a nutlet. *Globularia family.*

EE. Stamens same number as lobes of corolla.

F. Ovary cells and stamens 3. *Phlox family.*

FF. Ovary cells usually 2 or more, but not 3.

G. Ovules 2, fastened bottom of cell. *Morning-glory family.*

GG. Ovules fastened center wall of cell.

H. Capsule 2-celled. *Acanthus family.*

HH. Capsules not 2-celled.

I. Corolla lobes valvate or plicate in bud, flowers usually regular, leaves alternate. *Nightshade family.*

II. Corolla lobes imbricate, flowers usually irregular. *Figwort family.*

AA. Ovary inferior.

B. Plants with tendrils. *Cucumber family.*

BB. Not as above.

C. Anthers separate.

D. Stamens inserted on corolla.

E. Stamens fewer than lobes of corolla.

F. Stamens 2 or 4, ovary 1-celled, many ovules. *Gesneria family.*

FF. Stamens 1 to 3, ovary 3-celled, 2 cells aborted. *Valerian family.*

EE. Stamens same number as lobes of corolla. *Madder family.*

DD. All stamens free from corolla. Milky juice. *Campanula family.*

CC. Anthers united in tube above style.

D. Flowers not capitate, corolla irregular. *Lobelia family.*

DD. Flowers in head. *Composite family.*

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Acanthaceae. Acanthus family. Shrubs and herbs. Over 170 genera, 2,000 species. Flowers usually irregular	....	Acanthus Ruellia Thunbergia	Beloperone Fittonia Jacobinia Ruellia Strobilanthes
Aceraceae. Maple family. 2 genera of trees and shrubs, over 100 species. Leaves opposite, simple or compound. Sepals 4–5, petals 4–5, stamens 4–10. Ovary superior, 2-lobed. Fruit 2-parted	Acer		
Aizoaceae. Carpet weed family. About 20 genera and over 500 species. Usually fleshy, inhabitants of desert or seashore. Flowers regular	....	Mesembryanthemum	
Amaranthaceae. Amaranth family. Mostly herbs. Over 40 genera, about 500 species. Flowers small but inflorescence often showy. Foliage often colorful	....	Amaranthus *Celosia* Gomphrena	Iresine Telanthera
Amaryllidaceae. Amaryllis family. Over 70 genera, 800 species. Distinguished from lily family by inferior ovary, from iris family by 6 stamens	....	Alstroemeria Amaryllis Galanthus Hymenocallis Leucojum Lycoris Narcissus Nerine Polianthes Sprekelia	Agave Clivia Crinum Eucharis Haemanthus Hippeastrum (Amaryllis)
Anacardiaceae. Cashew family. Trees and shrubs. About 60 genera, 400 species. Leaves usually alternate. Includes California peppertree and pistachio (nuts)	Cotinus Mangifera Rhus Schinus		
Apocynaceae. Dogbane family. Trees, shrubs, herbs, often vines. About 130 genera, 1,100 species. Milky juice. Flowers regular, sepals 5, petals 5, stamens 5	Carissa Nerium (Oleander) Plumeria	Tabernaemontana Vinca	Allamanda
Aquifoliacae. Holly family. Trees and shrubs. 3 genera, 300 species. Leaves usually alternate, often evergreen	Ilex		
Araceae. Arum family. Over 100 genera, about 1,500 species. World-wide, mostly tropical; mostly herbs. Inflorescence, a	....	Acorus Arisaema Colocasia	Aglaonema Anthurium Caladium Dieffenbachia

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
spadix surrounded by usually showy bract or spathe			Monstera Philodendron Scindapsus (Pothos) Schismatoglottis Zantedeschia (Calla)
Araliaceae. Aralia or ginseng family. Trees, shrubs, herbs. Over 50 genera, about 500 species. World-wide. Often prickly. Leaves usually alternate. Flowers usually small	Acanthopanax Aralia Hedera	Panax	Aralia Fatsia Hedera
Asclepiadaceae. Milkweed family. Shrubs, herbs, often vines. Usually milky juice. About 220 genera, 2,000 species. Leaves usually opposite. Flowers regular, sepals 5, petals 5, stamens 5; united in column, ovary superior	Periploca	Asclepias	Ceropegia Hoya Stapelia Stephanotis
Balsaminaceae. Balsam family. Herbs. 2 genera, over 500 species. Flowers irregular	....	Impatiens	Impatiens
Begoniaceae. Begonia family. Mostly herbs. 5 genera, over 400 species. Leaves alternate, usually oblique base. Flowers more or less regular, sexes separate	....	Begonia	Begonia
Berberidaceae. Barberry family. Herbs or shrubs. About 10 genera, about 200 species. Leaves alternate	Berberis Mahonia Nandina	Aceranthus *Epimedium*	
Betulaceae. Birch family. Trees and shrubs. 6 genera, over 100 species. Leaves alternate. Flowers monoecious in catkins	Betula Alnus Carpinus Corylus Ostrya		
Bignoniaceae. Bignonia family. Mostly trees, shrubs, often vines. About 100 genera, 600 species. Leaves usually opposite. Flowers usually irregular	Bignonia Campsis Catalpa Jacaranda Tecoma	Incarvillea	
Boraginaceae. Borage family. Mostly herbs. About 85 genera, 1,500 species. Leaves usually alternate. Plants often rough, hairy	....	Anchusa *Cynoglossum* Echium Heliotropium Mertensia Myosotis Omphalodes Pulmonaria	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Buxaceae. Box family. Trees and shrubs. 6 genera, 35 species	Buxus Pachysandra Sarcococca		
Cactaceae. Cactus family. About *100* genera, *1,000* species. Mostly American. Succulent plants; usually spiny; a few hardy in north. Leaves usually absent	....	Opuntia	Cereus Echinocactus Epiphyllum Mammillaria Opuntia Pereskia Selenicereus Zygocactus
Cannaceae. Canna family. 1 genus with over 50 species of tropical plants. Sepals 3, petals 3, stamens often petal-like; ovary inferior, 3-celled	....	**Canna**	
Capparidaceae. Capper family. Herbs and shrubs. About 35 genera, 450 species. Flowers irregular	....	**Cleome**	
Calycanthaceae. Calycanthus family. Shrubs. 2 genera, 6 species. Aromatic bark. Leaves opposite, entire	Calycanthus Meratia		
Campanulaceae. Bellflower family. Trees, shrubs, herbs. About 40 genera, about 1,000 species. Usually milky juice. Leaves usually alternate. Flowers usually regular; sepals 5, petals 5, stamens 5	....	Adenophora Campanula Jassione Phyteuma Platycodon Wahlenbergia	
Caprifoliaceae. Honeysuckle family. Mostly shrubs. *11* genera, about 350 species. Leaves opposite	Abelia Diervilla Kolkwitzia Lonicera Sambucus Symphoricarpos Viburnum	Linnaea	
Caryophyllaceae. Pink family. Herbs. About 70 genera, about 1,200 species. Leaves opposite, entire, stems swollen, at joints. Flowers regular, sepals 4–5, petals 4–5, stamens 8–10, ovary superior	....	Arenaria Cerastium Dianthus Gypsophila Lychnis Sagina Saponaria Silene Spergula Tunica	**Dianthus**

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Celastraceae. Stafftree family. Trees, shrubs and vines. About 45 genera, 400 species. Often colorful fruits	Celastrus Euonymus Pachistima		
Chenopodiaceae. Goosefoot family. Herbs, annuals and perennials. Over 75 genera, 500 species. Flowers small, inconspicuous. Family includes spinach and beets	....	Beta Kochia	
Cornaceae. Dogwood family. Mostly trees and shrubs. About 10 genera, 85 species. Leaves usually opposite	Cornus	....	Aucuba
Compositae. Composite family. Mostly herbs, a few shrubs. Over 800 genera, about 12,000 species. Sometimes milky juices. Flowers in compact heads. Easily distinguished as a family but difficult to determine within the family	Baccharis	Achillea Actinea Ageratum Ammobium Antennaria Anthemis Arctotis Artemisia Aster Bellis Boltonia Brachycome Calendula Callistephus Catananche Centaurea Chrysanthemum Coreopsis Cosmos Dahlia Dimorphotheca Doronicum Echinacea Echinops Emilia Erigeron Eupatorium Felicia Gaillardia Gazania Gerbera Helenium Helianthus Heliopsis Helipterum	Gynura Senecio

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
		Helichrysum Hieracium Inula Layia Leontipodium Leptosyne Liatris Matricaria Rudbeckia Santolina Sanvitalia Senecio Solidago Stokesia Tagetes Ursinia Venidium Xeranthemum Zinnia	
Commelinaceae. Spiderwort family. 26 genera, about 300 species of annual and perennial herbs. Leaves alternate. Flowers 3 sepals, 3 petals, stamens 3 or 6. Ovary superior	....	Commelina Tradescantia	Rhoeo Tradescanthia Zebrina
Convolvulaceae. Morning-glory family. Trees, shrubs, herbs, often vines. Over 40 genera, about 1,000 species. Juice sometimes milky. Leaves alternate. Flowers regular, sepals 5, stamens 5, ovary superior	....	Calonyction Convolvulus Ipomoea Quamoclit	
Crassulaceae. Orpine family. Mostly fleshy herbs. About 20 genera, 900 species. Usually called *succulents.* Flower characters variable	....	Sedum Sempervivum	Bryophyllum Cotyledon Crassula Echeveria Kalanchoe Rochea Sedum
Cruciferae. Mustard family. Mostly herbs. Over 200 genera, about 1,800 species. Leaves usually alternate. Flowers regular; sepals 4, petals 4, stamens 4 long, 2 short. Ovary superior. Many ornamental and vegetable plants in this family	....	Aethionema Alyssum Arabis Aubrieta Cheiranthus Draba Erysimum Hesperis Iberis Ionipsidum Lunaria Malcomia Matthiola	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Cucurbitaceae. Gourd family. Tender herbs. About 90 genera, about 700 species. Leaves alternate. Flowers, regular, unisexual, sepals 5, petals 5	....	Cucurbita Echinocystis Lagenaria Momordica	Abobra
Cyperaceae. Sedge family. World-wide, usually distinguished from grasses by 3-angled, solid stems, 3-ranked leaves. Many genera and species	....	....	Cyperus
Dipsaceae. Teasel family. Herbs. About 7 genera, 140 species. Leaves opposite. Flowers small	....	Cephalaria Dipsacus Scabiosa	
Elaeagnaceae. Oleaster family. Trees and shrubs. 3 genera, about 45 species. Plants covered with silvery or light brown scales	Elaeagnus Hippophae Shepherdia		
Ericaceae. Heath family. Small trees, shrubs, subshrubs. About 70 genera, 1,400 species. Wide distribution. All require acid soil	Andromeda Arctostaphylos Calluna Enkianthus Erica Gaylussacia Kalmia Leiophyllum Leucothoe Oxydendrum Pieris Rhododendron Vaccinium Zenobia	Epigaea	Azalea
Euphorbiaceae. Spurge family. Trees, shrubs, herbs. About 250 genera, over 4,000 species. World-wide. Sap often milky. Flowers relatively small, sexes sometimes separate; flowers often surrounded by colorful involucre	....	Euphorbia Ricinus	Acalypha Codiaeum Euphorbia Pedilanthus
Fagaceae. Beech family. Trees and shrubs. 5 genera, 600 species. Leaves alternate. Flowers without petals. Fruit a 1-seeded nut	Fagus Quercus Castanea		
Fumariaceae. Fumitory family. Herbs. 5 genera, about 170 species. Related to poppy family but no milky juice. Flowers irregular	....	Adlumia Corydalis Dicentra	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Gentianaceae. Gentian family. Usually annual or perennial herbs. About 70 genera, 750 species. Leaves usually opposite. Flowers regular	....	Eucommia Exacum Gentian Sabatia	
Geraniaceae. Geranium family. Mostly herbs. 11 genera, over 600 species. Flowers usually regular, sepals and petals usually 5	....	Erodium Geranium	Pelargonium
Gesneriaceae. Gesneria family. Usually herbs. 84 genera, about 500 species. Commonly cultivated ones usually with fleshy leaves; leaves usually opposite	....	....	Achimenes Saintpaulia Sinningia (Gloxinia) Streptocarpus
Ginkgoaceae. Ginkgo family. 1 genus, 1 species. Sole survivor of prehistoric group	Ginkgo		
Graminae. Grass family. About 400 genera, 4,500 species. Includes foods as rice, corn, oats, wheat, barley, rye, sugarcane; ornamentals as bamboo and grasses	Arundinaria Bambusa Phyllostachys	Agrostis Arrhenatherum Briza Coix Eulalia Festuca Miscanthus Pennisetum Poa Zea	Oplismenus
Guttiferae. Garcenia family. Trees, shrubs, herbs. 45 genera, about 700 species. World-wide. Leaves opposite. Flowers regular, stamens many	Hypericum	Hypericum	
Hamamelidaceae. Witch-Hazel family. Trees and shrubs. About 20 genera, 50 species	Corylopsis Fothergilla Hamamelis Liquidambar		
Hippocastanaceae. Horsechestnut family. Trees or shrubs. 2 genera, over 20 species. Leaves opposite, digitately compound. Flowers irregular	Aesculus		
Hydrophylloceae. Waterleaf family. Mostly herbs. 18 genera, about 225 species. Mostly American. Leaves usually alternate. Flowers regular	....	Nemophila Phacelia	
Juglandaceae. Walnut family. Trees. 6 genera, 35 species.	Carya (Hicoria) Juglans		

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Leaves alternate, pinnately compound. Include many of edible nuts as walnut, hickory, pecan			
Iridaceae. Iris family. World-wide. Around 60 genera, 1,000 species. Flowers with bracts beneath. Perianth, 6 parts. 3 stamens, 1 pistil, inferior ovary	....	Belamcanda Crocus Gladiolus Iris Moraea Tigridia Tritonia Watsonia	Acidanthera Babiana Freesia Ixia Marica Sparaxis
Labiatae. Mint family. Shrubs or herbs. 160 genera, about 3,000 species. Many cultivated for aromatic qualities. Leaves opposite or whorled. Flowers irregular, ovary superior	Elsholtzia	Ajuga Dracocephalum Lamium Lavandula Mentha Monarda Nepeta Perilla Physostegia Rosmarinus Salvia Scutellaria Stachys Teucrium Thymus	Coleus
Lauraceae. Aromatic trees and shrubs. About 40 genera, 1,000 species. Include cinnamon, avocado, and camphor. Leaves usually opposite. Flowers regular	Cinnamonum Laurus *Lindera* (Benzoin) Persea Sassafras		
Liliaceae. Lily family. World-wide. Over 200 genera, over 2,000 species. Usually perennial. Bulbous or fleshy rooted. Flowers 6 parts or lobes, stamens 6 or 3, superior ovary	Smilax	Allium Anthericum Brodiaea Calochortus Camassia Chinonodoxa Colchicum Convallaria Eremurus Erythronium Fritillaria Galtonia Gloriosa Hemerocallis Hosta Hyacinthus Kniphofia Liriope	Agapanthus Aloe Asparagus Aspidistra Chlorophytum (St.-Bernard's-lily) Cordyline Dracaena Lachenalia Sansevieria

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
		Lilium Muscari Ophiopogon Ornithogalum Paradisea Scilla Tricyrtis Tulipa Yucca	
Lardizabalaceae. Lardizabala family. Mostly woody vines. 8 genera, 20 species. Largely Asiatic Leaves compound	**Akebia**		
Leguminosae. Pea family. Trees, shrubs, herbs, vines. About 500 genera, about 3,000 species. Leaves usually pinnate compound, usually alternate; sepals 5, petals 5. Several distinct types of flowers. Not always irregular. Family contains vegetables besides many ornamentals	Albizzia Amorpha Caragana Cercis Cladrastis Cytisus Genista Gleditsia Gymnocladus Indigofera Laburnum Maackia Robinia Sophora Wisteria	Baptisia Coronilla Dolichos Galega Lathyrus Lupinus Phaseolus	**Acacia** **Swainsona**
Linaceae. Flax family. Herbs and shrubs. About 14 genera, 150 species. Leaves usually alternate. Flowers regular	....	Linum	
Lobeliaceae. Lobelia family. Usually herbs, usually milky juice. About 20 genera, 600 species. Leaves alternate. Flowers irregular, 5 sepals, 5 petals, 5 stamens, ovary inferior	....	Lobelia	
Loganiaceae. Logania family. Trees, shrubs, herbs. Over 30 genera, 400 species. Leaves usually opposite. Flowers usually regular; sepals 4–5, petals 4–5, stamens 4–5	Buddleia Gelsemium		
Lythraceae. Loosestrife family. Trees, herbs, shrubs. Over 20 genera, 400 species	Lagerstroemia	**Cuphea** **Lythrum**	
Magnoliaceae. Magnolia family. Trees and shrubs. 10 genera, about 80 species. Leaves alternate	Illicium Liriodendron Magnolia Michelia		

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Malvaceae. Mallow family. Trees, shrubs, herbs. Over 40 genera, over 900 species. World-wide. Flowers regular; stamens united in tube around pistil, ovary superior	Hibiscus Malvaviscus	Althea Anoda Callirhoe Hibiscus Lavatera Malva Malvastrum Sidalcea	Abutilon
Meliaceae. Mahogany family. Trees and shrubs. About 40 genera and 600 species. In tropics	Cedrela Melia Swietenia		
Moraceae. Mulberry family. Trees, shrubs, vines, herbs. About 55 genera, 1,000 species. Juice often milky. Leaves usually alternate. Fruit various	Broussonetia Ficus Humulus Maclura Morus	....	Ficus
Musaceae. Banana family. Herbs. About 6 genera, about 60 species. Stem sheathed by leaf bases	....	....	Musa Strelitzia
Myrtaceae. Myrtle family. Tropical trees and shrubs. 72 genera, about 3,000 species. Used extensively in south for ornamentals. Leaves usually opposite, evergreen. Flowers regular	Callistemon Eucalyptus Eugenia Melaleuca Myrtus		
Nyctaginaceae. Four-o'clock family. Trees, shrubs, and herbs. About 25 genera, 350 species. Leaves simple. Flowers regular, calyx petaloid	....	Abronia Mirabilis	Buginvillea
Nymphaeaceae. Waterlily family. Aquatic herbs. 8 genera, about 60 species	....	Cabomba Nelumbium Nymphaea Victoria	
Oleaceae. Olive family. Trees and shrubs. About 20 genera, 500 species. Leaves usually opposite. Flowers regular, ovary superior	Chionanthus Fontanesia Forsythia Fraxinus Jasminum Ligustrum Osmanthus Syringa		Olea
Onagraceae. Evening-primrose family. Mostly herbs, annual or perennial. About 36 genera, 470 species. Largely American. Flowers usually regular, ovary inferior	....	Clarkia Epilobium Fuchsia Gaura Godetia Oenothera Zauschneria	Fuchsia

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Orchidaceae. Orchid family. World-wide; over 300 genera, over 15,000 species. Stamens and pistil joined. Pollen in masses. Flowers irregular, ovary inferior	....	Cypripedium Goodyera Habenaria Orchis	Cattleya Cymbidium Dendrobium Laelia Odontoglossum Phalaenopsis
Oxalidaceae. Oxalis family. Trees, shrubs, and herbs. About 10 genera, over 350 species. Sap usually sour. Leaves usually compound. Flowers regular; sepals and petals 5, ovary superior	....	Oxalis	Oxalis
Palmaceae. Palm family. Trees and shrubs. Over 140 genera, over 1,200 species. World-wide in tropics. Include cocoanut and date palms	....	Caryota Chrysalidocarpus Cocos Howea Livistona Phoenix Rhapis Roystonea Syagrus Washingtonia	
Pandanaceae. Screwpine family. Tropical plants. 3 genera, 400 species	....	....	Pandanus
Papaveraceae. Poppy family. Mostly herbs. About 25 genera, 115 species. Sap usually milky, sometimes colored. Flowers regular	....	Argemone Bocconia Chelidonium Eschscholtzia Glaucium Hunnemannia Meconopsis Papaver Romneya	
Pinaceae. Pine family. Trees and shrubs. 33 genera, over 250 species. Leaves needles or scales, usually evergreen. Fruits usually cones, sometimes berrylike	Abies Cedrus Chamaecyparis Cryptomeria Cunninghamia Cupressus Juniperus Larix Libocedrus Picea Pinus Pseudolarix Pseudotsuga Sciadopitys Sequoia Taxodium Thuja Thujopsis Tsuga	....	Araucaria

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Piperaceae. Pepper family. World-wide, tropics and subtropics. Over 1,000 species, over 10 genera	....	....	Peperomia
Platanaceae. Planetree family. Trees. 1 genus, 6 species. Leaves alternate, large-lobed.	Platanus		
Plumbaginaceae. Leadwort family. Shrubs and herbs. About 10 genera, 300 species. Flowers regular, sepals 5, petals 5, stamens 5, ovary superior	....	Ceratostigma Limonium Statice	Plumbago
Polemoniaceae. Phlox family. Mostly herbs. Largely American. 12 genera, about 270 species. Flowers 5 sepals, 5 petals, 5 stamens, ovary superior	....	Cobaea Gilia Phlox Polemonium	
Polygonaceae. Knotweed family. Trees, herbs, shrubs. About 40 genera, 800 species. Stems enlarged points. Leaves simple. Flowers small	Coccolobis Polygonum	Antigonum Muehlenbeckia Polygonum Rheum	
Polypodiaceae. Common fern family. Low-growing plants without a distinct trunk. Over 100 genera and around 5,000 species. Includes three-fourths of all ferns	....	Adiantum Asplenium Dryopteris Osmunda Pellaea Polypodium Polystichum	Adiantum Asplenium Blechnum Cyrtomium Davallia Nephrolepis Platycerium Polystichum Pteris
Portulacaceae. Purslane family More or less fleshy plants. About 20 genera, around 200 species. Sepals 2, petals 4–5	....	Calandrinia Lewisia Portulaca Talinum	
Primulaceae. Primrose family. Herbs. About 30 genera, 700 species		Anagallis Androsace Dodocatheon Lysimachia Primula	Cyclamen Primula
Ranunculaceae. Crowfoot family. Mostly herbs. About 30 genera, 1,200 species. Flowers regular, no fusion of parts, sepals 3–15, stamens many, ovary superior	Clematis Xanthoriza	Aconitum Actaea Adonis Anemone Aquilegia Caltha Cimicifuga Clematis Delphinium	Anemone Ranunculus

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
		Eranthis Helleborus Hepatica Nigella Paeonia Ranunculus Thalictrum Trollius	
Resedaceae. Mignonette family. Herbs. 6 genera, 65 species. Leaves alternate. Flowers irregular, sepals 4–7, petals 4–7	....	Reseda	
Rhamnaceae. Buckthorn family. Trees and shrubs. About 50 genera, 600 species. Leaves usually alternate, simple	Ceanothus Rhamnus Zizyphus		
Rosaceae. Rose family. Trees, shrubs, vines, herbs. About 100 genera, about 2,500 species. Leaves usually alternate. Flowers regular, sepals 4–5, petals 4–5, stamens usually numerous. Many fruits and ornamentals included in this family	Amelanchier Aronia Chaenomeles Cotoneaster Crataegus Exochorda Holodiscus Kerria Malus Neillia Neviusia Photinia Physocarpus Potentilla Prinsepia Prunus Pyracantha Pyrus Raphiolepis Rhodotypos Rosa Rubus Sorbaria Sorbus Spiraea Stephanandra	Acaena Aruncus Dryas Filipendula Fragaria Geum Potentilla Sanguisorba	
Rubiaceae. Madder family. Trees, shrubs, herbs. Largely tropical. About 350 genera, 4,500 species. Leaves opposite or whorled. Flowers usually regular	.... Cephalanthus	Asperula Crucianella Galium	Bouvardia Gardenia

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Rutaceae. Rue family. Trees, shrubs, herbs. Over 100 genera, about 1,000 species. Usually aromatic, includes the *citrus* fruits	Choisya Citrus Erodia Phellodendron Poncirus Ptelea Skimmia Zanthorhiza	Dictamnus Ruta	
Salicaceae. Willow family. Trees and shrubs. 2 genera, over 200 species. Flowers in catkins	Populus Salix		
Sapindaceae. Soapberry family. Trees and shrubs. About 125 genera, over 1,000 species	Koelreuteria Xanthoceras	Cardiospermum	
Saxifragaceae. Saxifrage family. Herbs and shrubs. About 70 genera, around 1,000 species. Differs from rose family in fewer stamens. Flowers usually regular	Deutzia Hydrangea Itea Philadelphus Ribes Schizophragma	Astilbe Bergenia Heuchera Saxifraga	Tolmeia
Scrophulariaceae. Figwort family. Trees, shrubs, herbs. About 180 genera, about 3,000 species. World-wide. Flowers usually irregular, sepals 4–5, petals 4–5, stamens usually 4 in 2 pairs, ovary superior	Paulownia	Alonsoa Antirrhinum Chelone Collinsia Digitalis Linaria Maurandia Mazus Mimulus Nemesia Penstemon Torenia Verbascum Veronica	Calceolaria Cymbalaria
Solanaceae. Nightshade family. Trees, shrubs, herbs. Over 75 genera, over 2,000 species. Including food and drug plants as well as ornamentals. Potato, tomato, pepper, eggplant, tobacco in this family	Cestrum Lycium	Browallia Datura Nicotiana Nierembergia Petunia Physalis Salpiglossis Schizanthus Solanum	Brugmansia Schizanthus Solanum Streptosolen
Styracaceae. Storax family. Trees and shrubs. 6 genera, about 115 species. Leaves alternate. Flowers regular, sepals 4–5, petals 4–5	Halesia Styrax		
Tamaricaceae. Tamarisk family. Trees and shrubs. 4 genera, about 100 species. Leaves alternate, usually small. Flowers regular	Tamarix		

The More Common Families of Cultivated Plants and Their Commonly Grown Genera.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Taxaceae. Yew family. Evergreen trees or shrubs. 12 genera, about 100 species. Leaves alternate. Fruit often red fleshed	Cephalotaxus Podocarpus Taxus Torreya		
Theaceae. Tea family. Trees and shrubs. 16 genera, about 175 species. Leaves alternate	Camelia Gordonia Stewartia		
Thymelaeaceae. Mezereum family. Mostly trees and shrubs. About 39 genera, 425 species	Daphne Dirca		
Tiliaceae. Linden or Basswood family. Trees, shrubs, herbs. About 35 genera, over 350 species. Leaves usually alternate	Tilia		
Trochodendraceae. Trochodendron family. Trees and shrubs. 3 genera, about 6 species	Cercidiphyllum		
Tropaeolaceae. Tropaeolum family. Herbs. 1 genus, 50 species. South American. Leaves alternate. Flowers irregular, sepals and petals 5, stamens 8	....	Tropaeolum	
Ulmaceae. Elm family. Trees and shrubs. 13 genera, about 140 species. Leaves alternate	Celtis Ulmus Zelkova		
Umbelliferae. Parsley family. World-wide herbs, a few shrubs. About 250 genera, over 1,500 species. Often aromatic, most culinary herbs in this or mint family. Leaves alternate, usually compound. Flowers small, in umbel. Family includes carrot, parsnip, parsley, celery	....	Aegopodium Coriandrum Eryngium Ferula Trachymene	
Urticaceae. Nettle family. Trees, shrubs, herbs. Over 40 genera, 500 species. Flowers small	....	....	Helxine Pilea
Valerianaceae. Valerian family. Herbs, occasionally shrubs. About 9 genera, over 300 species. Leaves opposite. Flowers small, irregular; ovary inferior	....	Centranthus Valeriana	
Verbenaceae. Vervain family. Trees, shrubs, herbs. 67 genera, about 750 species. Leaves usually opposite. Flowers usually irregular	Callicarpa Clerodendron Vitex	Caryopteris Verbena	Clerodendron Lantana Lippia
Violaceae. Violet family. Mostly shrubs and herbs. 15 genera, 400 species. Flowers 5 sepals, 5 petals, 5 stamens	....	Viola	

THE MORE COMMON FAMILIES OF CULTIVATED PLANTS AND THEIR COMMONLY GROWN GENERA.—(*Continued*)

Family and description	Woody genera	Garden flower genera	House and greenhouse genera
Vitaceae. Vine or Grape family. Trees, shrubs, vines. About 12 genera, over 500 species. Leaves usually alternate. Fruit small berry	Parthenocissus Ampelopsis Vitis	....	Cissus
Zingiberaceae. Ginger family. Tropical. 40 genera, 400 species. Flowers irregular, perianth 6 parts, 1 fertile stamen, ovary inferior	....	....	Hedychium

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CHAPTER V

SOILLESS CULTURE

The growing of plants without soil is an old story despite the xtravagant claims and exaggerated publicity that have flooded he press, the popular journals, and even the most conservative f other publications. As early as 1609 we have reports of pearmint having been grown in water cultures, but little thought ɾas given then and for many years afterward to its practical ossibility.

As a tool for the study of plant growth the method has been niversally used by plant physiologists since the original experiıents of Jean Boussingault, a French chemist, in the early part of he nineteenth century. By means of sand and water culture, ıany of the fundamental facts of plant growth have been nunciated.

Popular interest in soilless culture was fostered by the experiıents conducted by W. F. Gericke in California in 1929 and timulated by gullible writers who pictured a changing world of lants based on this new "miracle of science." Enthusiasm ran igh, and soon advantage of the situation was taken by promoters o that all sorts of equipment and prepared chemicals appeared n the market and were sold at fabulous prices and with large rofits. Actually, except as a hobby, the water-culture method or growing plants out of doors presents few possibilities.

The growing of plants in the greenhouse in inert mediums on ny scale dates back to the experiments of Pember and Adams at he Rhode Island Experiment Station in 1921 while they were tudying the influence of the physical structure of the mediums n the growth of the carnation. In 1927 Biekart and Connors t the New Jersey Agricultural Experiment Station and Laurie n 1929 at the Ohio Agricultural Experiment Station attempted uccessfully to grow plants in sand, with the nutrients applied ither in dry or in liquid form. A modification of this method o automatic subirrigation was suggested by Withrow of Purdue

Agricultural Experiment Station in 1936 and was followed and developed to its present state by the New Jersey Agricultural Experiment Station and the Ohio Agricultural Experiment Station.

Essentially there are three methods by means of which plants may be grown without soil—water culture, drip culture, and gravel culture.

WATER CULTURE

Briefly, plants are grown with their roots in solution, no inert medium being used for support. Nutrients are supplied in the solution in which the roots are immersed.

A solution tank varying in size from a milk bottle up to any suitable container about 8 in. deep is required. Width and length are dependent upon the location desired for the container, but 3 ft. is a convenient width for ease of working. If metal tanks are used, it is necessary to *asphalt* them to prevent the solution of copper, zinc, etc., which are toxic to plants. Never use *tar*, as this is more toxic to plants than the metals named. Wooden tanks are made waterproof by a coating of thin watery asphalt emulsion followed by a heavier application of emulsion after the first coat is dry. If glass bottles are used as solution tanks, a coating of black paint on all the outside surface will prevent growth of algae. For visibility leave a narrow line the length of the bottle.

Support is given to the plants by a wire netting stretched across the tank. Chicken wire or hardware cloth (¼-in. mesh) is satisfactory, and for a large tank cross supports of wood should be installed to prevent sagging of the wire. A cork with a hole in it is excellent support for the person using milk bottles for tanks. On top of the wire should be placed such material as excelsior, peat moss, pine shavings, sawdust, or rice hulls, but no redwood by-products. The acceptable materials act as additional support to the plant and also provide a place for the formation of such plant parts as fleshy dahlia roots, gladiolus corms, and lily bulbs. The formation of these organs is dependent on the moisture of the material on the wire support, but continued soaking is inadvisable; neither is it desirable to depend on a constant moisture condition by allowing the mediums to hang in the nutrient solution. Although seeds may be sown in this light medium, it is best to germinate them, in sand or on blotting paper, and transplant them to the tank, using the excelsior, etc., as a support for the plant to prevent falling into the solution.

The water level in the tank should be 1 in. below the wire screen when the plants are young. As the plants grow, more air will be required and the level should be dropped to 2 to 3 in. below the screen, provided an 8-in. tank is used. Young plants should be set so that at least two-thirds of the root system is immersed in the nutrient solution. As the plants grow, water will be absorbed, and some will be lost by evaporation; hence daily additions to the tank are necessary.

Spacing of the plants will depend on their size. Young plants are set closer together than old ones of the same type.

The chemicals that are added to the water to make a nutrient solution may be obtained from your druggist. Have him weigh the chemicals, then measure the amounts in tablespoonfuls. Knowing the number of tablespoonfuls eliminates the necessity of further weighing. Following is a formula recommended for water culture by the California Agricultural Experiment Station.

Monobasic potassium phosphate	0.5 oz.
Potassium nitrate	2.0 oz.
Calcium nitrate	3.0 oz.
Magnesium sulphate (Epsom salts)	1.5 oz.
Iron sulphate	1 tsp.
Water	25 gal.

The chemicals are weighed and dissolved in the water, and the solution is then ready for use. It is best to make up just enough solution to fill the desired volume in the tank. Since the plants will absorb many of the nutrients, it will be necessary to supply them continually. Not only do the nutrients vary, but the solution will very quickly become too alkaline or acid for the plants. For those who do not wish to correct the alkalinity or acidity, the solution should be discarded every week and a new one made to replace it. Somewhat more complicated, but more interesting, is the adjustment of the acidity or the alkalinity of the solution. If this is necessary, retain the solution for a month, and add 0.5 oz. of monobasic potassium phosphate every week and 1 tsp. of iron sulphate twice a week. This ensures a constant supply of both phosphorus and iron, the absence of the latter causing a yellow color to develop at the top of the plants.

To correct the alkalinity or the acidity, several methods may be used satisfactorily. The Soiltex Company, Lansing, Mich., manufactures a convenient kit which is very simple to operate yet gives accurate results. Bromthymol blue indicator papers can be obtained from a druggist, and testing should be done as follows: Dip the paper in the solution; if a blue color develops, the solution is alkaline. Then add a few drops of sulphuric acid, followed by thorough agitation. Test again; if a green color develops, the solution is neutral—*i.e.*, neither acid nor alkaline. A few drops of acid to the solution will change the color of the test paper from green to yellow, indiating an acid condition. The best reaction is at the point where the color of the paper turns from green to yellow.

If the paper turns yellow, the solution is acid. Add sodium hydroxide until a green color develops. Then a few drops of acid will cause the paper to begin to change to yellow, and at this point the reaction is all right. To ensure proper mixing, remember to stir the solutions thoroughly after any chemicals (phosphorus, iron, acid, or alkali) are added.

The greatest obstacle to the successful growing of plants in water lies in the lack of suitable aeration to the roots. Unless forced aeration from pumps is installed, large-scale operations are often a complete loss because of failure of the roots to grow. As a result of this, the other two methods of nutrient solution culture have arisen—drip and gravel culture.

DRIP CULTURE

This method of growing plants is called *intermittent renewal*, *sand culture*, or *slop culture*. Plants are watered with a nutrient solution similar to the method by which plants in soil are watered. Sand is most generally used as a medium to support the plants, as it also provides aeration and will not absorb the nutrient salts as does soil. Too frequent waterings of soil with fertilizer dissolved in the water results in the accumulation of a toxic level of salts, which often ends in death of the plants. Sand does not possess the absorbing power of soil and is therefore a quite suitable medium.

An ordinary glazed flower pot with a drainage hole is a suitable container for the sand. Seeds may be sown directly in the sand in the pot or may be handled on blotting paper. After sowing of the seed or setting the plants in the sand, watering with the nutrient solution is the first step. Below is a formula that will give satisfactory results.

Potassium nitrate	1.0 oz.
Monocalcium phosphate	0.5 oz.
Magnesium sulphate	0.75 oz.
Iron sulphate	1 tsp.
Water	5 gal.

Watering may be accomplished by any means, the easiest of 's a small watering can or a teakettle, hence the name

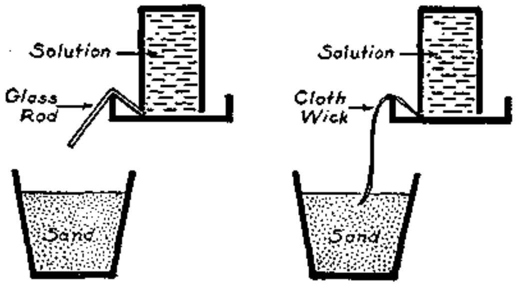

FIG. 8.

slop culture. Another method is to invert a quart jar (Fig. 8) full of nutrient solution into a shallow dish in which a capillary glass tube or a cloth wick made of twisted surgical bandage has been placed. The other end of the glass rod or cloth wick is placed in the sand in the pot. It may be necessary to put a small container underneath the pot to catch excess solution dripping from the bottom of the pot. The nutrients and the water will be drawn by capillarity over to the sand, and the plant is automatically and continually watered. Blackening the wick by the use of carbon ink reduces algae formation, which will clog the wick. If the solution is slopped on the sand with a watering can, one application of nutrients a week will be sufficient, meanwhile during the week water with tap water to keep the sand moist.

It is best to make up only the required amount of solution each time that the reservoir is filled, as this eliminates the possibility of nutrients precipitating out of solution.

It may be necessary to add iron to the tap water in order to prevent yellowing of the plants, which often occurs as a result of precipitation of the iron in the sand.

Plants may be grown successfully in drip culture; but sometimes aeration is too poor, and they die from lack of root action. Hence the development of gravel culture in which a more coarse medium is used as well as a modification of the method of applying the solution.

Mineral Maid. This is a patented pot so constructed as to permit the solution to rise by capillarity through a porous wick into the sand or gravel surrounding the roots. Actually, the container consists of three parts—the reservoir that holds the solution, the clay wick that hangs in the solution and is attached to the third part, the upper pot in which the plant is set in coarse sand. The whole is so constructed as to appear as one container. For the growth of orchid seedlings, the starting of seeds, and the growth of plants indoors this is very useful, since it does away with guesswork in watering and eliminates daily care.

GRAVEL CULTURE

This method of growing plants without soil promises to be of greater benefit to the florist than either of the other two mentioned. Amateurs also succeed easily when this adaptation of soilless culture is operated.

It is necessary to secure a waterproofed container, preferably of wood, to allow for the installation of a drainage hole. Be sure to use *asphalt*, not tar, when making the boxes watertight. Glazed pots with a drainage hole in the bottom also are adaptable to this method of culture. A convenient-sized container for a 10-qt. pail is a waterproofed box 2 ft. long, 1 ft. wide, and 6 in. deep.

If a box is used, it must be slanted toward the drainage hole to allow complete drainage. Standing water in gravel culture is fatal.

The formula used is listed below:

Potassium nitrate	1.0 oz.
Monocalcium phosphate	0.5 oz.
Magnesium sulphate	0.75 oz.
Iron sulphate	1 tsp.
Water	5 gal.

Best results are obtained if only the amount of solution necessary to fill the container is made up, as this avoids possibilities of precipitation of iron and phosphorus. Since there is danger of their going out of solution, it is advisable to add ½ oz. of monocalcium phosphate every week. One teaspoonful of iron sulphate should be added to the solution container twice weekly. Water is, of course, added to keep the solution at the proper level. To correct the acidity or the alkalinity of the solution, the same methods are used as described for water culture. If no adjustments of the reaction of the solution are to be made, change the solution weekly, omit the weekly application of phosphorus, and add iron but once a week.

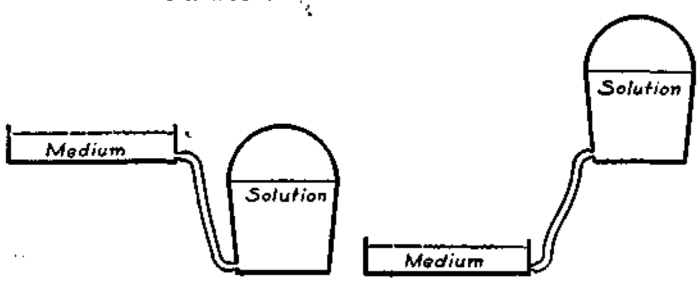

Fig. 9.

Ordinary gravel that is used for concrete work can be used to fill the waterproofed container. Silica gravel, well-washed cinders, etc., are also suitable. Haydite, manufactured by the Hydraulic-Press Brick Company of South Park, Ohio, is the best medium known to date. The most satisfactory size is between ¼ and ½ in. in diameter.

The method of application of the nutrient solution to the container is illustrated in Fig. 9.

In position 1 the pail will contain the nutrient solution. When the pail is raised, the solution will flow into the container by gravity. After the medium is flooded, lower the pail, and it will fill by gravity from the container. It will be necessary to flood the medium no less than twice a day and no more than five times a day. The size of plants, the particle size of medium, and the amount of light will govern the number of floodings per day. Under low light conditions with a fine medium and small plants, few floodings are most desirable. At all times keep the solution level in the pail at a constant level by the additions of tap water.

To avoid formation of algae on the surface of the medium, put just enough solution in the pail so that a complete flooding (position 2) brings the water level in the container only up to within 1 in. of the surface of the medium.

If for any reason the plants in gravel or water culture must be sprayed, flood the container with water or nutrient solution, spray, and discard the resulting solution. This prevents root injury by the spray. Drip-culture setups should have a protective shield placed over the sand.

GRAVEL CULTURE IN THE GREENHOUSE

The most satisfactory results of a practical nature have been secured under the artificial conditions of the greenhouse. It is felt that the real possibilities lie in this direction; hence the equipment and methods are presented in detail.

Equipment

Benches. The most satisfactory bench for growing crops in inert mediums is made of concrete with a V bottom. The bench should slope 1 in. per 100 ft.; although when an auxiliary pipe is used for inlets and outlets, no slope at all is required, since the pipe may be slanted to suit the needs of good drainage. The sides of the bench may be 6 to 8 in. high, and the bottom so shaped as to have a slope of 1½ in. from the sides to the center, thus making the V. If flat-bottomed concrete benches have already been built, they can be converted to gravel culture by the following method. A form should be made as shown in Fig. 10 to fit within the bench. The inside of the bench should be covered with emulsified asphalt to prevent the old concrete from binding with the new; and if drainage holes are large, they should be covered with old cheesecloth, and asphalt applied to it. A "dry" concrete mix should be prepared, using a 1:4 mix of cement and AAA haydite or sand. This is placed in the bench and tamped roughly in the form of the modified V. To finish the V in the bench, the form (Fig. 10) should be used by pushing it down into the wet concrete and moving it back and forth. The concrete should be smoothed with a metal trowel. To

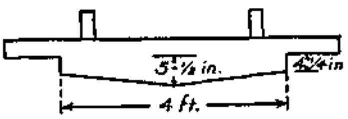

Fig. 10.

minimize the amount of water in the bottom of the V, a short length of 1-inch pipe should be rolled back and forth in the V to form a notch or small depression. The water that will stand then will be in the depression under the tile, and no damage will result. A layer of concrete at least ½ in. thick should be retained between the bottom of the V notch in the V and the top surface of the old bench, to prevent cracking of the new concrete (Fig. 11).

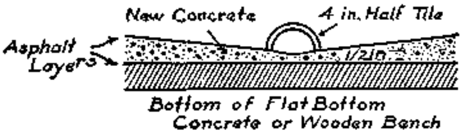

FIG. 11.

Wooden benches with bottom boards running across them can be converted by placing additional supports under the bench to prevent sagging. The inside of the bench should be cleaned, and the sideboards made level. The same procedure as outlined for the flat-bottom concrete bench should be followed. Benches with bottom boards running lengthwise will sag unless heavy supports are placed between the bench legs. A wooden V can be made as shown in Fig. 12. For an all-wood bench, the joints must fit perfectly and the support be rigid.

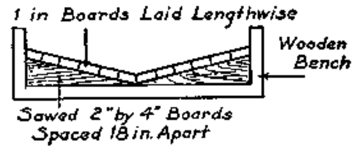

FIG. 12.

Both concrete and wooden benches should be coated inside with a watery dressing of asphalt emulsion and then covered again with a thicker coating. As soon as dry, the benches should be filled with water and tested for leaks. If any develop, a patch of cheesecloth covered with asphalt usually corrects the trouble. A cheap grade of emulsified asphalt such as is used for road building is satisfactory, provided it contains no oil or tar. One gallon of undiluted asphalt emulsion will cover about 50 sq. ft. of surface.

Tanks. In order to provide suitable containers for the nutrient solutions, tanks are installed under benches or in other suitable locations. Such tanks have several requisites. They must be waterproof, acid resistant, and of sufficient size to hold about 40 per cent of the total volume of the benches that they fill. These tanks may be made of concrete, wood, or metal. For small installations milk vats or even grave vaults have been used. All tanks made of concrete should be coated with either sodium silicate diluted 1:4 of water or else with emulsified asphalt or both. Wooden and metal tanks should be coated with asphalt and made absolutely acidproof. It has been suggested that tanks should contain enough solution to equal the total

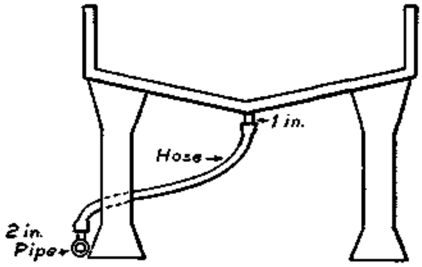

FIG. 13.

volume of the benches instead of our recommendation of 40 per cent of the volume. Although true that a larger volume of solution makes it easier to maintain the proper levels of nutrients, the additional costs of construction are so high as to make such recommendations impractical. For benches over 100 ft. long, tanks may be placed in the middle of the house so that the bench drains from each end to the center, or else they may be placed at the end of the greenhouse and the benches slope toward them.

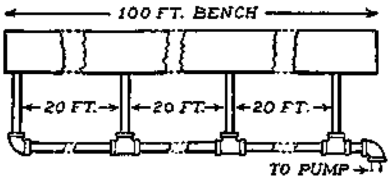

FIG. 14.

Inlet Pipes. Black iron pipe, not galvanized, should be used for the inlets. For a 100-ft. bench one inlet of 1- or $1\frac{1}{2}$-in. pipe near the pump at the end of the bench is sufficient, although better drainage may be provided by the placement of a separate pipe under the bench or beside it. The size will depend on the length of the bench. One and one-half inch pipe will suffice for small installations, and proportionally larger sizes for long benches (Figs. 13 and 14). The inlet into the bench should be flush with the bottom of the V and completely waterproofed, since it is frequently the source of leaks.

Valves. Figure 15 indicates the method of manipulating valves when spraying is done and solutions are changed. In the upper diagram of Fig. 15 for normal operation valve 1 should be open and valve 2 should be closed. To pump out the tank, valve 1 should be closed and valve 2 opened. To flood the bench prior to spraying, valve 1 should be closed. To drain water from the bench after spraying, the cap on the pipe projecting from the

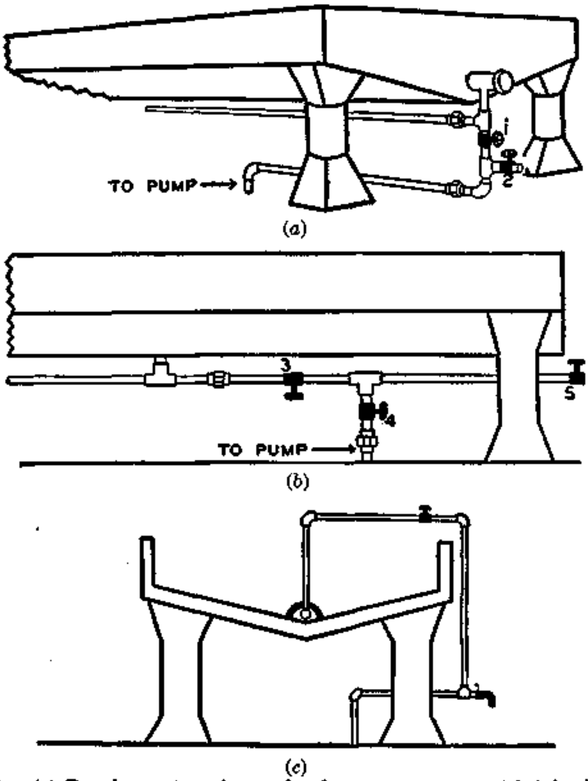

FIG. 15.—(a) Bench construction and valve arrangement with inlet located at end of the bench. (b) Bench construction and valve arrangement with inlet located under the bench. (c) Cross section of V-bottom bench showing half-tile and pipe arrangement for flooding bench prior to spraying.

end of the bench should be removed. In the central diagram of Fig. 11*b* for normal operation valves 3 and 4 should be opened and valve 5 closed. To pump out the tank, valve 3 should be closed and valves 4 and 5 opened. To flood the bench prior to spraying, valve 3 should be open and valves 4 and 5 closed. To drain water from the bench after spraying, valve 5 should be open.

Trough. To obtain rapid spread of solution in the bench, half tile (Fig. 15), eaves trough with beads removed, or a wooden inverted V may be used. Eaves trough should be asphalted to prevent zinc damage, and wedges should be placed between it and the bench bottom to allow for entrance and exit of the solution. Large cracks or openings should be covered with a black iron screen.

Pumps. Either a sump or a side-suction centrifugal pump may be used. Sump pumps are easier to install, since a separate compartment is unnecessary in the tank to keep the motor dry. *The quicker the pumping and drainage is completed the better the results.* Benches should be filled in at least 30 min. and should drain in 60 min. The following pumps have been used in the tests and found satisfactory.

Deming No. 3000-*M*—*No.* 1 *Side-suction Centrifugal Pump.* When ordering, specify that a grease cup be supplied rather than the water-lubricated mechanism at the main bearing. Its capacity is 30 gal. per minute, 10-ft. head, and it is manufactured by the Deming Company, Salem, Ohio.

Deming No. 4602—*Sump Pump.* Its capacity is 40 gal. per minute, 10 ft. head.

Gould "Cid" Sump Pump—*No.* 3151. This pump is manufactured by Gould's Pumps, Inc., Seneca Falls, N.Y.

Myers No. 6101 *Sump Pump.* The capacity of this pump is 25 gal. per minute, 10-ft. head, and it is manufactured by F. E. Myers & Bro. Company, Ashland, Ohio.

Other manufacturers make pumps that are just as suitable. Allow at least 6 in. from the surface of the solution to the electrical box on all sump pumps for slopping of the solution when agitated.

Electric Clocks. These ensure regular pumpings. The present empirical recommendations of so many times per day serve the purpose. The following types are available:

Type T-27, time switch, single pole, single throw, General Electric Company, Schenectady, N.Y. (Specify if 115-V or 230-V is desired.) Any number of additional "on" and "off" tabs can be secured.

Type K-11 Sangamo Time Switch, Sangamo Electric Company, Springfield, Ill., is satisfactory if a maximum of three pumpings per day is desired.

Mediums

The most satisfactory material for the growth of plants with the subirrigation method is one that is inert, does not give off any undesirable elements, does not change the pH, retains a sufficiency of water, and does not disintegrate. To date we have nothing that approximates this ideal so closely as haydite. In some sections of the country where traprock, granite chips, or silica gravel (acid) is available, they serve the purpose as well as haydite. The C grade of haydite composed of a mixture of coarse (¾ in. diameter) and fine particles is the most suitable size, although it has been found that finer sizes may be more suitable, particularly when inadequate drainage is provided. Owing to the coarseness of the medium, there is a tendency for the roots to form at the bottom of the bench instead of throughout the entire body of the medium. This is probably due to excess aeration. The formation of the entire root system at the bottom necessitates complete drainage, else damage may occur to the roots even though a very small amount of solution remains standing. In finer mediums, root development occurs over a greater territory, and standing solution at the bottom may not cause serious damage.

Hard- and soft-coal cinders may likewise be used to advantage, although statements about their cheapness should be tempered, since screening and leaching consume time and labor. Cinders vary with the source of coal and in some localities may contain toxic substances. Excess of boron has been found in some localities and if present may be neutralized by the addition of 10 cc. of commercial sodium silicate to 100 gal. of solution. This addition may be made even after the plants are benched. Some cinders disintegrate readily and may be troublesome because of high water-holding capacity and insufficient aeration. Occasionally cinders are alkaline and may precipitate iron, phosphorus, and manganese. As a precautionary measure cinders should be leached thoroughly. One-fourth- to three-fourths-inch sizes are suitable.

Calcareous gravels are suitable for crops that grow satisfactorily in the pH of 7 or above. As a consequence of the high pH, precipitation frequently occurs. When used, a safe precaution is the broadcasting of monocalcium phosphate at the rate of 5 lb. per 100 sq. ft. before planting. This should be watered in thoroughly. Apparently after a period of time a coating of phosphorus over the gravel particles minimizes the initial difficulties with high pH. Calcareous gravels are particularly unsuitable for roses and gardenias. One-quarter- to one-half-inch particles are best.

Limestone chips may be used in a manner similar to calcareous (lime-bearing) gravel. Slag from blast furnaces should be avoided because of its extreme alkalinity and possible toxic contents.

Solutions

Many different formulas have been advocated by various workers. The differences are not very great; but even so, to save confusion, we present the solution that has proved satisfactory on many crops.

Composition of the WP* Formula

Chemicals	Per 1,000 Gal. of Water
Potassium nitrate	5 lb. 13 oz.
Ammonium sulphate	15.5 oz.
Magnesium sulphate	4 lb. 8 oz.
Monocalcium phosphate†	2 lb. 6.5 oz.
Calcium sulphate	10 lb. 12 oz.
Total	24 lb. 7 oz.

* Developed by Arnold Wagner and G. H. Poesch.

† The monocalcium phosphate should be of the "food grade" since it is desirable that the fluorine content be low. Monsanto Chemical Company, St. Louis, Mo., carries a food grade phosphate of very low fluorine content.

The chemicals given in the preceding formula should be mixed together in dry form. The mixture will not deteriorate but can be stored and used as needed.

Because of occasional difficulty of securing the commercial grade of *potassium nitrate*, the following modification of the WP formula is suggested:

Chemicals	Per 1,000 Gal of Water
Sodium nitrate	5 lb.
Potassium chloride	5 lb.
Ammonium sulphate	1 lb.
Magnesium sulphate	4.5 lb.
Monocalcium phosphate	2.5 lb.
Calcium sulphate	5 lb.

The chemicals in this formula should be weighed out individually and mixed in the tank.

A single-strength WP solution should be used for the first month on all newly planted crops. (This same solution is best for all types of bulbs or corms during their entire period of growth.) When the plants have become well established—usually 3 to 6 weeks—the concentration should be doubled, which means that twice the amount of chemicals per 1,000 gal. of water recommended in the WP solution should be used.

Manganous sulphate should be added to all solutions. One ounce of manganous sulphate is dissolved in 1 gal. of water acidified with 3 to 5 drops of commercial sulphuric acid. All this solution should be used for 1,000 gal. of nutrient solution. Iron should be added weekly in the form of ferrous sulphate at the rate of 4 oz. per 1,000 gal.

Sources of Chemicals. The chemicals used are of commercial grade and reasonably priced.

Commercial potassium nitrate is difficult to obtain and for the present should be eliminated from consideration.

Monocalcium Phosphate (Monsanto Chemical Company, St. Louis, Mo.; or Akron, Cleveland, and Cincinnati, Ohio). The reason for the use of this food-grade material is its low fluorine content. However, the fluorine may not be so dangerous as originally thought, and treble phosphate has been used satisfactorily.

Ammonium sulphate, calcium sulphate, magnesium sulphate, manganese sulphate, and ferrous sulphate may be obtained from local dealers.

Since the materials used are not chemically pure, they contain the necessary trace elements without additions, except those mentioned. Recommendations for adding boron, zinc, copper, and others should be followed only with specific advice. Considerable damage has resulted in some cases because of overzealousness. The addition of small amounts of thiourea, tryptophane, liquid manure, indolebutyric acid, sugar, nicotinic acid, or Vitamin B_1 has not proved beneficial.

Changing Solutions. The original recommendation called for a change of solutions weekly, but at present no complete change is necessary more frequently than once in two months. In some instances solutions have not been changed for several months, but as a precautionary measure a change every two months is advocated.

Testing Solutions. The Simplex Soil Testing Kit or the LaMotte Soil Testing Kit may be used for general purposes. (Simplex, Edwards Laboratory, Lansing, Mich.; LaMotte, LaMotte Chemical Company, Baltimore, Md.) For accurate tests for nitrogen use the phenol disolphonic acid method.

The analysis of a WP and 2 WP solution is given below—the differences between the nutrient levels of the calculated and the fresh solutions are accounted for by precipitation of the nutrients, low solubilities, or inaccuracies of the present quick tests.

Analysis in Parts per Million

	WP		2WP	
	Calculated	Fresh solution	Calculated	Fresh solution
Nitrates	400	400	800	750
Ammonium	28	25	56	50
Phosphorus	65	60	130	120
Potassium	250	125	600	250
Calcium	310	150	620	250

Since phosphorus may readily precipitate from the solution or be absorbed by the plant, tests and additions should be made weekly. Nitrate and potassium tests made every other week after changing are all that are necessary. The following nutrient levels may be maintained with satisfactory results:

Levels in Parts per Million

	WP	2WP
Nitrates	400	600+
Ammonium	25	50
Phosphorus	25	40
Potassium	100	200
Calcium	125	200

'mall additions of the deficient nutrients, followed by thorough ation, and testing again will soon give the operator the relative amounts of chemicals to add to bring the nutrient levels ıp to requirements. Since ammonium is quickly converted ı ıitrate, add the full amount of ammonium sulphate to the solı tion every other week.

The water level in the tank is fully as important as the nutrieı level and should be checked daily.

pH. The pH of the solution should be checked twice a wee *without fail.* It should be maintained at 6.5 for most crop Gardenia does best at a pH of 5.6 to 6; sweet pea, stock, aı others will grow satisfactorily in the pH of 7.

To raise the pH, a stock solution of 2 oz. of sodium or pota sium hydroxide to 1 gal. of water should be used. Ammoniuı hydroxide and water, 1:3, may also be used. To lower the pI a stock solution of 1 oz. of either concentrated sulphuric or pho phoric acid per gallon of water should be used.

When any materials are added to a solution, thorough stirriı is necessary to obtain proper mixing.

Time of Pumping. The number of times per day that tl solution should be pumped depends on the type of medium, tl season, and the size of plants. In summer, mature rose plan in a coarse (½ to 1 in.) medium should be pumped three to foı times during the daylight period (7 A.M., 11 A.M., 2 P.M., 5 P.M. In winter this should be reduced to one or two times dail Carnations should rarely be pumped more than twice daily i summer and every other day in winter provided no wilting occur Young plants that are not established should be pumped le frequently, as root action is slow. Experience is the best guid together with a close check of growth of the plants. *The solutic should be pumped to within 1 in. of the surface of the medium prevent algae (green scum).* Night pumping is not essential.

Planting

Plants may be set in the mediums in a V-bottom bench wit a ball of soil out of 2- to 3-in. pots. The roots spread rapidl into the inert medium, and no check in growth is observed suc as occurs when the soil is washed off. If drainage is poor, th planting practice is dangerous, especially with soft-stemme crops such as snapdragon and chrysanthemum, since they rı easily. The soil does not dissolve into the medium but remaiı intact and is removed when the plants are pulled out. Bull are planted so that their "noses" are ½ in. below the surfaı of the mediums. Too deep planting results in rotting, which can be partially overcome by less frequent pumping. Plants are spaced in gravel as in soil. Large seed (sweet pea) may be sown directly in the medium.

Pest Control

Since the mediums do not contain any organic matter that would act as a buffer, any spray materials used may cause damage to the roots. To prevent such damage, the benches should be flooded with clear water prior to spraying. Some commercial tests show that this may not be necessary, but it is better to be sure. If the nutrient solution is to be changed, it should be pumped into the bench, the plants sprayed, and the solution discarded by manipulation of the valves described previously. It is advantageous to run a permanent water line to the half tile in the bench so that the bench may be flooded for spraying by opening a valve as shown in Fig. 15. Sulphur sprays or dusts drop the pH. Cyanide fumigation is not always safe. Nicofume fumigation is safe. For sterilization purposes, copper or mercury compounds should be avoided, as toxicity is apt to result. Insects in the medium may be controlled by flooding the bench to float them and spot fumigating with Nicofume pressure fumigators. Fulex fumigation is reported to be safe.

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CHAPTER VI

COLD FRAMES, HOTBEDS, AND GREENHOUSES

Greenhouses are necessary for the culture of plants in the North during the colder seasons. As such they may be used in connection with the home, as a hobby, or commercially for the forcing of plants and flowers for sale. Cold frames and hotbeds supplement both the greenhouse and the garden and are more or less necessary adjuncts to them.

COLD FRAMES

Cold frames, or frames, as they are sometimes called, are the simplest form of forcing structure. They may consist of an old window frame or a frame made of boards or, for greater permanence, of masonry or of concrete. They depend entirely upon the heat of the sun and of the earth but have no provision for holding it other than the sash covering them.

Where to Place the Cold Frame. The cold frame may be placed in any well-drained location where the surface water will not accumulate. For the growing of seedlings, it should preferably face the south, but east or west exposures may be used. For the propagation of cuttings it may face the north. It may be built against the side of the house, garage, or other building or be in the open. Convenience to water supply and the house should be considered. Protection from excessive wind is desirable.

Uses of Cold Frames. A cold frame has a wide range of uses. Perennial seeds may be sown in it in November, in the spring from February to May, or in August. Hardy-annual flower seeds may be sown in it in the spring from March to April, in September and November; tender annuals, in the spring from April to May. Divisions of perennials and rock plants may be planted in it in the early fall (September or October) or the spring (March to June). Pansies may be sown in it in August and kept in them over winter. Tender perennials, such as the Canterbury bell, foxglove, and hardy chrysanthemum, may be wintered in it. Shrub and evergreen cuttings may be put in it in July; perennial cuttings, in June or July; and evergreen cuttings, in November, December, February, and March. Young plants of perennials, lilies, shrubs, and evergreens may be wintered in it. Lily bulbs may be potted and kept in a frame over winter. Cuttings of ground covers such as pachysandra, English ivy, wintercreeper, and *Vinca* may be put in it to root in November, December, March, April, or July.

Sash. The standard cold-frame sash is glass covered and is 3 ft. wide by 6 ft. long, with three rows of 10-by 12-in. glass. Occasionally smaller sashes are available for home use. Sash should be glazed with double-strength "B" glass set in putty. The sash itself should be of cypress or redwood, thoroughly painted, and reinforced with an iron bar across the middle. Double-glazed sash, although theoretically better, is not practical. Its greater weight, together with the accumulation of dust and dirt between the glass, makes it unsatisfactory.

It is usually cheaper to buy sash ready made and glazed from a sash or greenhouse manufacturer than to attempt to have it made locally. For home use old window sash and storm windows may be used, although glass breakage and repairs are more expensive because of the larger size pane.

Glass Substitutes. A number of glass substitutes are on the market. Of these Celo-Glass is the most satisfactory. It consists of galvanized-wire netting covered with a cellulose preparation. It comes in rolls 3 ft. wide. With normal use it should last from 5 to 10 years. Its advantages are that it enables one to use homemade frames, which are easily constructed of 1- by 2-in. wood strips, and its lightness and convenience in handling. Its disadvantages are that because of its lightness it blows off easily unless fastened down and that it does not let so much light through as does glass.

Cellulose acetate, the same material as used in photographic film, is satisfactory if properly applied. It comes in various thicknesses, but 0.075 is recommended for cold-frame sash. If tacked directly to a wooden frame, it is likely to tear loose with stretching and shrinking caused by wetting and drying. If strips of cellulose acetate ½ by 1⁄16 in. are nailed around the opening and the sheet of cellulose acetate soaked with water a few hours and then stretched and cemented on this nailed strip,

;h acetone, it will remain smooth and taut whether wet or dry. e manufacturer claims that it does not turn yellow or get ttle. Except for the additional labor of applying it, it is less)ensive than Celo-glass.

The various other forms of glass substitutes, such as glass th, muslin that has been waterproofed with paraffin, or Vitane in which a string mesh has been covered with cellulose ;paration, are suitable for temporary use only.

All in all, glass sash will probably be the cheapest over a period 10 years or more, provided the breakage is not too great and ; sash is repainted occasionally.

Cold-frame Covers. For the protection of cold frames during ; winter, wooden shutters are made the same size as the sash. these are to be used alone, they should be made of 1-in., ıtched, yellow-pine flooring. If used over the glass sash, they ıy be made of ½-in. packing-box material, which is much hter and easier to handle. They will protect the sash from ısiderable breakage during the winter. In cold climates ıts of rye straw or padded burlap are used as further protection,)ecially in the spring when seedlings are being grown.

Shades may be made of ordinary plaster lath nailed to 1- by 2-in. wooden side pieces. These are again made the same size as the sash. The lath should be spaced 1 to 1½ in. apart. These are used for shading cuttings, newly transplanted seedlings, young evergreens, and other materials requiring this protection.

Construction of the Cold Frame. A permanent cold frame may be made of redwood or cypress. Number 2 common cypress, although not planed, is inexpensive. Frames of this type should last 8 to 10 years. According to the use to which the frame is to be put, the front should be from 8 to 12 in. high and the back 6 in. higher, for the proper runoff of water and the intake of sunlight. Permanent frames with a foundation below frost line may be made of brick or reinforced concrete. All frames should have a crossbar every 3 ft., for standard sash, so that the sash may be pushed back and forth with the minimum of lifting.

Pit Cold Frames

For the winter storage of large plants, such as pots or tubs of rosemary, tender hydrangeas, and similar plant materials, pits

$2\frac{1}{2}$ to 4 ft. deep may be lined with cypress or redwood boards or masonry of brick or concrete. It is highly essential that such pits be drained or so built that water cannot run into them. They are covered with sash or shutters during the winter.

HOTBEDS

Hotbeds differ from cold frames in that they are heated. The heat is supplied by decaying barnyard manure, hot-water or steam pipes, or electric heating cables. Occasionally they are heated by electric light bulbs. The value of a hotbed is that it permits the starting of plants earlier and growing them more quickly than in the cold frame. Hotbeds are particularly valuable north of the latitude of New York City, St. Louis, and Kansas City. Naturally plants in the hotbed, with its higher temperature which makes for more active growth, will require more attention than those in a cold frame.

Manure-heated Hotbeds. The old-fashioned method of digging a pit 2 ft. deep and filling it with fresh barnyard manure is still used. Unless manure can be obtained cheaply, it is more expensive than the modern electrically heated hotbed. From 12 to 18 in. of manure, preferably horse, containing approximately one-third straw bedding should be used. Fresh manure should be obtained two weeks before the hotbed is to be started and piled aboveground. It should be turned over once or twice during this time. Additional water may be necessary to prevent its burning. It should be tramped well into the pit and covered with 2 in. of straw and 6 in. of garden loam. The sash should be put on, but the hotbed should not be used until the temperature drops back to about 80°F. This will take several days.

Hotbeds may be steam or hot-water heated, either from the house or from a separate boiler. Automatic gas hot-water boilers may be used for this.

Electric Hotbeds. In electric hotbeds heat is furnished by lead-covered cable using 110-volt current. Fifty feet of cable is necessary for a 6- by 6-ft. hotbed. Four to six inches of cinders are placed in the bottom of the hotbed, with 2 in. of sand above them. The electric cable is placed on this with 6 in. of soil covering it. Although manual operation is possible, a thermostat will control the temperature automatically. A 50 to 75°F. soil temperature and a 40 to 75°F. air temperature should be maintained. If the cable cannot maintain this minimum, hotbed mats should be used. Commercial mats are made of quilted burlap or rye straw. The cost of 50 ft. of lead-covered cable is about $2.50, and the thermostat will cost $5 to $8. In addition to this will be the cost of the wiring from the house to the bed. With a thermostat controlling the operation, a 6- by 6-ft. hotbed will cost from $2 to $3 per season where the current is 3 cts. per kilowatt hour, during the spring months.

Care of Hotbeds and Cold Frames. On warm days to prevent excessive humidity, the sash should be raised. This will also tend to harden off the seedlings. Daily inspection is necessary. Watering should be done only on sunny days. All in all, a hotbed requires more attention than a cold frame, but it may be started earlier and will produce quicker results.

Hotbeds are used for the early starting of flower and vegetable plants in the spring. Electric hotbeds are sometimes helpful in the summer rooting of shrub and evergreen cuttings.

Soil. For convenience in heeling in perennials or plunging pots, fill in the frame with a 4- to 6-in. layer of peat moss, well-weathered sawdust, sand, or sifted cinders. In sowing seeds, if they are not in pots, sow directly in a 2-in. layer of sand and peat or other suitable seedbed. The larger seeds may be put directly on top of the soil. This same material may be used for planting seedlings, perennial divisions, and rock plants. Once plants are established, they should be lightly fertilized.

GREENHOUSES

Greenhouses offer unlimited possibilities for the enjoyment and growing of plants throughout the year, especially during the winter months. Their use and the results obtained from them will depend to a considerable extent upon the type of greenhouse and the care and attention given to it. Properly managed, they may be used for a variety of purposes.

A greenhouse may be built either attached to the house or some other building or separate. For ease of care it will usually be more convenient to have it attached directly to the dwelling. There are several distinct types of greenhouses. The simplest is a lean-to, using a building for one side. A south exposure is preferable, but an east or west will give satisfactory results. A north exposure could be used only for propagation of plants or for growing those plants such as ferns which do not require direct sunlight.

When attaching a greenhouse to a building, care must be taken to avoid snow and ice sliding from the house roof, breaking greenhouse glass.

Construction. The most inexpensive type of greenhouse is that made of cold-frame sash, each 3 by 6 ft., fastened to a wood or a pipe framework. Its advantage is that it can be easily taken down. Its disadvantage is that it is difficult to ventilate adequately and that unless the joints are sealed, there is considerable air leakage between the individual sashes. Its use is mainly confined to spring for starting early plants.

Regular greenhouses are made with a wood, a pipe, or a steel frame to which the wooden sash bars are fastened, with the glass imbedded in putty or some other glazing compound. They may have wood or metal bars at the eaves, as is usual, or a curved glass in place of the eave.

A convenient size is 8 to 10 ft. wide for two side benches and 15 or 16 ft. wide for two side benches and a center bench. The length may be anything from 10 to 50 ft. or more.

A ventilating sash 2 ft. or so in width should extend the length of the house. It should be hinged to the ridge. Side ventilation will be necessary only in much larger houses.

The foundation of any greenhouse should be below frost level with a wooden or a masonry wall up to the level of the benches. Tops of benches may be 30 to 36 in. above the floor. If attached to the house, it may be built with the benches at ground level and the walk below that with an entrance from the cellar.

Planning the Greenhouse. For convenience and general utility, benches rather than ground beds are recommended. Their advantages are ease of working, better winter growth due to warmer soil, and better control of soil moisture. They should be made of cypress or redwood; 4 to 6 in. of soil is adequate. Benches worked from one side should not be over 3 ft. wide. Center benches should be not over 4 ft. wide. Walks may be from 2 to 2½ ft. for the home greenhouse. Additional racks and shelves may be used, provided they do not reduce the light sufficiently to be detrimental to the plants beneath. Walks may be gravel, cinders, concrete, or wooden slats, but surface drainage is necessary whatever the material.

A door to the outside for a small greenhouse is not necessary but is often desirable. In larger houses it is needed for handling large amounts of soil.

Heating. Hot water is preferable for small greenhouses, although steam may be used. A separate heating system from that of the home is desirable, since the greenhouse will require heat when the house will not. If possible, a thermostat should be installed to control the heat. With a gas hot-water boiler this is entirely automatic, but with a coal boiler the fire still requires attention. Open-fire heaters in the greenhouse are injurious to plants.

The amount of heating pipe will be determined by the lowest anticipated outside temperature, the desired house temperature, and the size of the pipe used. It is suggested that this be calculated by a commercial greenhouse-construction company from whom the materials are purchased. The heating pipes will be placed under the benches if such are used or along the walls if the beds are ground beds.

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CHAPTER VII

GARDEN DESIGN

A survey of any community will plainly show that not everyone is interested either in gardening or in a well-planted home. Different families have different attitudes toward their home grounds, those interested in beautifying them to any appreciable extent being in the minority. Some are satisfied with a lawn; others, with shade trees; and still others, with nothing but flowers. This lack of complete appreciation of landscape planting is one of the problems of the landscape architect, the nurseryman, and the teacher. Possibly if we started with the landscape planting of all our schools, churches, and public buildings, followed by teaching its appreciation in our public schools, we might notice progress. What then comprises a true appreciation of landscape design?

A knowledge of flowers and plant materials alone is not sufficient and will never in itself enable one to plan a garden. A thorough understanding and an appreciation of garden design is necessary. Interpretations of design are individualistic. The conception of what constitutes a garden varies with different individuals. Some want seclusion and privacy; others, just the opposite. Yet the word *garden* itself means an enclosed area. One of the garden needs in America today is a greater appreciation of good landscape design.

The aim of this book is not to train landscape architects but rather to develop an appreciation of their art. Although some gardeners may have sufficient talent and ability to do their own planning, many others will no doubt wish to employ professional help.

A discussion of the fundamental principles of art is seldom of interest or of use to the average person. Therefore, an effort will be made in this discussion to give definite suggestions and recommendations. These are not to be taken as rules or principles but merely as short cuts in planning. They will hold true in the majority of instances. The material in this chapter is, therefore, based not on the theory of landscape design but upon practical experience in teaching home beautification to the average homeowner.

Importance of a Plan. A carefully developed landscape plan is the first step in any effort to beautify the home grounds. If a professional landscape architect is not employed, it is even more important to have a complete plan before doing any planting. Since there is no one way to plan any one place, it may be helpful to make several small sketches, roughly drawn to scale, on 8- by 10-in. cross-section paper. These will outline some of the possibilities. After study, one of these or parts of all may be used to make the final plan. For convenience this should be drawn to the scale of 1 in. = 8 ft. or larger. Thus each shrub, tree, and evergreen may be individually located. Enlarged plans will be necessary for flower borders, rock gardens, and other small plantings. Properties with irregular surfaces and varying levels may require a topographic map before making the final plan.

No matter how carefully a plan is drawn, it seldom can be used exactly in the actual planting. Therefore, it is well to transfer it to the grounds by locating every plant with a small wooden stake on which is written the key number of that plant. In this way the plan may be fitted to the grounds and the necessary adjustments made to avoid any changes afterward.

Another value of a plan is found in a long-time planting schedule, where but a part of the entire plan is planted each year.

On small properties an experienced landscape man can often develop the plan directly on the ground by locating the various plants with stakes as described above. In fact a considerable saving may be made if time is not taken to draw a plan to scale. This, however, calls for experience.

For those who are spending, say, $100 or more, the cost of the plan drawn by a professional will usually be saved in the avoidance of unnecessary mistakes, provided, of course, that an undue amount is not paid for the plan.

Selecting the Lot. Before building, the size of the lot should be considered to allow adequate space around the house for the necessary planting and for recreational use. Lots as narrow as 60 and even 50 ft. may be developed to advantage; but if an appreciable interest in gardening exists, a lot at least 75 ft. in width may be advisable. In the same manner 100 ft. in length may be ample, but 125 ft. is preferable, and 150 ft. advisable.

A wooded lot is usually higher priced and considered more desirable. Actually such a lot is difficult to landscape because of improper placing of trees and usually overabundance of trees and the resultant shade. A lot in a wooded section but with few if any trees within its boundaries is often preferable. Trees of adequate size and acceptable varieties may be planted for less than the additional cost of a wooded lot.

The proper placing of the house on the lot is important to make the best use of the available space. This is especially true with the relatively small size of the average lot. It is usually advantageous to place the service end of the house nearer the side boundary than the living-room end of the house. This allows a large space for garden use and wastes less for the service area. However, as we have previously mentioned, the individual preference and interests of the property owner may alter this. If possible, the north side of the house should be used for service. Frequently no consideration is given to the landscape planning until after the house is built. Since few if any contractors and few architects give any consideration to the landscape problems, it is up to the owner to do so. Local building regulations often control the distance that the house must be set from the street as well as from the side boundaries. They may also include the location of a separate garage. If no restrictions exist, the distance from street to house should for the sake of uniformity conform to those of other houses on the street. Except on narrow lots, it is not necessary that the house face the street; the entrance may be on the side.

A direct connection between the house and the garden is highly desirable, not only by views of the garden from the windows but by direct access to it through a door. Sometimes it is possible to install French doors in place of a window to give this access. Yet there are many houses with lovely gardens and no apparent connection between the two. Intimate connection may be increased by a porch or a terrace on the garden side of the house. Additional contact may be made by developing the plan around the axis from the living-room window, the porch, or the terrace. In developing the landscape plan, every effort should be made to make the most of views from the living-room, dining-room, and

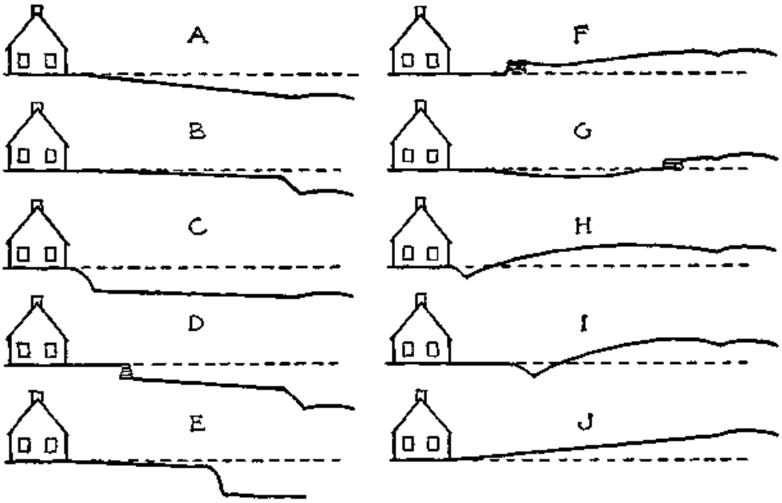

Fig. 16.—Grading your yard.

A. The lawn may be sloped gently from house to street.

B. For a more level yard a terrace may be placed near the street or 8 or 10 ft. out from the house.

C. Narrow terraces around the house are undesirable. They are difficult to plant and do not tend to lower the apparent height of the house.

D. For steeper slopes a terrace 8 or 10 ft. wide may be combined with another one at the street. One or both of these may be held in place by stone walls.

E. Terraces or banks across the middle of the yard are not desirable since they give the effect of shortening the distance.

F. When the house is lower than the street, a wall 10 to 15 ft. from the house gives a more gentle slope as well as keeping surface drainage from the house by a slight depression above the wall.

G. A wall or bank along the street gives a level yard with a slight depression to keep surface water away from the house.

H. The depression near the house drains surface water to the house. This is not desirable.

I. A preferable solution to the problem is *I*.

J. Here again all drainage is carried directly to the house and will be highly undesirable. This should be treated as in *I*, *G*, or *F*.

even kitchen windows. The closer and more intimate the garden can be made with the living part of the house the greater will be the enjoyment derived from it.

Grading. Grading has much to do with the final effect of a property. A first consideration is the elevation of the house. The common practice of setting houses rather high to avoid extra cellar excavation and allow complete use of subsoil without hauling any away is not to be recommended. Houses placed relatively low in relation to existing grades with low foundations above the final grade usually appear better placed than those not so built. A slight slope away from the house is necessary for adequate drainage of surface water.

All refuse from building operations should be hauled away rather than buried. If topsoil exists on the lot, it should be scraped off and saved to cover any subsoil used. Rather than have additional topsoil brought in, good soil may be made on the grounds by the growing and plowing under of winter wheat or rye sown in September and plowed in April. This may be followed by soybeans sown in May and plowed under when a foot high. The plowing under of green-manure crops such as these is often the least expensive method of soil preparation. It must be accompanied by adequate fertilization.

Fortunately not all lots are perfectly level, for a sloping surface lends itself to a more interesting treatment than a flat one. Yet often the contractor and the owner feel that everything must be level. Since a variety of levels is often desirable in a garden, it is not necessary to grade or fill in all lots. It may even be desirable to grade an otherwise level lot so as to have at least two different levels, even though there may be but a foot difference in elevation. The diagram in Fig. 16 shows how sloping yards may be treated to handle drainage and avoid undesirable slopes. Those in Fig. 17 show how different levels may be made in a level yard.

Consideration must be given to present and anticipated grading of adjacent property, particularly with regard to drainage of surface water. Differences of grades between the properties are permissible and may be cared for by the use of a dry wall, a concrete wall, a ground-covered bank, or even a rock-ribbed bank, hidden by plantings.

Sloping and irregular-surfaced lots may have the irregularities used to advantage rather than being graded to a regular surface. Slopes to be in turf should be gentle; steep slopes may be planted with ground-cover plants or held in place by a wall.

A terrace, paved or turfed, across one side of the house may be planned to lessen the slope of lawn from the house. Such a terrace should be sufficiently wide, 8 to 12 ft., to allow adequate use. It may be faced with a dry stone wall or a planted slope.

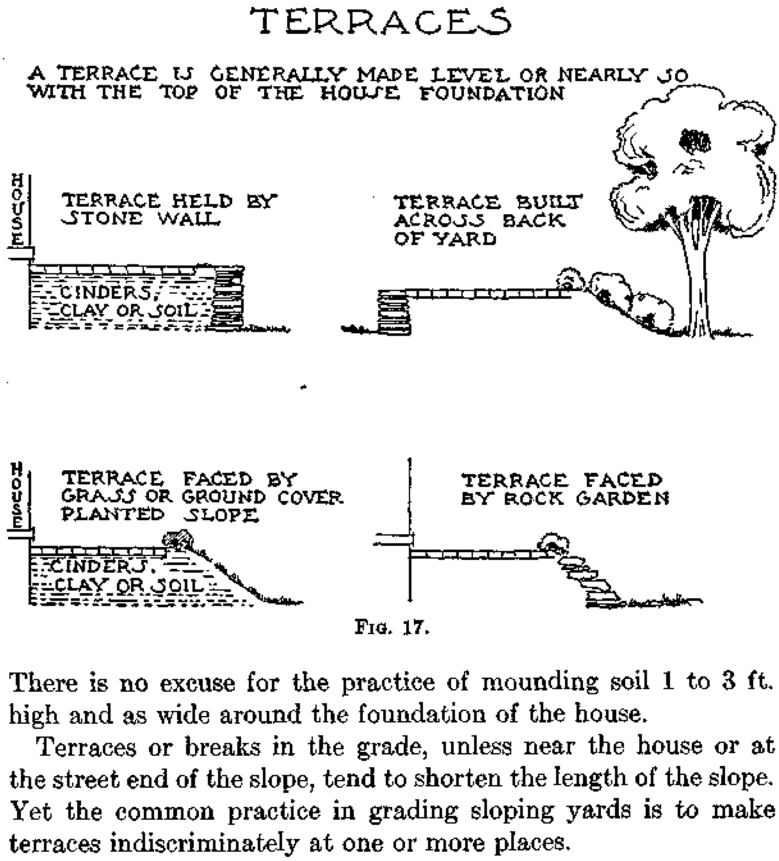

FIG. 17.

There is no excuse for the practice of mounding soil 1 to 3 ft. high and as wide around the foundation of the house.

Terraces or breaks in the grade, unless near the house or at the street end of the slope, tend to shorten the length of the slope. Yet the common practice in grading sloping yards is to make terraces indiscriminately at one or more places.

Even though the surface of the yard may be sloping, if the soil is heavy, drainage may be inadequate. Agricultural drain tile should be installed as described in Chap. II.

Changes of level involving filling in soil over tree roots is extremely dangerous. Any fill over 4 to 6 in. thick, especially of *clay soil, may kill existing trees by smothering the roots.* Recommendations for proper methods of fills will be found in Chap. XVI.

Planning. One requirement of any landscape planting is that it be practical and in keeping with the ability of the owner to maintain it. Unless additional labor is to be employed for its

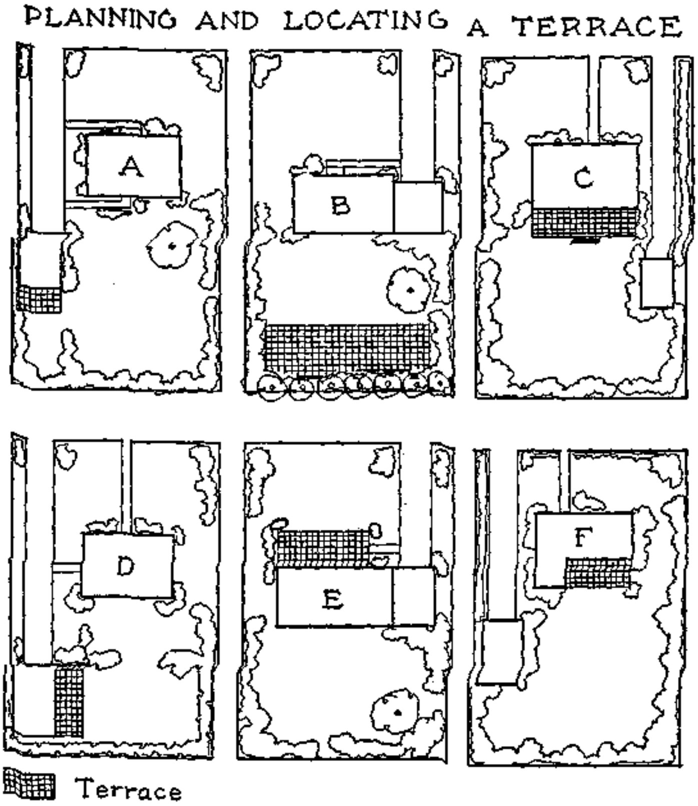

FIG. 18.

maintenance, every yard should be sufficiently simple so that it can be cared for with the minimum effort. Extensive flower borders, sheared hedges, espalier trees, bent-grass lawns, and formal gardens requiring excessive attention are among the features that call for more care than can be given without the employment of a gardener. Therefore, no more yard should be developed than can be adequately cared for.

On the other hand, shrub borders, foundation plantings, flowering trees, shade trees, and even lawns require the minimum attention and give a maximum of effect. The prevalent idea that a rock garden will reduce care of a shaded area or that a flower garden will be less work than a lawn is obviously erroneous. Unfortunately, many of the old ideas of landscape gardening, such as avoiding straight lines, avoiding red flowers, and other equally old-fashioned ones, are misleading.

Incidentally, ease of upkeep as indicated by easily mowed lawn areas, woody plants so selected as to demand the minimum of attention, and ground covers for areas difficult to turf are rather good indications of a simple but artistic layout.

Styles of Gardens. The two types of gardens, formal and informal, are familiar to everyone, but not always completely understood.

The informal, or, as it is often called, the *naturalistic*, is perhaps the more misinterpreted of the two. In the desire to produce informality all form of design is sometimes forgotten. Actually a garden of this type should have just as much design as a formal garden except that balance is secured by an asymmetrical plan instead of a symmetrical one. Curves may be used, but so may some straight lines. The curves must not be awkwardly wiggly in an effort to simulate naturalness. The grading need not produce level areas. Features need not be architectural in line, but otherwise there is no great difference. And yet, despite this, many so-called informal gardens are merely formless gardens, planted without rhyme or reason.

The formal or architectural or geometric plan is often scorned by the layman. Actually small properties with limited space may often be developed formally to better advantage than informally. Straight lines conform to the boundaries of the property, to the lines of many houses. Hedges, straight borders, and straight walls take the minimum of space. All in all they are easier to plan and develop than informal gardens. Features may be placed at the end of an axis without the danger of destroying the balance as in the case of informal gardens.

Frequently it is possible to combine these two types in one property. A formal effect may be developed near the house around the main axis with an informal area at the back of the property or behind the garage. Such small areas as the space alongside the house may be formally planned, whereas the rest of the property may be informal.

Such a bit of formality as a dry stone wall along a drive or around a terrace may be appropriately included in an otherwise informal yard.

The same general principles may be applied to the front yard. If the house is symmetrical, a symmetrical, balanced planting is required. Obviously under these conditions straight walks are in keeping, and curved ones ludicrous. If the house is not symmetrical, the front planting will not be the same on each side but will be planned to harmonize with the architecture.

Scale and Proportion. Just as all parts of a house should be in proportion, *i.e.*, windows, doors, and porches, just so the plantings, features, and general design of the garden should be in proper scale and proportion.

Here again a few examples may best serve to clarify the idea. A planting of small, slow-growing evergreens in front of a large house on a relatively high foundation will look very skimpy for some years. Either relatively large specimens should be used, or else faster growing materials such as deciduous shrubs may be selected.

Similarly, very small shade trees only 8 or 10 ft. high will look lost in a large treeless yard with a two-story house. A pool 3 by 5 ft. is obviously too small to use as a central feature in the middle of a 30- by 50-ft. lawn area. Huge shrubs 15 ft. high at the corners of a Cape Cod cottage are entirely too large to be in scale.

A wisteria smothering a trellis over a 4- by 6-ft. entrance porch is going to require constant pruning to keep it in proper proportion. And yet we have but to look at the average planting, both new and old, to find very few that consider proportions. When new, the plants are usually too small and, when old, altogether too large. Once again, we are brought face to face with the necessity of knowing ahead of time what the various plants that we are using will do—whether they are slow growing or fast growing—and what their ultimate size will be. And with this arises the need to consider most carefully the size and proportion of any architectural features that we may use, whether it is a formal pool, an arbor, a garden urn, or a piece of statuary.

Effects of Foliage. The effect produced by the foliage of plants should be given more careful consideration, and yet it is one topic that is almost impossible to convey in words. The feeling for varying tones of green, for different foliage effects and textures, for the proper handling of foliage blends and contrasts comes largely from experience. But even to be aware of this phase of plant selection is a step in advance.

Possibly a few examples may serve to illustrate some of the basic principles. A foundation planting of coniferous evergreens is rather somber without the benefit of contrast from the inclusion of broadleaf evergreens. The use of the dull dark green foliage of Vanhoutte spirea is uninteresting unless livened by combination with brighter greens. On the other hand, too much variety of form, size, or color in foliage destroys the unity and the harmony of any planting. The very large-leaved plants such as *Catalpa* in the North or *Ficus pandurata* in Florida are too heavy for use with the average house.

On the other hand, small-foliage plants such as *Spiraea thunbergi* and *Tamarix* are not advisable except as a contrast. Fortunately the vogue for excessive quantities of golden-leaf and red-leaf shrubs for foundation plantings and hedges is on the wane. A hedge or a foundation planting consisting of alternate plants of two contrasting types is not advisable although still seen in combinations of globe and pyramidal arborvitaes or red and green barberries.

The use of foliage applies to the flower border and rock garden as well as to tree, shrub, vine, and evergreen plantings. It applies to our northern states and even more so in the southern states with their more abundant broadleaf evergreens. It is even more important in subtropical climates of Florida and Southern California with their more luxurious foliage plants.

In all landscape planning, by controlling size, nature, and foliage texture, the layman can obtain the various desired effects after careful study of other plantings, noting the effect achieved through the use of different shrubs, vines, and evergreens.

Views from the House. Views, or vistas as they are often called, are an important part of any landscape design. First to be considered are those of the garden from the house. To obtain the greatest degree of connection between the house and the garden the entire plan may be evolved around the view or axis from the living-room window or other strategic viewpoint such as a terrace, porch, hall door, or dining-room window. To focus this view, a terminal feature will be necessary at the opposite end of the axis. It may consist of a planting of evergreens, of striking deciduous shrubs, or of an architectural feature such as a seat, a paved terrace, a pool or a bird bath, or even an arbor. Its nature would be determined by various factors including the size of the lot, type of the garden, design of the garden, and interests of the owner. Under no circumstance should this feature be so large or so conspicuous as to overshadow the rest of the garden. It should harmonize with the house as well as with the garden in every respect. An informal yard would call for an informal terminal feature; a formal layout would obviously demand a formal one.

After the main axis has been established in the plan, a secondary axis may be considered. This may be a cross axis to attract attention as one walks along the main axis, or it may parallel the main axis at one or both sides of the yard. Naturally, plantings will be necessary to divide and set off each separate axis. The terminal features of this secondary axis will usually be less prominent than that of the main axis. The overemphasis of the terminal feature of the secondary axis will counteract its value and give a garish effect. Even a small lot 40 by 100 ft. may have several axes developed. In general the major difference between a plan designed by a professional and one by an amateur is the division of the area into several smaller areas and the use of appropriate axes with their terminal features. In this manner any property is made to appear much larger than it actually is, to say nothing of its greater landscape interest. Part of this effect is obtained by the element of surprise in going from one section of the garden to another.

A few specific examples of the placing of an axis may be helpful. A walk or path may be planned from the front yard along the side of the house to the back yard and even to the back boundary. A similar development may be made across the back of the property with a vista into each end of it from the rest of the yard. The area back of the garage may be made into a separate unit with its own axis and a cross axis extending to the opposite side of the yard.

Walks and Paths. Walks are a necessary feature, not always adding to the artistic effect. The front walk may go from the front door to the street, in which case a straight line is the most convenient and least offensive. The modern practice of curving walks is more often in poor taste than not, especially if the house is relatively close to the street as in most town properties. Level lawns and short distances give no reason for a curved walk. With the present use of automobiles and hard-surfaced drives, it is often more convenient to take the front walk to the drive. In the case of front porches, it may even be advisable to shift the

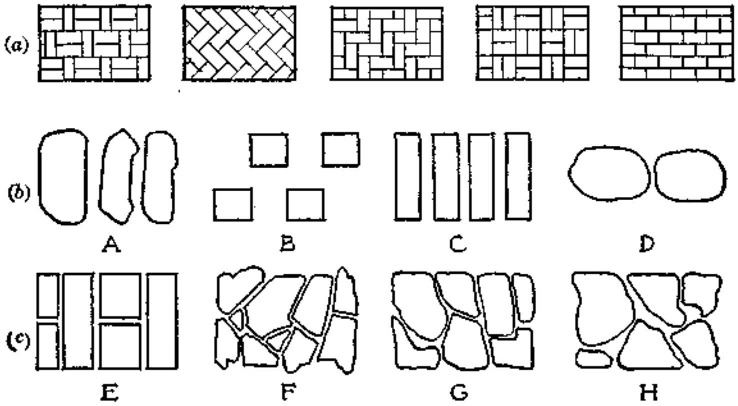

Fig. 19.—(*a*) Patterns for brick paving.
(*b*) Stepping stones: (*A*) Difficult to walk on. (*B*) Most unsatisfactory. (*C*) Fair. (*D*) Good.
(*c*) Stone walks: (*E*) Cut stone—expensive but satisfactory. (*F*) Poorly made—edges of walk uneven; small pieces will come up. (*G*) A well made walk with narrow joints. (*H*) A poorly made walk with wide joints.

steps from the front of the porch to the end toward the drive. Every effort should be made to avoid dividing the lawn into awkward areas by the front walk.

The same principle applies to the back walk. No walk should be placed so close to the house that there is not room between it and the building for the proper planting. It is sometimes advisable to move existing walks to allow the desired planting. Occasionally walks along the side of the house, a carry-over from preautomobile days, may be removed entirely, since with the drive they are no longer necessary.

Concrete walks are serviceable and permanent but seldom necessary for the average home. A brick walk, even if laid on sand or cinders and unmortared, is usually sufficient. A brick-surfaced concrete would give a more formal effect. Various patterns may be used. A patched stone walk, or crazy stone, as it is sometimes called, may be preferred. If so, the stone should be absolutely smooth, and the joints sufficiently narrow so that women's heels do not catch in them. Such a walk may be laid on a bed of sand or sifted cinders. No mortar or cement is necessary, and a colored mortar is uncalled for. Individual steppingstones are not sufficiently serviceable for regular use. They are adapted to garden use only.

The width of the walks will depend on their use. Even for limited use they should be 30 in. wide. Front walks from house to street should in most cases be at least 3 ft. and preferably wider.

Steppingstones should be ample in size to walk on. Stones at least 10 by 12 in. may be placed 18 to 20 in. between centers. All walks and steppingstones should be flush with the surface of the lawn so that the lawn mower may be run over them.

It is difficult to suggest appropriate plantings in connection with walks except that usually little if any planting is necessary. Low entrance plantings where the walk intercepts the street sidewalk are sometimes used. The practice of edging with flower beds or low hedges is not usually recommended, since it tends to overemphasize the walks.

Garden paths leading from one section of the yard to another give an added attraction to any grounds. A 10-ft. strip along one side of the yard consisting of a 3- to 4-ft. grass, gravel, crushed-stone, or brick path and a 3- or 4-ft. flower border on each side, backed by a vine-covered fence or trellis, makes a separate garden unit. Or a straight or winding path may be planned between shrub borders across the back of the property. Another place where a path may be used to advantage is leading from the front yard past the side of the house to the back yard.

These paths give an opportunity for planting annuals, perennials, bulbs, and even wild flowers where they may be more or less intimately viewed from the path. Steppingstones may be used in these paths, surrounded by ground-cover plants rather than by grass to reduce the labor of mowing and edging the turf. An occasional flowering tree along the paths will give the added attraction of shadows or a site for a garden seat.

Drives. Drives are a problem at best. They should be so planned and constructed that they are convenient and serviceable the year around. For small lots with no turnaround or Y, they should be absolutely straight for ease in backing out. In fact unless a property is fairly good sized and the house some distance from the street, a straight drive is often the most logical. To avoid unnecessary waste of space, the drive may be put fairly close to one side of the property. If possible, leave sufficient space between the house and the drive for planting. If space is limited, a 12- or 18-in. space may be saved for a vine. Likewise, the garage, if not attached to the house, need not be put back any farther than necessary. Building codes often specify the distance from the street. In small lots the garage is probably best placed at the end of the drive rather than at the back of the house where it often interferes with the view from windows.

For larger properties drives should not be so placed as to cut across views from the house into the garden, nor should they cut across between the house and the street except where absolutely necessary.

Turnarounds are convenient but require a diameter of at least 60 and preferably 70 ft. for adequate turning of trucks. It is often easier, more convenient, and greatly saving of space to have a Y back-out. Again, this should not protrude between house and garden if it is possible to avoid.

Concrete drives are seldom necessary for home use, to say nothing of their glare and conspicuous nature; and because of the difficulty of staying on them, concrete ribbons are seldom satisfactory. Black-top drives as used today are permanent and satisfactory. Crushed-stone and gravel drives are inexpensive, convenient, and attractive; 4- to 6-in. layer, especially under the wheels, will be thick enough. Hard brick laid on 4 to 6 in. of gravel or cinders makes a very serviceable surface.

If the drainage is not adequate, a row of agricultural drain tiles may be laid on either side of the drive to carry excess water to a lower level or to a storm sewer.

Slopes along drives, which are so often rutted by driving, may be protected by a low stone wall with each layer of stone set back an inch or so from the row beneath it. If not mortared, they may be planted with rock plants. Perpendicular walls are not advisable, since they give no protection to automobile fenders and hub caps.

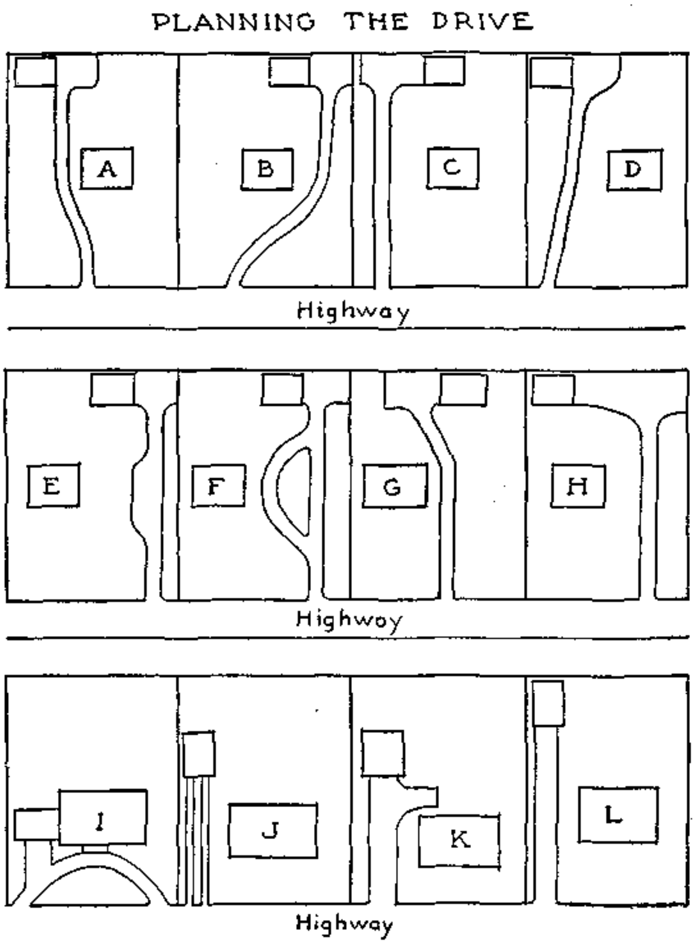

Fig. 20.—Planning of drives.

A. The drive cutting across a lawn in front of the house narrows the front lawn and spoils the front view.

B. This is even worse than *A* with the drive on two sides of the house.

C. A practical solution where space is limited.

D. Preferable to *C* where sufficient space is available.

E. Where drive is not too close to the house it allows for parking along side of drive.

F. It takes up too much space, with the island in the center of the driveway more or less waste space.

G. It would be better if the garage were in the far corner of the yard so that less area back of the house would be taken up with drive and parking.

H. Unless ample space is available, this layout reduces the yard behind the house to too great an extent.

I. Possibly necessary for places of business but unsuited to the average home.

J. Ribbon drives are difficult to use in backing.

To protect the lawn from careless drivers, heavy stones may be sunk in it projecting 8 or 10 in. above the ground to hit the front axle of automobiles. They may be covered with a small evergreen vine such as self-branching English ivy.

Plantings along drives should be of varieties that will not grow over the drive and scratch automobiles.

The Front Yard. An open front yard is an American tradition, but unfortunately the effect of the street as a whole is seldom considered. First, the street trees should, if possible, be uniform, spaced at proper distances of 50 to 75 ft., depending on the species. Similarly the front part of the yard should more or less harmonize with those on each side of it. For one person to enclose the front yard completely when all the other yards are open tends to break the unity of the street. Aside from this, it is each person's privilege to plan his yard as he sees fit. At times an enclosed front lawn surrounded by shrubs and even enclosed with a gate is an advantage. Fences and gates may be a necessity for the control of dogs and possibly peddlers and handbill passers. For those houses with living rooms facing the street and with no view to the back, a dooryard garden may give greater enjoyment than an open lawn. Unless the front is used in this manner, the lawn is best left free of plantings except for shade trees. Plantings should be confined to the borders of the property and across the front of the house itself. All should be of such a nature as to emphasize the house rather than the plants themselves.

Trees are normally planted at each side of the yard to frame the view of the house from the street. There will, however, be conditions that call for other placing.

The foundation planting should also tend to frame the house, with the greatest height at the corners. Unless undesirable architectural features are being hidden, the corner plantings should not be over half the height of the eaves. In other words, there is a tendency to use plant materials growing far too large in proportion to the house. As discussed in Chap. XVI, Woody Plants, the mature height of all plant materials should be deter-

K. It would be better to back out than use up the area immediately behind the house with the wide drive.

L. More garden space could be obtained by moving the garage nearer the street.

mined before use. Porch plantings should seldom be higher than the rail. House plantings should not be allowed to grow above window sills or completely to cover the front of the house. There is even more danger of this with evergreens than with deciduous shrubs. In a like manner any vines used on porches or on the house itself should be kept within bounds to prevent a "long-haired" effect.

The question of evergreens or shrubs for a foundation planting is a matter of individual taste and expense. Houses with poor architectural lines, high foundations, or difficult growing conditions such as shade are best planted with deciduous shrubs. After all, shrubs may be just as attractive the year around as most evergreens. The use of coniferous evergreens alone tends to produce a somber effect. A combination of deciduous shrubs and broadleaf evergreens or coniferous and broadleaf evergreens is preferable. All these plantings can be made more effective by the use of evergreen ground covers.

Good taste precludes the placing of trellises, arbors, bird baths, sun dials, rock gardens, and other features in the front lawn itself, except as a natural slope calls for the use of a rock wall or other planting to maintain it.

Hedges across the front of the property and along the side boundaries are a matter of individual preference. If used, they must harmonize with the plantings of the rest of the front. They may be deciduous or evergreen and may be allowed to grow naturally or be sheared. Suitable plants are listed in Chap. XVI.

A hedge will give to a yard in a few seasons the feeling of age and permanence.

Planning the Garden. Gardens, like houses, may be made up of one or more "rooms," each separated from the other by walls. Such division has several advantages. By not seeing the entire place at once, interest is aroused. By going from one part into another, an element of surprise is added. This scheme may be accomplished on a very small scale in a 40-ft. lot as well as on a larger scale. Figure 21 shows how the idea may be carried out in planning a picnic site. Otherwise unusable areas such as the space at the side of the house and the space in back of the garage may be developed into charming garden bits. Where space is limited, free-growing shrubs are out of place, but backgrounds may be furnished trellises; brick, stone, or concrete walls; or wooden sapling fences. Even a wire fence covered with an evergreen vine can give an adequate effect. The arrangement will be determined by the placing of the house and garage, the size of the lot, the topography, and the interest and desires of the owner.

Backgrounds and Privacy. A background is needed to set off the lawn, flowers, and other features properly. It may be furnished by a hedge surrounding the back yard or garden or by a border planting of mixed shrubs. If space is lacking, a vine-covered fence or trellis may serve. Without a background a garden loses a large part of its charm and all its privacy. Today most Americans realize that the area back of the house to be most usable and enjoyable must furnish privacy and seclusion. Otherwise it is just another back yard but no garden. So in planting the background two purposes are combined in one. In some ways the background planting is as important as the planting in front of the house. Often it is put in after all other planting has been done. Actually it may be advisable to do it first.

In selecting the plant materials for the border planting, consideration should be given to the height and the spread. Plants may vary from head high on up. If flowers are to be planted in front of them or if the space is limited, use the less spreading varieties. Succession of bloom, variety of decorative fruits, variety of autumn color, and contrast in foliage effect may be obtained by consulting the lists in Chap. XVI. Likewise, shrubs and evergreens for various types of hedges are listed in Chap. XVI. Occasionally touches of evergreen may be included as accents among the shrubs. Informal shapes of evergreens such as Pfitzer juniper, firethorn, or Scotch pine are preferred for this purpose.

Livability of the Garden. All these factors increase the use and livability of the garden. More and more are the American people coming to realize the enjoyment to be derived from gardens and are using them for recreation and relaxation. The entertainment area may be developed next to the house as a paved terrace (for all-weather use) or a paved area beneath a shade tree. Or it may be away from the house, perhaps hidden and secluded in a separate section of the garden. Possible locations for an outdoor living room are given in Fig. 21.

Shade may be furnished by such small trees as *Cercis canadensis* and others listed in Chap. XVI or by such large, overhanging shrubs as *Lonicera maacki* or *Viburnum prunifolium*.

For cooking, a small charcoal grill will be smokeless and not so apt to scorch overhanging branches as a wood-burning fireplace would be.

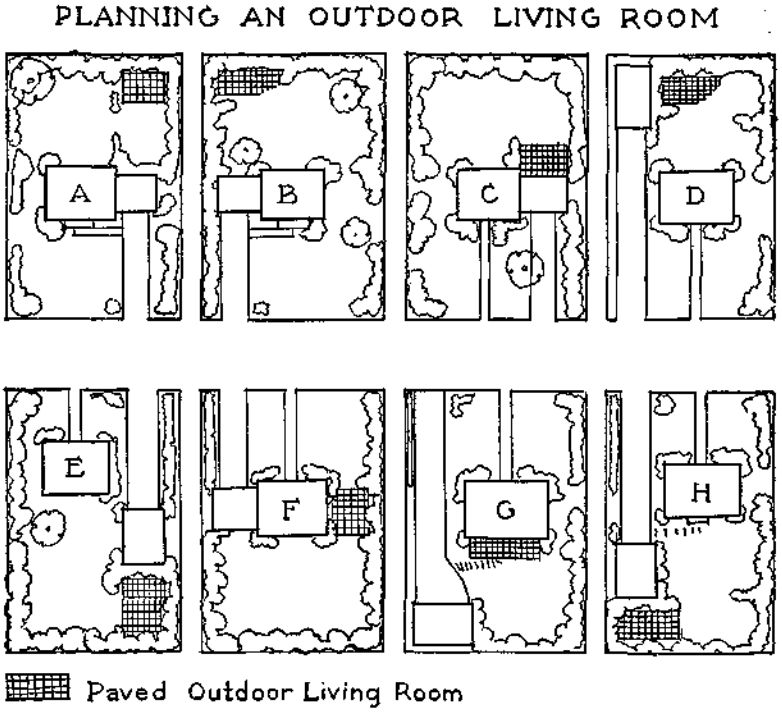

FIG. 21.

Seats and tables may be wooden ones of permanent nature or more easily portable kinds made of canvas or steel.

Use of Garden Features. Lovely as plants are in themselves, but few gardens cannot be improved by the use of architectural or other man-made features. Such features may be the echo or repetition of the architecture of the house. Unfortunately the general tendency seems to be toward overfeaturing the home grounds either in size of features or in their number. All should be kept in the proper scale and in proportion to the rest of the property.

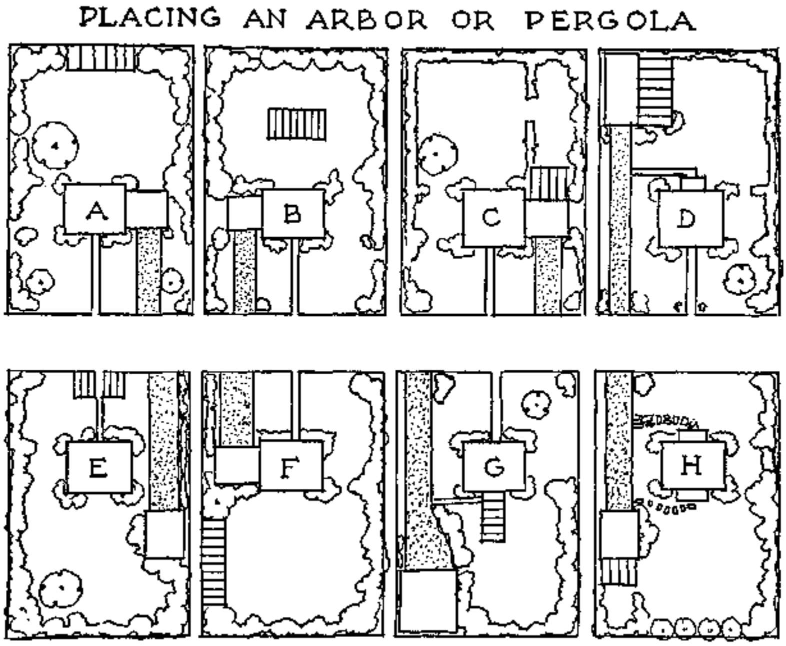

Fig. 22.—Placing an arbor or pergola.

A. A logical location at back of property with shrubs or evergreens tying it to the background.

B. The center of the lawn is obviously a very poor location.

C. A practical use of the back of the garage with the arbor connected to it.

D. Or it may be built along the side of the garage and of course blended into the garden by appropriate plantings.

E. There is no excuse for an arbor across the front entrance.

F. Built into the background planting along the side of the yard gives an opportunity for an informal layout.

G. Arbors projecting out from the house itself really have no excuse for their existance.

H. A modification of *C.*

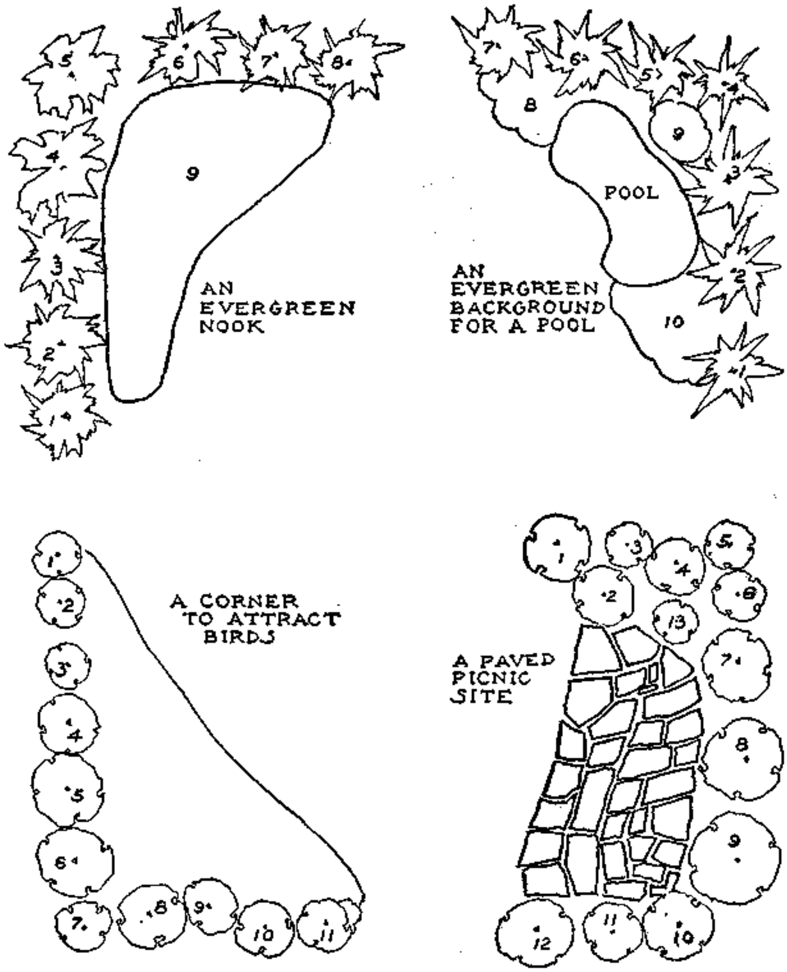
AN EVERGREEN NOOK
AN EVERGREEN BACKGROUND FOR A POOL
POOL
A CORNER TO ATTRACT BIRDS
A PAVED PICNIC SITE

Fig. 28.

FIG. 23.—Corner plantings.

An evergreen nook

1. Euonymus fortunei vegetus	1. Pyracantha
2. Euonymus fortunei vegetus	2. Juniperus chinensis pfitzeriana
3. Pyracantha	3. Ilex opaca
4. Ilex opaca	4. Pinus sylvestris
5. Ilex opaca	5. Pinus sylvestris
6. Ilex opaca	6. Pinus sylvestris
7. Pyracantha	7. Juniperus chinensis pfitzeriana
8. Euonymus fortunei vegetus	8. Pyracantha
9. Vinca minor	9. Phlox subulata

An evergreen background for a pool

1. Pieris japonica	1. Juniperus chinensis pfitzeriana
2. Pieris japonica	2. Pyracantha
3. Rhododendron	3. Taxus cuspidata
4. Rhododendron	4. Taxus cuspidata
5. Rhododendron	5. Taxus cuspidata
6. Pyracantha	6. Pyracantha
7. Pyracantha	7. Pyracantha
8. Vinca minor	8. Saxifraga cordifolia
9. Pachysandra	9. Yucca filamentosa
10. Teucrium	10. Lavandula

A corner to attract birds

1. Symphoricarpos chenaulti	1. Cotoneaster apiculata
2. Symphoricarpos chenaulti	2. Cotoneaster apiculata
3. Ligustrum regelianum	3. Viburnum triloba
4. Viburnum dilatatum	4. Viburnum triloba
5. Viburnum dilatatum	5. Ligustrum vulgare
6. Lonicera maacki	6. Lonicera tatarica
7. Lonicera maacki	7. Lonicera tatarica
8. Lonicera maacki	8. Euonymus atropurpureus
9. Lonicera morrowi	9. Cornus racemosa
10. Aronia arbutifolia	10. Cornus racemosa
11. Aronia arbutifolia	11. Cotoneaster divaricata

A paved picnic site

1. Euonymus fortunei vegetus	1. Indigofera kirilowi
2. Euonymus fortunei vegetus	2. Indigofera kirilowi
3. Euonymus fortunei vegetus	3. Indigofera kirilowi
4. Ilex opaca	4. Euonymus americana
5. Spiraea arguta	5. Cotoneaster dielsiana
6. Spiraea arguta	6. Cotoneaster dielsiana
7. Viburnum carlesi	7. Acer ginnala
8. Sorbaria aitchisoni	8. Acer ginnala
9. Cercis canadensis	9. Crataegus phaenopyrum
10. Cornus mas	10. Viburnum tomentosum
11. Cornus mas	11. Viburnum tomentosum
12. Pyracantha	12. Lonicera korolkowi
13. Lilium regale	13. Annual flowers

If a bird bath or a sun dial alone is too small, its effect may be enlarged by placing it on a brick or stone base. A paved area beneath it will further increase its effect. In a similar manner a seat or a bench may be emphasized by a paving beneath or in front of it or by a background of appropriate shrubs or evergreens. A plant such as boxwood or *Mahonia* on either side of it will greatly add to its size.

A pool may be too small, but its value can be enhanced by a background of upright Japanese yews or Cannart junipers or even by the use of evergreen ground covers on either end and in back of it. A white arbor or a pergola can be made apparently smaller and certainly less conspicuous by staining it a weathered brown or covering it with vines or partially hiding it with shrubs or other plantings.

The use of any feature, even as small as a bird bath or a sun dial, without due consideration of its placement and without appropriate plantings is inexcusable. For the most part, features may be used at the terminus of an axis as previously discussed.

One of the errors often committed is the painting of all wooden features white, whether or not the style and color of the house warrant it. Especially in informal gardens with informal architecture, the use of a weathered effect for large features such as arbors, pergolas, summerhouses, and even trellises and fences may be worth considering. Another point often overlooked is the expense of upkeep when structures are painted. White picket fences and white trellis fences are especially difficult to maintain.

Shade. Adequate shade is an important factor in yard or garden. Not only does it increase the livability and use of any landscape development by giving comfort in summer, but it increases the enjoyment by means of varying light intensity. The love of shade is expressed in such home names as Shadow Lawn and Oak Shadows. Tracery of the twig shadows, whether on the snow in winter or on the lawn in summer, is bound to give aesthetic pleasure.

On the other hand, excessive shade as so often encountered in places overplanted with trees is depressing in addition to being a handicap to proper planting and growth. In such cases the removal of one or more trees is necessary.

In planning for shade, consideration must be given to the mature size as well as the rate of growth of trees and shrubs. Small trees and large shrubs may often furnish shade more satisfactorily than do large shade trees. This is especially true of small properties and small houses.

Street tree plantings no doubt require large trees, and large trees may also be necessary to shade the house itself. But terraces, outdoor living rooms, garden seats, backgrounds, and screens as required for the average property may be shadowed by small trees such as the redbud, flowering crab, hawthorn, and even large shrubs such as the Amur honeysuckle and common mockorange. The desirability of purchasing a lot without trees and then selecting and placing them to the best advantage must again be emphasized.

Vines may be used for shade on porches, arbors, and pergolas or even as a temporary frame above a window until the trees become sufficiently large to furnish it. Annual vines give quick results. Shade from the south and west is important. Shade from the late afternoon sun may be supplied by a few fast-growing trees along the boundary, to be taken out after other plantings have reached sufficient size. For this purpose Simon poplar, bay willow, and even Chinese elm may be used.

Variety in Plant Materials. The landscape architect is inclined to use relatively large masses of a small variety of plant materials, whereas the horticulturist is more inclined to use a greater variety of plants. From the standpoint of design, the landscape viewpoint is correct. However, the layman who is at all interested in plant materials derives a certain thrill and consequently has more interest in planting a wider range. It is not impossible to use a relatively large number of varieties of plant materials and still preserve the desired effect of unity and harmony. To effect such a combination, plants with striking habits of growth or strongly contrasting foliage must be limited. However, the majority of our deciduous shrubs blend together surprisingly well. If all planting details are ignored until after the general plan or layout is made, there will be less chance of poorly designed grounds.

Thus it will be seen that the horticulturally inclined gardener, the plant collector, must compromise between large collections of varied plants and good landscape design.

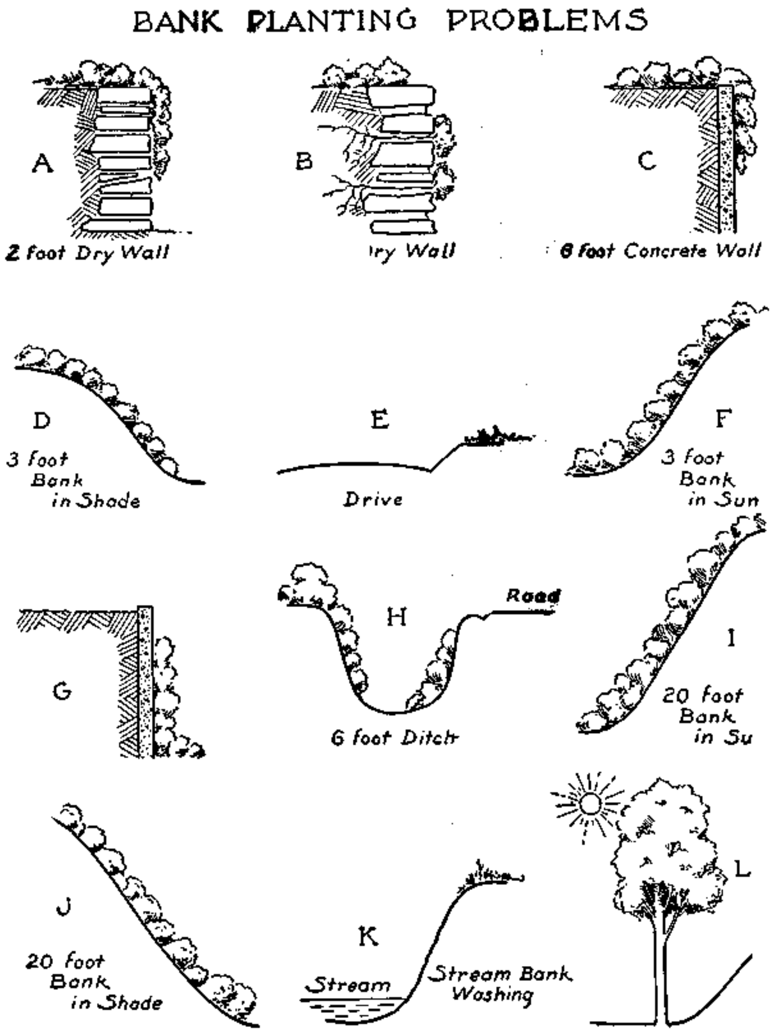
BANK PLANTING PROBLEMS
A
2 foot Dry Wall
B
ry Wall
C
6 foot Concrete Wall
D
3 foot
Bank
in Shade
E
Drive
F
3 foot
Bank
in Sun
G
H
Road
6 foot Ditch
I
20 foot
Bank
in Su
J
20 foot
Bank
in Shade
K
Stream
Stream Bank
Washing
L

FIG. 24.

FIG. 24.—Bank planting problems.

A. A dry stone wall may be planted with *Vinca minor* (Periwinkle), Winter-creeper (*Euonymus fortunei* and its varieties), or if it is shaded, by these and by English Ivy (*Hedera helix*). All of these will eventually grow throughout the wall.

B. Another method of planting a dry stone wall is with rock plants and dwarf perennials. The more spreading ones will cover the entire wall, while compact types will leave some rock exposed.

C. Concrete or brick mortared stone walls may be draped with vines or trailing shrubs. *Euonymus fortunei coloratus*, *Parthenocissus quinquefolia*, *Cotoneaster adpressa*, or *Cotoneaster horizontalis* may be used. *Hedera helix* would be satisfactory where hardy. *Forsythia suspensa* would give a charming effect.

D. If in conspicuous place, an evergreen plant is preferred, as *Vinca minor*, *Euonymus fortunei*, *Euonymus fortunei coloratus*, *Hedera helix*, or *Pachysandra*. Otherwise any ground cover plant withstanding shade may be used.

E. A slope along a drive, especially if likely to be driven over, is best planted with a ground cover that is not woody. Any of the sedums, *Phlox subulata*, *Vinca minor*, or *Thyme* would be suitable.

F. Here again *Vinca minor* and *Euonymus fortunei coloratus* show their versatility. *Thyme*, *Phlox subulata*, *Sedum album*, or *Sedum reflexum* would all give evergreen effects.

G. Any clinging vine may be used, but preferably evergreen. Any of the *Euonymus fortunei* varieties or where it is hardy, *Hedera helix*. *Cotoneaster* is sometimes espaliered against a wall.

H. Drainage ditches may be grassed and mowed or planted to vigorous ground covers, as Japanese honeysuckle or *Vinca minor*. They may be hidden from the house by a low unsheared hedge along the top.

I. Large banks call for use of vigorous plants. Japanese honeysuckle, *Rosa wichuraiana*, *Forsythia suspensa*, *Parthenocissus quinquefolia*, and *Symphoricarpos vulgaris* are among the best.

J. Shade tolerant plants for such a situation would include *Rhus aromatica*, *Lonicera japonica halliana*, *Parthenocissus quinquefolia*, and *Symphoricarpos vulgaris*.

K. Willow poles 2 to 3 in. in diameter and 6 to 10 ft. long may be laid in shallow trenches with lower ends driven into stream bottom. They will root and grow. Or a vine such as *Lonicera japonica halliana* may be used.

L. The dry shaded bank will require the most hardy of plants such as *Vinca minor*, *Euonymus fortunei colorata*, and where hardy, *Hedera helix*.

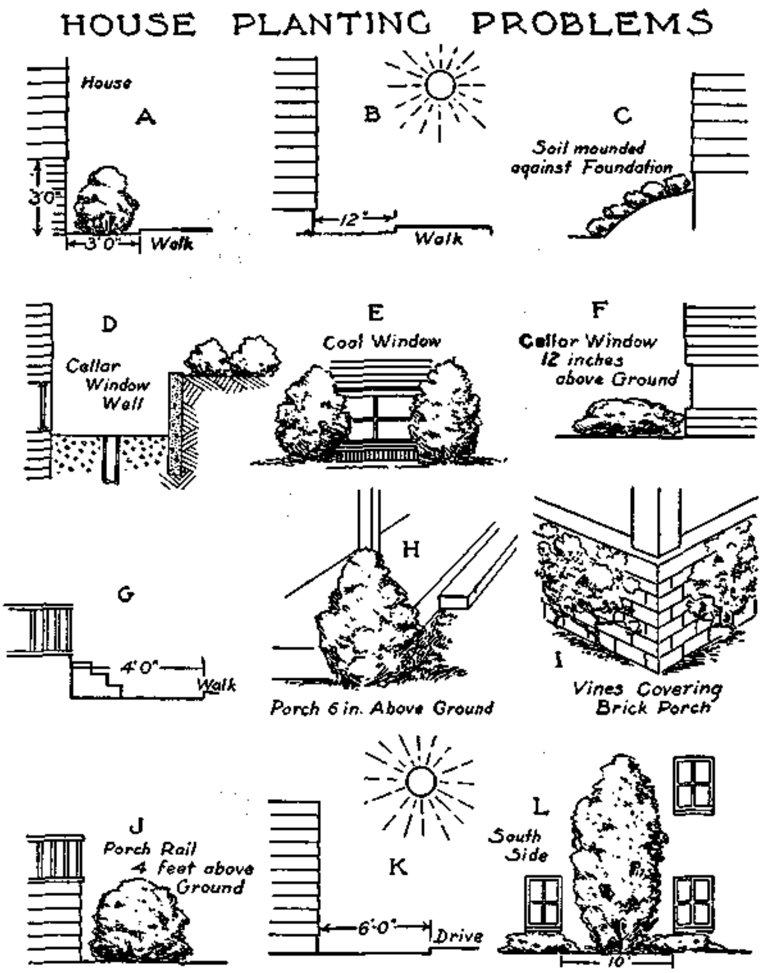
HOUSE PLANTING PROBLEMS
House
A
3'0"
3'0"
Walk
B
12"
Walk
C
Soil mounded against Foundation
D
Cellar Window Well
E
Coal Window
F
Cellar Window 12 inches above Ground
G
4'0"
Walk
H
Porch 6 in. Above Ground
I
Vines Covering Brick Porch
J
Porch Rail 4 feet above Ground
K
6'0"
Drive
L
South Side
10'

FIG. 25.

Fig. 25.—**House planting problems.**

A. To avoid a difficult pruning problem, only very compact plants should be used. *Deutzia gracilis*, *Hypericum patulum*, or *Potentilla fruticosa* would all stay within bounds. Or a ground-cover plant might be used as *Pachistima*, *Iberis sempervirens*, *Euonymus fortunei vegeta*, or *Euonymus fortunei radicans*.

B. No shrub can be this compact. With the sun and the glare from the walk, only the hardiest plants would be satisfactory. *Euonymus fortunei* clinging to the foundation would be the best solution.

C. Soil mounded around a house such as this, if it cannot possibly be removed, may be covered with a ground-cover plant such as *Vinca minor*, *Euonymus fortunei* or one of its varieties, *Juniperus horizontalis* or one of its varieties.

D. To allow light into the window of the cellar, only low-growing material should be planted. *Vinca minor* will do well, as will *Iberis sempervirens*, *Lavandula*, and where hardy, *Hedera helix*.

E. To allow entrance to the coal window, flexible shrubs are necessary. They would include *Symphoricarpos chenaulti*, *Kerria japonica*, *Spiraea thunbergi*, and *Spiraea arguta*.

F. In keeping with the modern practice of fewer shrubs and more ground covers around the house foundation, *Vinca minor* or any other low growing evergreen ground cover would be satisfactory.

G. Obviously spreading plants as *Juniperus chinensis pfitzeriana* and *Spiraea vanhouttei* would be out of place. Use *Spiraea bumalda froebeli*, *Deutzia lemoinei*, *Deutzia cornea*, *Chaenomeles japonica*, or other compact shrubs.

H. As a frame for the porch and at the same time in proportion to the height use a 3–4 ft. plant. *Euonymus fortunei vegeta*, *Berberis julianae*, *Mahonia*, *Aronia arbutifolia*, or *Spiraea arguta*.

I. With brick or stone porches evergreen vines are often sufficient. No shrubs or other evergreens are needed. Ideal for this are *Euonymus fortunei radicans*, *Euonymus fortunei vegeta*, *Euonymus fortunei colorata*, and where hardy, *Hedera helix*.

J. To avoid obstructing the view from the porch, use plants such as *Deutzia lemoinei*, *Spiraea arguta*, *Indigofera kirilkowi*, *Ceanothus pallidus roseus*.

K. To avoid branches scratching passing automobiles and to avoid unnecessary shearing, use compact shrubs as *Aronia arbutifolia*, *Philadelphus lemoinei*, *Viburnum carlesi*, *Rosa hugonis*, and *Spiraea billardi*.

L. Large compact shrubs withstanding the heat of the south side of the house would include *Cornus mas*, *Ligustrum obtusifolium*, *Acer ginnala*, *Caragana arborescens*, and *Viburnum prunifolium*.

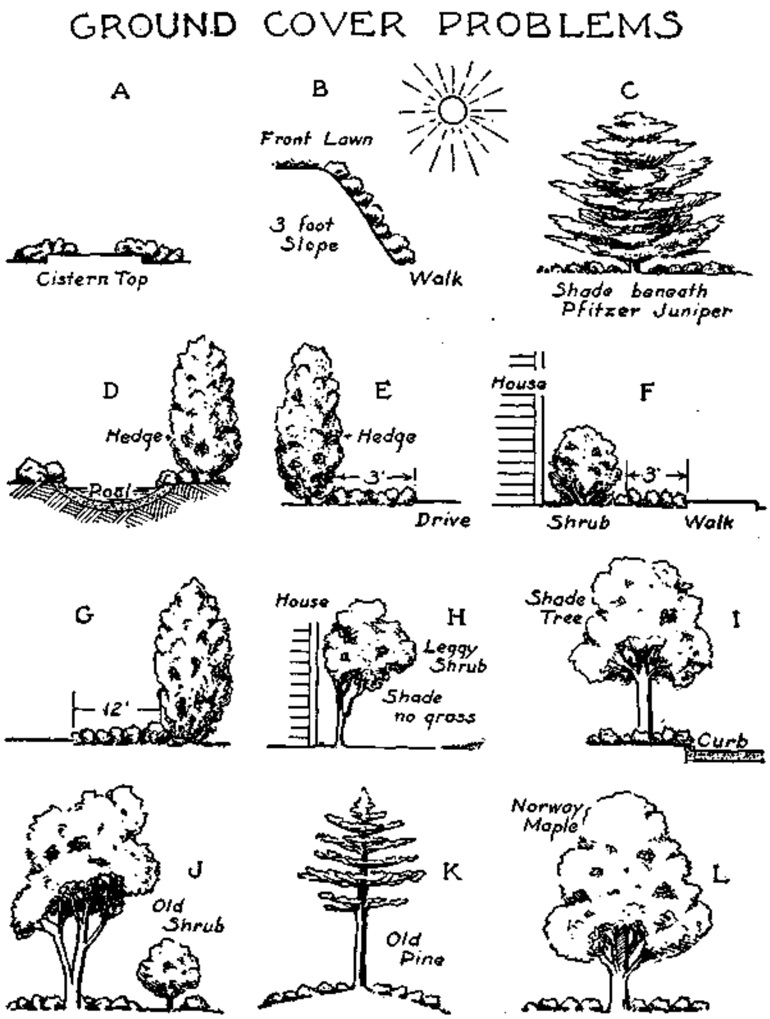
GROUND COVER PROBLEMS
A
Cistern Top
B
Front Lawn
3 foot Slope
Walk
C
Shade beneath Pfitzer Juniper
D
Hedge
Pool
E
Hedge
3'
Drive
F
House
3'
Shrub
Walk
G
12'
H
House
Leggy Shrub
Shade no grass
I
Shade Tree
Curb
J
Old Shrub
K
Old Pine
L
Norway Maple

FIG. 26.

FIG. 26.—Ground cover problems.

A. To avoid making cistern tops more conspicuous, use low-growing evergreen materials that can be pushed aside to get into the cistern. *Vinca minor, Euonymus fortunei*, and *Hedera helix* are the most satisfactory.

B. In a conspicuous place on the slope along the sidewalk use only evergreen foliage plants. These would include *Vinca minor, Euonymus fortunei, Sedum album, Sedum acre, Phlox subulata, Iberis sempervirens, Arabis procurrens*, and where hardy in the sun, *Pachysandra* and *Hedera helix*.

C. The heavy shade beneath low-spreading evergreens may be planted with *Vinca minor, Pachysandra, Sedum ternatum*, or *Saxifraga sarmentosa*. Do not use evergreen vines, as they will climb into the evergreens and become a nuisance.

D. To cover the concrete edge of a pool without becoming too vigorous, use *Iberis sempervirens, Pachistima, Santolina, Lavendula, Euonymus fortunei minimus* or *Phlox subulata*.

E. To avoid care of grass between a hedge and the drive, use grass substitutes. *Thymus, Arabis, Phlox subulata, Vinca minor*, or any others that are not vines may be used.

F. The same plants would be used as in *E*.

G. In the narrow space more restricted plants are preferable as *Sedum acre, Sedum album, Iberis sempervirens, Lavendula, Pachistima*, or *Sedum reflexum*.

H. If it is impossible to rejuvenate the shrub, use relatively tall growing ground covers as *Xanthoriza, Iberix sempervirens, Yucca*, or *Vinca minor*.

I. In the parking area lower growing ground covers should be used as *Ajuga, Euonymus fortunei, Veronica filiformis*, or *Arabis procurrens*.

J. In plantings of old shrubs a variety of the more vigorous ground covers may be used as *Ranunculus repens, Ranunculus acris, Convallaria majalis, Viola canadensis*, or even *Xanthoriza*.

K. Contrary to popular belief, the soil beneath pine trees is not necessarily acid. Any ground cover tolerant of shade may be used. *Pachysandra, Vinca minor, Hedera helix, Euonymus fortunei coloratus* are among the more desirable.

L. The same plants may be used as in *K*.

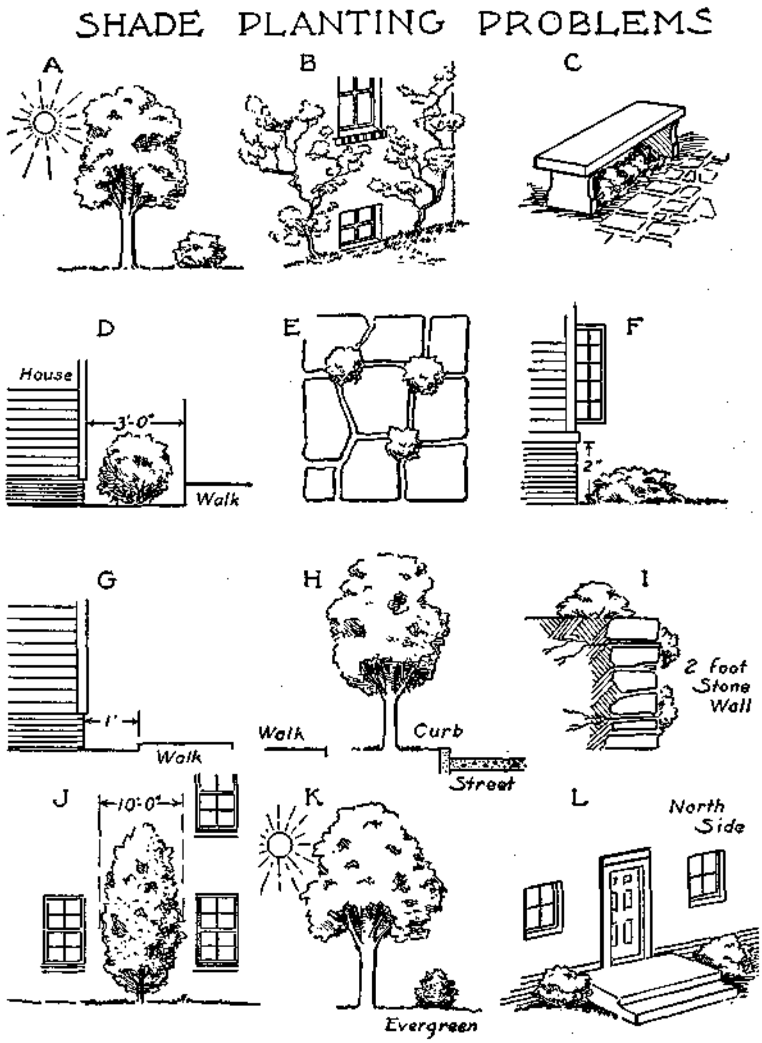
SHADE PLANTING PROBLEMS
A
B
C
D
House
3'-0"
Walk
E
F
2"
G
1'
Walk
H
Walk
Curb
Street
I
2 foot Stone Wall
J
10'-0"
K
Evergreen
L
North Side

FIG. 27.

FIG. 27.—Shade planting problems.

A. In the shade of trees, plants must be able to withstand not only shade but xtra-dry soil caused by the tree taking most of the moisture. The hardiest hrubs for this purpose are *Lonicera morrowi, Ligustrum obtusifolium, Acanthoanax sieboldianus, Aesculus parviflora, Rhus aromatica, Rhamnus frangula,* and *Symphoricarpos. Viburnums* have difficulty with the excessively dry soil.

B. Vines clinging to the building, withstanding shade, include *Parthenocissus uinquefolia, Hedera helix,* and *Euonymus fortunei* and its varieties.

C. In the shade beneath a garden seat *Ajuga, Asperula, Viola canadensis, Iedera helix* self-branching, *Euonymus fortunei minima,* or *Saxifraga sarmentosa.*

D. Compact shrubs for narrow shaded spaces include *Philadelphus lemoinei, Euonymus fortunei radicans* (a bushy type), *Symphoricarpos chenaulti, Spiraea umalda froebeli,* and *Yucca.*

E. Low plants for stone-paved or brick-paved areas include *Arenaria verna,* Ajuga, *Dianthus deltoides, Veronica filiformus, Mazus,* and *Sedum nevi.*

F. An evergreen ground cover is a good solution to this problem as *Pachyandra, Vinca minor,* or *Iberis sempervirens.*

G. Since no shrubs are this narrow, use an evergreen vine to cling to the oundation. If necessary trim once a year at top of foundation to prevent its limbing a frame house. Use *Hedera helix, Euonymus fortunei coloratus.*

H. Where there is difficulty in growing grass in the parking area beneath trees, ry *Ajuga, Vinca minor, Veronica filiformis,* or *Euonymus fortunei.*

I. A shaded dry wall is an ideal place for choice alpines as encrusted *Saxiragas, Androsace, Saxifraga sarmentosa,* and all other alpines likely to scorch in he sun.

J. One shrub is usually ample in such a space. Any of the *Viburnums,* or *Cornus mas, Acer ginnala,* or *Cornus alternifolia* will be satisfactory.

K. An extremely difficult situation for evergreens. If they must be used try *Taxus, Mahonia, Euonymus fortunei vegetus, Euonymus kiautschovicus,* or *Pyracantha.*

L. This is an ideal place for broadleaf evergreens as *Mahonia, Ilex glabra, Berberis julianae, Buxus,* or *Euonymus fortunei vegetus.*

VINE PLANTING PROBLEMS

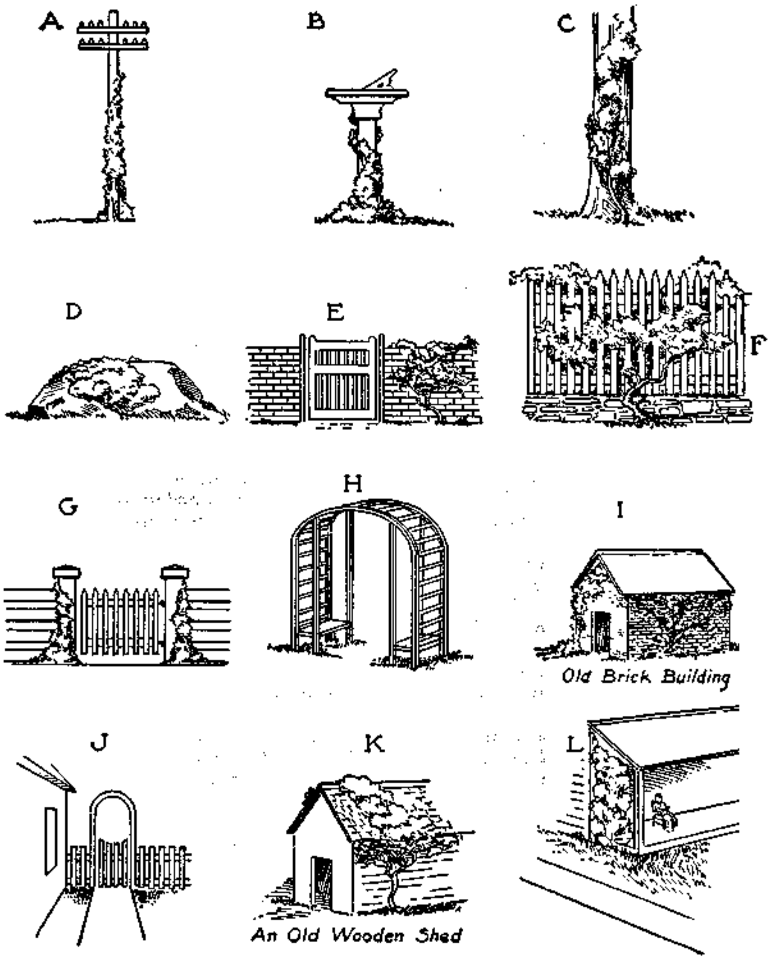

FIG. 28.

FIG. 28.—Vine planting problems.

A. Vines clinging to the pole would include *Euonymus fortunei colorata, Euonymus fortunei vegetus, Hedera helix, Bignonia capreolata, Parthenocissus quinquefolia engelmani.*

B. Any vine on the base of small structures is best cut to the ground every year with the exception of *Euonymus fortunei minimus.* Use *Parthenocissus tricuspidata lowi, Hedera helix,* or *Euonymus fortunei.*

C. As long as the vines do not cover the foliage of the tree, there is no harm in their use on tree trunks. They may be cut back to the ground every few years to prevent excessive growth. Any clinging vine as recommended in *A* or *B* may be used.

D. Boulders or rock outcrops difficult or impossible to move may be covered with *Cotoneaster adpressa, Cotoneaster apiculata, Forsythia suspensa, Hedera helix,* or *Euonymus fortunei* and its varieties.

E. For softening the effect of brick walls, any of the clinging vines suggested in *A, B,* or *C* may be used, or climbing roses, *Forsythia suspensa* or *Jasminum nudiflorum* may be fastened up one side and allowed to hang over the other.

F. A bit of snow fence given additional height by a wall beneath may be more or less completely hidden by covering with evergreen vines as *Hedera helix, Bignonia capreolata,* or *Euonymus fortunei coloratus.*

G. Excessive growth is not desirable on gate posts, consequently it is best to cut the vines to the ground every year or two. Clinging vines as *Hedera helix, Euonymus fortunei,* or *Parthenocissus tricuspidata lowi* may be used, or *Akebia* may be trained around the posts.

H. On small arbors and trellises avoid the use of excessively vigorous vines. Wisteria would be too vigorous. Use less vigorous vines of *Clematis,* climbing roses. An evergreen effect may be obtained by the use of *Euonymus fortunei vegetus, Bignonia capreolata,* or *Hedera helix.*

I. Any evergreen clinging vine may be used to advantage, as *Hedera helix, Bignonia capreolata,* or *Euonymus fortunei.*

J. A small arch is soon smothered by vines. *Akebia* is ideal. Most other vines require severe pruning, as climbing roses and *Clematis. Euonymus fortunei vegetus* would be effective if kept within bounds.

K. The smothering effect of vigorous vines as *Wisteria, Polygonum,* and even wild grape is desirable.

L. For privacy, shade or wind protection relatively dense foliage of *Lonicera japonica, Aristolochia,* or *Actinidia* is desirable. A permanent evergreen screen could be obtained by the use of some form of *Euonymus fortunei.*

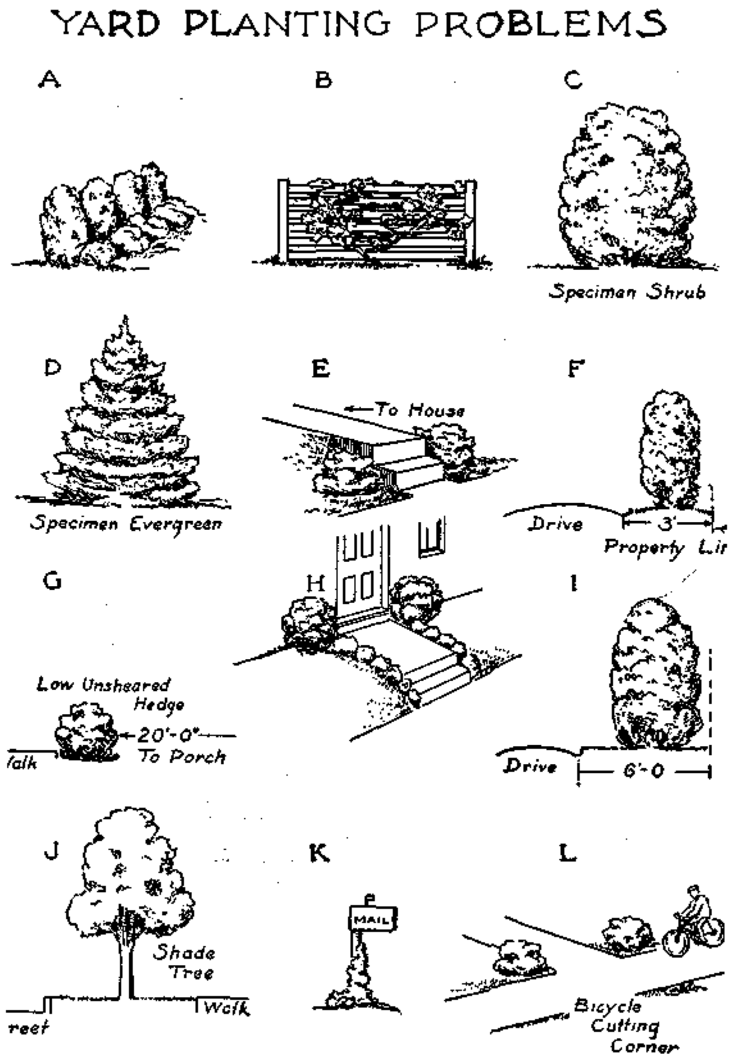
YARD PLANTING PROBLEMS
A
B
C
Specimen Shrub
D
Specimen Evergreen
E
To House
F
Drive
3'
Property Li
G
Low Unsheared Hedge
20'-0"
To Porch
H
I
Drive
6'-0
J
Shade Tree
Walk
reet
K
MAIL
L
Bicycle Cutting Corner

Fig. 29.

Fig. 29.—Yard planting problems.

A. Shrubs or evergreens back of a flower border should be more or less compact and restricted in their growth. Avoid Forsythia, most *Loniceras*, and spreading junipers. Satisfactory plants would be *Taxus cuspidata, Juniperus virginiana canaerti, Ilex crenata, Ilex glabra, Philadelphus lemoinei, Viburnum carlesi.*

B. To soften the effect of a fence, any sort of vine including annuals, herbaceous perennials, or woody ones may be used. *Wisteria, Polygonum auberti, Celastrus, Actinidia*, and *Clematis* are effective.

C. Shrubs developing into striking specimens include *Acer ginnala, Cornus alternifolia, Cornus mas, Cotoneaster dielsiana, Lonicera korolkowi, Rosa rubrifolia, Salix elaeagnos, Viburnum tomentosum, Viburnum tomentosum sterile.*

D. Evergreens developing into good individual specimens include *Cedrus atlantica glauca, Abies concolor, Picea omorika, Sciadopitys, Thuja plicata, Tsuga caroliniana.*

E. Low growing plants on either side of the steps would include *Juniperus horizontalis varieties, Euonymus fortunei radicans, Euonymus fortunei vegeta*, and where partially shaded, *Hedera helix* and *Pachysandra.*

F. In the narrow space along the drive a hedge of *Juniperus virginiana canaerti, Juniperus virginiana kelleeri, Thuja plicata, Ilex crenata* might be used.

G. To prevent crowding the sidewalk and lessening the lawn areas, only compact plants should be used, as *Berberis mentoriensis, Potentilla fruticosa, Viburnum opulus nanum*, and *Hypericum patulum.*

H. It is seldom desirable to outline the walk from the house to the street with either a hedge or narrow planting since it tends to over emphasize the walk.

I. To do away with unnecessary pruning use *Viburnum carlesi, Philadelphus lemoinei, Chaenomeles japonica, Deutzia lemoinei*, or *Euonymus americana.*

J. Good shade trees for street planting include *Acer platanoides, Acer saccharum, Gleditsia triacanthos inermis, Liriodendron, Quercus coccinea, Quercus palustris, Quercus borealis*, and where elm diseases are not a problem, *Ulmus americana, Ulmus carpinifolia.*

K. The various forms of *Euonymus fortunei* will be hardy and evergreen.

L. A large stone or rock placed at the intersection of the walks covered with *Euonymus fortunei* or *Hedera helix* will protect other plantings.

HOUSE PLANTING PROBLEMS

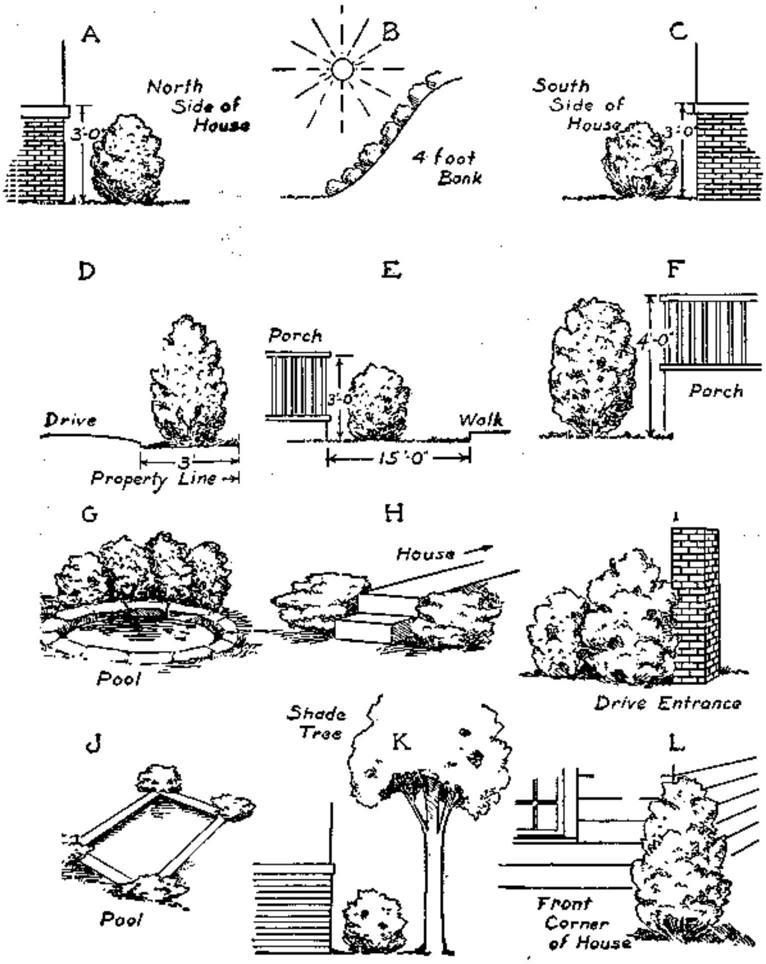

FIG. 30

FIG. 30.—House planting problems.

A. Shade tolerant shrubs not over 3 ft. high would include *Mahonia aquifolia, Euonymus fortunei vegeta, Spiraea bumalda froebeli, Symphoricarpos chenaulti.*

B. Since this bank is in the sun, a wide variety of ground-cover plants are available. If it is along the street in front of the house, evergreens would be preferable. *Vinca minor, Phlox subulata lilacina, Sedum album, Thymus serpyllum coccinea.*

C. Beneath a 3-ft. window, low growing shrubs that would never interfere with the view would include *Spiraea bumalda Anthony Waterer, Deutzia gracilis, Hypericum patulum, Potentilla fruticosa, Cotoneaster adpressa, and Euonymus fortunei vegeta.*

D. In the narrow space between a drive and the property line a sheared hedge might be used. Plants that would require but little shearing would include *Philadelphus lemoinei, Berberis plurifolia erecta,* and *Hibiscus syriacus.*

E. The same plants might be used here as in *C,* with a slightly higher one at the corner as *Spiraea arguta, Kerria japonica,* or *Deutzia lemoinei.*

F. Again plants should be used which will not grow much above the porch rail. This might include *Indigofera kirilkowi, Deutzia lemoinei, Symphoricarpos chenaulti, Mahonia aquifolia,* or any others not growing over 4 ft. high.

G. To prevent crowding of the pool, erect or compact growing plants should be used as *Philadelphus lemoinei, Deutzia lemoinei, Juniperus virginiana cannarti, Euonymus americanus, Potentilla fruticosa,* or *Kerria japonica.*

H. Low, more or less spreading plants to soften steps would include *Cotoneaster adpressa, Cotoneaster apiculata, Hypericum patulum, Juniperus horizontalis plumosa, Euonymus fortunei vegeta,* or even a patch of *Vinca minor.*

I. More or less spreading materials to blend the gate post into its surroundings would include *Ribes alpinum, Ligustrum obtusifolium regelianum, Rosa hugonis, Rhus aromatica,* or *Lonicera korolkowi.*

J. More or less formal plants for the corners of a formal pool would include *Viburnum opulus nana,* compact forms of Boxwood, *Pinus mugo mughus, Euonymus fortunei vegeta,* sheared to keep it compact, *Pachistima, Ilex crenata helleri.*

K. Evergreens should not be attempted in a situation such as this. Deciduous shrubs would grow under these conditions. *Ribes alpinum, Ligustrum obtusifolium regelianum, Lonicera morrowi, Chaenomeles japonica, Symphocarpos chenaulti.*

L. Do not use too large a shrub in this location. *Ligustrum obtusifolium, Cornus racemosa, Cornus mas, Pyracantha,* or an upright *Juniperus chinensis pfitzeriana.*

One possible solution, if space permits, is to devote a separate area to a rock garden; another, to a wild garden or a bog garden. In this way each will be a unit in itself connected with one or more other units by paths. A definite axis or vista may logically lead from one to another, tying the different units into a harmonious whole, just as we go from living room to dining room to kitchen inside the house.

Use of Flowers. It is possible to have a completely satisfactory garden without a flower by the use of contrasting foliages and habits of growth. Unfortunately, few would be satisfied with such an effect. Yet, as has been stated before, flowers alone do not make a garden unless given an appropriate setting with adequate backgrounds. In planning any home grounds, the actual flowers themselves are one of the last considerations. True, showy bloom will be obtained from most deciduous shrubs, most vines, many broadleaf evergreens, and some trees. But here, again, the layman thinks of flowers in terms of annuals and perennials so planted as to give a constant supply of color, and as such their use is discussed in the appropriate chapters.

When the desire for a flower garden cannot be satisfied with the normal amount of border space, it may be well to set aside a portion of the yard for flowers alone. In English cottage gardens where space is limited, this may be the front yard. Similar ideas are found in the fenced-in front-yard gardens of Cape Cod cottages or the use of the back half of the property as a flower garden. Under all these conditions the lawn is reduced to a minimum if utilized at all. In fact paths and walks of turf, brick, stone, or gravel may be employed. Depending on the design of the rest of the property and upon the desire of the owner, such flower gardens may be formal or informal. In either case the need for a background is apparent to supply seclusion and privacy as well as artistic effect. Another added advantage is wind protection for the taller flowering plants.

Planning the home grounds is not an impossible project for the homeowner, but it should not be attempted unless adequate time is spent in studying the principles of design, learning plant materials, and above all observation of not one but many well-planned home grounds. Under these conditions it may be a fascinating hobby which can be carried on over a period of years. In most instances a consultation with a reliable landscape architect should result in a more satisfactory and finished scheme.

Extensive experience in teaching garden planning to home-owners has shown the need and the value of a practical application of the use of plant materials. With this in mind, the preceding pages of landscape problems have been developed, each problem having been taken from an actual yard. The plants recommended will grow throughout the cooler sections of the country; they will need to be changed somewhat for the South and the Pacific coast.

It is suggested that specific individual problems be added to those given for class discussion. In fact it is possible to have a complete discussion of garden planning by the selection of actual problems for solution. This method has been thoroughly tried out in the extension meetings in home beautification throughout Ohio and is being used in preference to other types of approach. Although largely replacing the use of natural-color lantern slides, it may be supplemented by them. The ownership of a home and the resultant contact with these problems in actuality will of course make them more vital.

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CHAPTER VIII

PROPAGATION OF PLANTS

In nature plants propagate themselves by seeds and vegetative parts. Vegetative propagation occurs in various ways, and present-day practices are largely specialized methods based on those observed in nature. Among the more common methods that may be observed are: adventitious shoots from roots (suckers of sweet potato); adventitious shoots from leaves (*Saintpaulia*, begonia); stolons (chrysanthemum, bent grasses); runners (Boston fern); layers (rose); rhizomes (iris); detachment of scales (lily); crowns (pips of lily-of-the-valley); natural grafts when a close contact between branches occurs.

Seeds. A seed is a ripened ovary produced by the fusion of a pollen-grain nucleus with the egg nucleus in the embryo sac of the ovule. As the ovule develops, differentiation takes place into the embryo, seed coats, and the endosperm. The endosperm, composed of stored foods, may surround the embryo, or it may be absent. The seed coats consist of thick-walled cells which protect the embryo from drying out.

Germination. Germination is the resumption of growth of the embryo, the breaking of the seed coats, and emergence of the radicle and the plumule (Fig. 31). The radicle produces the parts below the ground; the plumule develops into the aerial parts. Most flowering plants are either monocotyledonous or dicotyledonous. The monocots produce a temporary root system which is later followed by a permanent one; the dicots develop a permanent root system at once. The cotyledons either may remain in the ground or else may be pushed up above ground by the extension of the hypocotyl, and they often function as leaves.

Under favorable conditions most of the seeds of annuals and perennials germinate readily after ripening. Others may fail to germinate because of immature embryos, so that time is required to reach maturity. Usually the food stored in the embryo has sufficient energy for germination; although in such isolated cases as the orchids, nutrients have to be supplied externally to cause germination.

Hard-coated seeds require external treatment for germination. Seeds of palm and canna and cormlets of gladiolus are excellent examples. Cracking of the coats by mechanical means, abrasion, soaking in acids or water, and stratification are the means resorted to. Sulphuric acid may be used at full strength for periods varying from 10 min. to ½ hr. Soaking in water for 12 to 24 hr. is another method of hastening germination. Stratification is the

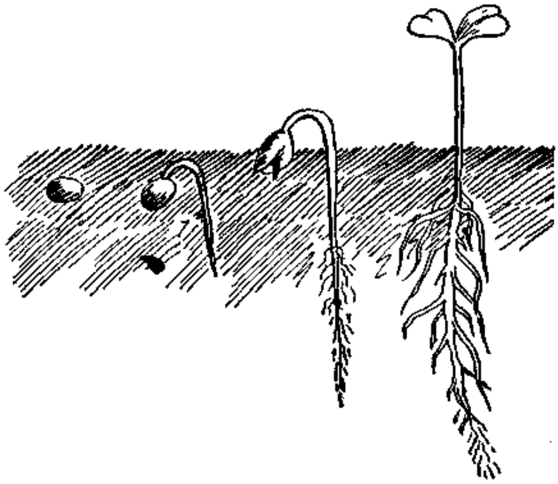

FIG. 31.—Development of a seedling.

placement of seeds between layers of sand or soil so that the action of water and temperature will effect the softening of the seed coats.

Seeds of some alpines, a few perennials, and many woody plants require a rest period, or an afterripening period, before germination can take place. This can be obtained by sowing out of doors or in a cold frame during November or December. During such a period changes in food supply occur based on enzymatic and acidity reactions. This afterripening period may be shortened by treatment in low temperatures of 35 to 41°F. for periods ranging from 30 days to 4 months. Rose seeds have to be subjected to such a treatment, and larkspur germinates much better during the summer if stored in a moist, cool place for several days previous to sowing.

Factors influencing seed germination are moisture, temperature, presence of oxygen, and occasionally light, but great variations exist in the parts that they play. The presence of water softens the seed coats and permits its entrance together with oxygen. This affects the respiration process and the change and translocation of foods so that growth develops. Moderate amounts of water are usually needed—just enough to saturate completely and soften the seed coats. However, some xerophytes and such annuals as portulaca and eschscholtzia germinate better with low moisture, whereas aquatics are completely submerged. Except in such extreme cases excessive amounts are detrimental largely because of exclusion of oxygen.

Oxygen is needed for the initiation of growth, and extremely compact, poorly prepared, excessively wet mediums are therefore objectionable. Coarse sand is an excellent medium because of sufficient aeration, adequate water-holding capacity, and freedom from parasitic organisms. It may be treated with a solution of 15–30–15 fertilizer at the rate of 1 oz. to 2 gal. of water previous to sowing the seed so that sufficient nutrients are available for the growth of seedlings.

Temperature for germination should be constant for each specific group. In general it may be stated that a 10° rise above the optimum for normal growth is most suitable for the majority of crops. Thus, annuals that grow readily in the cool temperature of spring will germinate well in 60°F.; whereas tropical lilies, ferns, and other warm crops will germinate better in 75 to 85°F.

Plants that germinate better when light is available are comparatively few and include certain species of *Epilobium*, *Lythrum*, *Ranunculus*, *Rumex*, *Veronica*, and others.

Viability of seeds determines their germinative power. Seeds of poor viability may come from weak plants and from those grown under improper humidity and temperature. The age of seeds also determines their viability—some lose it after a year; others remain viable for several years.

Seed Sowing. The type and the size of the seed will govern the method of planting. Seeds started indoors, in frames or greenhouses, should be sown in seed pans or flats or boxes. If soil is used, it should be porous, light, and preferably sterilized with steam, formalin, or formaldehyde dust. Sterilizea coarse sand is to be preferred to soil. For fine seeds that have a tend-

LONGEVITY OF SEEDS OF THE MORE COMMON FLOWERING PLANTS

Name	Years	Name	Years
Achillea	2–3	Heuchera	3
Aconitum	4	Hollyhock	3–4
Acroclinium	2–3	Hunnemannia	2
Ageratum	2–3	Ipomoea	3
Agrostemma	3–4	Iris	2
Alyssum	3	Kochia	2
Amaranthus	4–5	Lantana	1
Anchusa	3	Lathyrus	3
Anthemis	3	Lavendula	2
Antirrhinum	3–4	Lavatera	3
Aquilegia	2	Liatris	2
Arabis	2–3	Lilium	2
Arctotis	3	Linum	5
Arenaria	2–3	Lobelia	4
Aster (annual)	2–3	Lupinus	4–5
Aster (perennial)	1	Lychnis	3–4
Balsam	5–8	Lythrum	2
Baptisia	3–4	Marigold	4
Bellis	2–3	Matricaria	2
Bocconia	1–3	Matthiola	4
Boltonia	3	Mesembryanthemum	3–4
Browalia	2–3	Mignonette	3–4
Cacalia	2–3	Mimulus	4
Calendula	3–4	Myosotis	2–3
Calliopsis	3–4	Nasturtium	3–5
Campanula	3	Nemesia	2–3
Canna	3–4	Nicotiana	4–5
Carnation	4–5	Nigella	3
Celosia	4–5	Pansy	2
Centaurea	2–3	Penstemon	3–5
Cerastium	2–4	Petunia	3–5
Cheiranthus	5	Phlox	1
Chrysanthemum	3	Physalis	4–5
Clarkia	2–3	Platycodon	2–3
Cleome	2–3	Poppy	3–5
Cobaea	2	Portulaca	3–4
Cosmos	3–4	Primula	2–5
Cypressvine	4–5	Pyrethrum	4
Dahlia	5	Ricinus	3
Delphinium	1	Rudbeckia	4
Dianthus	3–5	Salpiglossis	4
Digitalis	2–3	Salvia	1–4
Dimorphotheca	2	Sanvitalia	2–4
Dolichos	3	Saponaria	3–5
Echinops	2	Scabiosa	2–3
Eryngium	2	Statice	2–3
Eschscholtzia	2	Stock	2
Eupatorium	2	Stokesia	2
Gaillardia	2	Sweet pea	2
Gerbera	1	Thunbergia	2
Geum	2	Tritoma	1
Godetia	3–4	Tunica	2
Gourd	5–6	Valeriana	3
Gypsophila	5	Verbena	2
Helenium	3	Veronica	2
Helianthus	3–4	Vinca	2
Helichrysum	2–3	Viola	1
Heliopsis	2–3	Wallflower	5
Heliotrope	1–2	Zinnia	3

ency to dry out, sand may be mixed with one-half peat. The seeds should be sown in rows and covered lightly (depth should be about twice the diameter of the seed). If several kinds are sown in one flat, those which germinate approximately at the same time should be grouped together. Watering should be done with a fine hose to prevent washing.

If sown directly outdoors, the soil should be well pulverized and finely raked and the seeds sown in rows and covered with sand or peat. The type of plant will determine the proper time of the year for sowing. Except the quickly growing annuals, most plants should be started in frames or greenhouses, pricked off into flats (*i.e.*, transplanted after the first true leaves appear, about 1 to 2 in. apart), and later either potted or else planted directly in the ground. If facilities are available, such a method is more satisfactory than sowing directly in the ground. If sown directly, seedlings should be thinned to their proper spaces before they begin to crowd.

Germinating Fine Seed. A satisfactory method for germination of such small seed as begonia, gloxinia, snapdragon, and others, is as follows:

A flat is filled to ¼ in. of the top with sterilized soil. On top of this is placed a ¼-in. layer of fine vermiculite (No. 2 or horticultural grade). This is leveled flush with the top of the flat, but it should not be firmed. The seed is broadcast or sown in rows on the vermiculite. Peat moss which has been run through a ¼-in.-mesh screen is then dusted lightly over the entire flat so as to give a very *light* covering.

The flat should be watered carefully with a fine rose so that the seed and peat are not disturbed. No covering of glass, paper, or cloth is needed, but the flat should be placed in a shaded spot until the seedlings appear, then in full sun. The color of the peat serves as an indication of the time to water the flat. When the peat is moist enough, it is dark brown or black, but when it begins to turn reddish brown or light brown in color, the flat should be watered.

The purpose of the soil underneath is to prevent starvation of the seedlings which is a common occurrence when vermiculite alone is used. By filling the flat entirely full, air circulation is provided around the seedlings, which is vital in prevention of damping-off.

Seed Germination in Sphagnum Moss. Crude sphagnum is not satisfactory, but when shredded through a wire screen having three meshes to the inch, it is a useful material for seed germination because of its sterility and water-holding capacity. Furthermore, less injury is sustained by the roots when the seedlings are removed for transplanting. When a flat or pot is used, either it is filled completely with the moss or else the bottom inch is covered with soil and the top inch with chopped sphagnum moss. After a thorough watering the seeds are sown on the surface and the flat or pot is covered with glass until such time as germination takes place and the seedlings begin to draw. If no soil is used under the sphagnum and the seedlings are allowed to remain in the moss for any length of time, fertilization is necessary to keep the young plants in good condition.

A useful fertilizer solution consists of 1 tsp. of potassium nitrate and 1 tsp. of superphosphate in a gallon of water, applying enough to saturate the moss. As a matter of fact, any complete fertilizer may be used for this purpose by dissolving 6 tsp. in a gallon of water. There will be insoluble residues which can be discarded, but enough will dissolve out of the recommended quantity to do the work. These soluble fertilizers will have to be applied about once a week to keep the plants growing.

VEGETATIVE PROPAGATION

The most important methods of vegetative propagation are cuttage, division, grafting, budding, and layering.

Cuttage. Cuttage is the process of propagating plants by the use of vegetative portions severed from the plants and rooted in a suitable medium under proper conditions. Parts used are roots, modified stems (rhizomes, tubers, corms, and bulbs), stems, and leaves.

Root Cuttings (Fig. 32). Any plants that sucker readily may be propagated by root cuttings. Oriental poppy, phlox, bouvardia, locust, and many other ornamental plants belong in the group that lends itself readily to root-cutting propagation. Cuttings are made from roots no less than $\frac{1}{16}$ in. in diameter and lengths varying from 1 to 6 in. These cut pieces are then placed in boxes, flats, cold frames, or directly outdoors and covered lightly with soil. They should be mulched heavily during the winter. The best way is to use the hotbed or the greenhouse so that bottom heat may be made available and quicker development may take place. The work may be done in the fall or during the winter. New shoots develop from adventitious buds with roots branching from the base of these buds or from the cut sections of the old roots.

PLANTS THAT ARE PROPAGATED BY ROOT CUTTINGS

Herbaceous perennials (those marked with an asterisk * should be placed perpendicularly in soil, so the upper end protrudes about ½ in.)

Achillea	*Helianthus scaberrinus
Anchusa italica	*Limonium
Anemone japonica	*Monarda
*Bocconia	*Paeonia
Bouvardia humboldti	*Papaver
Campanula pyramidalis	Phlox decussata
Ceratostigma plumbaginoides	Polygonum
Coronilla varia	Romneya
*Dicentra spectabilis	Salvia
*Dodecatheon meadia	Saponaria
Eryngium	Senecio pulcher
Euphorbia corrollata	Stokesia
*Gypsophila	Thermopsis
Gaillardia	Verbascum

Woody plants (planted in open ground, 4 to 6 in. long, covered 2 in. deep)

Aesculus parviflora	Paulownia
Amelanchier	Prunus (plum, cherry, peach)
Aralia	Rhus
Calycanthus	Robinia
Campsis	Rosa
Caragana	Rubus (raspberry, blackberry)
Ceonothus	Sambucus
Cladrastis	Sassafras
Clerodendron	Staphylea
Cydonia	Syringa
Halesia	Wisteria
Hypericum	Xanthocerus
Koelreuteria	Zanthorhiza
Lagerstroemia	Zanthoxylum
Malus (apple)	Yucca

Modified Stems (bulbs, corms, rhizomes, tubers). Many plants persist during rest periods by means of underground buds which are borne on specialized stems and are known as *bulbs, corms, rhizomes,* and *tubers.* These subterranean buds consist largely of storage tissue containing foods.

Bulbs. Bulbs are extremely short stems reduced to disks with fleshy leaf scales attached to them, either in continuous layers around the axis (tulip) or loosely (lily). Roots develop from the basal plate while the new shoots arise in the axils of the scales from the central axis.

Narcissus (Fig. 33) is propagated by the development of buds in the axils of the fleshy leaves. As these grow, they form

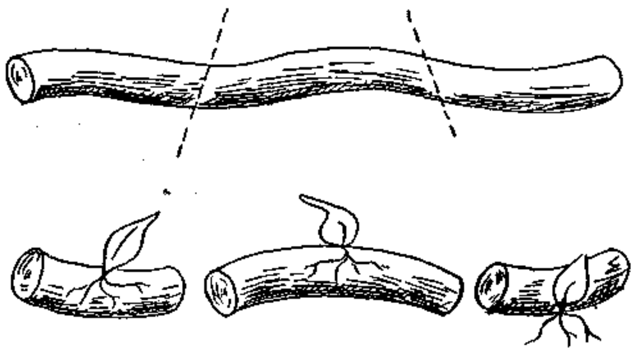

FIG. 32.—Root cutting.

"slabs," which are small, flattened bulbs. They are separated at the end of the growing season and, upon planting, develop the various stages known as *round*, *double-nose*, and *mother* bulbs. Usually 3 years is required to reach the mother-bulb stage from a slab.

FIG. 33.—Narcissus—propagation by offset.

In the hyacinth (Figs. 34 and 35) a similar mode of propagation is noted, except that a ring of small bulbs forms about the basal plate. These are removed and planted, maturing in about 4 years. To hasten the method and produce greater uniformity, the bulbs are "scooped" or "scored" after flowering of the mother bulbs. Scooping means making a concave cut, which removes the entire basal plate and cuts through the bases of the scales; in scoring, three cuts are made crisscross across the base of the plate and through the growing point. Following this treatment, the injured bulbs are placed in trays in well-ventilated sheds and kept at temperatures ranging from 70 to 90°F. By fall new bulbs will have formed at the cuts, and then the mother bulbs and the small bulbs are planted together. After a year these small bulbs are removed from the mother bulb and set out separately in beds.

Tulips split off small bulbs in much the same way that the narcissus splits off and differ essentially only in the fact that the

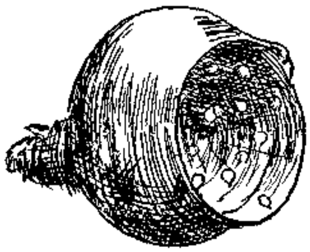

FIG. 34.—Hyacinth—scooping of bulb.

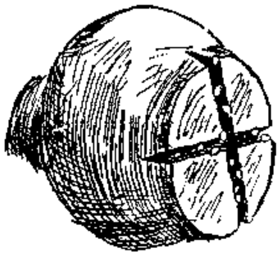

FIG. 35.—Hyacinth—scoring of bulb.

old bulbs disintegrate in the tulip, forming usually one large bulb surrounded by a few small ones. The latter require 1 or 2 years to reach maturity.

Scaly bulbs like lilies (Fig. 36) may be propagated by lifting

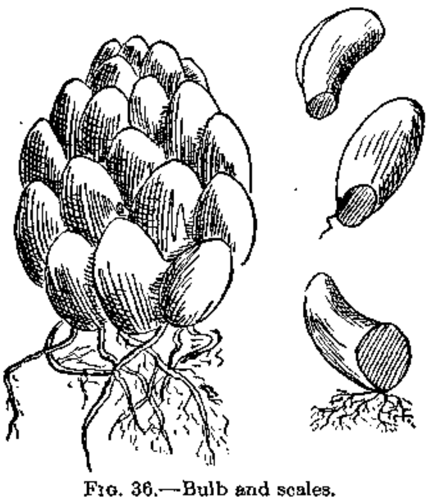

FIG. 36.—Bulb and scales.

after flowering during the summer, removing several of the outer scales, and then replacing. The scales removed may be planted in light soil and covered to a depth of 2 in. New bulbs will develop the next season but require 2 to 5 years to reach maturity, depending on the species. To hasten this development the scales may be set in flats of sand with the basal end down, little moisture and 10° additional bottom heat applied in a hotbed or a greenhouse. Grown in this fashion, a year may be saved. Lilies are likewise propagated by bulblets developing along the stems, by the placement of stems slantingly in hot beds so that they are covered almost completely (new bulbs develop in the axils of leaves), and by division of the bulbs.

Corms (Fig. 37). The corm is an underground stem with a short, fleshy, vertical axis, sheathed with a covering of dried leaf bases. The corm differs from the bulb in that it is actually a solid stem with no scaly leaves and no definite basal plate. Buds develop on the upper surface, whereas roots are produced from the base.

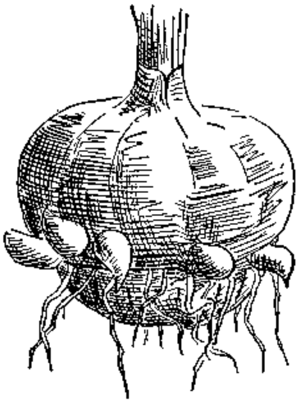

FIG. 37.—Corm and cormlets.

In the gladiolus, when the corm is planted in the spring, root and top growth start almost simultaneously. Each bud produces a shoot; and when the leaf blades reach a height of 6 to 8 in., the base of each thickens just above the old corm. That is the beginning of the new corm. When the plants reach a height of 12 to 15 in., the new corm has grown to a diameter of about 1 in. and throws out new rootlike organs. A little later the flowering spikes develop, and small cormlets start at the base of the new corm.

At digging time the old corm is practically gone, and the one or more large ones have completed their growth on top of it and are surrounded at the base by numerous cormlets.

The most common method of propagation is by means of the cormlets, which produce flowering size the second or third year. Sometimes the old corms are divided in the spring, so that each section has a bud and preferably a piece of the base. Each division will act in the same manner as the mature corm and produce new corms above it. This method is employed with newly introduced varieties to hasten increases. Some kinds are not vigorous enough for such a procedure and may be injured in the process.

Frequently, higher crowned corms are secured by this means, which is thus used as a rejuvenation process of flat corms.

New varieties are produced from seed, which is sown in the spring, and will often develop flowering corms during the second year. Since our present-day varieties are hybrids, seed sowing will result in a miscellaneous array of seedlings, which may or may not resemble the parents.

Rhizomes and Tubers (Fig. 38). A rhizome is a stem that rises from a lateral bud near the base of the main stem axis and extends

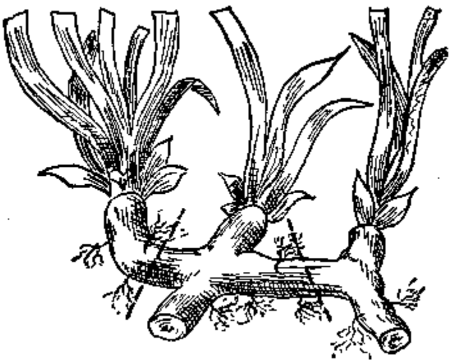

FIG. 38.—Division of rhizome.

rizontally through the soil or along the surface. The rhizome s a superficial resemblance to a root, but internally and exter- lly it has all the characteristics of a stem with its nodes and :ernodes, its aerial shoots developing from lateral buds and ventitious roots. Good examples of rhizomes are the canna d the German iris. While the rhizome remains on the surface is often called a *runner*, as in ferns, or a stolon, as in grasses. further variation of the rhizome is the tuber (potato), in which e terminal portion is thickened but contains buds in the axils reduced leaves. Plants possessing rhizomes are propagated · cutting these stems into sections, each containing a bud, and ınting them at the proper time (canna in the early summer or ring if done in the greenhouse, potato in the spring, iris after ›wering). Dahlia roots are often misnamed tubers. They e actually roots and can be used for propagation only if they ntain portions of the stem with present or adventitious buds.

Stem Cuttings. Stem cuttings may be divided into three main oups—softwood, semihardwood, and hardwood.

Softwood cuttings are made from stems of herbaceous plants which may be started in the greenhouse with specific requirements of moisture and temperature. Good examples are geranium, carnation, chrysanthemum, petunia, ageratum, and coleus. Outdoor-grown plants may likewise be propagated in the same manner. The usual procedure in rooting such plants is the provision of a propagating bench filled with sterilized, sharp sand or a combination of such sand and sphagnum peat. Other

FIG. 39.—Semihardwood cutting.

mediums such as fine cinders, fine haydite (fused shale and clay), sphagnum moss, and coconut fiber are occasionally used.

Vermiculite (expanded and granulated mica) has proved to be a satisfactory medium for propagation of cuttings as well as for seed sowing. Horticultural grades should be used and care observed in watering and packing. The material is very retentive of moisture and can be overwatered easily, particularly when subirrigated. Packing or handling makes vermiculite finer, and consequently still greater amounts of water may be held. With proper care this material makes an excellent propagating medium.

The propagation bench should be well drained with bottom heat provided by steam, hot water, or heating cables, and a regulatory covering over the top to exclude light and excessive circulation of air. Softwood cuttings are usually made just below the nodes and inserted in the medium to a depth of about 1 in. Excess foliage should be trimmed. The application of moisture to the top depends upon the plant used and the amount of transpiration that takes place. Rooting occurs in 8 to 30 days, depending upon the time of the year, the age of the wood used, and the type of plant. The rooted cuttings should be potted in light, well-aerated, but not too fertile soil and kept shaded and away from draughts until proper development has taken place.

Semihardwood cuttings (Fig. 39) refer to those taken from the current growth of trees and shrubs when the shoots snap clean. The actual rooting takes place either in a propagating bench in the greenhouse or in a hotbed constructed with fermenting manure or heating cables to provide bottom heat. Sand or sand and peat are the usual mediums used. The cuttings are made, inserted, and treated much as are softwood cuttings.

FIG. 40.—Hardwood cutting.

Hardwood cuttings (Fig. 40) of deciduous shrubs and trees are made during fall and winter from dormant plants. They range from 6 to 12 in. in length and are bunched in batches of 25. Then they are stored in moist material such as moss, shingletoe, or peat at a temperature of 40°F. In the spring they are set out in nursery rows with but an inch of each cutting aboveground. In some southern and even northern localities hardwood cuttings are set directly in rows without the preliminary cold-storage treatment.

Coniferous hardwood cuttings (Fig. 41) are taken in the fall 4 to 6 in. long and are placed in propagating benches or frames, depending on the locality. Sand and sand and peat are the best mediums. Rooting takes place in 2 to 6 months, depending upon the genus. A temperature of 50 to 55°F. is suitable for most kinds, with an additional heat from the bottom.

Propagation by Leaf-bud Cuttings. The leaf-bud method of propagation has been known for a number of years and has been used to propagate plants when stock is scarce or to build a population of plants from one specimen. Its present-day value to the florists has been stressed by work at the Ohio State University.

Leaf-bud cuttings taken at the same time as the stem cuttings have shown that there is little or no difference in the size of the plants at maturity. This has been illustrated with the geranium, poinsettia, and hydrangea, as well as with numerous other plants.

To make the cutting on an alternate-leaved plant, place the knife about ½ in. above a bud on the stem and cut in and down so that the knife leaves the stem about ¾ in. below the bud. The cut extends about one-third of the way into the stem. For opposite-leaved plants, cut off the stem about ¼ in. above the pair of leaves and about ¾ in. below the leaves. Then split the stem in half, and two leaf-bud cuttings will result. The leaves may be trimmed to conserve space in the propagation bench but should not be removed completely. The cuttings are stuck with the bud slightly below the surface of the rooting medium or just deep enough so they will not fall over when watered. Treatment with Rootone or Hormodin hastens rooting. Leaf-bud cuttings are potted when well rooted even though the bud at the base of the leaf has not started to develop. Once started, the bud rapidly develops into a shoot. Leaf-bud cuttings taken from hardwood will not root satisfactorily, and the leaves may fall. The same type of wood is used for leaf buds as would be selected when propagating by stem cuttings.

FIG. 41.—Evergreen cutting.

Chemical Treatments. To induce root formation many different chemicals have been used. For years the most satisfactory was potassium permanganate at the rate of 1 oz. per 7½ gal., the bases of cuttings being soaked for 12 hr., or at the rate of 1 oz. per gallon if the sand were saturated with the solution. Quicker rooting and higher percentages were secured, presumably due to the oxidation effect of the chemical. Sugar, acetic acid, etc., were used in like manner.

More recently, however, much ado has been made about the synthetic root-forming substances. The miraculous power first attributed to them has been largely dispelled through comprehensive and widespread tests. We now accept them not as wondrous cure-alls in the field of propagation but merely as supplementary aids to assist us with the more difficult plant materials. The major role of the synthetic growth substances in cutting propagation is to hasten the formation of roots, which sometimes may not be significant, and to provide the young plant with more roots and thus increase its chances of becoming established. The percentage of rooting may or may not be increased, depending on the plant in question and the conditions of the environment. Since treated cuttings mostly root more quickly, the period of critical attention is shortened. This may, in itself, give a better percentage, owing to human weakness. The percentage of rooting of soft cuttings may also be increased by treatment because treatment apparently improves the water relations of the cutting. Thus, treated cuttings under certain environmental conditions may remain turgid while the untreated cuttings wilt.

In order to understand the effects of synthetic growth substances on the rooting of cuttings, it is necessary to have at least an elementary understanding of hormones. Hormones are common to both plants and animals. When the term was first applied to the former, it referred to a definite chemical substance made in one part of the plant and transported to another where it brought about definite results. But it is not quite so simple as that. For instance, we may not speak of a "root-forming hormone," for a complexity of hormones and hormonelike substances is responsible for the formation of roots. The idea of explaining root formation on the basis of hormones is not so recent as one might suppose. J. Sacks was of the opinion that the phenomena of root formation in cuttings could be best explained by the assumption of a specific substance formed in the shoots. This substance, normally transported toward the base, could go no farther than the cut end and therefore accumulated there. Thus was the normal manner of root formation at the base of cuttings explained by Sachs in 1880.

Boysen-Jense, through his publications of 1910 and 1911, was largely responsible for the development of the hormone concept of plant growth, but not until 1925 were hormones definitely connected with the rooting of cuttings. Van der Lek showed that root formation in cuttings of willow, poplar, currant, and grape is largely dependent upon the existence of buds, especially of strongly sprouting ones. In most plants tested, root germs or initials were already present at the time of making the cutting. The removal of buds did not materially affect the rooting of such plants; but in the plants entirely free from root initials, root formation was almost completely stopped. Van der Lek therefore assumed that one or more hormones are formed in sprouting buds which are transported to the base of the cutting where they stimulate root formation.

In 1929 Went found a corresponding effect with *Acalypha* cuttings. He was able to show that the buds strongly and the leaves less strongly promoted the formation of roots. Through a series of later experiments he has contributed much of the present knowledge of root-forming hormones.

In 1935 other investigators found that auxin *b*, one of the growth-promoting hormones, and synthetic indoleacetic acid were very active in root formation. Since indoleacetic acid can easily be synthesized chemically and is comparatively stable, this discovery naturally led to investigations of practical importance.

Cooper used the lanolin method. One part of indoleacetic acid was mixed with 2,000 parts of pure lanolin, and some of this paste was then smeared on a small area of the cutting near the top. This area has been previously scraped with a knife. A striking stimulation of root formation was obtained with lemon, lantana, and *Acalypha*.

At the Boyce Thompson Institute investigations were begun with many different substances, some closely related to indoleacetic acid and others quite different. Some of the most active root-forming substances discovered were indolebutyric acid, naphthaleneacetic acid, phenyl-proprionic acid, phenylacetic acid, and indoleproprionic acid. Of these only the first two have proved of considerable practical importance. Later investigations carried out at the Boyce Thompson Institute and the U.S. Department of Agriculture have revealed that the potassium salts and the acid amides of indolebutyric acid and naphthalene-acetic acid are also effective although to a slightly lesser degree.

When these substances are spoken of, the word *synthetic* is usually applied, synthetic growth substance being one of the common expressions. This is to differentiate the synthetic root-forming substances from the natural hormones that are formed in the plant. According to the theory of Went, synthetic substances act indirectly, causing a change of potential within the cutting and resulting in comparatively rapid movement of the natural hormone to the base of the cutting where it promotes the formation of roots.

Shortly after the reports of the effectiveness of synthetic compounds, various commercial preparations began to appear on the market. The earlier method of application was the immersion of the bases of cuttings in solutions for 3 to 24 or even 48 hr. The advantage of the solution method was the ready control of dosage by regulating the concentration of the solution or the time of immersion. But some fatalities resulted, particularly in commercial places, due to careless management. And if the recommendation called for a 12-hr immersion, it was often a nuisance to arrange the time so that the cuttings could be placed in the propagating medium at the proper time. Therefore, when the synthetic growth substances began to appear in powder form, the pure crystal mixed with very fine talc, they were immediately accepted and used extensively.

In most cases the talc mixtures are as effective or nearly as effective as the solution mixture, and they have the advantage of being effective over a wider range of concentration so that there is not so much chance of injuring the cuttings.

The usual method of applying the dust is to dip the base of a bunch of cuttings in water, shake off the excess, and then immediately immerse the base in the powder so that the lower quarter or half inch of each cutting is covered with the powder. If the base of the cutting is hairy, as in geranium, enough powder will adhere without premoistening. Indeed, if too much powder adheres and the medium is kept rather moist, basal rot is encouraged. This also applies to some of the conifers.

Since the solution method is still used in many sections, a table of approximately equivalent concentrations may be of assistance in transferring to the powder method. Indolebutyric acid is probably effective with a wider range of plant material than any of the other synthetic growth substances; therefore the following table has been formulated on the basis of this acid. The table also assumes the use of very fine talc, about 300 mesh, since ordinary talc requires higher concentrations.

	Solution, mg. per liter (24 hr.)	Powder, mg. per gr. (dip)	Proportion of acid to talc
1	2– 5	1	1:1,000
2	10	2	1: 500
3	20–40	4	1: 250
4	60	10	1: 100

The ideal method of mixing the synthetic growth substance in crystalline form with the talc is to place them together in the desired proportions in a small ball mill and allow them to mix thoroughly for 2 to 3 hr. However, if a ball mill is not available, add sufficient water to make a thin paste, mix the two materials thoroughly, and allow them to dry. The mixture can then easily be pounded back to dust or put through a very fine screen.

The use of synthetic growth substances on cuttings must be subjected to several qualifications. In the first place, it is not advantageous to use these substances on any and all plants. Many plants that root easily do not root any more quickly when treated, and many more difficult plants that do show quicker rooting when treated do not root any better. In fact there are scarcely any really difficult plants that root readily when treated with the best of the synthetic growth substances. One notable exception is Canada hemlock. Mature cuttings, taken in autumn or winter, fail almost completely under all conditions, without treatment. With treatment and the proper conditions, they root with a good percentage.

Also, treatment is not beneficial on all types of cuttings. Practical use is limited almost entirely to leafy cuttings. The reason for this is rather simple. Recall the explanation of the effect of the root-forming substances; it is necessary for a certain amount of the synthetic substance in solution to enter the tissues of the cutting. This occurs regardless of the method of application, be it a solution or a dust method. The only way for the solution to enter the base of the cutting is through the process of transpiration, and the amount of transpiration is sufficient only on leafy cuttings. This principle has been proved by placing hardwood cuttings in a solution of synthetic growth substance, setting the whole in an airtight jar, and expelling most of the air by means of a vacuum pump. A sufficient amount of the solu-

PLANTS THAT RESPOND SIGNIFICANTLY TO TREATMENT WITH GROWTH-PROMOTING SUBSTANCES

Abelia grandiflora
Amorpha
Aristolochia sipho
Azalea
Bouvardia
Camellia japonica
Carnation
Celastrus
Chaenomeles
Cordyline stricta
Cornus florida and vars.
Coronilla
Cotoneaster
Cydonia
Cytisus
Daphne cneorum
Erica (treatment not significant with some species)
Euphorbia (Poinsettia)
Fuchsia
Gardenia
Geranium
Gordonia
Gypsophila paniculata var.
Hibiscus syriacus
Hydrangea hortensis
Hydrangea quercifolia
Ilex (evergreen)
Impatiens
Iberis sempervirens
Jasminum
Juniperus
Lantana
Leucothoe
Magnolia
Myrica
Osmanthus aquifolium
Pieris japonica
Poinsettia
Prunus cerasifera
Rhododendron (treatment not effective with all varieties)
Rhodotypos kerrioides
Rosa
Salvia
Sansevieria
Skimmia japonica
Stewartia
Styrax
Syringa
Tsuga canadensis
Vaccinium
Viburnum
Vitex agnus-castus

PLANTS THAT HAVE NOT RESPONDED SIGNIFICANTLY TO TREATMENTS WITH GROWTH-PROMOTING SUBSTANCES

Alternanthera
Annona
Begonia
Buddleia
Buxus
Callicarpa
Caragana arborescens
Chrysanthemum
Cornus (shrubby)
Deutzia
Diervilla
Euonymus
Forsythia
Ginkgo biloba
Grevillea
Hedera helix
Hydrangea paniculata
Iresine
Kerria japonica
Kolkwitzia amabilis
Ligustrum
Lonicera
Pachysandra terminalis.
Philadelphus
Physocarpus
Populus
Prunus triloba plena
Pyracantha
Tamarix
Taxus
Thuja

tion was pulled up into the cuttings and a stimulating effect observed. The effect is of course greater if the cuttings have swelling buds, for then a larger amount of natural hormone is available. But such a method of treatment is evidently beyond the scope of practicality; therefore we shall continue to limit ourselves to leafy cuttings.

At least two environmental factors are important. Unless the temperature in the propagating medium is at least nearly 65°, the synthetic growth substances have very little effect. Therefore, if it is not possible to maintain this temperature for late autumn or winter propagation, treatment is usually a waste of time. The pH, or relative acidity, of the propagating medium is also of apparent importance, although this point is still in the experimental stage, with a difference of opinion on the part of authorities. At least more significant results can be expected from treatment under neutral or acid conditions. Thus if the tap water is highly alkaline, it may be advantageous to acidify it with glacial acetic acid at the rate of about 10 drops for each gallon, before watering treated cuttings.

Another very important point is emphasis on the same favorable conditions and the same watchful care that are required for successful propagation of untreated cuttings. The environment is only very slightly less important when the cuttings are treated. These synthetic root-forming substances that are often advertised in very glowing terms provide no substitution for skillful propagation.

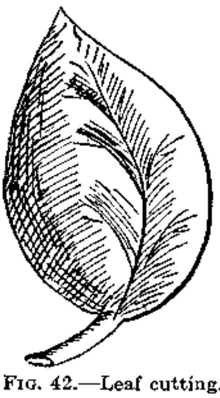

FIG. 42.—Leaf cutting.

Leaf Cuttings. Tropical plants, which are used in the greenhouses, possessing fleshy veins are frequently propagated by leaf cuttings, particularly if the plants are rare. Such leaf cuttings may be cut in triangles with the point at the thickened vein, and this point inserted in the sand. Both roots and shoots develop at the base, the original portion of the leaf being discarded upon the development of a new plant. Rex begonia is a good example. Some plants, like the *Peperomia*, Melior begonia, and *Saintpaulia*, are propagated by leaves with petioles attached (Fig. 42), the petiole of the leaf being inserted in the sand and developing a new plant at its base. *Bryophyllum* and various fleshy-leaved begonias (Fig. 43) are also propagated by the placement of leaves on the surface of the sand with cuts made across the heavy veins and covered with sand. At each cut a new plant

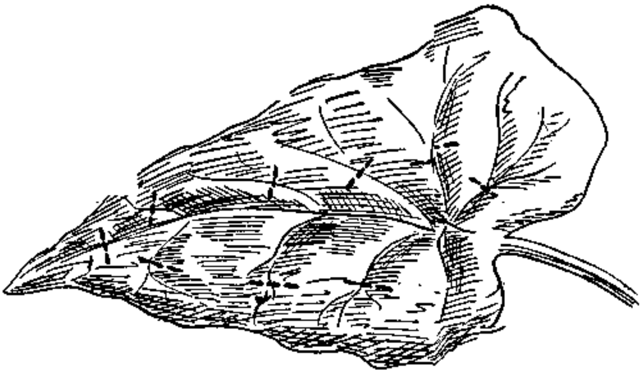

FIG. 43.—Leaf cutting.

will develop, provided proper moisture and temperature are maintained. Some plants, such as chrysanthemum, dahlia, rubber plant, geranium, and rhododendron, may be propagated by leaf cuttings but will produce new plants only if a small portion of the stem and an axillary bud are attached to the leaf (Fig. 44). In such cases the leaves and the attached stems may have to be supported in the sand by means of toothpicks fastened to the leaves.

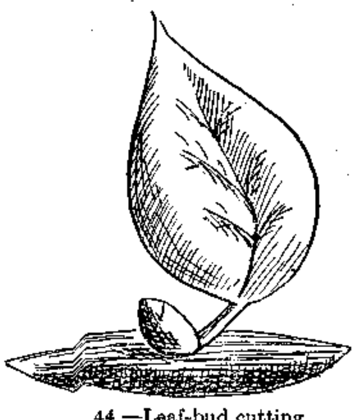

FIG. 44.—Leaf-bud cutting.

Layering. Many plants like the raspberry and its close relatives form roots on stems that are still attached to the parent plant. Such stems with the newly formed roots may be detached from the parents and constitute new individuals. *Layering* is the term given the natural process, which has been modified by propagators and has become useful as a form of plant perpetuation. In addition to the raspberry group, the Dendrobium orchid, the rose, the quince, the chrysanthemum, the rhododendron, and other plants develop natural layers.

The most common method of layering is known as the *simple layer* (Fig. 45), which consists of bending a branch to the ground in the spring and covering the portion just back of the tip with 3 to 6 in. of soil. The tip itself remains exposed and develops new buds and further growth. To facilitate the formation of roots in the covered portion, the underside should be notched and a toothpick placed in the cut to prevent healing together again. Usually

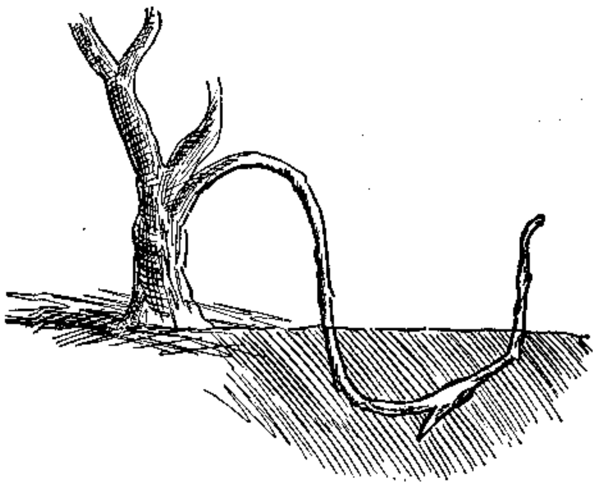

FIG. 45.—Simple layer.

under favorable conditions a sufficient number of roots will develop during the first season so that severance of the newly developed plant may be made in the fall or next spring. The plants most commonly propagated in this manner are raspberry, blackberry, rhododendron, rose, and honeysuckle.

Other types of layering are bud modifications of the simple layer. In *serpentine* or *compound* layering (Fig. 46), the stems are covered with soil at several points, alternating sections being left exposed (grapes and other vines). The *continuous* layer differs from the compound by having the entire branch completely covered with soil, new plants developing from axillary buds (dogwood, willow, *Hydrangea arborescens*, filbert, and such herbaceous plants as *Dianthus*, *Nepeta*, *Sedum*, *Thymus*, and *Veronica*). Mound layering (Fig. 47) consists of covering the bases of plants deeply with soil and thus developing new plants from each stem so buried. Gooseberry, quince, and apple stock are propagated in this fashion.

Pot layering (Fig. 48) is a modified method used largely in the greenhouse with such tropical plants as *Ficus*, *Nerium*, *Croton*,

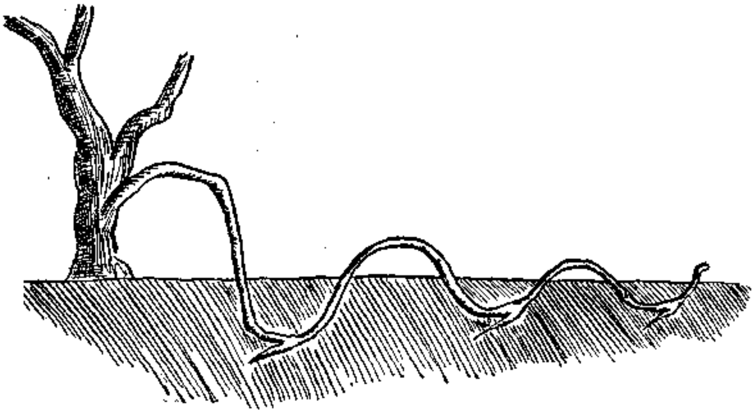

FIG. 46.—Serpentine layer.

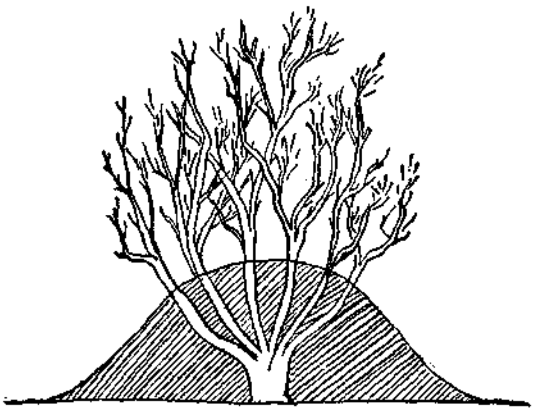

FIG. 47.—Mound layering.

Dracaena, *Pandanus*, *Rhododendron*, and *Vanda*. The operation is performed on plants growing upright in their natural positions. A cut is made through the cambium of branches, a toothpick inserted in the cut, and the entire section covered with sphagnum moss and tied with raffia or string. In place of moss, peat may be used in pots that have slots cut in them to go around the stem or else have hinged sides. If proper temperatures are maintained (65 to 75°F.) and the moss or peat kept moist constantly, new roots develop from the cuts made; and when a number have formed, the section may be severed from the parent plant and potted as a separate individual.

Budding. Budding is a useful method of propagating horticultural plants. It is responsible for the securing of better plants by means of hardier and more vigorous roots, obtaining large

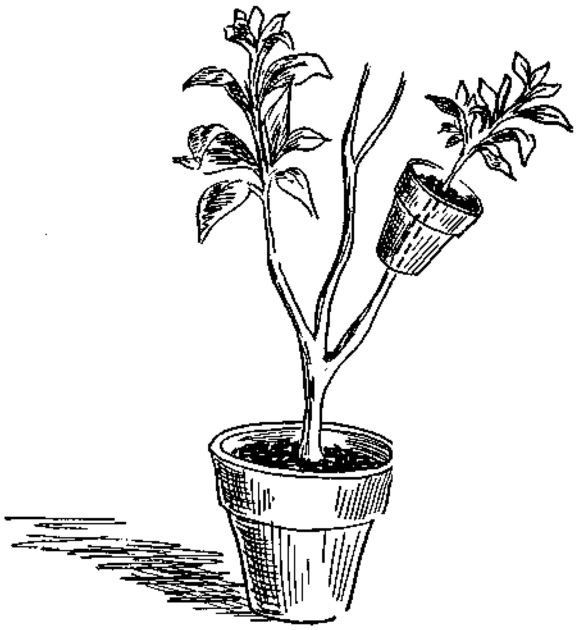

FIG. 48.—Pot layering.

numbers of plants from a given quantity of material, permitting top-working certain trees, and developing new plants more quickly and more cheaply. Named varieties of fruits such as the apple, pear, plum, and cherry as well as named varieties of roses are usually budded.

Roses grown for outdoor use and in recent years for greenhouse production are budded in the fields. For outdoor purposes *Rosa multiflora* is the most commonly used stock. This rose is readily propagated by cuttings, forms an excellent root system, produces few suckers, and is highly resistant to nematodes. For greenhouse forcing, because of its tendency to become somewhat dormant during the winter, *R. multiflora* is rarely used. In place of it *R. chinensis manetti* and *R. chinensis odorata* are used.

Hardwood cuttings are planted in the field during late winter in the warm sections of our country, and in cooler sections one-year-old plants are lined out in the spring or previous fall. In California and Texas, late May and early June budding produces plants with 18 to 24 in. of growth during that season. For outdoor purposes such plants are not large enough to be sold as No. 1, but for forcing purposes they are known as *started eyes* and make excellent subjects for planting in the greenhouses in January and February as dormant plants.

Late summer budding produces dormant plants which are not forced into growth until the following spring. For greenhouse forcing purposes these are known as *dormant buds* and are being used extensively.

The actual method of budding roses consists of taking bud sticks from the current year's growth either from outdoor plants or from greenhouses. The bud sticks should be kept cool and moist and when taken from outdoor plants should be cut every morning for the day's operations. However, if kept in temperatures of 32 to 40°, they will retain their vitality for several days. The leaves on the bud sticks are clipped to ⅓ in. from the bud, and a shield bud is used. The buds are set in T-shaped slits in wood that was made early in the season and as low on the plant as possible. Removal of the surface layer of soil around the plant is necessary to accomplish this purpose, because low budding is essential to eliminate suckering from below. Raffia, twine, or rubber bands hold the buds in place. In case of the early budding the tops of the understocks are cut off as soon as a union between the bud and the stock has been produced. That forces the new growth during the season. When late budded, the top of the understock is not removed until late winter or early spring.

When *R. odorata* is used as an understock, a variation in the procedure may be followed. During the growing season several buds are inserted, 6 in. apart, in the canes. After the union takes place, in about 2 weeks, cuttings are made of the budded sections and are rooted.

Fruit trees are budded in the summer—usually during July and early August, depending upon the climate—when the growth is active, the bark slips well, and the buds of the current season are mature. The bud sticks are taken from the new growth, and only the mature buds are selected for use. Actual budding procedure is similar to that of roses (Fig. 49).

Specifically a T-shaped opening is made through the bark with a sharp knife. The horizontal is made first by a rocking action of the knife. Then the knife blade is drawn upward lightly

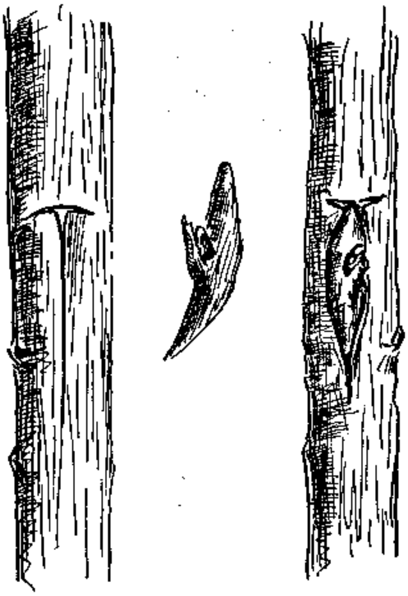

FIG. 49.—Shield bud.

about 1 in. long to meet the first cut. The depth of cut should be to the cambium. Before removal of the blade it should be twisted slightly to loosen the edges of the bark. The bud is cut with a shield-shaped piece of bark and a thin layer under it. The top of the bud stick should be held toward the budder, and the cut made from below. In fruits the wood accompanying the bud may be thinner than that for roses.

To insert the bud it is held with thumb and forefinger by means of the leaf stalk and slipped downward under the loosened bark so that it is completely covered. To hold in place the tie is made both above and below the bud. In about two weeks, raffia ties should be cut; but if rubber bands are used, this is unnecessary.

Patch Budding (Fig. 50). Patch budding is used in the propagation of species difficult to propagate otherwise. It is particularly necessary in the case of pecans and other nut trees. The practice consists of removal, with a special two-bladed tool, of a square or rectangular piece of bark from the stock and its replacement by a bud and bark from the scion wood of similar shape. The patches are about $\frac{3}{4}$ in. wide and 1 in. long. Because of their large size, rapidity of movement is necessary to avoid drying out of the wood. Tape or waxed twine is used for tying together

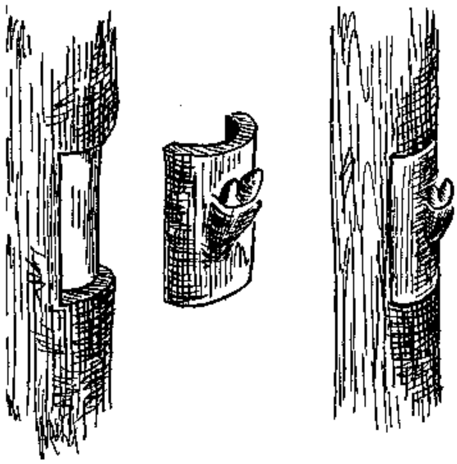

FIG. 50.—Patch bud.

rith a covering along the joints of grafting wax or melted paraffin. 'ariations of this method are known as the *ring bud*, the *H bud*, he *skin bud*, etc.

Chip Budding (Fig. 51). Chip budding is used when the bark oes not slip, usually about 2 weeks before growth starts in the pring and continuing for a period of 6 weeks. It consists of utting a mortise in the stock and fitting to it a bud of similar ize and shape. If the cambium layers are made to fit snugly, a ood union will result by the mere tying with raffia or waxed tring.

Grafting. Grafting is the process of inserting one part of a lant into another in such a manner as to cause a union between he two portions. It is useful in the propagation of plants that ail to grow properly on their own roots either because of lack of vigor or because of susceptibility to attacks of certain diseases and pests (nematodes on the rose). Likewise it becomes useful in plants that, because of their hydrid character, have to be propagated vegetatively and yet cannot be rooted readily from cuttings (apple). Grafting may also be used to improve the quality of foliage and flowers (rhododendron), to obtain certain shapes (azalea), to secure vigor (tree peony), to adapt plants to

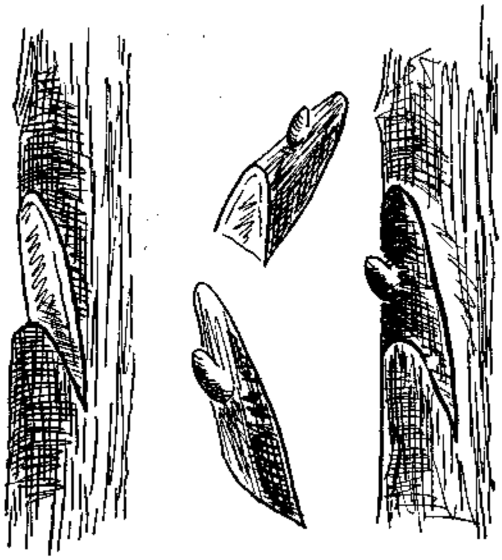

FIG. 51.—Chip graft

environmental conditions (rose), to develop specime.. (gypsophila), to instill new life into old plants.

In grafting, the term *understock* refers to the plant on which other varieties are grown and the stems that are to be grafted on to this understock are known as *scions.*

Success in grafting depends upon securing a close union between the cambium layers of the understock and the scion. This takes place by the formation of a callus. This, however, would tend to separate the two component parts unless they were held very closely together. Therefore, tying and waxing are necessary in many cases, the former to provide a close connection; the latter, to prevent drying out. However, where grafting is done in grafting cases, as in roses, the maintenance of a close, humid atmosphere eliminates the need of waxing.

Grafting is limited to plants that possess a continuous cambium layer between the phloem and the xylem and that have a close botanical relationship. The most satisfactory grafts occur between varieties of the same species, although in many instances interspecies grafts are likewise satisfactory (peach on plum, pecan on hickory, rose species, cactus species). Beyond these limits, intergrafting is not always successful, although in some instances generic grafts take (apples on *Crataegus*, chestnut on oak, lilac on privet).

Unsuccessful grafts may be due to poor anatomical unions, where breaks may occur in the cambium regions, or to lack of congeniality based on inadequate transfer or supply of foods between the adjacent parts of the union.

Types of Grafting. Many variations occur in the types of grafting. The more common are the splice, side, saddle, veneer, flat, and inarching for the ornamentals and cleft, bark, whip, crown, and bridge grafts for the fruits.

FIG. 52.—Splice graft.

Splice Grafting (Fig. 52). Roses for greenhouse purposes are grafted usually with a splice graft. The best understock is *R. chinensis manetti*, which is propagated by hardwood cuttings grown in Holland, France, England, and the United States. This stock is received by the propagator in a dormant condition, usually in January. The plants are then potted in 2½-in. pots, with a portion of the roots removed, and placed in a cool house in a temperature of 40 to 45°F. As soon as new roots develop, the grafting operations start. First a tight grafting case is built which provides a temperature of 75 to 80°F., high humidity, and exclusion of direct light. The actual operation consists of cutting the ends of the stock and the scion diagonally and then fitting them together so that the cambium layers join at least on one side. Rubber bands or raffia is the most common tying material. The stock should be cut close to the surface of the pot; the scion should be made from flowering wood with the flowers partially open. When taken at this stage of growth, the wood is sufficiently mature to give a good take. Each scion usually contains from one to three buds. After the operation is completed, the newly grafted plants are set in grafting cases which are kept closed for several days until callusing is noticed at the union; then gradually more air is admitted. In 3 to 4 weeks the plants are ready for removal from the cases.

FIG. 53.—Side graft.

FIG. 54.—Saddle graft.

Side Grafting (Fig. 53). The rose may again be used as an illustration of the side graft. This type of grafting is useful when the scions are much smaller than the understocks. It is performed by making a vertical cut 1 to 1½ in. in length into the stock just above the top of the pot and extending to the cambium. A piece of bark is removed from one side of the scion, and a similar cut is made to that of the splice graft. The cut scion is inserted between the bark and the cambium. The top of the understock should be cut on a slant, and the scion placed at the base of the slant, which will permit moisture to run around the union and prevent drying. Tying is done with raffia or rubber bands. Evergreens are frequently propagated by side grafting.

Saddle Grafting (Fig. 54). Saddle grafting is used in the propagation of rhododendron and lilac. The stock is cut to form an inverted wedge, and the scion is split vertically an inch or more at the center and fitted over the wedge. Since these grafts are kept in grafting cases, as are roses, tying with raffia is sufficient, and no waxing is necessary. The work is usually done during winter, the stocks having been dug and stored during the fall.

Veneer Grafting. Veneer grafts are usually made in the greenhouse and treated similarly to splice-grafted plants in grafting cases. The process involves making a cut about 1 in. in length along the stem of the stock with a notch at the bottom left by a diagonal cut. The scion is cut in a similar manner and tied to the stock with raffia. Spruce, rhododendron, Japanese maple, and tropical plants may be treated in this fashion.

Flat Grafting. This type of grafting is suitable for cacti. Species of *Cereus* and *Selenicereus* are used as stocks. They should be from 6 to 12 in. high. In flat grafting, the stock and the scion should be of the same diameter. Both are cut with a smooth transverse cut, and the flat surfaces held firmly together with raffia or thin thread. A warm, moist greenhouse is suitable

FIG. 55.—Inarch grafting.

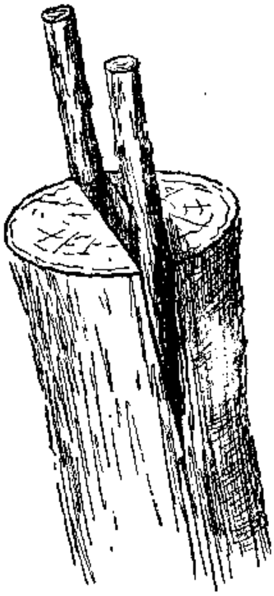

FIG. 56.—Cleft graft.

for the work, but water should be excluded from the cut surfaces. Usually the globose types such as *Echinocactus*, *Echinopsis*, and *Mammilaria* are flat grafted.

Inarching (Fig. 55). Inarching is useful in the greenhouse where seedlings of roses are grown, in order to accelerate their development and determine the usability of the crosses made. Understock may be any variety of rose growing in a pot. The seedling grown in a small pot is attached to the stock, pot and all, so that both the stock and the seedling are growing on their own roots. To facilitate the formation of a union, the bark is scraped placed together and tied securely. As soon as the union takes place, the roots of the seedling are removed.

Cleft Grafting (Fig. 56). Cleft grafting is used for top-working fruit trees and grafting of cacti and tree peonies. Any branch of a tree more than 1 in. in diameter may be cleft grafted. A clean horizontal cut is made across the branch, and with a cleft knife it is split across the center to a depth of 2 or 3 in. The scions, usually with two or three buds, are cut so that their basal portions are wedge shaped. These are inserted at either end of the cleft, so that the cambium layers match, with the lowermost bud just above the surface of the stock. As soon as placed, all exposed surfaces are completely covered with grafting wax. After union, one of the scions may be removed.

Bark Grafting. This method is similar to the side grafting of indoor plants. However, if done outdoors on large trees, the branches should be cut across squarely, the scions inserted under the bark and nailed to secure their position, and grafting wax applied.

Whip Grafting (Fig. 57). Root grafting of many ornamentals and fruit trees is done by means of a whip graft. Root cuttings or young seedlings are stored in the fall to serve as understocks, and scion wood cut in lengths of 4 to 6 in. is treated in a similar fashion. Actual work is done during winter. Using a stock and a scion of approximately the same thickness, the practice is to make long, slanting cuts at the ends of the stock and the scion. Then a sloping cut is made halfway between the upper and the lower ends of the first cut. This cut is not exactly with the grain, and thus it makes a tongue. The two tongues are fitted together and tied tightly with waxed string, tape, or raffia. Finished grafts are stored in a moist medium like peat or sawdust and planted out in the spring so that one or two buds of the scion are exposed.

Crown Grafting. This is similar to bark grafting except that a triangular piece of wood is cut in the stump of a tree to be grafted, and a scion corresponding in shape is attached, nailed, and covered with wax.

Bridge Grafting (Fig. 58). Girdled trees may be saved by the use of bridge grafts. This is usually done in the spring just as the sap begins to flow. The girdled or wounded section of the tree is cleaned, and the bark edges are smoothed. The size of the scions depends on the size of the tree. For small trees, dormant one-year-old seedlings of the same kind of tree may be used. They should be longer than the wound to be bridged. A slanting cut about 2 in. long is made at each end of the scion, and the scion inserted under the bark at either end, the bark having been previously cut as for bark grafting. Nails may be used for keeping the scions in place, or they may be inserted and waxed.

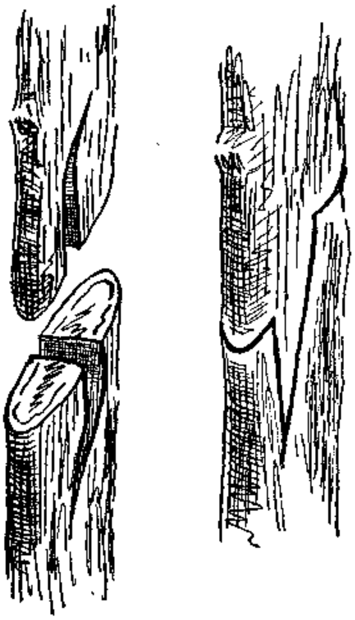

Fig. 57.—Whip graft.

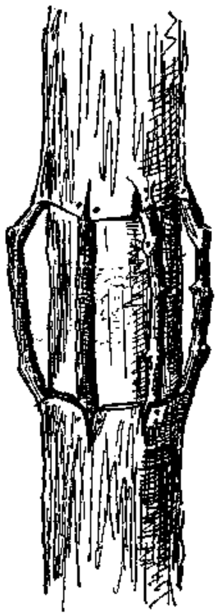

Fig. 58.—Bridge graft.

The usual spacing of these scions around the trunk is 2 to 3 in. apart. After union, the scions will transport the elaborated sap to the roots and eventually, as they enlarge, will cover the entire injured surface.

Grafting Waxes. The ideal grafting wax, it has been said, would have at least these qualifications: (1) It would exclude air and fungi and retain the moisture of the wood; (2) it would contain no material to injure live tissue in the strength at which it is used; (3) it would not crack in cold weather; (4) it would not run in hot weather; (5) it would have semipermanent possession of its various virtues; (6) it would have more or less elasticity, to accommodate itself to changes in dimension of stock and scion consequent upon growth; and (7) it would be economical.

Hand Wax. A hand wax or soft wax is a good general-purpose wax. It requires no special equipment for its application, since it can be worked and spread by hand. It is not now so popular as it was formerly (for years it was the only wax used), because the cost per pound is higher, a larger quantity is used per graft, and the time required to use it is greater than for brush wax. It is made as follows:

	Pounds
Resin	4
Beeswax	2
Tallow	1

These materials are melted together slowly without boiling, cooled somewhat, then poured into cold water. With the hands well greased with tallow, pull the wax (as soon as it becomes cool enough to handle), as in making taffy, until it becomes straw colored and uniform in texture. It may then be used immediately or stored in rolls in oiled paper. In cold weather, 1½ pt. of linseed oil may be substituted for the tallow, to make a softer wax. A harder wax is made by increasing the amount of resin.

Standard Brush Wax. This is popular for extensive operations. It is made as follows:

	Pounds
Resin	5
Beeswax	1
Linseed oil	¼
Lampblack or powdered charcoal	½

Slowly melt the resin; add beeswax, and melt; add linseed oil; take the mixture from the fire; stir in the lampblack a little at a time to prevent boiling over. The lampblack provides toughness and pliability. This wax is solid at ordinary temperatures. In the orchard it is kept melted by means of a small portable heater of simple construction.

Brush wax is applied in melted condition, often with a 1-in. paint brush, and hardens on the grafts after being applied. It flows into crevices, covers well, and can be applied in a thin coat. Although it must be melted to a consistency that will flow easily, it should not be heated any hotter, as it might then be injurious to tissues of the trees.

A lanternlike heater may be purchased, or the grafter may contrive a device that is easily carried and will shelter a small flame and keep the wax liquid in a small container above it.

Alcoholic Brush Wax. This wax is liquid at ordinary temperature, and it is made as follows:

	Pounds
Pulverized resin	4
Tallow	1/4
Wood alcohol	2

Melt the tallow; add the resin; and heat until entirely melted. Remove the mixture from the fire, and stir until partially cool. Add the alcohol gradually until the cooled mass is the consistency of paint. Keep the wax in a sealed container, such as a fruit jar, to prevent evaporation of the alcohol and hardening of the wax. It is applied cold, with a brush, and upon drying leaves a solid coat.

Paraffin Brush Wax. Paraffin, used alone as a grafting wax, often cracks and breaks in cold weather and on warm days is inclined to run, hence leaving the graft with insufficient protection. For a heavy coating, a number of light applications of plain paraffin may be necessary, especially if it is not applied while smoking hot.

High-melting-point paraffin has been increasingly used as an ingredient for brush waxes in recent years. Other ingredients are mixed with it to give it added elasticity and sticking qualities.

Resin	1 lb.
Linseed oil	3 fl. oz.
Paraffin	5 oz.

Melt the resin and linseed oil together, and the paraffin separately. Then mix well. Pour into a shallow pan lined with oiled paper to cool in a cake 1 to 2 in. thick. This cake can be broken up and melted in a heater as wanted.

Another paraffin mixture used especially for coating scions and also suitable for covering grafts is: paraffin, 4 parts; a gluelike substance sold by commercial manufacturers largely for gluing packages, labels, etc., 1 part. The following formula has been suggested to substitute when the "gluelike substance" is not available: resin, 1 part; yellow beeswax (pure), 1 part; paraffin, 8 parts. Melt the first two on a low flame; when clear, add the paraffin, and apply a little more heat until clear. Allow to solidify. Melt later as needed.

This almost transparent brush wax may be used in covering the entire scion, buds and all, as well as the cut surfaces of the stock, in grafting. It may be used for coating young nursery stock before setting out to keep it from drying out or for coating scions or nursery stock for long shipment. On scions with latent buds that have not started growth, it may be successfully applied even during the growing season. Covering the entire scion should eliminate drying out even under adverse conditions; drying out of grafts is quite troublesome.

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CHAPTER IX

LAWNS

The beauty of any landscape is due primarily to the lawn. The lawn is the foreground of the house and of every landscape picture and the setting for architectural and garden features. Practically, a beautiful green lawn with its plantings contributes greatly to the intrinsic value of the property and serves as a source of pride and satisfaction to the owner.

In starting a new lawn attention must be given to subsurface drainage, grading and leveling of the soil, kind of soil, preparation and fertilization of the seedbed, and the use of suitable seed. If any of these features is overlooked and the fundamentals not adhered to perfectly, the results are sure to be disappointing.

Failures in lawn making are the result usually of inferior soil; wrong time of seeding; inferior seed; shady locations; improper cultural practices such as too frequent liming, close mowing, and inadequate fertilization and watering; and infestation by weeds.

Grades. The first step in the construction of a new lawn is the establishment of a suitable grade. The general contour, as finally developed, should be pleasing and so sloped as to drain the water away from the house and the property. To get a clear conception of the final effect to be secured it is advisable to set grade stakes at various points. This may be done after the ground is plowed and rough grading done. The stakes may be set 20 to 30 ft. apart and connected by strings. Such a procedure will demonstrate the outlines that when viewed from a distance will show the final contours. Adjustments made in the lines can be marked on the stakes, and the grading conformed to these marks. In this way a suitable grade can be established without instruments.

Drainage. Insurance of good drainage provides a suitable physical condition of the soil for the development of the root systems of grass. Water standing in pockets is sure to cause injury. The best method of securing drainage is by tiling.

Four-inch drain tile laid in lines 15 to 25 ft. apart, 2 to 2½ ft. deep, with a fall of 4 to 6 in. in every 100 ft. will be found satisfactory. On city lots difficulty is often experienced in obtaining adequate outlets for tile lines. If there is a decided slope from the house to the street, the lines may be carried underneath the sidewalk and allowed to empty into the street or into storm sewers.

Preparation of the Soil. Soil from cellar excavations makes good lawns almost an impossibility; hence it should never be used, and building contractors should be urged to remove the top layer of soil and set it aside for use after all construction is completed. To forestall the temptation of reuse of the excavated soil it should be hauled away before the lawn is graded. A good garden loam, not too clayey or too sandy, is a satisfactory medium for the growth of most grasses and should be provided irrespective of the initial cost, since without it expectations of a good lawn will be minimized. Topsoil used in the lawn should be no less than 4 in. thick. To make sure of its quality, incorporation of manure, mushroom compost, or peat is desirable. Approximately 1 to 1½ tons of well-rotted manure, or 3 cu. yd., should be used to every 1,000 sq. ft. of surface, incorporated in the upper 4 in. The only objection to the manure is its weed content; but if applied several weeks before seeding, most of the weeds will germinate and may be eradicated. Approximately two bales of peat would be needed for a similar area. Peat makes a satisfactory substitute, providing the needed organic matter and, as it decomposes, supplying some nitrogen.

On large areas where manure may prove too costly, and when it is feasible to wait a season before seeding, green manure may be substituted for the introduction of organic matter. Such crops are particularly advantageous when the lawn area is ready for grading in the spring. Soybeans could be used, sown at the rate of 2 bu. per acre in May or June and plowed under in August, while still green. On heavy soils, buckwheat may be substituted. To increase the amount of organic matter by producing heavier growth of the crop the soil should be fertilized previous to cropping by adding a 4–12–4 fertilizer at the rate of 20 lb. per 1,000 sq. ft. of area.

Previous to seeding, all debris, rubbish, and stones should be removed from the surface, and the level brought up to the proper grade. Hand raking is necessary to provide an even surface; then a heavy roller should be used to crush any clods and to indicate any possible low spots. Following the rolling a fertilizer should be applied, and then the soil should be raked to a depth of 2 in. The final smoothing may be accomplished by using a straight-edged board with a handle. The board is pulled with a shearing motion across the ground, producing a uniformly even surface. An ideal seedbed is one that is firm but has a finely pulverized surface.

Fertilization. Even though liberal amounts of manure were used in the preparation of the soil, the development of a good turf is hastened and ensured by fertilizer additions several days before seeding, preferably at the time of preparation. Since it has been shown that fairly high amounts of phosphorus are necessary for proper root development of the grasses, 20 to 25 lb. of 20 per cent superphosphate should be incorporated to every 1,000 sq. ft. and with it 15 to 20 lb. of a 4–12–4 fertilizer. The superphosphate should be mixed all through the top 4 in. of soil, by hoeing or by raking. This is essential, since phosphorus does not move downward in the soil very readily. The fertilizers may be applied by hand or by means of small spreaders sold for the purpose. Uniformity of application is essential.

Lime. Indiscriminate use of lime is to be avoided. Its purpose is to provide the necessary calcium for proper root development, to help the physical structure of the soil, and to decrease acidity. Since any agricultural experiment station can supply the necessary test for calcium and acidity, it is well to take advantage of that service. If a sufficient amount of calcium is shown to be present, and if the pH of the soil is between 5.5 and 6.0, there is no need to add lime, since most grasses thrive best on the slightly acid side. Unwarranted additions of lime are conducive to greater weed growth. When needed, lime should be applied in the form of calcium carbonate (ground limestone) at the rate of 20 to 40 lb. per 100 sq. ft. of surface.

Sodding. When immediate establishment of a lawn is desired at almost any time of the year, sodding is resorted to instead of seeding. The latter method, however, is cheaper, more uniform, and freer of weeds. Slopes, much used areas, and borders close to walks or roads should be sodded whenever possible. Since sod consists of a grass population, the same thorough preparation of the soil is essential as for seeding. To lay sod on top of unproductive, hard subsoil is tantamount to failure. Likewise, sodding of shady areas where no grass will grow is wasteful, since the cause of grass failure will work similarly with sod.

Sod is usually cut to a uniform thickness of about 1 in. and in varying lengths. It should be laid so that the joints are even without any cracks between. After laying, it should be watered thoroughly and then tamped or rolled. The practice occasionally employed of sifting soil between the squares or rolls of sod and sowing seed is not to be recommended, since a checkerboard effect is apt to result because of the difference between the color and the texture of the sod and the new seedlings. If properly treated, sod should be well knitted to the soil below in about two weeks. When sods are used on steep terraces, it may be necessary to peg them down to prevent sliding.

Lawn Grasses. An ideal lawn grass is one that will germinate rapidly, develop a turf quickly, stand regular cutting, resist drought and disease, retain its color throughout the season, and be cold resistant. Such an ideal is hard to obtain, but Kentucky bluegrass comes closest to it. In addition to Kentucky bluegrass others in use in different sections of the country are Chewings fescue, redtop, white clover, bent grasses, Bermuda grass, buffalo grass, centipede grass, St. Augustine grass, carpet grass, and Italian or English rye grasses. Some of the cheaper mixtures likewise contain timothy and Canada bluegrass—both unsuitable for high-quality lawns.

Kentucky Bluegrass (*Poa pratensis*). This grass, thought to be a native of Kentucky, actually was brought from Europe by the early settlers. Most of our seed now comes from Kentucky, Missouri, and Iowa. It weighs 14 to 28 lb. per bushel and contains about 2,500,000 seeds per pound. The plant has creeping, underground stems, each bearing a tuft of leaves at the tip. It blooms once a season. The leaves are green and not blue and are V-shaped in cross section, with a peculiar tip which resembles the bow of a boat. The fact that Kentucky bluegrass grows in limestone regions is no indication that it requires an alkaline soil. As a matter of fact it grows very well in slightly acid soils, provided they are well drained and supplied with nutrients.

Chewings fescue (*Festuca rubra fallax*) is a native of New Zealand. It is especially suitable for lawns on sandy or gravelly soil and in shady locations. The plant creeps by underground stems; the leaves are bright green, stiff, and sharp. The turf produced is fine textured. Because of low germination rate and slow spread of the plants the rate of sowing is twice as high as that of Kentucky bluegrass. The seed weighs 10 to 15 lb. per bushel, with about 500,000 seeds per pound.

Redtop (*Agrostis alba*) is a native of Europe. It forms a coarse, loose sod by underground stems. It is adapted to a wide range of conditions, thriving whether wet or dry, and is very useful for holding banks to prevent erosion. The leaves are about ¼ in. wide, and the stems slender. The loose, pyramidal, usually reddish panicle is very characteristic. This grass is generally used in mixtures. It is produced mostly in Illinois, the seed weighing 36 lb. per bushel and each pound containing 5,000,000 seeds.

Rough-stalked Meadow Grass (*Poa trivialis*). This grass is adapted to shade in the northern localities, where it thrives even in the sun. South of New York or Toledo, Ohio, it will not survive the hot summer even in the shade. Rough-stalked meadow grass resembles Kentucky bluegrass but is lighter in color and has a roughened stem. It possesses, at the surface of the ground, short, creeping stems which spread slowly. A pound contains approximately 450,000 seeds.

White clover (*Trifolium repens*) is used extensively in mixtures. It germinates rapidly and has a tendency to shade the other more slowly germinating kinds, thus serving a useful purpose. It thrives well in poor soils. The seed weighs 60 lb. per bushel, and each pound contains 700,000 seeds.

Colonial bent grass (*Agrostis tenuis*) is a native of New Zealand and is distinguished by its small narrow leaves and the ability to stand frequent cutting and make a fine close turf. Its shallow-rooting propensities make it undesirable when drought conditions prevail. Frequent top dressings of compost are necessary because of the habit of surface stolons rooting to form new plants. Colonial bent grass is useful in mixtures and for putting greens. The average per pound is 600,000 seeds.

Bermuda grass (*Cynodon dactylon*) is native to India but has been established in this country since 1807. It is used in lawns in the South, particularly on clays and loams. It is characterized by white underground rootstocks and leafy stolons which creep along the surface of the ground. Bermuda grass is very resistant to drought and high temperatures but has a tendency to winterkill and to lose foliage after frost. It makes a dense turf during the heat of the summer and spreads by stolons which root at each joint. It will not thrive in the shade. The weight of seed is 35 lb. per bushel, with 1,800,000 seeds per pound.

Buffalo grass (*Buchloe dactyloides*) is a native of the United States and makes an excellent substitute for bluegrass in hot, dry regions. It has a dry and somewhat unattractive appearance during fall and early spring months. In Nebraska it has found considerable favor. Buffalo grass is propagated by seed or by stolons. Since seed is expensive and does not germinate too readily, sodding is recommended where such sods are available. Because of poor germination during cold weather, planting of seed should be deferred until May. Sodding may be done from May until August by using small pieces, planted 12 to 24 in. apart. These will make a complete covering in one season. Being drought resistant, buffalo grass requires little watering during the summer and comparatively little mowing.

Centipede grass (*Eremochloa ophiuroides*) is a native of China whence it was introduced into the South in 1918. It creeps by stolons and is deep rooted and drought resistant. A dense mat of yellowish- to bluish-green foliage is formed. Centipede grass is especially suitable in the full sunshine of the southern states.

St. Augustine grass (*Stenotaphum secundatum*) is a native of the southern states. The leaves are broad, with stolons on the surface of the ground. Because of its lack of hardiness, St. Augustine grass is limited to the lower south. One of its special features is the ability to grow in the shade, and it does well on heavy soils. It has a tendency to brown rather quickly and is subject to chinch-bug attacks.

Carpet grass (*Axonopus compressus*) is a native of the West Indies but since its introduction to the United States in 1832 has become established in many of the southern states. It makes a dense, close turf, easily distinguished by the compressed, two-edged, creeping stems, rooting at each joint, and by the blunt leaf tips. It is especially adapted to sandy soils but requires considerable moisture.

Italian rye grass (*Lolium mutifolium*) produces a turf very quickly, and in the South it is common practice to sow seed on

Bermuda-grass lawns every fall so as to have a bright green winter lawn.

Canada bluegrass (*Poa compressa*) is often used in mixtures with Kentucky bluegrass where dry conditions do not favor the latter. If kept closely clipped, it makes a fairly satisfactory lawn.

SUITABLE LAWN MIXTURES

The foundation of most lawns in the northern tier of states is Kentucky bluegrass; but since this starts rather slowly, various other quick-starting grasses are usually sown with it. For fall seeding, however, pure Kentucky bluegrass is more satisfactory than any mixture for the average lawn. The other grasses make too much growth when sown in the fall.

Among the *quick-starting mixtures* several are used. One of the best is 80 per cent Kentucky bluegrass and 20 per cent redtop, sown at the rate of 4 lb. per 1,000 sq. ft. The cheaper mixtures contain 10 to 20 per cent of timothy or rye grass and give a quicker cover but are not so satisfactory in the end. White clover may be added up to 5 per cent, and this will tend to act as an insurance in somewhat neglected lawns. Some people like white clover in any lawn.

For the northern tier of states, another suitable mixture, which makes a much finer textured turf than the bluegrass and redtop combination, is one that contains 70 per cent Chewings fescue, 20 per cent Kentucky bluegrass, and 10 per cent colonial bent. Four pounds of this mixture per 1,000 sq. ft. of surface is advisable.

In the lower southern states, Bermuda grass predominates. It is started from seed or from stolons (set 6 to 12 in. apart) in the spring or early fall. Since it dies down in the winter, it is mown closely in the fall, and the soil is loosened with a rake, top-dressed, and sown to Italian rye grass at the rate of 5 to 10 lb. per 1,000 sq. ft. The rye grass comes up quickly and continues to grow until spring, when Bermuda grass begins to grow again.

In Florida, lower Louisiana, and parts of Texas along the Gulf of Mexico, Bermuda grass, carpet grass, centipede grass, and St. Augustine grass are used largely, the last for shade.

Mixtures for Shade. Failures to grow grass in the shade are based on the fact that in addition to the lack of sufficient light, the grass plants suffer from drought and lack of nutrition due to roots of trees. Where the shade is extremely dense, the best method of approach is to use ground covers such as *Vinca minor, Pachysandra terminalis, Hedera helix,* and *Euonymus fortunei,* as discussed in Chap. XI. For partial shade and where proper moisture and fertilization are practiced, the best grass is Chewings fescue, or it may be used in a mixture as indicated for fine-textured lawns.

SEEDING THE LAWN

The importance of securing high-quality seed cannot be overemphasized. Gaudy packages sold at various outlets are not indicative of quality. Only reliable seedsmen should be patronized; and when buying, the contents of packages should be watched for high amounts of Canada bluegrass, orchard grass, or timothy, and such mixtures avoided. Weed content should not run over 1 per cent.

Time of Sowing. In the northern tier of states, fall seeding is to be preferred to spring seeding, because spring seeding, unless done very early in March, does not provide the most desirable condition for germination and sufficient growth before hot weather. Kentucky bluegrass in particular does not germinate well during hot weather. In addition, in fall seeding such summer weeds as crab grass are not a problem; and once a thick turf is established, the elimination of weeds is not a serious consideration. Late spring or early summer seeding usually will result in complete or partial failure. In the lower south the seeding or the planting of stolons should be done in June, although where moisture is available the work may be done as early as April and as late as August.

Sowing the Seed. To obtain an even distribution of seed, the lawn may be divided into strips 10 ft. wide, and the seed weighed out for each strip. Using half the amount at a time and sowing it one way and then taking the other half and sowing it the other will give greater uniformity. Sowing should be done when the air is still, since the seed is fine and will blow easily. After seeding on small areas cover with ¼ in. of peat, or rake the surface lightly. Afterward roll the seeding lightly to ensure quicker germination. Large areas may be seeded with wheel-barrow seeders, and the seed covered by dragging brush harrows over the ground. This harrow may be made by binding long spreading branches of brush together to form a drag 6 to 10 ft. wide.

GENERAL MAINTENANCE

Maintenance practices include fertilization, mowing, rolling, watering, and the eradication of weeds and pests.

Fertilization. Regular use of fertilizers is essential to provide a good lawn. Constant mowing, with its removal of clippings and frequent watering causing some leaching, necessitates renewal of nutrients at regular intervals. Nitrogen is the element needed most and yet lost the most quickly; hence it should be contained in every fertilizer used. Phosphorus is essential with such shallow-rooting grasses as those constituting lawns in order to develop and maintain an extensive root system. Potassium is necessary for the maintenance of a healthy growth.

No one kind of complete fertilizer nor a single carrier can be recommended for use in all localities. The most satisfactory way is to test the soil and then apply fertilizers in accordance. Considerable controversy exists between the advocates of chemical (inorganic) fertilizers and those who believe in the use of organic kinds. As a matter of fact a combination of both is the most desirable. The inorganic fertilizers are more quickly available and leach out more quickly. The organic materials are slower in availability and last longer. Thus when an application is made during the cool weather of spring, organic fertilizers will be too slow in action, whereas later in the summer they would be more suitable. Mixtures made of both inorganic and organic carriers in proper proportions are probably the most satisfactory in the long run.

The following fertilizers are most commonly used:

	Pounds per 1,000 Sq. Ft.
Organic:	
Soybean meal (6.5–3–2)	20
Cottonseed meal (6.5–3–2)	20
Tankage (6–20–0)	2[illegible]
Activated sludge (6–2–1)	2[illegible]
Inorganic:	
Ammonium sulphate (20–0–0)	[illegible]
Superphosphate (0–20–0)	2[illegible]
Ammophos (11–48–0)	5
Mixed:	
4–12–4	20
10–6–4	10

Of the organic fertilizers mentioned, soybean meal and cottonseed meal are particularly satisfactory when applied in the spring for a long carryover effect and supplemented in early fall with a 4–12–4. In place of the organics, two applications of 10–6–4 or ammonium sulphate, or Ammophos, may be made in the spring and then followed with the 4–12–4 in the fall.

The surface application of bone meal is just so much waste of time and effort. The little nitrogen that it contains is soon utilized, and the phosphorus remains close to the surface and does little good. The same is true of superphosphate when applied to the top. In their place, to secure the needed phosphorus, Ammophos should be applied. Bone meal and superphosphate should be used only when the soil is being prepared and then mixed thoroughly with it. Sheep manure is costly, and its use is not warranted.

Among the mixed fertilizers the two ratios mentioned are sufficient for all needs. There is no purpose in complicating practices by advocating all sorts of varying ratios. If soil tests show that a certain element is lacking, it may be applied in individual form. In localities where certain trace elements are deficient, these may have to be added in general conformity to the recommendations made for such localities. Some trademarked materials contain trace elements and because of that may be more desirable than mixtures that do not. Most of the good trade-marked mixtures analyze 4–12–4 or 10–6–4 or approximate these formulas closely.

Commercial fertilizers should be applied when the soil contains a sufficiency of moisture but when the grass is dry. Thorough watering after application is necessary. Even distribution is very essential. This may be obtained with a small fertilizer spreader.

The use of stable manure as top-dressing is to be avoided. Nothing is gained except the introduction of weeds. However, a rich compost may on occasion be used as a top-dressing for reseeding or for filling depressions.

GENERAL CARE

Mowing. Lawns should be mowed frequently enough to permit the clippings to remain, become decomposed, and thus add nutrients to the soil. In addition the clippings make a ght mulch and have a tendency to prevent the germination of ıch weeds as crab grass. If the grass is allowed to go too long ithout mowing, it will be necessary to remove the clippings to revent matting and molding, particularly if abundance of rainıll is prevalent and likewise if the lawn is shaded. As a conseuence the use of catchers behind the mowers is unnecessary ı sunny locations and with frequent mowings.

The height of grass cutting is an important factor in the eneral well-being of the lawn. Close cutting may improve the ppearance temporarily but necessitates more frequent fertilizaon and watering. Mowing actually is detrimental to grass, that the height of cut should be sufficient to provide for good ppearance and yet be consistent with proper growth. The verage lawn mower can be set to cut the grass 1½ in. long, hich is about right for most grasses except bents.

In the northern tier of states, if regular watering is not resorted), frequency of mowing should be reduced after June. Since entucky bluegrass grows very little during the hot summer ıonths, it should be permitted to enter that stage with a suffiency of foliage to carry it through until the middle of August nd at the same time reduce weed-seed germination and growth. n general, the less mowing done the better, so long as the general eat appearance is retained.

Watering. Lawns should be watered thoroughly, which means ıat, when soaked, a penetration of 3 to 4 in. is desirable. Light prinklings by hand do little good and may do harm by causing n accumulation of roots at the surface and subsequent burning uring hot weather. The usual procedure of watering by hand is obviously inadequate, because the average person has not the patience to water long enough in one spot to give deep penetration. Rotary sprinklers set for a sufficient period in one spot are much more satisfactory, and on large lawns underground lines of irrigation are advisable. No damage is caused by watering while the sun is shining, but unquestionably less water is required when there is less heat for evaporation.

Rolling. Lawns should be rolled in the spring after the frost is out of the ground. This compacts the sod and brings any heaved sections into close contact with the soil below.

Mulching. The practice of covering lawns with manure, leaves, or straw in the fall to reduce winterkilling has no foundation in fact. Mulches do more harm than good and in addition add undesirable weed seeds.

Poor Lawns. These usually result from improper preparation of the soil, cheap seed, overzealousness in liming, and inadequate care. In such cases the mere sowing of more seed and fertilizer additions will not improve conditions materially. A complete rebuilding is the only sure method of rejuvenating an old lawn. Spading or the use of a Rototiller, together with incorporation of manure and fertilizers early in the fall, will fit the ground for satisfactory sowing of seed. If necessary, proper drainage should be provided.

If the lawn is spotty, such drastic measures may not be necessary. A top-dressing of good compost and seeding may bring about satisfactory results.

Bent Lawns. Because of the greater care required and susceptibility to disease, the average homeowner should not attempt to make bent-grass lawns. Closer mowing at frequent intervals, top-dressing with compost regularly, and greater care in fertilization and watering are essentials rarely carried out in the home lawn. For putting greens, bent grass is necessary. If bent-grass lawns are wanted, the following procedure should be observed.

Seed Method. Colonial bent, velvet bent, seaside bent (*Cocoos*), and a mixture known as *south German mixed bent* are the most satisfactory for seeding purposes. The colonial bent spreads by underground stems; the velvet and creeping bents, by means of surface stolons. Therefore the colonial bent is less exacting in its requirements. When mixed seed is used, a variegated color is apt to develop due to the variation in the grasses. Seeding should be done in the fall, using 4 lb. of seed per 1,000 sq. ft.

Stolon Method. Stolons are chopped runners of the creeping varieties of bent. These runners are jointed at short intervals and, when in contact with moist soil, produce roots and develop into new plants. By their means a lawn may be established much sooner than from seed. Some of the best strains of creeping bent for this purpose are Washington and Metropolitan, whereas Capitol and Highland are the most suitable for the velvet bents. The latter two may be used in partial shade, but they spread more slowly than do the creeping bents.

The stolons may be planted any time sufficient water is available, but early fall is the most suitable season. The soil should be prepared as for seeding, and a supply of compost should be on hand to cover the stolons. This compost should contain sand to avoid caking and should be fine enough to pass through a ¼-in. screen. About 1 cu. yd. of compost is needed for every 1,000 sq. ft. of lawn area. The stolons should be planted as soon as cut, by scattering evenly over the seedbed at the rate of 1 bu. per 100 sq. ft. of area. Then the top-dressing should be scattered to a depth of ¼ in., and the area rolled and watered with a fine spray and in sufficient amount to penetrate to a depth of several inches.

Once planted and for a period of about 4 weeks the surface soil should not be allowed to dry out. As many as three and four light sprinklings per day may be needed during hot sunny weather. This initial care is very important to secure a satisfactory stand.

The first mowing should take place when the growth has reached about 1½ in. with the clippings left on. After cutting to a height of 1 in. four or five times, the mower should be set down to ½ in. Following the first few mowings a top-dressing of compost should be brushed lightly into the lawn with a broom.

Almost any organic matter will make good compost. Leaves, grass clippings, manure, or straw may be made into a flat pile—built by alternating layers of soil and organic matter, each about 6 in. thick. Its decomposition may be hastened by adding a complete fertilizer (4–12–4) and ammonium sulphate to each layer as it is laid down. Additions of ground limestone to each layer are also desirable. If a pile is 5 by 10 ft. and 4 ft. high, it will require 5 lb. of 4–12–4 fertilizer and 5 lb. of ammonium sulphate. The lime may be sprinkled at the rate of 2 lb. to each layer. The completed pile should be dished in to allow water to soak through. If it is kept moist and made in the spring, it should be ready for use in the fall. During the season, however, it is necessary to chop it down twice and mix it thoroughly each time.

To maintain a bent-grass lawn, it should be mowed every other day to a height of ½ in. It should be watered daily during the hot weather. Top-dressing should be applied three or four times a season, and the lawn fertilized every 2 weeks with a 10–6–4 fertilizer at the rate of 1 lb. per 1,000 sq. ft.

Bents are subject to a disease known as *brown patch.* This develops during periods of hot, damp weather and is recognized first by a fine, cobweblike growth on the grass, usually early in the morning. Later the grass looks scalded and finally browns and dies. Spots may be either small or large, depending upon the causal organism. At the first indication of cobweb appearance, brushing of the grass with a flexible pole will dislodge the fungus from the grass blades. If the disease spreads in spite of this treatment, the lawn should be sprayed with bichloride of mercury at the rate of 1 oz. to 10 gal. of water to every 1,000 sq. ft. of area. Calomel (mercurous chloride) may be substituted, using 3 oz. to 10 gal. of water. Either of these materials may be used in dry form, first being mixed with sand or screened soil and broadcast over the infected areas.

Control of Lawn Weeds. Weeds are ever a problem of the lawn owner. Yet many roadsides will show that weeds find it nearly impossible to invade good bluegrass. The weediness of the average lawn is due (1) to the poor soils on which lawns are attempted and (2) much more important, to the close cutting of the grass. Weed seedlings cannot establish themselves in the shade of thick vigorous grass, and by far the easiest way to prevent weeds is to fertilize well and cut intelligently.

Dandelions and Other Broad-leaved Weeds. The control of dandelions has been revolutionized in the past few years by the introduction of a new weed killer, *2,4-dichlorophenoxyacetic acid* (usually called "2,4-D" for short). This material applied as a spray has killed dandelions, roots and tops, without killing bluegrass.

What Weeds Are Affected by 2,4-D? 2,4-D will kill not only dandelions, but buckhorn plantain, common plantain, black medic, ground ivy, common and mouse-ear chickweed, speedwell, heal-all, in short most of the common broad-leaved lawn weeds. Doorweed or knotwood and some others, are only moderately affected. The weeds of the grass family, crabgrass, goosegrass, nimblewill grass, pigeon grass, foxtails, and others, are not affected by 2,4-D at any stage.

How to Use 2,4-D? The various commercial forms of 2,4-D are put up to go into solution or emulsion in water. This is applied as a spray at the rate of 3 to 5 gal. per 1000 sq. ft., or just enough to wet the foliage of the plants. Any runoff is wasted and may do harm if it reaches the grass roots. Applications with a sprinkling can require far more solution and are not desirable.

The *best time to treat* any weed appears to be when it is rapidly growing and immature. For dandelions and most other lawn weeds, late April and May is the most effective period. However, the bare places left by these weeds will be filled by crabgrass if the lawn is not well fertilized and properly cut. From this point of view, treatment during the active growing season in the fall might be more desirable. Treatment when the ground is dry and the plants more or less dormant is less favorable, and many roots are not killed. 2,4-D acts slowly. It may be a month before the complete killing action is manifest. Do not treat again until and unless new growth starts. Rain 4 to 6 hr. after applying 2,4-D does not usually reduce its effectiveness, though clear weather is preferable.

How Is 2,4-D Sold? There are at least 30 to 40 commercial preparations based on 2,4-D being offered to the public. Some of these are powders, some tablets, some solutions. These products contain from 9.6 to 100 per cent 2,4-D. Therefore, do not judge a 2,4-D product by the size of the bottle! Look at the label for the percentage of 2,4-D. If that is not given, get some other product. Compare the products on the basis of the cost per ounce of 2,4-D.

CAUTION: Keep 2,4-D spray off from any plants you do not wish to kill! Practically all vegetables and most flowers and ornamentals are damaged by this spray. Even drifting spray may cause serious injury. Furthermore, if you use the same sprayer for 2,4-D and other sprays, clean it thoroughly with strong soapsuds or trisodium phosphate solution (2⁄3 oz. to the gallon). It is safer to use a different sprayer.

Crabgrass. The only real cure for crabgrass has already been outlined—thick, high-cut lawn grass. Then watch for the occasional plants of crabgrass. In tall dense lawn grass they must grow up and cannot run along the ground, so they can be readily pulled. Crabgrass does not live over winter. The seeds germinate about June 1, so it is particularly important to cut the grass high in June and for the rest of the summer. Bluegrass is semidormant in summer and, if once cut short, may not become thick again.

Chemical "crabgrass killers" are not recommended for the home lawn. Lead arsenate, 30 to 40 lb per 1,000 sq. ft., has prevented the germination of crabgrass seed on some soils but failed on many others.

Nimblewill Grass. In the southern parts of the United States, this is worse than crabgrass, yet many people do not know it at all. It is somewhat like crabgrass, but perennial. However, it is brown and dead appearing from October through April, and hence spots of it give a bare appearance to the lawn in fall and especially in spring. In the summer it is much like bent grass. Removal by hand is easy because the running stems are all fine, weak, and above ground.

Other Lawn Pests. White grubs and earthworms can be controlled by applying 10 lb. of arsenate of lead or 5 lb. of 10 per cent DDT powder to each 1,000 sq. ft., preferably in early spring. Mix the lead arsenate or DDT with 1 bu. of dry sifted soil, and scatter broadcast over the lawn. Wash the mixture down with a stream of water from a hose.

Ants can be destroyed by putting about 1 tps of carbon bisulphide in each hill with an oil can and covering with a wet newspaper to keep in the explosive fumes. Ant poisons containing thallium are sold in cans. Place these near the hills.

Moles. Many remedies have been suggested for mole control. Traps and the placement of a spade behind the heaving run are probably the most efficient. The use of poisonous gases like calcium cyanide and carbon bisulphide depends upon whether or not the runs are used frequently. If not, such remedies are useless. The placement of poisoned baits in the runs, the use of castor-oil beans, etc., are not effective. Probably the most efficient method, if it can be made practical in all cases, is the introduction of carbon monoxide gas from automobile exhaust pipes. The attaching of a hose to the exhaust and running it into runs will kill all moles in a large area. The motor should be allowed to run about 30 min., and all holes in the runways should be carefully closed previous to the gassing.

An application of arsenate of lead at the rate of 15 lb. per 1,000 sq. ft. has proved of value in mole eradication. To avoid such heavy applications a 3-ft.-wide border of it may be made around the infested areas.

Fungous Diseases. Occasionally Kentucky bluegrass lawns suffer from attacks of fungi. Usually overfertilization with nitrogenous fertilizers and overwatering during hot, humid weather may be the contributing cause. Lawns located in extremely sheltered areas, bordered by trees, may suffer particularly because of the stagnant atmosphere. The same remedies as suggested for brown patch will prove reasonably effective.

CHAPTER X

ANNUALS

Annuals are a more or less logical starting point for any flower garden as well as a necessity in any well-planned garden. They offer many advantages not found in perennial and biennial flowers. Being more easily grown, they give a greater amount of effect for a smaller expenditure than any other type of flower. And yet with the exception of some of the more common ones, a large percentage of those ordinarily available are but seldom seen in gardens. There is no reason why a far greater variety should not be grown than at the present time. They are not new; the majority of them have been listed in catalogues for many years.

The term *annual flower* is an extremely elastic one. It is normally applied to those plants the seeds of which are sown in the spring, the blooms produced the same season, with the plants killed by freezing weather in the fall. Also included in this classification are tender perennials such as the snapdragon and pansy, which, although they may live over winter, are seldom worth while the second season.

The range of forms found among the annuals is tremendous, from the dainty little Ionopsidium to the large and coarse castor-bean. Annuals have been gathered from all parts of the world—some from the United States, some from the subtropics, and in recent years many from South Africa. One of their outstanding virtues is the ability of a number of them to bloom during the hot summer months when but few perennials are in flower. On the other hand, many will not bloom satisfactorily during the hot summer of the Midwest and South.

The Season of Bloom. Some annuals like cosmos, tithonia, and late varieties of China-aster are short-day plants which do not bloom until the days become shorter in the late summer no matter how early they may be started in the spring. Others such as gypsophila come into bloom quickly but soon go to seed. Many such as stock and salpiglossis grow and bloom satisfactorily only in relatively cool summer climates. Others require comparatively long periods between seed sowing and time of bloom so that they must be sown indoors to be given an adequate start. Verbena, petunia, and vinca are examples of this type. For the most part, annuals must be sown anew each year, but some such as *Delphinium* and *Centaurea* normally selfsow. A few such as portulaca, *Kochia,* and *Euphorbia marginata* may selfsow to the extent of becoming pests. Others like *Trachymene, Papaver,* and *Eschscholtzia* are difficult to transplant and are best sown where they are to bloom. Some like the China-aster and snapdragon are usually attacked by serious diseases unless disease-resistant strains are planted. Such groups as the zinnia, marigold, and petunia can be depended upon to give a long season of bloom. These are the essential points to consider in the selection of annuals, most of which are represented in the lists at the end of the chapter.

Where Annuals May Be Used. Since the old-fashioned idea of growing flowers in beds in the middle of the lawn is no longer in good taste, those who wish to grow annuals should consider carefully the layout of their yards and place the flower beds or borders so that they add to rather than detract from the beauty of the grounds. We have already discussed, under The Design of Small Properties, the need of an adequate setting for the garden. Unfortunately, where annuals are used exclusively, as in rented properties and summer homes, these backgrounds and the seclusion and privacy supplied by them are all too often lacking. It may, therefore, be desirable to supply the background by the use of some of the taller growing annuals. Although the castor-bean is relatively coarse, it does produce results. In northern climates with early frosts, the height and vigor of the late-blooming cosmos may be used for hedges to form a background, even though no bloom is produced before they are cut down by frosts.

This background may also be supplied by a light trellis or a fence covered with annual vines or a more permanent woody vine. A trellis of this type need not be expensive or even permanent. It may be made by using light 1- by 2-in. wood strips, which may be scrap material, with horizontal and vertical bars spaced a foot apart. Such a trellis might be left to weather, stained with creosote, or even whitewashed. Light galvanized-iron wire strung 12 in. apart on 6-ft. posts with occasional strings between the wires would prove adequate.

Summer background is a phase of gardening that is all too often neglected. As has been stated before, one of the present-day needs of this country is a greater appreciation of landscape effects rather than a mere interest in flowers themselves.

The same principles apply to the use of annuals in the flower border as to perennials. The factors of height, season of bloom, foliage, and habit of growth should be considered. The amount of each kind used in the border depends on the distance from which the border is to be viewed. Groups of one kind running lengthwise of the border, rather than across it, will usually give a better effect from a distance.

Perennial borders, no matter how compactly planted with perennials, have a need for the inclusion of at least a few annuals for midsummer bloom. These may well be planted above groups of tulip, narcissus, and other spring-flowering bulbs. They may be planted close to oriental poppies and similar perennials to take their places as their foliage dies and disappears. It is a good practice to leave certain spaces in the perennial border unplanted with the idea of filling them with appropriate annuals. Since sowing the seed in such places is often difficult and undesirable, some gardeners adopt the practice of sowing them in separate plots and then transplanting them to the border when they are half grown.

Foundation Plantings. Around new houses that are just being developed, the yards just planted may be advantageously given over to annuals. The fact that beds are prepared for annuals, with the possible incorporation of organic matter and fertilizer, makes them that much more ready for the planting of shrubs. In much the same way, newly planted shrubs that have been adequately spaced for growth may have the bareness somewhat relieved by planting the intervening spaces with annuals the first and even the second season. Care must be taken, however, not to crowd and smother the shrubs by the more vigorous annuals.

After the shrubs have reached their maximum size, there is still the possibility of using small groups of annuals among part of them. Labor can sometimes be saved by having several patches of self-sown annuals, one kind to a space. Some of the taller annuals such as *Polygonum*, cosmos, and sunflower may be used in back of the lower growing shrubs and in front of the taller ones for a bit of summer bloom. Lower growing kinds may be used in front of any shrubs except those whose spreading habit, as in the case of forsythia, will crowd them.

Bulb gardens are naturally a problem after the bulbs have finished blooming. Whether or not the bulbs are removed, the beds may be successfully planted with annuals. When a season-long effect is desired, only those should be used which will bloom throughout the summer. Most bulbs may be planted sufficiently deep so that the annuals can be planted directly above them without damaging the bulbs.

The rock garden offers another use for annuals; but considerable disagreement exists on this subject, for alpine enthusiasts feel that they are entirely out of place, whereas the landscape gardener desires some summer bloom, which is not normally supplied by rock plants. Fortunately or unfortunately, as the case may be, relatively few annuals are to be recommended for this use. Included are the dwarf ageratum, alyssum, *Brachycome*, *Phlox drummondi*, *Tagetes tenuifolia* (*signata pumila*), sanvitalia, thunbergia, verbena, Tom Thumb zinnia, *Nierembergia gracilis*, lobelia, torenia, *Linaria alpina*, and dwarf petunias.

Annuals for the Cutting Garden. In many ways annuals stand supreme as summer cut flowers; with their profusion and their continuous bloom, they supply almost unlimited quantities. Although any of them may be used for cutting, some are far more satisfactory than others. With certain ones, such as the zinnia and the marigold, the practice of disbudding to remove the side branches will give longer stems and possibly larger flowers. Although annuals for this purpose may be planted in the regular border, it is usually preferable to grow them in rows in the vegetable garden.

Annuals for Window and Porch Boxes. With the present-day development of penthouses, the number of window and porch boxes is greatly increasing. However, here in America we seldom see boxes used to the extent that they are in Europe, where more or less complete flower gardens are maintained in them. Since continuity of effect is desired, only those annuals which bloom over a long period should be selected. Except in large boxes where tall plantings are developed to give privacy and seclusion, only the low-growing and more or less trailing forms should be used.

Trailing. Thunbergia, verbena hybrids, *Verbena pulchella*, sweet alyssum, sanvitalia, petunia (balcony types), *Nierembergia gracilis.*

Upright. Dwarf ageratum, *Eschscholtzia, Antirrhinum, Torenia, Phlox drummondi, Browallia*, petunia (giant, ruffled, and upright forms), nigella, dwarf French marigold, verbena (upright type).

Annuals as Ground Covers. The use of annuals as ground covers and grass substitutes is a relatively new development. For gardens where perennial ground covers are not available, or while a stock is being grown in another part of the garden, annuals may be used to advantage. Two of the best for this purpose are *Verbena pulchella* and *Sanvitalia procumbens,* the first being particularly vigorous and efficient. Others that may be used are *Portulaca, Eschscholtzia, Verbena hybrida*, and some of the annual vines. Although actual trials of these have been rather limited, indications are that the scarlet runner bean, the hyacinth-bean, the common and the Japanese morning-glory, the cardinal climber, and the cypressvine may be used. Even gourds, although their foliage is rather coarse, will cover a large territory.

Annual Vines. Annual vines have a wide range of uses; yet they are seldom seen in gardens. Vines may cover trellises and fences; may climb on porches of new houses or on fences to obtain privacy; mingle with climbing roses, wisteria, and other earlier blooming vines for midsummer bloom; climb over tree trunks, hang down over walls; may cover garages and sheds; and furnish shade on arbors and pergolas.

Since most of them are slightly tender, they should be started in April in the cold frame if quick results are desired. They do not have rootlike holdfasts but cling by means of tendrils or by twining; hence twine, string, or wire should be furnished for their support. As the wild cucumber and the common morning glory selfsow and quickly become pests, they should be avoided.

Starting Annuals. Annual flowers are for the most part easy to grow from seed. The larger seeded kinds, such as cosmos, zinnia, and marigold, are the easiest and can be sown directly in the beds where they are to grow. Smaller seeded sorts, such as petunia, snapdragons, and nicotiana, require more careful sowing and handling. If sown in the open ground in the garden, they may not give satisfactory results because of too deep sowing, washing, or compacted soil. These small seeds are best sown in a prepared seedbed in a cold frame to be transplanted when sufficiently large to handle.

Seeds of hardy annuals, those that normally selfsow in any particular climate, may be sown outdoors in late August or September. The resulting seedlings will live over winter. These same seeds may be sown in late November to germinate the following spring. Or they may be sown outdoors during the early spring. All other annual flowers are best sown in the late spring so they do not come up until after all danger of frost is past. However, if sown in a well-built cold frame with a sash to protect them from the cold, they may be sown 4 to 6 weeks earlier.

A few annuals can be kept in the greenhouse over winter and then propagated by cuttings. This is done with some double-flowered petunias, *Nierembergia gracilis*, *Nierembergia hippomanica* Purple robe, dwarf ageratum, *Browallia*, *Verbena hybrida*, lobelia, and Felicia. Added to this list would be bedding plants such as geranium, heliotrope, marguerite, coleus, begonia, impatiens, fuchsia, and lantana.

Planting. Annual plants should not be planted outdoors until all danger of frost is past, which will vary from May 1 until June 1. Annuals that have been grown in 2½-in. pots will transplant more easily than those grown in flats or beds. For transplanting, a cloudy day should be chosen.

For formal beds, definite rows should be followed. The distance of planting varies with the type of annual. The small-growing species should be planted 6 by 6 in.; the medium-sized species, such as snapdragons and French marigolds, should be spaced 8 by 8. Zinnias, salvia, and African marigolds should be placed 12 in. or more each way.

Annual seedlings are often benefited by pinching out the terminal buds to prevent erect unbranched growth. This applies to zinnias, cosmos, chrysanthemums, and any others not inclined to branch naturally.

In planting annuals in vacant spaces in rock gardens or perennial borders, a group of plants will present a more pleasing effect than will a single plant. All annuals should receive a liberal amount of water after they are transplanted.

The annual beds should be watched closely so that weeds do not overtake the young plants. Cultivation after each rain is recommended if the beds have *not* been mulched with an inch or so of chopped corncobs, peat moss, or similar material. Annual plants should never be allowed to remain dry.

Soil Preparation. Good soil preparation and good drainage may not be quite so important with annuals as with perennials and other plants, but nevertheless the better the soil and the drainage, the better the results. Annual flower beds can be seeded to rye or winter wheat in the early fall even before frost kills the flowers. This cover crop can be spaded under before annual flower seeds are sown the following spring. Or a 2-in. layer of manure, peat, rotted leaves, or similar material may be incorporated each year.

Some annuals are partial to limed soil; so, if the soil reaction is highly acid, additions of ground limestone may be made every 2 or 3 years at the rate of 5 to 10 lb. to 100 sq. ft. (if hydrated lime is used, half this amount), according to the tested reaction of the soil.

The plants requiring an alkaline condition are alyssum, candytuft, carnation, impatiens, mignonette, nasturtium, pansy, phlox, poppy, sweet pea, and zinnia. Those but slightly affected by acidity include ageratum, asters, calendula, gaillardia, lobelia, petunia, and salvia. Some that tolerate acidity are castor bean, calliopsis, marigold, nicotiana, and verbena. The following annuals grow fairly well even in the poorest of soils: alyssum, balsam, bachelor's-button, California poppy, calliopsis, godetia, amaranthus, nigella, nasturtium, and portulaca.

Before the soil is spaded or plowed, a complete commercial fertilizer should be applied at the rate of 2 to 4 lb. per 100 sq. ft. of garden surface. Such a fertilizer may have the analysis of 4-12-4, 4-12-8, 5-10-5, or similar ratio.

Additional applications at the rate of 1 to 2 lb. per 100 sq. ft. may be applied to the soil in late June or early July and again in early August.

A SELECTED LIST OF ANNUAL FLOWERS

ACANTHACEAE ACANTHUS FAMILY

Thunbergia alata. Black-eyed Susan vine. Tropical Africa. Small vine; yellow, orange, or white flowers often with dark throat.

AMARANTHACEAE AMARANTH FAMILY

Celosia argentea cristata. Cockscomb. Tropical. 2 to 3 ft. Dwarf varieties 1 to 1½ ft. The old-fashioned cockscomb is more or less of a monstrosity, but the plumed forms are excellent garden subjects. The yellow, orange, and red flowers are produced throughout the season.

Amaranthus. Amaranth. Tropics. A group of plants related to the cockscomb, some with colored foliage, others with coarse red inflorescences. Although they will withstand the hottest and driest locations, their character is such that they must be used sparingly. They often selfsow.

- *A. caudatus.* Love-lies-bleeding. 3 to 5 ft.
- *A. hybridus hypochondriacus.* Princesfeather. 3 to 5 ft. Flowers red, leaves red.
- *A. tricolor.* Josephs-coat. 2 to 4 ft.

Gomphrena globosa. Globe Amaranth. Old World tropics. 1½ ft. The salmon variety is preferable to the white or purple varieties. A long season of bloom. Flowers can be dried.

APOCYNACEAE DOGBANE FAMILY

Vinca rosea. Madagascar Periwinkle. 2 ft. Flowers pink. Also a white variety. Excellent foliage. Constant bloom even under adverse conditions. Start early indoors.

ASCLEPIADACEAE MILKWEED FAMILY

Asclepias curassavica. Bloodflower. Tropical America. 3 ft. Flowers red-orange. Start early for late summer bloom. Excellent foliage.

BORAGINACEAE BORAGE FAMILY

Cynoglossum amabile. Chinese Forget-me-not. East Asia. Blue flowers. 2 to 3 ft. The variety Firmament is dwarf and compact. Removal of old flowers necessary for continuous bloom. Seeds are sticktights.

Myosotis. Forget-me-not.

- *M. sylvatica* (*alpestris*). Europe, Asia. 8 to 12 in. Blue, yellow centers. Also white and pink forms. Best sown in summer or early fall for spring bloom.

CAPPARIDACEAE CAPER FAMILY

Cleome spinosa. Spiderflower. Tropical America. 4 to 5 ft. Pink flowers, strongly scented. Will thrive under most adverse conditions. There is a white variety.

CARYOPHYLLACEAE PINK FAMILY

Dianthus chinensis. Pinks. Portugal to China and Japan. This species and its variety *heddewigi* have given rise to a race of single and double forms, often living over winter to bloom a second year. White, pink, red, and various combinations of these colors are available. They usually bloom throughout the summer.

Gypsophila.

G. elegans. Caucasus. 1 to 1½ ft. Flowers white.

G. muralis. Europe. 1 ft. Flowers white.

The gypsophilas are quick-blooming with a short season of bloom. Several sowings must be made. Largely used as a cut flower.

Lychnis coelirosa. Rose-of-heaven. Mediterranean. Flowers dark rose. There are varieties that are white, red, and combinations. Short season of bloom. Several sowings may be made.

Saponaria vaccaria.' Soapwort. Cow-herb. Europe. 2 ft. Flowers pink. Usually a short season of bloom, calling for several sowings for a succession. Can be used as a filler among perennials. Usually selfsows.

CHENIPODIACEAE PIGWEED FAMILY

Kochia scoparia. Summer Cypress. Europe. 5 ft. A foliage plant with its light green foliage turning reddish in autumn. Often selfsows. May be used for temporary hedges. Most of that in gardens is probably the variety *trichophila,* which is dwarf and compact.

COMPOSITAE COMPOSITE FAMILY

Ageratum houstonianum (*A. mexicanum*). There are many forms ranging from dwarf varieties 4 to 6 in. high up to those 24 in. tall. Except when grown for cut flowers, the dwarf, compact forms are preferable. For uniformity those propagated vegetatively are more satisfactory than those from seed. When grown from seed, sow early indoors. The ageratum sometimes selfsows.

Ammobium alatum. Winged Everlasting. Australia. 2 ft. White flowered.

Calendula officinalis. Pot Marigold. Southern Europe. Ranges in color from almost white to deep orange. There are many named varieties. Preferring a cool climate, best sown early for early summer bloom or late for fall bloom.

Callistephus chinensis. China-aster. China and Japan. At one time China-asters were one of our most important annual flowers. Although wilt-resistant strains are solving one difficulty, the aster yellows is still a serious disease problem unless the plants are grown under cloth. There are a variety of types and wide range of color. Excellent named varieties are available in the following types: Queen of the Market, Royal, Comet, King, Crego, California Giants, American Beauty, and Sunshine. The seeds are preferably sown indoors. They should not be stunted, particularly during the seedling stage.

Arctotis stoechadifolia (*A. grandis*). African Daisy. South Africa. 2½ ft. White to pale violet flowers closing at night.

Brachycome iberidifolia. Swan-river-daisy. Australia. 12 in. White, blue, and pink flowers. A dainty edging plant requiring a cool climate.

Centaurea.

- *C. americana.* Basketflower. Southwestern United States. 3 to 4 ft. Flowers rose.
- *C. cyanus.* Cornflower. Southeastern Europe. 2 ft. White, blue, pink, and purple flowers. Frequently selfsows. There are dwarf varieties. Sow in September for early bloom.
- *C. moschata.* Sweet-sultan. Orient. 2 ft. Flowers white, yellow, or purple. Best results will usually be obtained from early outdoor sowing where they are to bloom.

'osmos.

- *C. bipinnatus.* Mexico. 5 to 8 ft. White, pink, or red flowers. The early-flowering kinds are necessary for the north. Both single and double forms are available.

nilia (*Cacalia*). Tasselflower, Flora's Paint brush. Old World tropics. 18 in. Flowers orange-red, also a yellow form. Free-blooming with showy flowers heads from basal leaves.

Dimorphotheca. Cape Marigold.

- *D. aurantiaca.* South Africa. 12 in. Orange-yellow flowers. There are also hybrids with *D. annua* with white, yellow, orange, or red flowers. They all have a tendency to cease blooming in excessively hot weather.

Jaillardia.

- *G. amblyodon.* Texas. 2 ft. Flowers red.
- *G. pulchella* and its varieties *picta* and *lorenziana* offer flowers in reds and yellows. Southern United States. The annual gaillardias are free blooming throughout the season and very satisfactory. Sow where they are to bloom.

Helianthus. Sunflower.

- *H. annuus.* United States. 6 to 10 ft. Flowers yellow with dark disks. Dwarf and double-flowered forms are available.
- *H. debilis* (*H. cucumerifolius*). United States. 3 to 4 ft. There are varieties with pink and rosy red flowers. Showy plants for July bloom. Inclined to go to seed in late summer.

Helipterum. Everlasting.

- *H. manglesi* (usually catalogued as *Rhodanthe manglesi*). Australia. 18 in. Flowers white and pink.
- *H. roseum* (often listed as *Acroclinium roseum*). Australia. 18 in. to 2 ft. Flowers white and rose. Slender plants. Sow where they are to bloom.

Helichrysum bracteatum. Everlasting. Strawflower. Australia. 3 ft. Flowers white, yellow, orange, and red. Probably the best of the everlastings. Cut before flowers are fully developed.

Leptosyne (properly included in the genus *Coreopsis*). Western United States.

L. stillmani. 1 ft. Bright yellow flowers. Fleshy leaves.

L. maritima. Sea Dahlia. 3 ft. Flowers yellow. Finely divided foliage.

Rudbeckia bicolor. Coneflower. Southern United States. 2 ft. Flowers yellow or yellow and mahogany with dark centers. Varieties Kelvadon Star and My Joy are slightly larger flowered than the species. One of the most satisfactory and best keeping annual flowers with a long season of bloom.

Sanvitalia procumbens. Mexico. 8 in. A trailing plant. Small yellow flowers with dark centers. Used mostly as an edging or a ground cover. Has a long season of bloom.

Tagetes. Marigold. Mexican and South American annuals. *T. erecta,* the African Marigold, from Mexico, and *T. patula,* the French marigold, also from Mexico, have been hybridized until today there are a number of types and hundreds of named varieties, many of them very similar. Selection has produced a practically odorless foliage. The heights range from 12 in. to 5 ft.

Some of the more common types of marigold include

Chrysanthemum flowered
African—tall double
African—dwarf
French—tall double
French—dwarf double
French—tall single
French—dwarf single

T. tenuifolia (T. signata). Mexico. 1 ft. This marigold with small yellow flowers and finely cut foliage is often used as an edging plant.

Tithonia. Mexican Sunflower. Mexico, Central America.

T. rotundifolia (speciosa). 6 to 7 ft. Flowers orange. Late summer blooming unless early variety used.

Venidium fastuosum. South Africa. 18 in. Flowers bright orange ith dark centers. Another one of the annuals doing best in cooler sections.

Zinnia.

Z. linearis. Mexico. 1 ft. Narrow leaves. Orange-yellow flowers.

Z. angustifolia (Z. mexicana). Mexico. 18 in. to 2 ft. Narrow leaves. Small flowers. *Z. haageana* is a broadleaf form.

Z. elegans. Mexico. 3 ft. This species has given rise to all the large-flowered zinnias including

Dahlia flowered—3 ft.
California giants—3 ft.
Fantasy—2½–3 ft.
Scabious flowered—2–3 ft.
Gaillardia flowered—2–3 ft.
Elegans—1½–2 ft.
Lilliput or pompon—1½–2 ft
Cupid—8–12 in.
Tom Thumb—4–8 in.

CONVOLVULACEAE MORNING-GLORY FAMILY

Calonyction aculeatum (*Ipomoea Bona-nox*). Moonflower. Florida and tropical America. Flowers white. Juice milky. Vigorous night-blooming vine. Sow seed early indoors.

Convolvulus tricolor. Dwarf Morning-glory. 12 to 15 in. Southern Europe. Flowers blue. An interesting little plant worthy of wider use.

Ipomoea. Morning-glory.

- *I. nil*, var. *limbata* (*I. imperalis*). Japanese Morning-glory. Tropics. Vigorous, large leaves.
- *I. purpurea*. Common Morning-glory. Tropical America. May become a pest. A number of improved varieties are available including Heavenly Blue, Scarlett O'Hara, Cornell.
- *I. setosa*. Brazilian Morning-glory. Brazil.

Quamoclit. Starglory.

- *Q. sloteri*. Cardinal Climber. Tropical America. Flowers scarlet.
- *Q. pinnata* (*Ipomoea quamoclit*). Cypressvine. Tropical America. Flowers scarlet. There is a white variety.

CRUCIFERAE MUSTARD FAMILY

Alyssum maritimum. (Botanically this plant is now classified as *Lobularia maritima*.) Madwort. Sweet Alyssum. Mediterranean. 8 in. Flowers white. Although usually grown as an edging, can be used equally well in masses in the border. One of the hardiest of annuals, blooming in about 6 weeks from seed. There are many varieties, some slightly colored, some compact, others trailing. They have one of the longest seasons of bloom of any annual.

Erysimum perofskianum (usually listed as *E. asperum*). Blistercress. North America. 2 ft. Orange flowers. Often selfsows.

Iberis. Candytuft.

- *I. umbellata*. Globe Candytuft. Southern Europe. Has flat heads of white, pink, lavender, red, or purple flowers. Is not fragrant.
- *I. amara* (*I. coronaria*). Rocket Candytuft. Elongated spikes of fragrant white flowers. There are many forms and named varieties of both these species. Cool-season plants, they stop blooming in summer with higher temperatures.

Lunaria annua (*L. biennis*). Honesty. Europe and Asia. 2 to 3 ft. A rather coarse annual with reddish-purple flowers resembling those of the radish in form. Followed by round, flat seed pods, which when the outer coat is stripped off leaves the silvery disk used for winter arrangements. Often acts as a biennial.

Matthiola.

- *M. bicornis*. Evening Stock. Europe and Asia. 1 ft. Fragrant lavender flowers, open only in the evening.
- *M. incana*. Stock. Europe. This species and its variety *annua* Ten Weeks Stock, one of the most satisfactory garden flowers for

foliage and blooms in cool climates. Will not bloom in warm sections. Colors range from white to pink to lavender to yellow to red to purple. Single and double forms.

CUCURBITACEAE GOURD FAMILY

Cucurbita pepo var. *ovifera*. Gourd. Yellow flower. Small fruit.

Lagenaria leucantha. Gourd. White flowers. Usually large fruits.

Echinocystis lobata. Wild Cucumber. United States. Selfsows to become a pest.

Momordica.

M. balsamina. Balsamapple. Tropics.

M. charantia. Balsampear. Tropics.

DIPSACEAE TEASEL FAMILY

Scabiosa. Scabious. Also called mourning bride and pincushion flower.

S. atropurpurea. Sweet Scabious. Southern Europe. 3 to 4 ft. Has been a source of many forms and varieties, some dwarf. Flowers white, pink, yellow, rose, blue, maroon, and purple. There has been much improvement in the varieties in the last few years. Usually has a long season of bloom. An excellent cut flower.

EUPHORBIACEAE SPURGE FAMILY

Euphorbia. Spurge.

E. marginata (*E. variegata*). Snow-on-the-mountain. Central United States. 1 to 2 ft. White flowers. Leaves white on the edges. Usually selfsows to the extent of becoming a pest. Sap poisonous to human skin.

E. heterophylla (often catalogued as *Poinsettia heterophylla*). Mexican Fireplant. Southern United States to Central America. 2 to 3 ft. Upper leaves blotched with red. Somewhat overrated as a garden plant.

HYDROPHYLLACEAE WATERLEAF FAMILY

Nemophila insignis. California. Low-growing, cut-leafed, blue-flowered annual with a short season of bloom except in cooler sections.

Phacelia. Native California annuals whose nomenclature seems confused in the trade. *P. campanularia*, 8–12 in., and *P. whitlavia*, 8–12 in., are usually listed. Bright blue flowers. Short season of bloom except in cooler sections. Sow in pots indoors or where they are to bloom.

LABIATAE MINT FAMILY

Perilla frutescens. Orient. The variety *crispa* with purplish or bronze foilage is the form commonly grown. Resembles *Coleus*. Usually selfsows. Height 2 ft. Grown entirely for its dark decorative foliage.

Salvia. Sage.

S. farinacea. Mealycup Sage. Texas. 3 ft. Flowers violet-blue. Stems whitish. Often selfsows. Sometimes perennial.

S. splendens. Scarlet Sage. Brazil. Sow early indoors, or propagate by cuttings. Dwarf varieties available. Many prefer the pink-flowered form to the brilliant scarlet of the species. The purple form is not particularly satisfactory.

LEGUMINOSAE PEA FAMILY

Lathyrus odoratus. Sweet Pea. Italy. Several types are available—winter-flowering Spencer for greenhouse culture; late-flowering Spencer for garden use; *Grandiflora* for garden use. Var. *nanellus*—dwarf sweet pea, cupid sweet pea. 12 in. high.

For summer bloom, deep soil preparation essential. Seed may be sown in late November on ridge of soil or in late February or early March. If soil is prepared properly, old method of sowing in trench and filling in as vines grow not necessary. Summer control of red spider necessary.

Dolichos lablab. Hyacinth-bean. Vigorous vine. Variety. Darkness, lavender flowers, purple seed pods, and purple stems, very striking.

Lupinus. Showy annuals satisfactory in some sections, not in others. Difficult to transplant; sow in place where they are to bloom.

L. hartwegi. Mexico. 2 to 3 ft. Flowers blue and rose.

L. hirsutus. Southern Europe. Flowers blue.

L. luteus. Southern Europe. 2 to 3 ft. Flowers yellow. Removal of old flowers has a tendency to lengthen the season of bloom.

Phaseolus coccineus (*P. multiflorus*). Scarlet Runner Bean. Tropical America. Vigorous vine, red flowers, pods edible. There is a dwarf form.

LINACEAE FLAX FAMILY

Linum grandiflorum. Flowering Flax. North Africa. 1 to 1½ ft. Red flowers. A striking plant worthy of more extensive use.

LOBELIACEAE LOBELIA FAMILY

Lobelia erinus. South Africa. There are a number of varieties of this commonly used edging plant, some dwarf, some erect. Flowers usually dark blue. In warmer sections best grown in partial shade. Constant bloomer throughout the season. Selected forms may be carried over winter in the greenhouse and propagated by cuttings.

LOASACEAE LOASA FAMILY

Mentzelia lindleyi (*Bartonia aurea*). California. 3 ft. Shiny yellow flowers, fragrant. Finely cut foliage. Difficult to transplant. Grow in pots, start early indoors.

MALVACEAE MALLOW FAMILY

Althaea rosea. Hollyhock. China. There are annual varieties, similar to perennials. Sown in spring will bloom in August. Often blooms a second summer.

Lavatera trimestris (*L. rosea*). Treemallow. Mediterranean region. 4 to 6 ft. Flowers rose or red. May be used as a background plant.

Malva sylvestris. Mallow. Europe. 3 ft. Flowers lavender-rose. Occasionally grown in gardens.

NYCTAGINACEAE FOUR-O'CLOCK FAMILY

Mirabilis jalapa. Four-o'clock. Tropical America. 3 ft. Red, yellow, or white flowers. Planted against house foundations will occasionally live over winter. Tuberous roots may be taken up and stored like dahlias. Flower colors a little difficult to use.

PLUMBAGINACEAE LEADWORT FAMILY

Limonium (Statice). Sea-lavender. Usually cataloged as *Statice.*

L. bonduelli. Algeria. 2 ft. Yellow flowers.

L. sinuatum. Mediterranean region. 2 ft. There are white, pink, and lavender varieties. One of the best Limoniums.

L. suworowi. Turkestan. 2 ft. Slender spikes of pink flowers

All the Limoniums may be dried as strawflowers.

POLEMONIACEAE PHLOX FAMILY

Gilia capitata. Western United States. 2 ft. Flowers light blue in light and airy heads. A short season of bloom.

Phlox drummondi. Annual Phlox. Texas. 6 to 12 in. There are a number of varieties, including dwarf, large-flowered, and star-flowered forms. Colors range from white, cream, pink, and lavender to purple. Usually has a long season of bloom.

POLYGONACEAE BUCKWHEAT FAMILY

Polygonum orientale. Princesplume. Asia. 6 ft. Slender, drooping spikes of pink flowers.

PORTULACACEAE PURSLANE FAMILY

Portulaca grandiflora. Rose Moss. Brazil. 6 to 12 in. White, pink, red, yellow, and lavender flowers, single and double forms. The newer named varieties are preferable to the older types. Usually selfsows profusely.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Clarkia.

C. elegans. California. 3 ft. Flowers purple to pink to white.

C. pulchella. Western United States. 18 in. Flowers pink to white. Single and double forms. Best sown where they are to bloom.

Godetia.

G. grandiflora. California. 1 to 1½ ft. Flowers white, pink, and red, with darker centers. Excellent in cooler climates, or under partial shade in warmer climates. There are a number of other species, all native to the Pacific coast.

Oenothera. Rather coarse annuals for sunny locations. Best sown in early spring where they are to bloom.

O. acaulis (often catalogued as America). Dandelion-leaved Sundrop. Chile. Flowers white to blush.

O. drummondi. Texas. 2 ft. Flowers yellow.

O. rosea. Southwestern United States. 2 ft. Flowers rose-purple.

Most evening-primroses open in the late afternoon and close the next morning.

PAPAVERACEAE POPPY FAMILY

Argemone grandiflora. Prickly Poppy. Mexico. 2 to 3 ft. White-veined leaves. White flowers. Often selfsows.

Eschscholtzia californica. California-poppy. Western United States. 8 to 12 in. Yellow or orange flowers and gray-green foliage. Many varieties are available, ranging in color from white through yellow and orange to pink and red. Selfsows. May be fall or early spring sown. Grows under exceedingly dry conditions.

Hunnemannia fumariaefolia. Mexican Tulip-poppy, Goldencup. Mexico. 18 in. to 2 ft. Shiny yellow flowers and finely cut gray-green foliage, making a striking combination. Variety Sunlight has an extra row of petals. Seed best sown early indoors. Difficult to transplant unless pot grown.

Papaver. Poppy.

P. rhoeas. Corn Poppy. Europe and Asia. 2 to 3 ft. Flowers white or red or combinations of these. The Shirley poppies are one of the varieties of this species. Dainty and airy. Often selfsow.

P. somniferum. Opium Poppy. Greece to the Orient. 3 to 4 ft. Flowers pink, red, purple, or white, in both single and double forms. This species includes the tulip-, peony-, and carnation-flowered poppies. Illegal to grow in the United States. They usually selfsow.

RANUNCULACEAE BUTTERCUP FAMILY

Delphinium. Larkspur. Oddly enough, catalogues have accustomed the gardening public to think of larkspurs as annuals and delphiniums as perennials, although the two names are synonymous. Annual larkspurs are cool-season plants probably best sown in September for spring bloom; otherwise, sown where they are to bloom in March or early April. Available types include Giant Imperial, Tall Double Stock-flowered, Tall Hyacinth-flowered, and Dwarf Imperial.

D. ajacis. Rocket Larkspur. Southern Europe. This species is largely responsible for the various annual forms available today. The flowers are white, pink, red, blue, or purple in both single and double forms. In warm climates they are good only for early spring bloom.

Nigella. Fennel Flower.

N. damascena. Love-in-a-mist. Europe. 1 to 1½ ft. Flowers light blue to white. Finely cut foliage. An old-fashioned annual persisting for years from selfsowing.

RESDACEAE MIGNONETTE FAMILY

Reseda odorata. Mignonette. North Africa. Flowers yellowish white, fragrant. There are a number of different varieties of this annual, which is usually grown for its fragrance. Difficult to transplant. Should be sown in pots or where they are to bloom. Not satisfactory with higher summer temperatures.

RUBIACEAE MADDER FAMILY

Asperula orientalis. Woodruff. Europe and Asia. 1 ft. Blue flowers, dainty, but often short season of bloom.

SAPINDACEAE SOAPWORT FAMILY

Cardiospermum halicacabum. Balloonvine. Southern United States. Flowers white. Fruit inflated, three-angled.

SCROPHULARIACEAE FIGWORT FAMILY

Antirrhinum majus. Snapdragon. Mediterranean. One of the standard cut flowers among the annuals. There are dwarf, intermediate, and tall forms. Preferably started early indoors. Only rust-resistant strains should be used. Obtainable in individual colors as well as in mixtures. Start early indoors for early bloom.

Collinsia. United States.

- *C. grandiflora.* Bluelips. 12 to 15 in. Flowers blue and white. Summer blooming. Prefers cool climate.
- *C. verna.* Blue-eyed-mary. 12 in. Blue and white flowers. Spring blooming. Sow in September where they are to bloom.

Linaria maroccana. Toadflax. Morocco. 1 to 1½ ft. Flowers white, blue, yellow, pink, red, purple. The linarias are all cool-season plants with a relatively short blooming period except in cool climates.

Mimulus. Monkeyflower.

- *M. luteus.* Chile. 1 ft. Flowers yellow, spotted with red.
- *M. moschatus.* Western United States. 1 ft. Flowers yellow, spotted brown.

Colorful annuals, preferring a cool, moist location. May selfsow.

Nemesia. Colorful annuals which bloom if the summer temperatures are not too high.

- *N. strumosa* and *N. versicolor.* South Africa. 1 to 1½ ft. Flowers white, yellow, pink, lavender, and combinations of these colors. There are dwarf forms. The hybrid forms usually offered in the trade are larger flowered than the species. Best started early indoors.

SOLANACEAE NIGHTSHADE FAMILY

Browallia.

- *B. americana (B. demissa, B. elata).* Tropical American. 2 ft. Blue flowers. Long season of bloom. Often selfsows.

B. speciosa. Columbia. 2 ft. Bluish-purple flowers. Large-flowei form may be carried over winter as a pot plant. Both species shoı be started early indoors to obtain satisfactory bloom.

Nicotiana. One of the most satisfactory annuals with a long period bloom. Often selfsows.

N. alata (*N. affinis*). South America. 5 ft. Fragrant white flow open at night.

N. sanderae (a hybrid form). 3 ft. Has a number of varieties w pink, red, and lavender flowers.

N. sylvestris. Argentina. 5 ft. Fragrant white flowers.

Petunia hybrida. Common Garden Petunia. Original species caı from Argentina. The many varieties are divided into a number of grou none of which is any too well defined. Following are some of the mo common divisions:

Bedding Hybrids. Free-blooming, medium-large flowers. Variet include Topaz Rose, Hollywood Star, Flaming Velvet, Violacea.

Balcony (*pendula*). Vigorous, more or less trailing. Varieties inclu Rose, White, Star of California, Black Prince.

Dwarf (*nana compacta*). Varieties include Cream Star, Lady Bird, R of Heaven, Twinkles, Glow, Rosy Morn.

Giant (*grandiflora*).

Plain—Snow Queen, Elks Pride
Ruffled—Copper Red, Robin Hood, Silver Rose
Fringed—Theodosia, Fluffy Ruffles
Double—usually mixed colors
Dwarf—Lace Veil, Gaiety, Setting Sun

Sow seed early indoors. Selected large-flowered varieties propagated cuttings.

Salpiglossis sinuata. Painted Tongue. 2 to 2½ ft. Chile. One of t best annuals for cool climates. Seed should be started indoors. Flow yellow, pink, red, lavender, and purple with contrasting colored veins.

TROPAEOLIACEAE NASTURTIUM FAMILY

Tropaeolium. Nasturtium.

T. majus. Garden Nasturtium. 12 in. South America. A numb of varieties including *nanum,* Tom Thumb. Dwarf, semidoul varieties available. Golden Gleam and others. Gleams are climbi

T. peltophorum (*T. lobbianum*). Climbing Nasturtium. South Am ica. Vine. 6 to 8 ft. Available in a variety of colors.

T. peregrinum. Canary Nasturtium. South America.

UMBELLIFERAE PARSLEY FAMILY

Trachymene caerulea (*Didiscus caerulea*). Blue Laceflower. Austral 2 ft. Blue flowers. Finely cut foliage. Difficult to grow even when se are sown where they are to bloom.

VERBENACEAE VERVAIN FAMILY

Verbena.

V. pulchella (*V. erinoides*). South America. 6 to 12 in. Creeping plants with finely divided leaves and lavender flowers, grown more for foliage effect than for bloom. One of the best annual ground covers.

V. rigida (*V. venosa*). South America. Although perennial in mild climates, it makes an excellent annual. 12 to 18 in. Flowers lavender. A harsh, stiff plant, spreading rapidly where hardy.

V. hortensis (*V. hybrida*). Garden Verbena. There are a number of forms, the normal one decumbent and spreading, but there are also dwarf, compact, and upright-growing types. Colors white, pink, red, lavender, and purple. Seeds should be sown early indoors or propagated from cuttings in greenhouse. One of the best all-season bloomers.

VIOLACEAE VIOLET FAMILY

Viola tricolor hortensis. Pansy. Seed usually sown in August. Protected in frames or under mulch over winter. May also be sown under glass in January or February. Prefers cool season. Will have a long season of bloom only in partial shade at higher temperatures. There are many different strains.

White-flowered Annuals

Alyssum	Datura	Matricaria
Ammobium	Delphinium	Mirabilis
Antirrhinum	Eschscholtzia	Nicotiana
Argemone	Godetia	Papaver
Callistephus	Gypsophila	Petunia
Centaurea cyanus	Iberis	Scabiosa
Chrysanthemum	Lathyrus	Vinca rosea
Clarkia	Limonium	Zinnia
Cosmos	Matthiola	

Annuals with Blue, Lavender, or Purple Flowers

Anchusa	Lobelia	Phacelia
Browallia	Matthiola	Salpiglossis
Centaurea	Myosotis	Salvia
Convolvulus tricolor	Nemophila	Scabiosa
Cynoglossum	Nigella	Trachymene
Delphinium	Papaver	Verbena
Gillia	Petunia	Zinnia
Iberis	Phlox	

Annuals with Yellow Flowers

Antirrhinum	Celosia	Coreopsis (Calliopsis)
Asclepias	Centaurea	Dimorphotheca
Calendula	Chrysanthemum	Emilia

Eschscholtzia
Gaillardia
Helianthus
Helichrysum
Hunnemannia
Limonium
Mirabilis
Nemesia
Oenothera
Salpiglossis
Sanvitalia
Scabiosa
Tagetes
Tropaeolum
Zinnia

Annuals with Red or Pink Flowers

Althaea
Amaranthus
Antirrhinum
Callistephus
Celosia
Centaurea
Clarkia
Cleome
Cosmos
Delphinium
Emilia
Gaillardia
Gomphrena
Helianthus
Iberis
Limonium
Linum
Lunaria
Mimulus
Mirabilis
Nemesia
Petunia
Phlox
Salpiglossis
Salvia
Scabiosa
Tropaeolum
Verbena
Vinca rosea
Zinnia

Annuals for Cut Flowers

Ageratum
Antirrhinum
Arctotis
Browallia
Calendula
Callistephus
Centaurea
Chrysanthemum
Coreopsis (Calliopsis)
Cosmos
Delphinium
Dianthus
Dimorphotheca
Gaillardia
Helianthus
Iberis
Lathyrus
Lavatera
Limonium
Matthiola
Matricaria
Nemesia
Papaver
Phlox
Reseda
Rudbeckia
Salpiglossis
Salvia farinacea
Scabiosa
Tagetes
Tropaeolum
Verbena
Viola
Zinnia

Annuals with a Long Season of Bloom

Ageratum
Alyssum
Antirrhinum
Browallia
Celosia
Chrysanthemum
Cosmos Orange Flare
Dianthus
Emilia
Eschscholtzia
Gaillardia
Gomphrena
Hunnemannia
Limonium
Lobelia
Matthiola
Petunia
Phlox
Salvia
Sanvitalia
Tagetes
Verbena
Vinca
Zinnia

Annuals with a Short Season of Bloom

Brachycome
Centaurea cyanus
Clarkia
Collinsia
Coreopsis (Calliopsis)
Dimorphotheca
Delphinium
Gilia
Gypsophila
Helianthus
Iberis
Linaria

Lunaria	Papaver	Saponaria
Myosotis	Phacelia	Venidium
Nemophila	Reseda	

Annuals Best Sown Where They Are to Bloom

Argemone	*Gypsophila*	*Papaver*
Centaurea	Helipterum	Portulaca
Collinsia (September)	Mentzelia	Reseda
Eschscholtzia	Nigella	Tropaeolum

Annuals That Often Selfsow

Ageratum	Cosmos	Mirabilis
Amaranthus	Convolvulus	Nicotiana
Antirrhinum	Delphinium	Nigella
Argemone	Eschscholtzia	Papaver
Browallia	Euphorbia marginata	Perilla
Calendula	Godetia	Petunia (small-flowered)
Centaurea	Gypsophila	Portulaca
Clarkia	Impatiens	Salvia farinacea
Cleome	Ipomoea	
Coreopsis (Calliopsis)	Kochia	

Annuals for the Rock Garden

Abronia	Gazania	Sanvitalia
Ageratum	Iberis	Silene
Alyssum	Lobelia	Tagetes (dwarf varieties)
Browallia	Myosotis	Torenia
Dianthus	Nierembergia	Verbena
Dimorphotheca	Petunia	Viola
Emilia	Phlox	Zinnia
Eschscholtzia	Portulaca	

Annuals for Porch and Window Boxes

Ageratum	Dimorphotheca	Sanvitalia
Alyssum	Gomphrena	Tagetes
Antirrhinum	Hunnemannia	Thunbergia
Browallia	Lobelia	Verbena
Calendula	Nicotiana	Vinca rosea
Celosia	Nierembergia	Viola
Convolvulus	Perilla	Zinnia
Dianthus	Phlox	

Annuals for Hot, Dry Places and Poor Soil

Argemone	Coreopsis (Calliopsis)	Phlox
Celosia	Eschscholtzia	Portulaca
Cleome	Petunia (small-flowered)	
Convolvulus		

Some Interesting Groupings of Annuals

Ageratum and calendula
Tasselflower and browallia
Spiderflower and nicotiana
Gaillardia, petunia, and verbena
Mexican zinnia and ageratum
Pricklepoppy, French marigolds, and Cape Bugloss
Calendula and mealycup sage
Cape Bugloss and marigold
California poppy, cornflower, and French marigold
Nemesia, stocks and ageratum
Gypsophila, Cape-marigold, and browallia
Snapdragon, phlox, and spiderflower
Cosmos, spiderflower, and giant zinnia
Pricklepoppy, perilla, and nicotiana
Clarkia, browallia, and mignonette
Perilla, snow-on-the-mountain, and summer-cypress
Tasselflower and ageratum
Pinewoods coneflower, gaillardia, and gypsophila
Gilia, striped marigold, and Chinese forget-me-not
Chinese forget-me-not and calendula
Forget-me-nots and gypsophila
Flax and ageratum
Salpiglossis, French marigolds
Thrift, Oriental Woodruff, and calliopsis

Annuals Preferring a Cool Climate

Antirrhinum
Brachycome
Calendula
Centaurea
Chrysanthemum
Delphinium
Iberis
Lathyrus
Lobelia
Lupinus
Matthiola
Nemesia
Nemophila
Phacelia
Reseda
Salpiglossis
Saponaria
Vaccaria
Venidium
Viola

Annual Vines

Calonyction aculeatum (Ipomoea bona-nox)—Moonflower
Cardiospermum halicacabum—Balloonvine
Cucurbita pepo var. ovifera—Gourd
Echinocystis lobata—Wild cucumber
Dolichos lablab—Hyacinth-bean
Ipomoea nil limbata (imperialis)—Japanese morning-glory
Ipomoea purpurea—Common morning-glory
Ipomoea setosa—Brazilian morning-glory
Lagenaria leucantha—Gourd
Momordica balsamina—Balsam-apple
Momordica charantia—Balsam-pear
Phaseolus coccineus—Scarlet runner bean
Quamoclit sloteri—Cardinal climber
Quamoclit pinnata (Ipomoea quamoclit)—Cypressvine
Thunbergia alata—Black-eyed Clockvine
Tropaeolium peregrinum—Canary nasturtium
Tropaeolium peltophorum—Climbing nasturtium

Annuals for Ground Covers

Alyssum	Petunia (balcony and bedding types)	Quamoclit pinnata
Dolichos lablab	Phaseolus coccineus	Sanvitalia
Eschscholtzia	Portulaca	Tropaeolium (climbing)
Ipomoea	Quamoclit sloteri	Verbena pulchella
Nierembergia gracilis		Verbena rigida

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CHAPTER XI

PERENNIALS

Perennial flowers have long been the dominant plants in flower gardens, the backbone of the flower border. This is partly due, no doubt, to their relative permanence but also to their appeal to gardeners, both beginners and advanced amateurs. Permanence, and with it the more or less lack of care and upkeep, is apparently the desire of every homeowner. The definition of perennials encourages this, in that it means that if once planted they come up year after year. Horticulturally in any discussion of them, we usually include biennials, those whose seed sown one year bloom the next year and then usually die. Experience shows, however, that all perennials are not permanent. Some live over only when conditions are favorable, although some may live on for a generation or more.

Perennials should not be confused with certain hardy annuals such as the cornflower, the mature plants of which die in the fall whereas summer-sown seedlings may live over winter or come up anew each spring from self-sown seed. There are a number of similar annuals often confused with perennials.

On the other hand, the popular belief is that perennials are expensive and more difficult to grow than annuals and consequently should be planted only under permanent conditions. Perennials from seed cost no more per plant than annuals from seed, except for the wait of the extra season for them to bloom. Perennial plants are often no more expensive than annual plants of the same relative size.

Every garden offers unlimited possibilities for the use of perennials for bloom, for foliage effects, or as ground covers.

In flower beds the possibilities are tremendous, for perennials are of many kinds—some low growing, some tall, some intermediate. They offer many and various habits of growth and practically all the colors of the rainbow, different seasons of bloom, and diverse types of foliage. The many kinds may be combined in various ways to secure different effects suited to each individual location and to the taste of the individual gardener. A satisfactory working knowledge of perennials can be obtained only by constant contact with them either in nurseries or preferably in gardens where their response to varying conditions may be observed.

WHERE PERENNIALS MAY BE USED

The perennial border, sometimes called the mixed-flower border, makes the most advantageous use of perennials. Such a border requires a background. It may consist of a shrub hedge, an evergreen hedge, a mixed-shrub border, a vine-covered fence or trellis, or a vine-covered wall to set the flowers off to advantage. A border may vary from a few feet to a hundred or more in length. The width should be at least 3 ft. for a short border and up to 5 or 6 ft. or even wider for a border 20 ft. or more in length. An open, sunny location should be selected. It is possible to have flowers near shade trees. Although such a border may be planted with shade-tolerant plants, best results will be obtained if a half day or more of sun is available. The competition of the roots of large trees or even large shrubs is detrimental to best results.

The shrub border offers an opportunity to use small groups of perennials, especially where space does not permit of a wider border planting. These groups may be of a single kind or of several kinds, *e.g.*, a group of coreopsis or foxglove with sweet-william in front. Even hollyhocks or plumed poppies may be used in front of the taller shrubs and behind the low ones to give a touch of bloom when shrubs are not in flower. The more rampant and invading perennials may be used in this way rather than in the border where they compete with the less vigorous species. Endless possibilities suggest themselves in the average garden for this type of planting.

As Ground Covers and Grass Substitutes. There is probably no garden that does not have areas here and there where grass is either difficult to grow or inconvenient to care for but that need some suitable plant growth to hide the bare soil. This would include banks and terraces, bare ground beneath old shrubs, the space between newly planted shrubs and evergreens, the area beneath large shade trees, the narrow space between the drive and the sidewalk, and dozens of others. The list on page 270 suggests plants for all these various uses. Here, again, is the place to use those low-growing plants which are inclined to crowd out others in the border such as lily-of-the-valley.

Shade Gardens. Shade need not be a limiting factor for the growth of perennials if those that are tolerant of shade are planted. Usually under these conditions adequate soil preparation, fertilization, and early fall planting are even more important than under normal conditions. A list of shade-tolerant perennials will be found on page 292.

Wild Gardens. Although normally wild gardens are planted with spring-flowering native plants, there is no reason why shade-tolerant perennials may not be naturalized under these conditions. They will require less soil preparation than will most wild flowers.

Naturalized Perennial Flowers. Although all gardens do not offer the same conditions, many of them have an ideal place for the naturalization of perennials. A back corner, the area behind the garage, a strip across the back where the right of way does not permit of more permanent planting may be planted to the more vigorous perennials, usually our native roadside and field species that can thrive under these conditions (see list on page 292).

Perennials for the Cutting Garden. For those who prefer to leave the bloom in their borders undisturbed, a cutting garden is desirable. Here should be grown the perennials and annuals best adapted to this purpose. They are best planted in rows and should be well fertilized and watered if they are to give the maximum amount of bloom (see list on page 292).

Some gardeners feel that the effect obtained from an extensive flower border is not worth the effort in their climate and, therefore, grow the bulk of their hardy flowers in rows in the vegetable garden. They are much easier to care for and often grow better under these conditions.

Perennials for Screens and Backgrounds. Where space is lacking and year-around effects are not desired, the taller growing perennials may serve as shrubs to furnish a screen for privacy or as a background for the lawn or for a lower planting. The more vigorous perennials that may be used for this purpose include

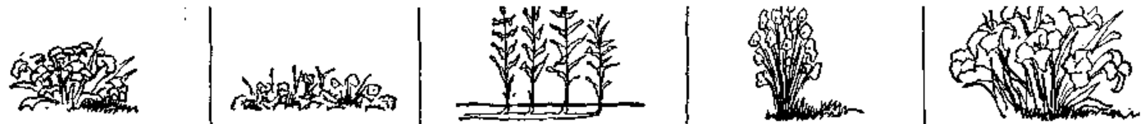
Macleaya (Bocconia) cordata, Helianthus orgyalis, H. maximiliani, Hibiscus, and *Polygonum sachalinense.*

FACTORS TO CONSIDER IN THE SELECTION OF PERENNIALS

Season of Bloom. By the selection of those perennials blooming at different seasons, from early spring until late fall, a succession of bloom may be obtained. There are no perennials that give continuous bloom, although some may remain in bloom over a period of several months. Where space is limited and the number of kinds must be kept low, those having longer periods of bloom should be selected. An easy method of planning for succession of bloom is to list the perennials in bloom in your garden each month or even each week. Then plan to add a sufficient number to bloom at those dates when nothing else is in bloom. *Usually early spring and fall are the weak periods* in a flower border (see list on page 288). An outline such as that in Fig. 60 will simplify the procedure.

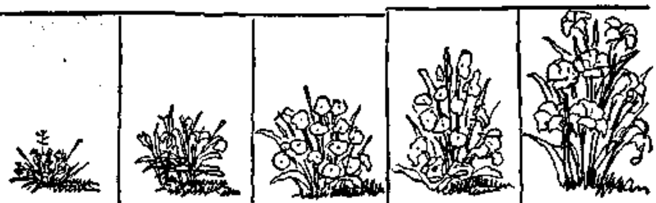
Habits of Growth. The need of considering the growth habits of the various perennials cannot be overemphasized. First, the height. Just how tall do established plants grow? Second, the form of growth, *i.e.*, if they are upright so that they may be used in a more or less restricted space, as *Delphinium* and *Phlox;* if they are sprawling and as such likely to smother adjacent plants, as is the case with the peony and coreopsis; or if they are creeping, spreading, and rooting, as are the various thymes and *Phlox subulata.* Still others may be invaders, spreading by underground stems and crowding out all neighbors, as in the case of *Bocconia, Physostegia*, and *Physalis.* This type of perennial is best planted by itself or among the shrubs. Others are compact and restricted in their habit of growth so that they will never encroach on the habits of their neighbors. Examples of these will include the *Primula* and *Incarvillea.* Since space prevents a complete classification, the table on page 261 gives a general idea of the habits of some of the more common varieties.

Foliage Characteristics of Perennials. Good foliage throughout the season is essential to the appearance of the perennial border. Wherever perennials alone are used, the majority of plants especially in the foreground should be those which have this quality. On the other hand, those which die down after blooming, as do the bulbs, the oriental poppy, and the bleeding-



Height	Compact	Spreading-rooting	Underground-stems suckering	Erect	Sprawling
Under 12 in.	Anemone pulsatilla Bellis perennis Bergenia (Saxifraga) cordifolia Campanula carpatica Dicentra eximia Euphorbia polychroma Festuca glauca Lychnis haageana Primula Sedum sieboldi Veronica incana	Ajuga Arabis Campanula garganica Dianthus deltoides Myosotis scorpioides Phlox subulata Saxifraga sarmentosa Sedum (most var.) Thymus Veronica teucrium Vinca	Campanula poschscharskyana Ceratostigma Convallaria Euphorbia cyparissias	Phlox divaricata	Alyssum Euphorbia myrsinites Nepeta mussini Oenothera missouriensis
1–2 ft.	Anchusa barrelieri Aquilegia flabellata nana Filipendula hexapetala Geum Helleborus Heuchera Hosta lancifolia Incarvillea Linum perenne	Ranunculus acris Ranunculus repens	Achillea ptarmica Coreopsis verticillata Oenothera speciosa	Lilium concolor Polemonium caerulea Stokesia	Clematis integrifolia
2–3 ft.	Aquilegia Clematis recta Delphinium chinensis Yucca		Eupatorium coelestinum Physalis	Asclepias tuberosa Belamcanda Chelone lyoni Doronicum Hesperis Lilium amabile Lilium umbellatum Veronica spicata	Anthemis tinctoria Gaillardia Gysophila paniculata
3–4 ft.	Baptisia Clematis heracleifolia Dictamnus Hemerocallis Lupine Lychnis chalcedonica		Asters (most var.) Campanula trachelium Monarda Physostegia Valeriana	Aconitum Anchusa Digitalis Filipendula rubra Liatris Phlox Salvia azurea	Pentstemon barbatus Peony
Over 4 ft.	Lythrum		Helianthus Macleaya (Bocconia) Polygonum		Buddleia Most asters Polygonum

FIG. 59.—Selecting perennials by their habit of growth.



	Less than 12 *in.*	1–2 ft.	2–3 ft.	3–4 ft.	Over 4 ft.
Mar. early					
Mar. late					
Apr. early					
Apr. late					
May early					
May late					
June early					
June late					
July early					
July late					
Aug. early					
Aug. late					
Sept. early					
Sept. late					
Oct. early					
Oct. late					

Use the lists of perennial flowers on pages 270–288 and annual flowers on pages 241–252 *to make out your own list.*

FIG. 60.—Planning for succession of bloom.

heart, should be so planted that the space is covered by the foliage plants or their place taken by annuals (see list on page 241). Ample amounts of good green foliage will frequently soften many otherwise harsh color combinations. All too often, insufficient green foliage is visible, resulting in a garish effect from too many flowers. This is especially true when annuals are combined with perennials.

Permanence and Hardiness. The more permanent and hardy the plants selected the less will be the upkeep, the care, and the replacement. Unfortunately, a number of perennials, although not biennials, are best treated as such, since their bloom is greatly reduced after the second or third season, as is the case with *Gaillardia*, *Coreopsis*, Shasta daisy, *Anthemis*, and others. Most perennials, except those in the list on page 293, should be divided and replanted every few years for best results.

Ease of Culture. Closely allied to the question of permanence is the ease or the difficulty with which the various kinds may be grown. This will naturally vary according to locality. For instance in the cooler summer climates *Delphinium*, *Aconitum*, and *Phlox* are relatively easy to grow and establish permanently, but in the warmer sections many difficulties are encountered. *Liatris*, *Incarvillea*, and *Gentiana* are but a few examples that should not be attempted by the beginner. Observation of varieties growing in neighboring gardens is the best basis for selecting easily grown kinds. Similarly, until experience is acquired, less expensive varieties should be planted. All perennials do better with proper soil preparation and adequate soil drainage.

PLANNING THE BORDER

Every flower bed and border should be planned on paper previous to planting. First, depending upon the size of the border, a certain number of kinds should be selected to bloom during each month of the season from March until October. Depending upon the available width, various heights should be selected, ranging from dwarf forms for the front to the tallest for the back. Narrow borders of 3 ft. will have space for but two heights at most, whereas borders 5 to 6 ft. in width may have three to four different heights. Fill in the chart in Fig. 60 with the kinds of plants you have or want. For succession of bloom at least one plant should be indicated in each one of the sections of the chart. In some cases one plant will bloom over a period of a month or more, and its name may appear several times in the chart. After the selection of plants has been made, the next step is the development of the general plan showing the actual placement of the plants in the border. During March, April, and May low-growing forms may be used even in the back of the border. This applies particularly to the spring bulbs, crocus, muscari, narcissus, hyacinth, and tulip, which may be planted in colonies throughout the border. As indicated in Fig. 61, the bloom to be

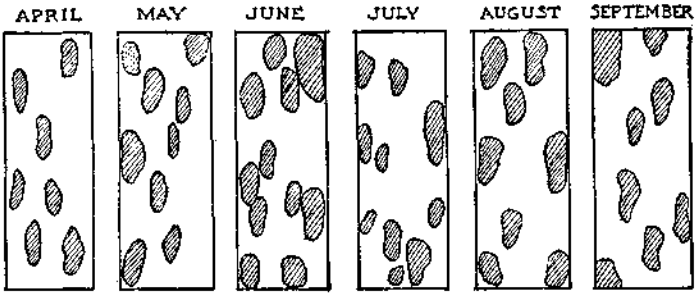


FIG. 61.—Bloom placement chart.

obtained each month of the season should be scattered throughout the border. Although the scheme of making a separate plan for each month of the year is more complicated, it may simplify the planning for the beginner. By the use of perennials, annuals, hardy bulbs, and tender bulbs a succession of bloom may be obtained. Zinnias may be planted above narcissus, gladiolus between coreopsis, nasturtiums above crocus, lilies between phlox, and marigolds above hyacinths.

Occasionally larger accents may be desired in the flower border. They may be obtained by using shrubs with either attractive foliage such as *Mahonia* or *Abelia* or a long season of bloom such as *Buddleia* and *Vitex*. The large shrubs should be planted only in relatively large borders. The number of perennial plants of any one kind to use will depend on the size of the border. In a small border possibly but a single plant may be used, whereas in a larger one a half dozen or a dozen may be necessary. A good basis for determination is the distance from which the border is to be viewed. There should be enough bloom of any one kind to be easily seen from a normal distance.

For maximum effect the border should be at least 5 or 6 ft.

in width. Where space is limited, borders 3 to 5 ft. wide may be planned. Length and width will depend on the desire for flowers; ability to care for them; and, of course, the landscape design of the plot. The layman's tendency is to plant more than can be properly cared for.

Color Combinations. The time and effort spent on planning color schemes and color combinations will be determined by the interest and the ability of the gardener. Combinations of certain colors or favorite groupings of varieties may be included in planning the border. These will vary with the individual taste of the planner. Much emphasis has been given in garden literature to the need of proper color combinations. Possibly this is as it should be. However, very lovely effects can be obtained by merely having an adequate amount of healthy, vigorous foliage to act as background for the bloom and a buffer between any chance discordant colors. Using this method alone, surprisingly few unfavorable effects develop. It is, therefore, a matter of personal choice whether color combinations are to become a hobby or a nightmare. Gardening is a unique combination of science, art, and actual experience.

Plant Combinations. The more advanced flower gardener often thinks of a flower garden not in terms of color combinations so much as in the pleasing combination of two or three varieties blooming at the same time. This may consist of combining perennials, of harmonizing annuals and perennials, or of creating pictures with garden flowers in front of shrubs or lilies against evergreens. In many ways this form of planning has more possibilities and a greater degree of satisfaction than color combinations alone. It might be kept in mind when visiting gardens, and records made of all striking or pleasing groups of plants. Naturally this will vary from one locality to another and even from one season to another in any one garden. Possibly that fact adds to the fascination.

PROPAGATION OF PERENNIALS

Most perennials are no more difficult to grow from seed than annual flowers. Those requiring a period of afterripening may be sown outdoors in late fall. This includes Trollius, anemone, Dicentra, narcissus, tulips, hyacinth, crocus, Meconopsis, Ranunculus, Helleborus, peony, phlox, Epimedium, and probably many of the alpines. All other seed may be sown in a cold frame in te winter or early spring, preferably under a glass sash. Or it ay be sown in the open until early June. After that it is best wait until early August. This summer sowing will need a heesecloth or lath shading until well germinated. The seedlings ay be left in the frame until spring or transplanted to another ame. Late November sowing is a good time, especially for hose seeds such as primrose and delphinium which lose vitality uickly unless properly stored.

Care of the Seedlings. The seedlings must never be allowed o dry out, yet the seedbed should not be kept so wet that it

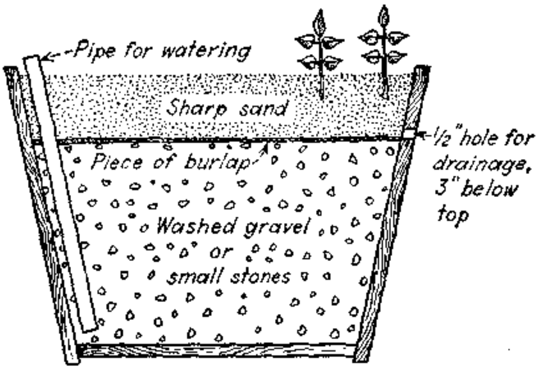


FIG. 62.—Constant-level propagation tub.

interferes with the best growth of the plants. When they are transplanted, usually with the appearance of the third pair of leaves, they should be put by themselves in well-prepared and drained beds where they do not have to compete with old-established plants. Some people prefer to grow them in a cold frame, planting them about 4 to 6 in. apart each way.

Water well after planting and shade with paper, flower pots, or lath shade if weather is hot or sunny.

Some shade-demanding perennials may be easily grown under lath or muslin shades during the entire summer.

Propagation by Cuttings. Many perennials may be grown from softwood stem cuttings taken during June and early July. These may be rooted in a constant-water-level propagating tub which will require watering but two or three times a week (see Fig. 62).

Keep the cuttings shaded during the heat of the day, or better still, place in the shade of a tree or on the north side of building.

As soon as the cuttings have developed roots ¼ to ½ in. in length (this will take from 10 days to 3 weeks), they should be transplanted into a growing bed the same as seedlings or potted in 2- to 2½-in. pots and plunged in soil or sand in a cold frame. Shade with lath until established.

Some perennials may be grown from root cuttings as described in Chap. VIII.

Dividing Perennials. Most perennials, with the exception of those with a long taproot, are easily propagated by the division of the established clumps. This is usually done every 2 or 3 years when the plants normally require shifting. There are some plants, like babysbreath, peony, bleedingheart, lupine, gasplant, Eremurus, and milkweed, which should be left undisturbed. On the other hand, chrysanthemums should be divided every spring. Shasta daisy, aster, bergamot, and similar kinds, do best if divided every 2 years. Iris usually require division every third year.

When perennials are divided, the parent clumps should be cut or broken into as many parts as desired. The need for division and resetting will usually be determined by the lack of vigor and the smaller size of flowers. Late summer- and fall-blooming perennials should be divided in the spring, and spring-blooming ones in August, or sometimes just after they have bloomed in the spring. Iris are usually divided in July and peonies in September. Oriental poppies are planted or divided in August when they are dormant.

Preparation of Perennial Beds and Borders. The need for proper preparation of the soil cannot be over emphasized. On the other hand the excavation and building up of the bed in alternate layers of manure and soil are not recommended. It is better to mix thoroughly all soil, fertilizer, and organic material together. There should be at least 12 in. and preferably more of this sort of material. In poorly drained soils the installation of a line of agricultural drain tile is advisable to carry excess moisture to a lower level. The old method of putting in rocks and bricks for drainage is worthless.

Care of the Perennial Border. Although practiced by many, cultivation can be largely done away with by the use of a summer mulch of chopped corncobs, straw, clover or alfalfa chaff, or even spent hops from a brewery. A 1- or 2-in. layer will serve for keeping down weeds, conserving soil moisture, absorbing rainfall, and maintaining a lower soil temperature during hot weather.

As most mulch materials are very dry when obtained, considerable watering and mixing may be necessary to prevent mulch from shedding rainfall.

If the material is not decomposed, there will be an additional beneficial effect in improvement of soil texture through the development of soil aggregates. Such materials however require a light application of nitrogenous fertilizer to prevent nitrogen starvation of the plants while bacteria are decomposing mulch materials.

Artificial watering is highly desirable, for the perennial border should never be allowed to dry out so that the plants show indications of wilting or drying, especially during the first year. When watering, the equivalent of 1 in. of rainfall, should be applied once a week. This is enough to soak down into the soil to a depth of 4 or 5 in. and will usually carry the plants through for a week without additional watering. To saturate the soil thoroughly, a mechanical sprinkler of some sort is advisable. It will require from 1 to 3 hr. to water any one area to a satisfactory depth, depending upon the area covered and the amount of water delivered.

Staking will often be necessary for taller growing perennials such as delphiniums and for sprawly ones such as peonies and gaillardia. All staking should be as neat and inconspicuous as possible, and at all times the natural effect of the plant should be maintained.

Removal of old flowers, unless seed is desired, is generally advisable both from the standpoint of appearance and, in case of coreopsis and gaillardia, for a succession of bloom.

Winter Protection. Winter protection of hardy perennials usually consists of proper drainage to prevent decay, and adequate mulching to cut down the alternate freezing and thawing of the soil. For some plants, this protection is supplied best by a mulch of straw or manure, placed over the entire bed during early December after the ground has started to freeze. This method works with most plants; however, the hollyhocks, foxgloves, Canterbury-bells, and sweet-williams will often suffer from this treatment. A light covering of peat moss over the soil, but not over the leaves, is more satisfactory.

Shading, consisting of a lath frame or a mulch of straw and cornstalks, excelsior, cattails, or evergreen branches from excess Christmas trees, held above the plants, is equally effective.

Foxgloves and Canterbury-bells may often be wintered most successfully by digging in November and storing in a shaded cold frame until April.

Leaves may be placed on the perennial borders in the fall, provided they are of the varieties that do not mat down. Poplar and maple leaves usually form a solid dense mat and do more harm than good. Oak leaves, on the other hand, seldom mat together and make an excellent winter protection. Snow would be better than any other covering if we could but have a steady supply of it during the winter.

GROUND COVERS AND GRASS SUBSTITUTES

The value of low-growing, spreading, and creeping perennials as ground-cover plants cannot be overemphasized. Because of their ease of propagation, relatively low cost, rapid growth, and usual ease of procuring, they are often preferable to woody plants for this same use. In fact many of these perennials are in gardens but used in the wrong places such as rock gardens and borders where they are a nuisance. When planting difficult spots where grass will not grow or exists only with unnecessary care, the logical choice of plant materials is a vigorous hardy perennial. Hardy perennials will succeed where grass cannot, if for no other reason than that they are not mowed and are given more adequate soil preparation before planting. Few, if any, home grounds would not be improved by the use of ground covers. Whenever and wherever bare ground is a problem, an appropriate plant may be found to cover it. In addition to the following, consult the ground-cover list of woody plants and annual flowers.

A Selected List of Perennial Ground Covers and Grass Substitutes

	Scientific name	Common name	Preferred exposure*
	1. Aegopodium podograria	Goutweed	*SSh*
	2. Ajuga reptans	Carpet bugle	*SSh*
*E**	3. Arabis procurrens	Rockcress	*SSh*
	4. Asarum canadense	Canada wildginger	*Sh*
	5. Asperula odorata	Sweet woodruff	*Sh*

* *E*—evergreen. *Sh*—shade only. *S*—sun only. *SSh*—sun or shade.

A SELECTED LIST OF PERENNIAL GROUND COVERS AND GRASS SUBSTITUTES (*Continued*)

	Scientific name	Common name	Preferred exposure*
	6. Campanula poschscharskyana	Bellflower	*SSh*
	7. Convallaria majalis	Lily-of-the-valley	*SSh*
	8. Coronilla varia	Crownvetch	*S*
	9. Crucianella stylosa	Common crosswort	*S*
E	10. Dianthus deltoides	Maiden pink	*S*
	11. Euphorbia cyparissias	Cypress spurge	*SSh*
	12. Hypericum calycinum	Aaron's-beard	*SSh*
E	13. Iberis sempervirens	Evergreen candytuft	*SSh*
	14. Lysimachia nummularia	Moneywort	*SSh*
	15. Myosotis scorpioides semperflorens	Forget-me-not	*SSh*
E	16. Pachysandra terminalis	Japanese spurge	*Sh*
E	17. Phlox subulata lilacina	Moss phlox	*S*
	18. Plumbago	Plumbago	*S*
	19. Ranunculus repens	Creeping buttercup	*SSh*
E	20. Sedum acre	Goldmoss	*S*
E	21. Sedum album	White stonecrop	*S*
	22. Sedum ellacombianum	Ellacomb stonecrop	*S*
E	23. Sedum reflexum	Jenny stonecrop	*S*
E	24. Sedum sexangulare	Hexagon stonecrop	*S*
	25. Sedum spurium	Running stonecrop	*S*
	26. Sedum ternatum	Mountain stonecrop	*Sh*
E	27. Teucrium chamaedrys	Germander	*SSh*
E	28. Thymus serpyllum album	Mother-of-thyme	*S*
E	29. Thymus serpyllum coccinea	Mother-of-thyme	*S*
	30. Verbena canadense	Rose verbena	*S*
	31. Veronica filiformis	Speedwell	*Sh*
	32. Veronica teucrium (rupestris)	Rock speedwell	*SSh*
E	33. Vinca minor	Common periwinkle	*SSh*
	34. Viola papillionacea	Common violet	*SSh*
	35. Viola canadensis	Canada violet	*SSh*

* *E*—evergreen. *Sh*—shade only. *S*—sun only. *SSh*—sun or shade.

A SELECTED LIST OF PERENNIAL GARDEN FLOWERS

APOCYNACEAE DOGBANE FAMILY

Vinca minor. Periwinkle. Europe. Has escaped throughout Eastern United States. Evergreen foliage, trailing stems. Blue flowers, June and July. Bowles variety, darker green foliage, larger flowers. Also white-flowered and variegated foliage form. One of best ground covers in sun or shade. Propagation exclusively from cuttings will prevent vinca blight.

ASCLEPIDACEAE MILKWEED FAMILY

Asclepias. Milkweed. United States.

A. incarnata. Swamp Milkweed. 4 ft. Flowers light rosy purple. July.

A. tuberosa. Butterflyweed. 2 to 3 ft. Flowers orange, July. These two native plants are well worth cultivation.

BIGNONIACEAE BIGNONIA FAMILY

Incarvillea. Often called hardy gloxinia. Comes up late in spring. Easily grown from seed.

I. delavayi. China. 1½ to 2 ft. Flowers dark rose, 2 in. in diameter. June.

I. grandiflora. China. Flowers crimson. Variety *brevipes* is dwarfer.

BORAGINACEAE BORAGE FAMILY

Anchusa. Alkanet. Bugloss.

A. azurea (*A. italica*). Mediterranean region. 3 to 5 ft. Bright blue flowers, June. The varieties Dropmore, Opal, and others are preferable to the type. Inclined to rot out unless drainage is good.

A. barrelieri. Europe. 18 in. to 2 feet. Flowers blue, June. Dwarf, compact, not so coarse as *A. azurea.*

Brunnera macrophylla (*A. myosotidiflora*). Siberia. 1 ft. Large leaves. Bright blue flowers, April. An excellent spring bloomer. Sun or shade.

Mertensia virginica. Virginia Bluebells. Eastern United States. 1 ft. to 18 in. April and May. Flowers blue. The plants die down after blooming. An excellent plant for shade or sun. Often selfsows.

Myosotis scorpioides (*M. palustris*). Forget-me-not. 12 to 18 in. Bright blue flowers with yellow centers. Variety *semperflorens* is a dwarf form only 8 in. high. May to September. Blue flowers with yellow center. Blooms best in moist location. Withstands shade. Spreads rapidly. Propagation by division or seed.

CAMPANULACEAE BELLFLOWER FAMILY

Campanula. Bellflower. A large genus of over a hundred species. Some alpine forms, others garden flowers.

C. carpatica. Carpathian Bellflower. Europe. 12 in. Flowers blue or white. Free-flowering.

C. persicifolia. Peachleaf Bellflower. Europe. 3 ft. Flowers blue. There are improved varieties and also double forms. An excellent plant.

C. pyramidalis. Chimney Bellflower. Europe. 5 ft. Flowers blue or white.

C. latifolia macrantha. Europe. 4 ft. July. Flowers purple.

C. medium. Canterbury-bells. 2 to 3 ft. Europe. Biennial. White, blue, or pink flowers. Sometimes difficult to winter over unless stored in cold frame. Variety *calycanthema* has corolla like calyx.

C. rapunculoides and *C. trachelium* are serious pests if introduced into the garden; even small pieces of root left in ground will grow.

Platycodon grandiflorum. Balloonflower. East Asia. 2½ ft. June and July. Flowers dark blue. Variety *mariesi,* dwarf. There is also a white and a double form. Present breeding promises a pink form. Showy and satisfactory, although it comes up late. Propagated by seed or divisions. Sometimes selfsows.

CARYOPHYLLACEAE PINK FAMILY

Cerastium tomentosum. Snow-in-summer. Europe. 6 in. Gray foliage, white flowers in June. Needs trimming after blooming or becomes bare in center.

Dianthus. Pink.

D. allwoodii. Hybrids between *D. plumarius* and *D. caryophyllus.* Propagated by cuttings.

D. barbatus. Sweet-william. Europe and Asia. 1 to 1½ ft. Many colors: white, pink, red, lavender; double and single flowers. Best treated as biennial.

D. deltoides. Maiden Pink. Europe. 6 in. Spreading plant, rooting as it spreads. Makes a good ground cover.

D. gratianopolitanus (caesius). Cheddar pink. Mountains of Europe. 6 to 8 in. Many forms. Usually more compact than *D. plumarius.*

D. plumarius. Grass Pink. Europe and Asia. 8 to 12 in. Many forms. Flowers single or double. Foliage gray-green, evergreen. Select desirable types, and propagate by cuttings.

Many other species and varieties are offered in catalogues.

Gypsophila.

G. paniculata. Babysbreath. Europe, Western Asia. 3 ft. Flowers white. June and July. Varieties *florepleno* and Bristol Fairy, double flowered. Propagated by grafting. Variety *bodgeri,* 2 ft., double pink flowers. Variety Rosy Veil, 2 ft., double pink flowers. (See rock plants.)

Lychnis. A genus of a number of species, many of which are good garden plants. Propagated by seed or division. Often selfsows.

L. chalcedonica. Maltese Cross. Russia. 2 to 3 ft. June and July. Flowers scarlet. There is a salmon-colored variety.

L. coronaria (Agrostemma coronaria). Mullein Pink. Southern Europe. 2 ft. Flowers purple-red. Foliage gray and woolly. There are white and pink forms which are easier to use because of color.

L. viscaria. Europe, Asia. 1 ft. Flowers red. There are a number of varieties, including a double-flowered one.

COMMELINACEAE SPIDERWORT FAMILY

Tradescantia. Spiderwort.

T. virginiana. United States. 3 ft. Flowers blue to rose-purple to purple. June to August. Improved blue, white, and pink dwarf forms are available.

COMPOSITAE COMPOSITE FAMILY

Achillea. Yarrow.

A. ptarmica. Sneezewort. 18 in. to 2 ft. Eurasia. White flowers in June and July. The double varieties Pearl, Boule de Neige, and Perry's White are preferable.

A. filipendulina. Fernleaf Yarrow. Orient. 3 to 4 ft. Flowers yellow in June and July.

Anthemis tinctoria. Europe and Asia. 2 to 3 ft. Golden-yellow flowers. Variety *kelwayi* has dark yellow flowers. Free blooming, inclined to be scraggly. Selfsows profusely. Summer blooming.

Artemisia. There are a number of *Artemisia* used for foliage effects including *A. stelleriana,* 12 in., Old Woman; *A. albula,* Silver King, 3 to 4 ft., used extensively for cut foliage; *A. lactiflora,* white mugwort, 3 to 4 ft., creamy white flowers in August. This genus includes *A. tridentata,* sagebrush, and *A. dracunculus,* tarragon.

Aster. Michaelmas Daisy.

A. tataricus. Siberia. 4 to 5 ft. October. Blue flowers. Stiff, upright plants.

A. novae-angliae. New England Aster. United States. 4 to 5 ft. September. Flowers purple or rose. Many selections of this aster are available.

A number of hybrids of our native American asters are available, largely developed in England, ranging in color from white to blue to lavender to pink to red and in height from 3 to 5 ft. Of more recent introduction are the dwarf asters, ranging in height from 1 to 2 ft. Most hardy asters are vigorous and inclined to spread rapidly.

A. frikarti. Wonder of Stafa. 2 to 2½ ft. June to August. Lavender-blue flowers 2 to 2½ in. across. Showy but often difficult to establish.

Bellis perennis. English Daisy. Europe. 6 in. White or pink flowers in spring and early summer. There are several named varieties.

Boltonia latisquama. Central United States. 4 to 5 ft. Blue-violet flowers. Variety *nana,* 2 to 3 ft., has pink flowers. Very similar to hardy asters.

Centaurea

C. montana. Mountain-bluet. Europe. 1 ft. Blue flowers in May.

C. macrocephala. Armenia. 3 ft. Flowers yellow with brown-fringed involucre beneath.

There are other perennial centaureas, including *C. dealbata.* Persia. 2 ft. Flowers red.

Chrysanthemum

C. articum. Arctic Chrysanthemum. 12 to 18 in. Flowers white, September to October. Has been used in breeding hardy garden chrysanthemums.

C. coccineum. Painted Daisy. Often called Pyrethrum. Southwest Asia. 2 ft. Flowers white, pink, red. Named varieties, some of which are doubles, are superior to seedlings. Propagate by division. Require adequate soil moisture for best results.

C. leucanthemum. Oxeye Daisy. Eastern United States. 12 to 15 in. June–July. Occasionally grows in gardens. Memorial Day Daisy is apparently a form of this.

C. maximum. Shasta Daisy. Pyrenees. 2 to 3 ft. Flowers white. Are single and double varieties as Esther Reed, Marconi, Alaska, Mount Shasta.

C. parthenium. Feverfew. 1 to 3 ft. Flowers white. June to September. Selfsows, easily grown, strong scent to foliage. Several named varieties available.

C. morifolium. Chrysanthemum, probably Chinese. This includes both the large-flowered greenhouse varieties and the smaller flowered garden varieties. Some of garden varieties are hybrids with *C. articum.* Divide and replant as single division every year, or take cuttings in April or May and set out rooted cuttings. They often give better result than divisions. Pinch plants several times up to July 1 to increase branching.

Coreopsis. Tickseed. Eastern United States. Easily grown, free flowering plants.

C. lanceolata. 2-ft. flowers yellow. June to September. Species propagated by seed, named varieties by division. Can be naturalized. Best treated as a biennial.

C. verticillata. 1 to 2 ft. Flowers yellow, leaves fairly divided. Plant forms a solid mat.

C. rosea. 1 ft. Flowers rose. June to September.

Doronicum. Leopardbane. Europe and Asia. Yellow daisylike flowers in early spring. Grows in sun or partial shade. Should be grown more widely. Propagated by seeds and division.

D. caucasicum, 2 ft., and *D. pardalianches,* 4 ft., are the most commonly grown of several species.

Echinacea purpurea (*Rudbeckia*). Purple Coneflower. Central United States in fields or thin woods. 4 ft. 3-in. purplish-rose flowers. June to August. Color varies greatly from seed. Variety King has horizontal petals. Grow from seed and select, then propagate by division. One of most satisfactory garden flowers.

Echinops. Globethistle.

E. ritro. Spain, Asia Minor, Siberia. 2 ft. Flowers blue. June to August.

E. sphaerocephalus. Europe, North Africa, Siberia. 5 to 6 ft. July to August. Flowers blue. Propagation by seed, division, or root cuttings. Rather striking thistlelike plants.

Eupatorium. Boneset. Native plants found along the roadsides.

E. coelestinum. Mistflower. Erroneously called hardy ageratum. 2 ft. Flowers lavender-blue. August and September. Spreads by fleshy roots. May become a pest. There are two forms: one green stems, the other purplish stems.

E. purpureum. Joe-pye-weed. 4 to 8 ft. Flowers pink, leaves whorled. August. A vigorous, showy plant. Select from roadsides for color.

E. urticeafolium. Snakeroot. 3 to 4 ft. White flowers. September and October. Sun or shade. Selfsows to become a pest. Poisonous to livestock.

Gaillardia. Blanket Flower.

G. aristata (*G. grandiflora*). 3 ft. Western United States. Flowers orange and red. A number of named varieties have been developed.

Helenium. Sneezeweed.

H. autumnale. United States. 3 to 6 ft. Flowers yellow. August. Has given rise to a number of varieties: Superbum, large flowered, yellow, 3 to 5 ft.; Riverton Gem, 3 to 5 ft., gold and terra cotta; Riverton Beauty, 3 to 5 ft., yellow with dark centers; Chippersfield Orange, 4 ft., yellow and copper; Peregrina, mahogany and yellow.

Helianthus. Sunflower. Vigorous, coarse native plants, usually inclined to spread and become pests.

H. orgyalis. 8 to 10 ft. Yellow flowers. August. Long narrow leaves. An erect and graceful plant.

H. maximiliani. 6 to 8 ft. Yellow flowers.

H. decapetalus florepleno (*H. multiflorus florepleno*). Double form of native Eastern Sunflower. Propagated by seed and division.

Heliopsis. Native United States roadside flowers.

H. helianthoides pitcheriana. 3 ft. Flowers deep yellow. July and August.

H. scabra zinniaeflora. 3 to 4 ft. Double flowered. July and August. *Incomparabilis.* 3 to 4 ft. Double flowered. Species propagated by seed; double forms by division.

Liatris. Blazing Star. A large genus of native prairie flowers.

L. pycnostachya. Central United States. 4 to 6 ft. August. Flowers lavender.

L. scariosa hybrid var. *September Glory.* 4 to 6 ft. Flowers lavender. Early September, variously sold as pcynostachya hybrids and scariosa hybrids. Propagated by seed or division.

Rudbeckia. Coneflower. United States. Summer blooming.

R. speciosa (*R. newmani*). 3 ft. Flowers yellow. August. Biennial blooming first year. Selfsows.

R. maxima. 6 to 8 ft. Flowers yellow, large. Cone brown, 1 to 2 in. high. Foliage glaucous. A striking plant useful for accent.

R. laciniata var. *hortensia.* Golden Glow. 6 to 8 ft. An old-fashioned garden flower, subject to mildew and aphis. Vigorous and spreading.

Another form, available from nurseries, is known as *R. hirta hybrids.* 2 ft. Flowers variable, yellow, orange, and mahogany. A biennial, blooming first year from seed. Bushy, compact plant. Blooms throughout the summer.

Solidago. Goldenrod. Native American plants with tendency to self-sow and become a nuisance; yet color, hardiness, and mid- to late-summer bloom gives them a place in yards. *S. canadensis* and *S. altissima* are two common species.

Stokesia. Stokes Aster.

S. laevis (*S. cyanea*). Southeastern United States. 12 to 18 in. Flowers lavender. June to September. Var. *lilacina grandiflora* large flowered. Excellent cut flowers.

CRASSULACEAE ORPINE FAMILY

Sedum. Stonecrop. A large genus of many species, much mixed in nurseries. Many best used as ground covers; some as rock plants.

S. sieboldi. Japan. 6 to 8 in. Flowers dark pink. September. Leaves glaucous blue, edged red in sun. Compact plant. One of the most desirable of sedums.

S. spectabile. Japan and China. 1 to 1½ ft. Flowers pink. August. Variety Brilliant, rose-pink flowers, superior.

S. kamtschaticum. Asia. 8 in. Flowers orange. June and July. A compact plant for the front of the border.

S. ellacombianum. Japan. 10 in. Flowers yellow. Resembles *S. kamtschaticum.* See Rock Plants for other varieties.

Among those best used for ground covers are

S. acre. Europe. 6 in. Flowers yellow. Leaves evergreen.

S. album. Europe, Asia, and Africa. 8 in. Flowers white. A variable species with many varieties. Leaves evergreen.

S. altissimum. Mediterranean region. Flowers yellow. Foliage gray-green, coarse, evergreen.

S. reflexum. Europe. 8 in. Flowers yellow. A variable species with green or gray-green foliage. Evergreen. Several varieties.

S. sarmentosum. China and Japan. 6 in. Flowers yellow. Leaves light green. A vigorous grower, usually becoming a pest. Not evergreen.

S. spurium. Caucasus. Flowers pink to white. Also a red variety. Often sold as *S. stoloniferum.* Not evergreen. Vigorous.

S. sexangulare. Europe. 6 in. Flowers yellow. Spreading but refined in effect. Evergreen. Bronze in winter.

S. ternatum. United States. 6 in. Flowers white. Evergreen. Prefers shade with adequate moisture.

CRUCIFERACEAE MUSTARD FAMILY

Alyssum. Madwort. Europe.

A. saxatile. Goldentuft. 8 to 12 in. This species and its variety *compactum,* Basket of Gold, are the best of many species. Requires excellent drainage for permanence.

A. argenteum. 12 in. Lighter yellow flowers and smaller leaved than *A. saxatile.* Often sold as *A. rostratum.*

Arabis. Rockcress.

A. albida (usually sold as *A. alpina*). Caucasus. 8 to 12 in. White flowers in April. There are double-flowered forms in pink and white and dwarf varieties.

A. procurrens. Southeastern Europe. 8 in. White flowers in April. Smaller evergreen leaves usually more permanent than *A. albida,* although flowers not so showy.

Hesperis matronalis. Rocket. Europe. 3 ft. Flowers white, lavender, or pink. May and June. Free blooming, selfsowing. Sun or shade. Inclined to be biennial.

Iberis. Candytuft.

I. sempervirens. Southern Europe. Western Asia. Flowers white. May. Variety Snowflake has larger flowers.

I. gibraltarica. Spain. Flowers pale lavender. May.

The hardy *Iberis* has evergreen foliage and is useful for edging and even ground cover.

DIPSACEAE TEASEL FAMILY

Scabiosa. Scabious.

S. caucasica. Caucasus. 2½ ft. Flowers blue.

S. columbaria. Europe and Asia. 2 ft. Flowers blue.

S. japonica. Japan. 2 ft. Flowers lavender-blue.

Recent introductions have larger flowers than the species. All are inclined to be tender. Propagation by seed, except named varieties by division.

EUPHORBIACEAE SPURGE FAMILY

Euphorbia. Spurge.

E. corollata. Flowering Spurge. Central United States. 3 ft. Flowers with white bracts. June and July. In some ways preferable to *Gypsophila.* A weed in some localities.

E. epithymoides (*E. polychroma*). Eastern Europe. 1 ft. Compact clumps with yellow bracts in May.

E. myrsinites. Europe. 6 to 8 in. A prostrate, scraggly plant with gray glaucous foliage. Inflorescence not so conspicuous as foliage.

E. cyparissias. Cypress Spurge. Europe. 6 to 8 in. Naturalized in the United States. A ground cover with gray-green foliage. Flower bracts yellow. Spreading by underground stems. Sun or shade.

FUMARIACEAE FUMITORY FAMILY

Dicentra. Bleedingheart.

D. eximia. Eastern United States. 8 to 12 in. May to September. Pink flowers. A constant bloomer with good foliage. Sun or partial shade. Seed best fall sown.

D. spectabilis. Japan. 2 ft. Rosy-red flowers in May. Showy and satisfactory, but foliage dies down in midsummer. Propagation by division.

GERANIACEAE GERANIUM FAMILY

Geranium. Cranesbill. A number of species in cultivation.

G. sanguineum. Eurasia. 18 in. June. Flowers reddish purple. Propagated by seed and division.

IRIDACEAE IRIS FAMILY

Belamcanda chinensis (Pardanthus chinensis). Blackberry-lily. China, naturalized in the United States. 3 ft. Flowers orange spotted with red. July. Fruit resembles blackberries. A striking plant in flower and in fruit. Resembles *Iris* in growth. Propagated by seed or division.

Iris. A large genus of 170 species, many of which are in cultivation. The genus is classified as follows:

I. Rhizomatous.

1. Bearded. Falls have beards or hairs on central part.
    - *I. germanica,* formerly called German iris. 2 to 4 ft. Many named varieties. Flowers white, yellow, pink, lavender, blue, purple. June.
    - *I. pallida dalmatica.* Flowers pale lavender-blue, similar to *germanica.*
2. Crested. Represented by
    - *I. tectorum.* China. 12 in. Flowers lavender. June.
    - *I. crista.* Eastern United States. 3 to 6 in. Flowers blue. May.
    - *I. gracilipes.* Japan. 8 to 10 in. Flowers lavender. May.
3. Beardless.
    - *I. siberica.* Siberian Iris. 2 to 4 ft. Europe, Russia. Erect growing, narrow leaves, flowers dark blue, purple, white. June.
    - *I. pseudacorus.* Yellowflag. Europe, Asia. Erect growing. 3 to 4 ft. Flowers yellow. June.
    - *I. ochroleuca.* Asia Minor. Erect growing. Flowers white, yellow blotch. June.

II. Bulbous.

- *I. xiphioides.* English Iris. Pyrenees. 18 to 24 in. Flowers various colors. June.
- *I. xiphium.* Spanish Iris. Europe. 18 to 24 in. Flowers various colors. June.

III. Cormous.

But one species, seldom grown.

LABIATAE MINT FAMILY

Lavandula. Lavender.

L. spica (L. vera). Mediterranean region. 18 in. to 2 ft. July. Flowers lavender. Evergreen foliage. Tender in some climates. Best cut to ground each year. Propagated by seed, division, or cuttings.

Monarda didyma. Beebalm. United States. Moist woods. 3 ft. June and July. Flowers dark red. A number of varieties are available, including scarlet, pink, and magenta flowers. Does best if grown in partial shade with ample moisture. Foliage aromatic. Propagation by division.

Nepeta mussini. Caucasus. 18 in. May to September. Flowers blue. Varies considerably from seed; select, and propagate by division or cuttings.

Six Hills Giant, and Souvenir d'André Chaudron are more vigorous growers. 2 to 2½ ft. Showy blue flowers. Gray-green foliage.

Physostegia virginiana. False-dragonhead. Eastern United States. Spreads badly. Has been largely replaced by

Variety Vivid. 18 in. to 2 ft. August. Flowers dark pink.

Variety Summer Glow. 3 to 4 ft. Midsummer. Flowers rosy red.

Variety Rosy Spire. 3 ft. Flowers rosy red.

Species propagated by seed; varieties by division.

Salvia. Sage.

S. azurea. United States. Plants under this name probably *S. pitcheri.*

S. pitcheri (*S. azurea* var. *grandiflora*). Western United States. 4 ft. Flowers blue. July and August. Stems white pubescent.

S. patens. Mexico. 2 ft. Tender, but large, bright blue flowers make it worth growing. Summer blooming.

S. pratensis. Europe. 2 to 3 ft. Often seen in gardens but seldom in nurseries. Flowers purple-blue. May and June. Hardy. Early blooming. Often selfsows.

S. greggii. Texas and Mexico. 3 ft. Shrubby but tender. Flowers red. Midsummer. A fine plant for mild climates.

S. sclarea and its variety *turkestanica* are coarse, hairy biennials. Flowers pink or white. Often appear unexpectedly in gardens.

Stachys. Betony.

S. lanata. Lambs-ears. Caucasus. 1½ ft. Flowers red-purple. Grown largely for gray wooly foliage, 4 to 6 in. high. Used as an edging plant and in flower arrangements. Propagation by seed and division.

Teucrium. Germander.

T. chamaedrys. Europe. 18 in. Flowers rose-purple. Used not for its relatively small flowers but for evergreen foliage. Often sheared as a substitute for box hedges. Propagated by seed, division, and cuttings.

LEGUMINOSAE LEGUME FAMILY

Baptisia australis. False Indigo. Eastern United States. 3 to 5 ft. Blue flowers. June. Foliage gray-green.

Lathyrus latifolius. Everlasting Pea. Europe. Flowers white to rose. Summer. Vine to 6 ft. Very hardy, vigorous.

Lupinus. Lupine. A large genus mostly of American species.

L. polyphyllus. Western United States. 3 to 5 ft. July. Flowers purplish blue. Varieties in white, pink, red, and blue.

English hybrids and Russell hybrids have introduced yellow, orange, salmon, and combinations of them.

Lupines are permanent in cooler climates but are seldom very satisfactory in the midwest. Soil reaction and inoculation apparently not important.

LILACEAE LILY FAMILY

Convallaria majalis. Lily-of-the-valley. Eurasia. Variety *fortunei* has larger flowers. Best used as ground cover in sun or shade. Replant every few years for maximum bloom.

Hemerocallis. Daylily. The daylilies have been developed in the last few years until there are a tremendous number of varieties, many very similar. The different varieties bloom in May, June, and July, a few in August. Colors range from pale yellow to orange to mahogany, or so-called red. A few representative species are

H. dumortieri. Siberia. May. 1 ft. Leaves narrow. Flowers light orange.

H. middendorffi. Siberia. May. Flowers light orange. Leaves broad, 1 in. or more.

H. flava. Lemon Daylily. Europe, Asia. 2 to 2½ ft. Flowers yellow.

H. fulva. Tawny Daylily. Europe, escaped in United States. 2 to 5 ft. Flowers orange-red. July and August. Variety Kwanso has double flowers.

H. serotina (*H. thunbergi*). Japan. 3 ft. July. Small yellow flowers.

Numerous varieties include Bay State, Hyperion, Don Wyman, Sir Michael Foster, Mrs. A. H. Austin.

Yucca.

Y. filamentosa. Adam's-needle. United States. 5 to 7 ft. Flowers cream. July. Leaves 2 to 2½ ft high, evergreen.

Other species include *Y. glauca* and *Y. gloriosa.* All natives of United States with white or creamy flowers and evergreen foliage.

LINACEAE FLAX FAMILY

Linum. Flax.

L. perenne. Europe. 2 ft. Flowers blue. June and July.

L. narbonense. Europe. 18 in. June to August. Flowers blue. Very similar to *L. perenne,* except that flower has a white eye.

L. flavum. Europe. 1 ft. June and July. Flowers yellow. Often difficult to grow.

Propagated by seed and division.

LOBELIACEAE LOBELIA FAMILY

Lobelia cardinalis. Cardinalflower. Eastern United States. 3 to 4 ft. August. Flowers cardinal. Propagated by seed and division. Prefers moist soil and shade but can be grown in gardens. Often acts as a biennial.

LYTHRACEAE LOOSESTRIFE FAMILY

Lythrum. Loosestrife.

L. salicaria. Europe. 3 ft. Purple flowers. Variety *roseum superbum* is the one usually grown. 3 to 5 ft. August. Dark rose flowers.

L. virgatum. Europe. 2 to 3 ft. July and August. Flowers rose.

MALVACEAE MALLOW FAMILY

Althaea rosea. Hollyhock. China. 5 to 7 ft. There are both single and double forms, including some named varieties. The flower colors range through white, yellow, pink, and red. Often is biennial. Hollyhock rust is a serious pest unless controlled by fungicide.

Hibiscus. Rose Mallow. Eastern United States.

H. moscheutos. There are many varieties and hybrids. 3 to 6 ft. Flowers white, pink, and red. July and August. Rather coarse plants best used with shrubs rather than in flower borders.

Sidalcea. Western United States. Most varieties in cultivation are hybrids. 3 to 4 ft. Flowers white, pink, and red. June. Should be used more extensively than they are.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Oenothera. Evening-primrose.

O. fruticosa youngi. United States. 1 to 2 ft. June and July. Flowers yellow. Inclined to spread.

O. missouriensis. Central United States. 1 ft. June and July. Large yellow flowers. Taprooted, does not spread. Showy. Propagated by seed.

O. speciosa. Central United States. 2 ft. Flowers white and pink. Spreading, easily grown plant. Propagated by division.

Fuchsia. Of recent years the so-called hardy fuchsia has been given considerable publicity. Flowers numerous, but small, red with purple-red center. 2 to 3 ft. in north.

F. magellanica. Peru. This species and its variety *riccartoni* are hardy if winters are not too severe. Scarlet Beauty is slightly hardier.

PAPAVERACEAE POPPY FAMILY

Macleaya cordala (*Bocconia cordata*). Plumepoppy. Mexico. 6 to 8 ft. Cream-colored flowers, glaucous leaves, tan seed pods. Plants are likely to become a pest in the flower border. Best used with shrubs.

Papaver. Poppy.

P. nudicale. Iceland Poppy. Arctic regions. 1 ft. Flowers white, yellow, orange, or red. There are several strains of larger size. Prefers a cool climate. May be spring sown for fall bloom. Often selfsows. Propagated by seed.

P. orientale. Oriental Poppy. Mediterranean region. Largely grown as named varieties. 2 to 4 ft. The colors are white, pink, red, or maroon, with or without dark splotches on petals. Many varieties should be eliminated. Propagated by root cuttings in fall or division in August. Pot grown for fall or spring planting.

PLUMBAGINACEAE LEADWORT FAMILY

Ceratostigma plumbaginoides (*Plumbago larpentae*). China. 1 ft. Flowers dark blue. August and September. A spreading plant, coming up late in spring. Best used as a ground cover.

POLEMONIACEAE PHLOX FAMILY

Cobaea scandens. Mexico. Flowers green and purple. Perennial vine, often blooms first year.

Phlox.

P. paniculata. Eastern United States. Flowers pinkish purple. Has been developed into hundreds of named varieties, many inferior. The better varieties are slow getting into gardens. The colors include white, pink, red, salmon pink, lavender, and purple. A need exists for varieties with better midsummer foliage. Propagation is by root cuttings and division. Selfsows profusely. The seedlings usually are inferior, giving rise to the popular belief that phlox reverts.

P. suffruticosa. Early Phlox. Variety Miss Lingard, white. July. There is a need for better varieties and more resistance to disease.

P. divaricata. Wild Sweet-william. Eastern United States in woods. 1 ft. April and May. Many color variations from white to pink and purple could be selected. Propagation by seed or division. Often selfsows.

P. subulata. Eastern United States. The species is seldom grown, but the named varieties are extensively used as a border or a rock-garden plant and as a ground cover. There are varieties with white, pink, red, and lavender flowers, some with a tendency to summer bloom. Variety *lilacina*, lavender flowers, very fast growing. Variety Vivid, pink flowers, compact and slow growing. Propagated by division or cuttings.

Other species sometimes grown are *P. amoena*, *P. pilosa*, and *P. ovata*.

Polemonium.

P. caeruleum. Jacob's-ladder. Europe. 2 ft. Flowers blue. Divided leaves.

P. reptans. United States. 1 ft. Flowers blue. Compact plant with good foliage. Grows in sparse shade. Often selfsows. Propagation by seed or division.

POLYGONACEAE KNOTWEED FAMILY

Polygonum. Fleeceflower. Although there are many polygonums, many of them are weeds or weedlike.

P. amplexicaule. Mountain Fleeceflower. Himalayas. 3 ft. Midsummer. Flowers red. It is a showy and not too invading plant Propagation by division.

P. reynouteri. Probably *P. attire.* Himalayas. Flowers rose, red. August to September. 12 to 24 in. Although listed in catalogues as a dwarf, is not. Inclined to spread.

P. sieboldi. Japan. Giant Knotweed. Flowers greenish white. Summer. 6 to 8 ft. A terrible pest once established. Incorrectly called hardy bamboo, giant buckwheat, etc.

PRIMULACEAE PRIMROSE FAMILY

Primula. Primrose. A large genus of over 300 species, many of them ather difficult to grow except under ideal conditions. Primroses prefer a ool climate with partial shade and ample soil moisture. Seed germinates asily if sown immediately, slowly if not. May germinate over a period f 6 months.

P. vulgaris (*P. acaulis*). Europe. 6 in. Flowers yellow or blue, solitary on short stems, among foliage. There is a double-flowered form.

P. polyantha. Polyanthus. A hybrid group to which *P. veris*, *P. vulgaris*, and *P. elatior* have contributed. Flowers various colors. One or more on a stem. The commonest primrose in gardens. A number of hybrid types are available as Kleyni, Munstead.

P. veris (*P. officinalis*). Cowslip. Europe. 8 in. Fragrant yellow flowers, several on stem. Flowers smaller than *P. vulgaris* or *P. elatior*.

P. elatior. Oxlip. Persia. 8 in. Flowers yellow.

P. japonica. Japan. 1 to 1½ ft. Flowers red, rose, or white, in whorls on stem. Prefers moist or even wet ground.

Other commonly grown species include *P. auricula*, *P. bulleyana*, *P. cortusoides*, *P. denticulata cashmeriana* (*P. cashmeriana*), *P. farinosa*, and *P. frondosa*.

P. japonica, *P. bulleyana*, and *P. florindae* can be grown in bogs.

RANUNCULACEAE BUTTERCUP

Aconitum. Monkshood.

A. fischeri. Asia. 4 ft. Blue flowers. Variety *wilsoni.* 4 to 5 ft. Purple flowers. October blooming.

A. napellus. Europe. 4 ft. Blue flowers in August. Sparks variety is an improved form.

The monkshoods prefer cool climates, otherwise shade with ample moisture.

Anemone. Windflower.

A. japonica. Japanese Anemone. China and Japan. 3 ft. White, light or dark pink flowers in September and October. There are a number of named varieties, both single and double. Best spring planted. Difficult to establish; should be protected the first winter.

A. pulsatilla. Pasqueflower. Europe. 1 ft. Lavender flowers in April, followed by silky, hairy seed heads. The variety *rubra* is dark red.

A. hupehensis is apparently a dwarf form of the Japanese anemone with pink flowers. 2 ft. September.

Aquilegia. Columbine. There are a considerable number of species including *A. canadensis, A. chrysantha, A. longissima, A. skinneri, A. vulgaris.* The long-spurred hybrids are the most commonly grown, although they are not so long-lived as the short-spurred ones. Columbine borer sometimes a serious pest. No control. Seeds rather slow to germinate. Flowers white, yellow, pink, lavender, blue, and red in June.

Clematis. Virgins-bower.

C. recta. Southern Europe. 3 ft. June. White flowers. Good foliage throughout the season. Showy seed head.

C. integrifolia. Europe. 2 ft. Flowers blue, fleshy, nodding. Showy seed head. Usually requires staking. Effective over rocks or at edge of pool.

C. heracleaefolia davidiana. China. 3 ft. Fragrant blue flowers in August. Bushy, compact, good foliage.

Delphinium. Larkspur.

D. cheilanthum. Siberia. Parent of Belladona, light blue; Bellamosum, dark blue.

D. elatum. Europe to Asia. Probably parent of all but the small-flowered forms. Hybridization has given many named strains of the tall large-flowered forms.

Preferring cool summers and well-drained soil, best grown as a biennial in many sections of the country. For the beginner, smaller types are often preferable to the taller, large-flowered kinds.

D. grandiflorum (D. chinense). Siberia and China. 2 to 3 ft. Because of dwarf nature often preferable to tall kinds. Flowers dark to light blue. Open and airy inflorescence.

D. cardinale and *D. nudicaule.* Western United States. Red flowers. Are not permanent in Central and Eastern United States. Used as basis for production of new pink-flowered forms, such as Pink Sensation.

Helleborus. Hellebore.

H. niger. Christmas-rose. Europe. 1 ft. Flowers white to green. November to March. Evergreen foliage. Once established will grow for years.

H. orientalis. Lenten Rose. Asia Minor. Flowers pink, purple, often spotted. March and April. Not completely evergreen.

Propagation by seed, very slow. Also propagated by division.

Paeonia. Peony. This genus has been popularized and hybridized until hundreds of named varieties are available. Many old, inferior varieties need to be discarded. The work of the American Peony Society in scoring varieties is to be commended. Most varieties were developed from *P. albiflora* and *P. suffruticosa.*

P. suffruticosa (P. moutan). Tree Peony. China. Once popular but now scarce because of difficulty of propagation of named varieties by grafting. Flowers often frosted. Common type—double pink. May, 3 ft.

P. tenuifolia. Southeast Europe. 18 in. Flowers red. Early May. Foliage finely divided. Old-fashioned.

Peonies are propagated by division and early fall planted. They do not come true from seed. The peony blight is often serious. Sanitation, the removal and burning of the foliage in late fall, and the spring application of fungicide may control.

The single-flowered peonies are gaining in popularity. Most peonies are difficult to use in the flower border because of overhanging stems.

Ranunculus. Buttercup.

R. acris. Europe. 3 ft. Flowers yellow. Variety *florepleno* with double flowers is most common.

R. repens. Creeping Buttercup. Europe. 2 ft. Creeping. Flowers yellow. Variety *pleniflorus* double flowered.

Two vigorous spreading plants best used for ground covers rather than in the perennial border. Sun or shade. Propagation by division.

Thalictrum. Meadowrue. Grows in sun or shade. Foliage good throughout season.

T. minus (*T. adiantifolium*). Europe, Africa, and Asia. 18 in. to 2 ft. Flowers yellow-green. June.

T. aquilegifolium. Europe and Asia. 3 ft. Flowers with pink or purple stamens. June and July.

T. glaucum. Europe. 4 ft. Flowers yellow. July. Foliage glaucous.

T. dipterocarpum. China. 2 to 3 ft. Flowers pink or lilac. August. Grown for foliage effect as well as bloom. Stamens and sepals give color.

Trollius.

T. europaeus. Globeflower. Europe. 18 in. Flowers yellow. May and June. A number of varieties of varying tones of yellow and orange are available.

T. ledebouri. Siberia. 2 ft. June after other *Trollius* have finished blooming. Flowers orange with a number of petaloid stamens.

Trollius prefers cool, moist situations. Propagation by seed, named varieties by division.

ROSACEAE ROSE FAMILY

Aruncus. Goatsbeard. North America, Europe, Asia. Often catalogued as spirea.

A. sylvester. 5 to 7 ft. Flowers cream-white. June and July. Showy plant in sun or shade.

Filipendula. Meadowsweet. Often catalogued as spirea.

F. hexapetala. Dropwort. 18 to 24 in. Europe, Asia. White flowers in June. Variety *florepleno* preferable. Propagate by division.

F. rubra. Queen of the Prairie. Eastern United States. 4 ft. Flowers pink. July. Variety *venusta* deep pink. Showy, hardy.

Preferable to *Astilbe* in Midwest. Propagated by division of selected colors.

...um. Avens. Europe, America. Colorful flowers, but often difficult to winter over unless drainage is above average. Propagated by seed. Named varieties by division.

G. borisii. Hybrid. 1 ft. Yellow flowers. Is one of hardiest geums. Mrs. Bradshaw, scarlet. *G. heldreichi,* orange-red. Lady Strathenden, yellow. Fire Opal, orange-scarlet.

Spiraea. See *Filipendula, Astilbe,* and *Aruncus.*

RUTACEAE RUE FAMILY

Dictamnus albus. Gasplant, Dittany. 3 ft. Europe and Asia. Flowers white. Variety *caucasicus* is a larger form. Grown from seed. *Dictamnus* is one of the most permanent of all perennials. Excellent foliage throughout the season. Plant seed in fall. Variety *rubra,* rosy-purple flowers.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Astilbe. Often confused with spirea, *Aruncus,* and *Filipendula.*

A. arendsi. Hybrid. 2 to 3 ft. Flowers white, to pink, or red. June and July. Prefers partial shade in warmer summer climates.

Heuchera. Alumroot.

H. sanguinea. Coralbells. Western United States. 1 to 1½ ft. Flowers red. June to September. There are a number of horticultural varieties of varying color and habit of growth.

H. lithophila (H. brizoides). California. 2 to 2½ ft. Flowers pink. June and July.

Saxifraga. Most of the saxifrages are essentially rock-garden plants. Two species, *cordifolia* and *crassifolia,* belong in genus *Bergenia.* Both have large, round leaves 8 to 10 in. long with 12- to 18-in. pink-flowered inflorescence. Foliage evergreen, turning bronze in winter. Used extensively as coarse ground cover on Pacific coast. Propagation by seed and division.

SCROPHULARIACEAE FIGWORT FAMILY

Chelone lyoni. Turtlehead. 3 ft. Eastern United States. August. Flowers rose. Thrives in wet shade but will do well in the average garden.

Digitalis. Foxglove.

D. purpurea. Western Europe, naturalized in Western United States. Common biennial form. 4 to 6 ft. Flowers white, pink, or lavender. Variety *gloxiniaeflora* has longer flower spikes and more blooms. Variety *campanulata* has upper flowers united into a large bell-shaped bloom. Lutz hybrids offer salmon and pink colors. Well worth growing.

D. ambigua (D. grandiflora). Europe. 2 to 3 ft. July. Flowers pale yellow with brown markings. Not so showy as *D. purpurea* but perfectly hardy.

D. laevigata. Southern Europe. 3 ft. July. Flowers yellow with purple markings. A hardy perennial with rather striking flowers.

Penstemon. Beard-tongue. A large genus mostly native in North America, many alpines. The latter are often of difficult culture. Tall species:

P. barbatus torreyi. 4 to 5 ft. June and July. Flowers red. Usually requires staking. Colorful. Propagation by division.

P. grandiflorus. 4 ft. June. Large lavender-blue flowers.

P. gloxinioides. A hybrid of several species. 2 to 2½ ft. Large red, pink, or white flowers. June to August. Tender. Not so hardy as most penstemons.

P. hirsutus (*P. pubescens*). 2 to 3 ft. Flowers lavender.

There are a number of hybrid forms found in nurseries.

Dwarf species:

P. rupicola. 4 in. Flowers red. June.

P. cardwelli. 10 in. Evergreen. Flowers purple. June.

Verbascum. Mullein.

V. olympicum. Greece. 5 ft. Flowers yellow. June and July. Foliage gray-green. A showy plant used as an accent in the border.

V. phoeniceum. Purple Mullein. Europe and Asia. 5 ft. Flowers purple. There are also garden hybrids in varying heights and in colors varying from white to pink to rose to red to purple. Late-summer bloomers.

Veronica. Speedwell. A large genus of many species. Nomenclature considerably confused in trade.

V. maritima (*V. longifolia*). Europe, Asia, and North America. 2 ft. Blue-purple flowers. Variety *subsessilis* has larger, deeper blue flowers. One of the best of the taller veronicas. Propagation by division.

V. incana. Asia. 1 ft. Flowers purple. Foliage gray-green. Contrast of foliage and flower makes it a striking plant.

V. spicata. Europe and Asia. 2 ft. Flowers blue in upright spikes. There are white and pink varieties.

V. virginica (now classified as *Veronicastrum virginicum*). Culvers Root. United States. 3 to 7 ft. Flowers pale blue or white. There are a number of horticultural varieties such as True Blue and Blue Spire. Many of these should be cut back after blooming to prevent open, bare centers in the plant.

Also see Rock Plants.

SOLANACEAE NIGHTSHADE FAMILY

Physalis alkekengi (*P. francheti*). Chinese Lantern. Southeastern ırope to Japan. 2 ft. Whitish flowers. Orange-red fruit, for which it is own, as it is unattractive except when in fruit. Coarse spreading plant, ːely to become a pest. Propagation by seed or division.

VALERIANACEAE VALERIAN FAMILY

Centranthus ruber. Jupitersbeard. Europe. 3 ft. Flowers crimson, ıgrant. Also a white form. Drought resistant. Long summer bloom.

Valeriana. Valerian.

V. officinalis. Garden Heliotrope. Europe and Asia. 4 to 5 ft. Flowers whitish, fragrant. June. Finely divided foliage. Spreading. White-, lavender-, and pink-flowered forms. Propagation by seed and division.

VERBENACEAE VERBENA FAMILY

Verbena canadensis. Clump Verbena. United States. 8 in. Flowers reddish purple. June to September. A hardy, spreading perennial. Several selected color forms available. An excellent ground cover.

VIOLACEAE VIOLET FAMILY

Viola. Violet.

V. cornuta. Horned Violet. Spain and Pyrenees. Has given the tufted pansies in a number of named varieties. Propagation by seed or division. Gives constant bloom if summer temperatures are not too high.

V. odorata. Sweet Violet. Europe and Asia. Flowers violet. Spreads by runners. A number of named varieties. Largely spring blooming, except in cool climates. Single- and double-flowered forms.

V. canadensis. Canada Violet. North America. 8 to 12 in. Flowers white, turning purplish. April to June. Leaves along flower stems. One of the best ground covers for shade.

V. papilionacea. Common Violet. United States. 8 in. Flowers violet. Spreads by seeds largely produced by cleistogamous flowers. May be a pest except as a ground cover.

Perennials for Succession of Bloom

March:
- Crocus imperati
- Crocus susianus
- Crocus tomasinianus
- Eranthis
- Helleborus niger
- Scilla sibirica

April:

Less than 12 in.:
- Anemone pulsatilla
- Arabis
- Aubrieta
- Bellis perennis
- Brunnera macrophylla (Anchusa myosotidiflora)
- Chionodoxa
- Crocus
- Dicentra cucullaria
- Fritillaria meleagris
- Helleborus orientale
- Hyacinthus
- Iris pumila
- Iris reticulata
- Muscari
- Myosotis sylvatica (alpestris)
- Narcissus February Gold
- Narcissus Golden Spur
- Narcissus Helios
- Phlox divaricata
- Phlox subulata
- Polemonium reptans
- Primula
- Pulmonaria angustifolia
- Sanguinaria

- Trillium
- Tulip (early varieties)
- Tulipa kaufmanniana

1 to 2 ft.:

- Aquilegia canadensis
- Dicentra spectabilis
- Doronicum caucasicum
- Fritillaria imperialis
- Mertensia virginica

May:

Less than 12 in.:

- Ajuga reptans
- Alyssum saxatile
- Asperula odorata
- Brunnera macrophylla (Anchusa myosotidiflora)
- Cerastium tomentosum
- Chelidonium majus
- Nepeta mussini
- Primula
- Pulmonaria saccharata
- Scilla hispanica
- Scilla nonscripta (nutans)
- Veronica teucrium

1 to 2 ft.:

- Hemerocallis Dr. Regel
- Hemerocallis dumortieri
- Hemerocallis middendorffi
- Narcissus (midseason and late varieties)
- Papaver pilosum (olympicum)
- Trollius europaeus

2 to 3 ft.:

- Dicentra spectabilis
- Doronicum
- Hemerocallis flava
- Paeonia
- Tulipa (Darwin, Cottage, and Breeder types)

3 to 4 ft.:

- Hesperis matronalis
- Iris (bearded type)

June:

Less than 12 in.:

- Campanula carpatica
- Campanula portenschlagiana
- Dianthus deltoides
- Dianthus plumarius
- Dicentra eximia
- Iberis sempervirens
- Papaver nudicaule
- Saponaria ocymoides
- Sedum ellacombianum
- Sedum reflexum
- Viola canadensis

1 to 2 ft.:

- Achillea ptarmica
- Astilbe
- Centaurea montana
- Chelidonium majus
- Dianthus barbatus
- Filipendula hexapetala
- Heuchera lithophila (brizoides)
- Hosta caerulea (ovata)
- Hosta sieboldiana
- Incarvillea
- Linum perenne
- Lychnis coronaria
- Platycodon grandiflorum var. mariesi
- Polemonium caeruleum

2 to 3 ft.:

- Anthemis tinctoria
- Aquilegia chrysantha
- Aquilegia Long-spurred Hybrids
- Baptisia australis
- Campanula latifolia
- Campanula persicifolia
- Chrysanthemum maximum
- Coreopsis
- Delphinium grandiflorum (chinense)
- Dictamnus albus (fraxinella)
- Gaillardia
- Hemerocallis
- Iris sibirica
- Lilium concolor
- Lilium elegans
- Lilium pumilum (tenuifolium)
- Lilium umbellatum
- Lychnis chalcedonica
- Monarda didyma
- Papaver orientale
- Penstemon barbatus
- Salvia argentea

Salvia pratensis
Trollius ledebouri

3 to 4 ft.:
Anchusa azurea (italica)
Digitalis purpurea
Hesperis matronalis
Lilium amabile
Lilium candidum
Lilium martagon album
Lilium testaceum
Lilium willmottiae (warleyense)
Sidalcea
Thalictrum aquilegifolium
Thermopsis caroliniana

4 ft. or over:
Althaea rosea
Campanula pyramidalis
Delphinium
Lilium canadense
Lilium regale

July:

Less than 12 in.:
Heuchera sanguinea
Oenothera missouriensis
Tunica saxifraga
Veronica incana

1 to 2 ft.:
Euphorbia corollata
Geranium sanguineum
Hosta undulata
Limonium latifolium
Oenothera fruticosa
Stachys grandiflora (Betonica grandiflora)
Stokesia laevis (cyanea)
Veronica Blue Spire
Veronica maritima subsessilis

2 to 3 ft.:
Asclepias tuberosa
Belamcanda chinensis
Campanula persicifolia
Centranthus ruber
Digitalis lanata
Echinops ritro
Lilium browni
Lilium formosanum—Prices var.
Monarda didyma
Phlox
Phlox Daily Sketch
Rudbeckia hirta hybrida

3 to 4 ft.:
Centaurea macrocephala
Digitalis laevigata
Eremurus
Filipendula rubra
Galtonia candicans
Helenium autumnale and var.
Heliopsis helianthoides var. pitcheriana
Hemerocallis fulva
Hemerocallis Hyperion
Lilium auratum
Lilium Hansoni
Lupinus polyphyllus
Thalictrum glaucum

4 ft. or over:
Aruncus sylvester
Cassia marilandica
Cimicifuga racemosa
Liatris pycnostachya
Lilium davidi
Lilium maxwill
Lilium pardalinum
Lilium pardalinum giganteum
Lilium Preston Hybrids
Lilium superbum
Lythrum salicaria
Macleaya cordata (Bocconia cordata)
Verbascum olympicum

August:

Less than 12 in.:
Ceratostigma plumbaginoides
Dicentra eximia
Sedum spectabile var. Brilliant
Verbena canadensis

1 to 2 ft.:
Aster frikarti

Physostegia virginiana var. Vivid
Stokesia laevis (cyanea)

2 to 3 ft.:
Aconitum napellus var. Sparks
Clematis heracleaefolia var. davidiana
Gaillardia
Lycoris squamigera
Phlox
Platycodon
Rudbeckia hirta **hybrida**

3 to 4 ft.:
Chelone lyoni
Echinacea purpurea
Heliopsis
Lilium speciosum
Lobelia cardinalis
Penstemon torreyi
Rudbeckia speciosa

Over 4 ft.:
Artemisia lactiflora
Eupatorium purpureum
Helianthus
Liatris scariosa hybrida September Glory
Lilium formosanum (philippinense formosanum)
Lilium henryi
Lilium tigrinum
Rudbeckia maxima
Solidago canadensis

September:

Less than 12 in.:
Ceratostigma plumbaginoides
Colchicum
Crocus sativus
Crocus speciosus
Sedum sieboldi
Sternbergia
Verbena canadensis

1 to 2 ft.:
Chrysanthemum arcticum
Chrysanthemum coreanum
Chrysanthemum hybrids
Gentiana andrewsi
Hosta japonica
Salvia patens
Tricyrtis hirta

2 to 3 ft.:
Anemone hupehensis
Anemone September Charm
Begonia evansiana
Coreopsis
Echinacea purpurea
Eupatorium coelestinum
Eupatorium urticaefolium
Gaillardia
Liatris scariosa
Platycodon

3 to 4 ft.:
Chelone lyoni
Chrysanthemum uliginosum
Lespedeza formosa (Desmodium penduliflorum)
Salvia azurea

Over 4 ft.:
Aster novae-angliae
Helianthus orgyalis
Lilium formosanum (L. philippinense formosanum)

October:

Less than 12 in.:
Papaver nudicaule
Rosa rouletti

1 to 2 ft.:
Chrysanthemum
Coreopsis
Gaillardia

2 to 3 ft.:
Anemone japonica
Cimicifuga simplex

Over 4 ft.:
Aconitum fischeri var. wilsoni
Aster tataricus

November:

Less than 12 in.:
Helleborus niger
Rosa rouletti

Over 4 ft.:
Aconitum fischeri var. wilsoni
Aster tataricus

Perennials for Wet or Poorly Drained Ground

Acorus calamus
Asclepias incarnata
Caltha palustris
Campanula americana
Chelone lyoni
Eupatorium purpureum
Filipendula rubra
Helenium autumnale
Iris pseudacorus
Lobelia cardinalis
Lobelia siphilitica
Lysimachia clethroides
Lythrum salicaria
Monarda didyma
Myosotis scorpioides semperflorens
Onoclea sensibilis
Osmunda cinnamomea
Osmunda regalis
Ranunculus repens
Saururus cernuus
Trollius

Perennials for Dry or Poor Soil

Anthemis
Asclepias tuberosa
Aster
Euphorbia corollata
Gaillardia
Gypsophila
Hemerocallis
Liatris
Limonium
Yucca

Perennials for Naturalizing

Aquilegia
Asclepias
Aster
Chelidonium
Coreopsis
Eupatorium
Euphorbia corollata
Gaillardia
Hemerocallis
Myosotis
Viola (native species)

Perennials for Shade (See Bulbs also)

Aconitum
Ajuga
Anemone
Aquilegia
Aruncus
Asperula odorata
Begonia
Chelidonium
Cimicifuga
Convallaria
Dicentra
Dictamus
Digitalis
Echinacea
Epimedium
Eupatorium
Helleborus
Hesperis
Hosta
Lysimachia clethroides
Mertensia
Monarda
Myosotis
Oenothera speciosa
Phlox
Polemonium
Primula
Pulmonaria
Ranunculus
Thalictrum
Trillium
Trollius
Veronica
Viola

Perennials for Cut Flowers

Aconitum fischeri wilsoni
Anemone japonica
Aquilegia Long-spurred Hybrids
Campanula latifolia
Campanula persicifolia
Centaurea montana
Chrysanthemum coccineum
Chrysanthemum maximum
Coreopsis
Delphinium grandiflorum (chinense)
Delphinium hybrids
Echinacea purpurea
Gaillardia
Gypsophila paniculata
Helenium autumnale and var.
Helianthus maximiliani
Heliopsis scabra
Heuchera lithophila
Heuchera sanguinea
Iris sibirica
Kniphofia
Limonium
Paeonia
Phlox
Rudbeckia hirt hybrida
Salvia azurea
Stokesia
Veronica maritima sub-

PERENNIALS WITH GOOD FOLIAGE THROUGHOUT THE SEASON

Alyssum	Chrysanthemum arcticum	Iberis
Anemone japonica	Chrysanthemum coreanum	Lavandula
Artemisia lactiflora	Cimicifuga racemosa	Macleaya cordata (Bocconia)
Aruncus sylvester	Clematis recta	Nepeta mussini
Aster tataricus	Dianthus plumarius	Paeonia
Baptisia australis	Dicentra eximia	Ruta graveolens
Begonia evansiana	Dictamnus albus	Thalictrum adiantifolium
Bergenia cordifolia (Saxifraga)	Helianthus orgyalis	Thalictrum glaucum
Boltonia asteroides	Heliopsis scabra	Vinca
Cassia marilandica	Hemerocallis	Yucca
Chelone lyoni	Hosta	

PERENNIALS WHICH SHOULD BE LEFT UNDISTURBED

Aconitum	Dictamnus	Lupinus
Asclepias	Helleborus	Paeonia

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CHAPTER XII

FLOWERING BULBS

Flowering bulbs are seldom used to the extent that they could be in the average garden. With the many different kinds, they offer a variety and a sequence of bloom, a range of color, and a mass of color that should not be neglected. The fact that many of them are early-spring bloomers adds to their usefulness. By a selection of varieties it is possible to have bulbs in bloom from March until September.

The term *bulb* is used horticulturally to include not only true bulbs with fleshy scales such as the narcissus and the lily but also corms such as the crocus and the gladiolus, roots such as the dahlia, and rhizomes such as the canna. All these plants are included in this classification because they may be handled in a more or less dormant condition as compared with the normal, fibrous-rooted plants.

The nature of bulbs is such that many of them can be planted beneath and between other plants, *e.g.*, as annuals and perennials, to give a greater amount of bloom in any given area. It is unfortunate that the possibility is not appreciated and advantage taken of it in planning flower borders. This lack of culture is partly due to a lack of familiarity with all except the more common forms and particularly to the prevalent idea that many spring-flowering bulbs must be dug up each year and summer stored out of the garden. Another possible reason for the lack of their use is the apparent expense, although actually the more vigorous forms, because of their permanence and multiplication, are relatively inexpensive investments. An additional advantage, especially of the spring-flowering forms, is that they may be grown in many locations where other plants find it difficult to survive.

Classification of Bulbs. *Hardy Bulbs.* This term is applied to bulbs that may be left in the ground year after year.

Half-hardy bulbs means those bulbs which may be left in the ground over winter in mild climates but require adequate protection and excellent drainage to live over in colder climates.

Tender bulbs are bulbs that must be taken indoors over winter, except in extremely mild climates.

USES OF BULBS

In the Flower Border. One of the most effective uses of bulbs is in the flower border and flower beds where they may take their places among other annuals and perennials as a unit in the succession-of-bloom cycle from spring to fall. The hardy bulbs may be left in the beds after blooming where their leaves, as they yellow, will be more or less hidden by the foliage of other plants.

In planting bulbs in such a situation, they will be more effective if massed in irregular groups, the number in each group depending upon the size of the border and the kind of bulb. There should be a sufficient mass of bloom to be visible, particularly of the spring-blooming bulbs, from the windows of the house. The old-fashioned idea of planting single rows around the front of the border does not give sufficient color in any one place to be of value. Whether one color or mixed colors of any one kind are used is a matter of personal taste, *e.g.*, one variety of Darwin tulip or a mixture of Darwins, one variety of Narcissus or a mixture of narcissi. Lilies may be planted in groups of three or more. In the same manner small colonies of gladiolus may be planted from Mar. 1 to July 1 for a succession of bloom. Under suitable conditions many of the other tender bulbs may be planted in the flower border. Care should be taken not to plant the hardy bulbs too close to or beneath those perennials forming solid mats of roots that might make it difficult for the bulbs to come up. This would include such perennials as bearded iris, Shasta daisy, and *Physostegia.* The low-growing, spring-flowering bulbs, such as crocus and grape hyacinth, bloom so early that the perennial foliage is not sufficiently high to hide them even though they are planted in the back as well as in the front of the border.

Bulbs among the Shrubs. The shrub border offers an effective setting for groups of bulbs, whether they are the low-growing crocus, grape hyacinth, and squill or the taller narcissus, hyacinth, and tulip. Here, again, groups rather than single rows of bulbs should be planted. The taller growing bulbs, such as the Henry lily, regal lily, and tiger lily, may be planted in among the low-growing shrubs. Even gladiolus may be used effectively in pockets in front of the shrubs.

Bulbs in Shady Spots. Spring-flowering bulbs that produce their foliage and bloom before trees and shrubs have completely leafed out can usually thrive in shaded locations where most other plants find it difficult. For this purpose narcissus, scilla, crocus, *Camassia*, *Eranthis*, and *Muscari* may be used with safety. For summer bloom *Lycoris* will give excellent bloom. Where the soil is completely filled with tree roots and nutrients are lacking, ample soil preparation and fertilization will give better results.

Bulbs in the Rock Garden. The lower growing types of bulb will not be out of place in the average rock garden. If not used in too great profusion, their foliage will usually be hidden by the other rock plants around them. Among the bulbs particularly adapted to this use are the many species of crocus, *Eranthis*, *Chionodoxa*, *Fritillaria meleagris*, *Lilium concolor*, *Lilium pumilum* (*tenuifolium*), *Lilium rubellum*, narcissus species including the triandrus hybrids, *Scilla sibirica*, and *Scilla bifolia*. In addition to this, if the climate is not too severe, *Calochortus* and the western erythroniums may be grown.

Bulbs for Naturalizing. In wooded areas, along farm drives, in meadows, or in any other location that is not mowed or pastured before the bulbs have an opportunity to ripen their foliage, certain of the hardy bulbs will be most effective. Under these conditions they will not only be permanent but multiply. Hardy bulbs are a relatively inexpensive method of beautifying the rough spots in large yards and at the same time are the means of obtaining charming effects. Particularly useful is narcissus. *Camassia*, *Fritillaria imperalis*, *Scilla*, crocus, *Muscari*, and even the more easily propagated lilies such as *L. umbellatum*, *L. tigrinum*, *L. henryi*, *L. hansoni*, *L. canadense*, *L. superbum*, and *L. regale*, may also be mentioned among others.

Bulbs in Nooks and Corners. In addition to the foregoing places are many odd ones around the garden where spring bulbs particularly may be planted; *e.g.*, around the base of trees, crocus, *Scilla*, *Muscari*, and narcissus; beneath tall shrubs, *Muscari*, crocus, *Eranthis*, *Chionodoxa*, narcissus, and tuberous begonias; at the base of hedges, any of the spring-flowering bulbs; beneath the grape arbor, hyacinth, tulip, narcissus, and, if the shade is not too dense, lily; in the wild garden, narcissus, *Scilla*, crocus, and *Muscari;* along the north side of the house, narcissus, hyacinth, crocus, *Muscari*, *Scilla*, and tuberous begonias; around the base of the sundial or the bird bath, any of the low-growing bulbs; beneath *Vinca* or other ground covers under trees, narcissus, crocus, and *Fritillaria;* in the rose bed, hyacinth, crocus, *Scilla*, *Muscari*, narcissus, and early tulip.

When to Plant Bulbs. Hardy bulbs should be planted as early as possible in the fall. The more perishable types such as *Eranthis*, anemone, and *Erythronium* should be planted during September if possible. Later than this they are often so dried out that they will not grow. Lily bulbs should be planted as soon as received. Narcissus are usually successful if planted before the ground freezes or at the latest by mid-December, although earlier planting is recommended. Tulip and hyacinth may be planted up until mid-December without damage except in severe climates. In general, the small bulbs, such as crocus, *Scilla*, and *Muscari*, are best planted during October or early November.

Each kind of bulb should be planted at its recommended depth. Planting too deep sometimes retards blooming in the spring and occasionally prevents adequate growth. In general, most bulbs except lilies should be planted about three times their own depth, with a minimum of 2 in.

Transplanting, Resetting, and Storage of Bulbs. No experimental work has been conducted to determine the exact time at which bulb foliage may be removed following blooming without ill effects on the next season's bloom. A considerable number of bulbs produce the next season's flower bud following blooming. Theoretically, at least, the foliage should not be removed until it normally begins to yellow and die down. It is possible to cut back the foliage, as of narcissus, halfway to lessen the matted mass otherwise present.

Tender bulbs should be dug and removed to cellar storage either before or after frost but before there is any possibility of the bulbs' freezing. Tender bulbs, such as gladiolus, may be stored in open boxes or paper sacks. The more perishable forms, such as tuberous begonia, tuberose, and spider lily, are best stored in dry sawdust or dry peat moss. Cannas and dahlias may be dug with the soil on them and simply placed on the cellar floor or on a shelf until divided in the spring. If difficulty is encountered in keeping them from shriveling, pack them in dry sawdust or dry peat.

For the average home garden, hardy bulbs are best left in the ground from year to year, being dug and replanted only when multiplication has reached the point where they need separation. Even then, immediate replanting, although contrary to customary practice, is simpler and more convenient than storage in paper bags or boxes during the summer.

Diseases and Pests Affecting Bulbs. *Moles* may cause some destruction, but much more annoyance, by burrowing among the bulbs. They may be trapped or gassed with cyanogas or methyl bromide.

Killing the grubs and other soil insects they feed upon will also tend to drive moles away. Apply 1 lb. of 50 per cent DDT or its equivalent to 1,000 sq. ft. of yard surface. Mix with sand and apply dry or mix with water and apply with a watering can.

Mice usually follow the mole runs and do considerable damage to the bulbs. Wheat soaked in 1 oz. of strychnine dissolved in 1 gal. of water may be placed in the runs.

Chipmunks, often unsuspected, are a serious pest, digging and carrying off many of the smaller bulbs. Large wire rat traps baited with squash or melon seeds are usually the best means of control. The animals may be drowned after they are caught.

Insect pests attacking bulbs include aphis, red spider, grubs, gladiolus thrips, blister beetles, and stalk borers. The control of these is discussed in Chap. XVIII. Bulb mite and the narcissus bulb fly are sometimes found on inferior stock. The bulbs should be destroyed by burning.

Diseases of bulbs are relatively rare. Those which do appear are best controlled by digging and burning the plants, bulbs and all. The *botrytis blight* of tulips, indicated at first by small, yellow spots surrounded by darker areas, later affects the entire leaf and flower-petal surface. Since this disease is carried in the soil, removal of the soil, as well as destroying the entire plant, is necessary. *Basal rot* of narcissus is controlled by destruction of the bulbs. *Tulip mosaic*, indicated by streaking and blotching of the color of the flowers, is also controlled by burning the bulbs; otherwise it is a source of infection for lilies.

A SELECTED LIST OF FLOWERING BULBS

AMARYLLIDACEAE AMARYLLIS FAMILY

Galanthus nivalis. Snowdrop. Europe. 6 to 8 in. The small white flowers in March are conspicuous only if planted in groups. Will selfsow.

Hymenocallis calathina (*Ismene calathina*). Spider lily. South America. White flowers, 4 in. in diameter, long slender petals at the end of a long tube on a 2-ft. stem. Plant out of doors in late May, 3 in. deep and 12 in. apart for midsummer bloom. Dig and store above 40° for winter. May be grown in partial shade.

Leucojum. Snowflake. Europe.

L. vernum. 1 ft. Early spring.

L. aestivum. 1 ft. Late spring.

Both have white flowers tipped with green. Not showy but different.

Lycoris squamigera (*Amaryllis halli*). Hardy Amaryllis. Japan. Rose-lilac flowers in July and August; *L. radiata* red flowers in September. The later form is not quite so hardy as the former. The foliage appears in spring and dies down before flowers are produced. For this reason it is best planted among other perennials to give a foliage background.

Polianthes tuberosa. Tuberose. Mexico. Fragrant white flowers. Plant out in early June. Should be in bloom by late July. Often uncertain in blooming habits. Winter store same as gladiolus.

Zephyranthes rosea. Zephyrlily. South America and West Indies. 12 in. in height. Flowers dark pink. Plant out in April or May. The planting of a group in a large pot is recommended. Plant bulbs 3 in. deep, 3 or 4 in. apart for summer bloom. Store over winter like gladiolus.

Narcissus. Narcissus is a large genus. Ease of cultivation, early bloom, and graceful habit of growth make it indispensable in the spring garden. About 10 species from Europe and the Mediterranean region have produced a number of types and the thousands of named varieties now available. Much confusion exists in the nomenclature, the name *jonquil* often being applied erroneously to the entire group. Properly they are *narcissus* or *daffodils.* The classification developed by the Royal Horticultural Society of England is the most satisfactory so far, although because of considerable interbreeding between the types it is no longer completely accurate. However, no better one has yet been devised, and it is given as a guide:

Classification of Daffodils

Division 1. *Trumpet Daffodils:*

Distinguishing Character. Trumpet or crown as long as or longer **than** the perianth.

a. Varieties with yellow or lemon-colored trumpets and perianth of same shade or lighter (but not white).

b. Varieties with white trumpet and perianth.

c. Bicolor varieties, *i.e.*, those having a white or whitish perianth and a trumpet colored yellow, lemon, or primrose, etc.

Division 2. *Incomparabilis:*

Distinguishing Character. Cup or crown not less than one-third but less than equal to the length of the perianth segments.

a. Yellow shades with or without red coloring on the cup.

b. Bicolor varieties with white or whitish perianth and self-yellow, red-stained, or red cup.

Division 3. *Barrii* (incorporating *Burbidgei*):

Distinguishing Character. Cup or crown less than one-third the length of the perianth segments.

a. Yellow shades, with or without red coloring on the cup.

b. Bicolor varieties with white or whitish perianth and self-yellow, red-stained, or red cup.

Division 4. *Leedsii:*

Distinguishing Character. Perianth white and cup or crown white, cream, or pale citron, sometimes tinged with pink or apricot.

a. Cup or crown not less than one-third but less than equal to the length of the perianth segments.

b. Cup or crown less than one-third the length of the perianth segments.

Division 5. *Triandrus Hybrids:*

All varieties obviously containing *N. triandrus* blood.

a. Cup or crown not less than one-third but less than equal to the length of the perianth segments.

b. Cup or crown less than one-third the length of the perianth segments.

Division 6. *Cyclamineus Hybrids.*

Division 7. *Jonquilla Hybrids:*

All varieties of *N. jonquilla* parentage.

Division 8. *Tazetta and Tazetta Hybrids:*

To include *N. tridymus*, *poetaz* varieties, the Dutch varieties of polyanthus narcissus, *N. biflorus*, *N. muzart*, and *N. intermedius*.

Division 9. *Poeticus Varieties.*

Division 10. *Double Varieties.*

Division 11. *Various:*

To include *N. bulbocodium*, *N. cyclamineus*, *N. triandrus*, *N. juncifolius*, *N. gracilis*, *N. jonquilla*, *N. tazetta* sp., *N. viridiflorus*., etc.

Varieties to Choose. By properly selecting early, midseason, and late varieties it is possible to have narcissus in bloom from 4 to 6 weeks. Selection of one or more varieties from each of the groups gives an interesting collection. In many instances inexpensive varieties are just as satisfactory although not so new as the expensive ones.

Uses of Narcissus. Narcissus may be used in a wide range of locations in any garden—in the flower border planted in groups, in front of shrubs as colonies, beneath trees as individuals or otherwise, in the wild garden or even in a meadow naturalized. They will produce a profusion of bloom.

In combination with perennials, in annual flower beds, or combined with other bulbs they are equally satisfactory. Plant the bulbs about twice their depth beneath the surface and 6 to 12 in. apart. Unless quick multiplication is desired, they may be left undisturbed for some years. Lengthy exposure to the sun may injure the bulbs when they are out of the ground. Narcissus are best planted in September or October, as later planted bulbs do not always bloom so well unless heavily mulched.

ARACEAE ARUM FAMILY

Hydrosome rivieri. Usually listed as *Amorphophallus.* Devil's-tongue. Cochin China. 2 to 4 ft. Huge green, purplish, spotted spathe resembling calla. Rank odor. Blooms indoors in spring from unplanted bulb. Set out in open ground after all danger of frost is past.

Colocasia antiquorum. Elephants-ear. Caladium. Tropical Asia. 3 to 6 ft. This is an old-fashioned foliage plant still occasionally grown. Plant out of doors in June. It must be brought indoors before freezing in the fall. Roots edible.

BEGONIACEAE BEGONIA FAMILY

Begonia evansiana. Hardy Begonia. China and Japan. 2 to 3 ft. August and September. Pink flowers. Large, showy leaves red underneath. When planted in shade in well-drained soil and well mulched, it is surprisingly hardy.

Begonia tuberhybrida. Tuberous Begonia. The result of the hybridization of eight or more South American species. Usually, they are large-flowered, upright-growing plants with white, yellow, apricot, pink, or red blossoms up to 4 in. in diameter. Many flower types have been developed, *e.g.*, camellia, narcissus, gardenia, carnation, and rose. There are also small-flowered, trailing forms to be used in hanging baskets. Originally developed in Europe, the best forms today are being produced in California. Difficult from seed. Dormant tubers may be started indoors in early spring, but seedlings sown in December and sold in bloom in June may be used. The latter are probably preferable. Grown in almost full shade, except in cool climates, with ample leaf mold in the soil, they bloom throughout the summer.

CANNACEAE CANNA FAMILY

Canna indica. The several species native to southern United States and South America have been hybridized to produce the numerous horticultural varieties listed today. Largely used for parks and cemeteries, they are seldom seen in home gardens, where the tropical effect is difficult to combine with other plants. Stored in the cellar over winter, they are best started indoors in March or April and set out after all danger of frost is past.

COMPOSITAE COMPOSITE FAMILY

Dahlia. Mexico and Guatemala. Five or six species have been used to develop present-day varieties which are classed in several distinct types—

including single, anemone, collarette, peony, cactus, formal decorative, informal decorative, miniature, and pompon.

Except in warmer climates, the dahlia must be dug and stored indoors over winter and planted in the spring only after all danger of frost is past and the ground has warmed up. Space plants of taller varieties 3 to 4 ft. each way; smaller ones less.

Divide all clumps, planting but a single root division, 3 to 4 in. below surface. Prune to a single stem as growth starts.

Soils high in nitrogen produce excessive growth and but little bloom. Adequate summer moisture is essential. Cultivation for weed control is best replaced by mulching, especially in warmer climates, to maintain lower soil temperatures.

Disbudding is required for the production of large blooms with relatively long stems.

Roots may be dug and stored after tops are killed by frost. Dry for a day or so before storing in cellar at 40 to 50°F. Clumps need not be stored upside down to prevent rotting. If difficulty is encountered in maintaining plumpness of roots, store in dry sawdust, dry peat, or dry shavings. Sand is apt to be moist. The clumps should not be divided until late winter or spring.

Varieties change from year to year, with quantities of new ones being constantly introduced. They will also vary according to the section of the country. Dahlias, like iris, peonies, gladiolus, and other prominent flowers, suffer from the introduction of altogether too many new varieties, many no better and often inferior to existing varieties.

Normally division of the clumps into individual roots gives sufficient multiplication. Care must be exercised to preserve the stem end of the root where the buds or eyes appear. The dahlia root is not a tuber like the potato and therefore will not produce buds except at the stem end.

Quicker multiplication may be obtained by means of cuttings. Plant the clumps in the greenhouse in early March. As growth starts, they may be pulled from roots; or, if a greater number is desired, cut back to one pair of leaves. Root in sand or sand and peat. It is also possible to root cuttings consisting of a leaf and a portion of stem. Pot in 2½-in. pots when rooted. Do not set out until weather is warm.

Dahlias may be grown from seed. This method is used regularly for Mignon and Coltness hybrids for summer bloom. Other single-flowered varieties may also be grown from seed. Otherwise, seed is used only for the production of new varieties, since many of those produced will be inferior to named ones now on the market.

IRIDACEAE IRIS FAMILY

Crocus. There are several dozen species most of which are from the Mediterranean regions. Some are spring-blooming; others, autumn-blooming. The Dutch crosses have supplied most of the large-flowered, named varieties. Other spring-blooming forms are *C. moesicus* (*aureus*), *C. tomasinianus*, and *C. susianus.* The fall-blooming species include *C.*

chrysanthus, *C. laevigatus*, *C. pulchellus*, and *C. speciosus*. The practice of planting crocus in lawns is unsatisfactory if the grass is to be mowed. Fall plant 2 to 3 in. deep and same distance apart.

Gladiolus. Of the 200 species largely natives of Africa and the Mediterranean regions, but 8 or 10 have contributed to present-day *Gladiolus hortulanus* with its thousands of named varieties. The present classification is as follows:

Exhibition—very large flowers, over 6 in. in diameter
Large decorative—flowers 3 in. or more in diameter
Small decorative—flowers less than 3 in. in diameter

Within each of these rather indefinite types may be varieties with plain, ruffled, fringed, or other types of petal. Colors and markings may be equally variable. All in all this classification is far from satisfactory, depending to some extent on purely cultural practices to produce size.

The summer bloom, convenience of handling and storing the corms, satisfaction as a cut flower, together with its variety of colors, have made the gladiolus an important commercial crop for corm production as well as for cut flowers.

Its hardiness permits spring planting as soon as the ground can be worked, and its dormant state permits planting at intervals until July 1 for succession of bloom. This may be done every 10 days to 2 weeks.

Depth of planting varies with the soil. Mature corms are planted from 3 to 6 in.; cormels or cormlets, 2 in. deep. Large corms may be set 2 to 3 in. apart. New ones are produced at the base of each shoot while the old one is gradually used up. Small corms, or cormlets, are produced around the base of the new corms. Their number and size vary with the variety, climate, moisture, and soil.

Propagation is largely from the cormlets which bloom in 2 to 3 years. They should be planted as early as possible in the spring. Soaking in water from 3 to 6 days before planting sometimes hastens germination. It is also possible to divide the old corms so that each piece has a bud and preferably a section of the basal center.

New varieties are produced from seeds which produce blooming-size corms in 2 to 3 years.

Gladiolus corms are graded according to the following sizes:

No. 1—1½ in. and up
No. 2—1¼ to 1½ in.
No. 3—1 to 1¼ in.
No. 4—¾ to 1 in.
No. 5—½ to ¾ in.
No. 6—below ½ in.

The blooming sizes are Nos. 1, 2, and 3, although No. 4 and sometimes even smaller sizes may flower during the season. Some varieties do not produce large corms, and as a consequence their scale of sizes varies somewhat. Sizing of stock may be accomplished by grading machines on a large scale and by grading boards or wire screens for the amateur grower. The smaller blooming sizes are often preferred for the home garden because of greater ease of arranging the shorter stems as cut flowers.

Gladiolus will grow in almost any soil, but a sandy loam is preferred for commercial production.

Flowers may be cut as soon as first floret opens, leaving at least three leaves on the plant to mature corm.

Gladiolus may be dug as soon as foliage starts to yellow. After digging with tops cut back to 2 in. from ground, allow to dry indoors for a week or two. Then clean.

Even if no thrips are apparently present, it is well to take no chances. Dust all corms lightly with 5 per cent DDT. Use 3 to 4 tbsp. of dust to 1 bu. of corms. Cormlets may be stored in peat moss to prevent their becoming too hard and dried out.

Contrary to popular belief, gladiolus do not revert or mix. Careless labeling and storage, together with faster multiplication of some varieties, has given widespread belief to this myth.

As a precaution against thrip and many corm-borne diseases, treat all gladiolus before planting. Dust with 5 per cent DDT, 7 per cent fixed copper dust.

The older method is to soak in bichloride of mercury, 1 oz. to 7 gal. of water, for 3 hr. just before planting. This may have a slight stunting effect on growth.

Iris. The several forms of bulbous iris may be completely hardy if placed in a well-drained location 8 to 10 in. deep and 6 to 8 in. apart. This includes Dutch, Spanish, and English iris.

I. reticulata. Caucasus. 12 in. April. A hardy and extremely early blooming form for the rock garden. Flowers violet, spotted orange.

Tigridia pavonia. Tigerflower. Mexico. 2 to 2½ ft. Flowers red, spotted with yellow, 6 in. in diameter. Each flower lasts but one day. There are white, pink, and yellow forms. Plant in groups of six or more 3 in. deep and 6 in. apart. Dig in fall, and store in cellar over winter.

Tritonia (Montbretia). Showy South African plants with orange to red flowers, 2 to 3 ft. high, resembling small-flowered gladiolus. They bloom best in milder climates where they may be left out of doors, even though mulching is necessary. Ample sun and moisture are desirable. In severe climates they must be dug and stored indoors.

LILIACEAE LILY FAMILY

Brodiaea. Western North America. This genus offers a large range of species and many different forms, some of them somewhat similar in bloom to onions. They range in color from white to lavender to blue to yellow to purple. They may sometimes be wintered over with protection in the northern states. Plant 2 to 3 in. deep.

B. uniflora, usually listed in the trade as *Triteleia uniflora,* the spring Starflower from Argentina, is apparently hardy in the northern states.

Calochortus. Mariposa Lily. Western North America. There are a number of different species with considerable variation in form, some being extremely showy, others not. Like the brodiaeas they are slightly tender in cold climates. Probably best planted in late fall and dug after ripening in summer. Planted in groups of six or more, 2 to 3 in. deep and 2 to 3 in. apart.

Camassia. Camas. North America. Of the four native species, *C. leichtlini* is usually preferred. 2 to 3 ft. Delicate blue flowers in June. They may be planted in the wild garden or the perennial border. All species grow in sun or shade. Plant bulbs 8 in. deep.

Chionodoxa luciliae. Glory-of-the-snow. Crete. 8 in. Small blue flowers in April. There are several varieties, *gigantea, grandiflora, sardensis,* and *tmolusii,* all of which are very similar to some of the scillas but distinguished from them by having the lower end of the petals united.

Colchicum. Autumn Crocus. There are five species from Europe and the Mediterranean. Flowers resemble those of the crocus, but the coarse foliage appears in the spring, whereas the flowers do not appear until September and October. They are white, pink, or lavender in color.

Erythronium. Troutlily. Although several species are native in the Eastern United States, the Pacific coast forms are larger and more showy. Since the bulbs deteriorate rapidly when dried, they should be planted in the early fall. Plant in colonies of a dozen or more, 2 to 3 in. deep, 2 to 3 in. apart. If well mulched, they may succeed in northern gardens.

Fritillaria.

F. imperialis. Crown-imperial. Persia. 2 to 4 ft. April. Flowers yellow to red. An old-fashioned, ill-smelling plant. Permanent when established.

F. meleagris. Checkered Lily. Europe and Asia. 8 to 12 in. Purplish-maroon flowers. Best grown where individual beauty may be observed.

There are many other species of fritillaries, many of them native to the Western United States but most of them are not particularly striking in effect.

Galtonia candicans. Summer-hyacinth. South Africa. 3 to 4 ft. July. Fragrant white flowers. Striking as an accent in the border. Tender in cold climates.

Hyacinthus orientalis. Hyacinth. Greece and Asia Minor. There is no reason why hyacinths should not be used much more widely than they are in gardens. The smaller bulbs are just as satisfactory for garden use as the large sizes sold for the florist trade. Hyacinths may be used in the form of individual plantings, scattered through the flower border, or in front of shrubs and evergreens.

Lilium. Lilies are one of the oldest of cultivated plants, having been grown in gardens at least a thousand years. Although many flowers are called "lilies," only those belonging to the genus *Lilium* are true lilies. All of the 82 species are native in the Northern Hemisphere, largely in America, Europe, India, China, and Japan. Practically all the known species are now in cultivation, most of them having been introduced and the hybrids developed in the last hundred years.

Lilies are true bulbs with loose unprotected scales and as such extremely perishable when out of the ground. Lack of proper handling and the sale of dried-up bulbs has been considerably responsible for the limited cultivation of lilies in the home garden in the past.

Lilies demand a well-drained soil, deep enough for proper rooting. Although most lilies grow in sunny locations, many of them will stand at least partial shade under cultivation. Most cultural instructions recommend an acid to neutral soil, but many will grow in an alkaline soil.

Where to Plant Lilies. Lilies may be planted in the perennial border, preferably with other plants with ample foliage. They may be used in the shrub border back of the lower growing ones and in front of the taller ones. In the same way they may be used among evergreens where the green background sets them off to advantage. The smaller types such as *L. concolor* and *L. pumilum* may be used in the rock garden.

Most lilies root from the stem above the bulb so that the bottom of the bulb should be 8 to 12 in. beneath the surface. Bottom-rooting kinds such as *L. candidum* and *L. testaceum* are planted 4 to 6 in. beneath the surface. The standard recommendation of planting lilies in a pocket of sand and dusting the bulb with sulphur or other fungicide is of questionable if any value.

Why Lilies Fail. The following factors are often responsible for the poor growth of lilies: poor drainage, heavy clay soils, poor bulbs dried out and shriveled, and, most important of all, virus-infected bulbs.

Most of the present-day difficulties with lilies are due to virus infection (mosaic), tests by the Bureau of Plant Industry of the U. S. Department of Agriculture having shown that lilies are infected with both cucumber and tulip virus, which is transmitted by the melon aphis and possibly by other insects. Since most of the lily stock is grown in nurseries near diseased stock, but few virus-free bulbs are available at the present time. Before lilies can be completely satisfactory as garden flowers, nurseries must produce 100 per cent healthy bulbs from immune or resistant species and varieties from seedlings grown under isolated conditions away from diseased bulbs. At the present time but few commercial growers are attempting to do this.

Lilies immune or resistant to mosaic include *L. hansoni*, *L. martagon*, *L. davidi*, *L. willmottiae*, *L. pardalinum giganteum*, the *hansoni-martagon* hybrids such as Marhan and the Backhouse hybrids, and possibly some of the *willmottiae* hybrids.

Horticultural varieties and species long propagated vegetatively are usually diseased. These include *L. elegans*, *L. batemanniae*, *L. candidum*, *L. sargentiae*, *L. tigrinum*, *L. bulbiferum*, *L. testaceum*, *L. auratum*, and the Creelman and Havermeyer lilies. Lilies usually grown from seed, if American grown, are not always infected and include *L. regale*, *L. formosanum*, and *L. pumilum*.

Lilies from Seed. Some lilies are easily grown from seed, germinating in a few weeks. Among these are *L. regale*, *L. formosanum*, *L. concolor*, *L. umbellatum*, *L. pumilum*, *L. amabile*, *L. candidum*, *L. henryi*, *L. maximowiczi*, *L. callosum*, *L. cernuum*, *L. dauricum*, *L. davidi*, *L. sargentiae*, and most of their hybrids.

Other lilies develop roots but no leaves until after 1 to 2 months of low temperature following root formation. These include *L. auratum*, *L. canadense*, *L. superbum*, *L. japonicum*, *L. chalcedonicum*, *L. columbianum*, *L. humboldti*, *L. martagon*, *L. pardalinum*, *L. parryi*, *L. speciosum*, *L. washingtonianum*, *L. pomponium*, *L. rubellum*, *L. pyrenaicum*, *L. szovitsianum*, *L. monadelphum*, *L. carniolicum*, and *L. philadelphicum*.

Time of Planting. Lilies are usually planted in the fall, the American- and European-grown stock being available in September and October. Oriental-grown stock is usually not received until late in November, often too late for fall planting. Except for the fact that lily bulbs develop considerably in the nursery during September and October, thus giving larger returns to the nurseryman, they can be planted at any time after the blooming season. Although the usual practice is to plant them where they are to bloom, there is much to be said for planting them in clay pots in the fall and keeping them in the cold frame under a mulch over winter. Transplanting to the garden, if the roots are not disturbed, may be done at any time.

Selection of Species and Varieties. From the foregoing lists of virus-immune and virus-susceptible lilies can be determined which of the following should be grown.

In the past few years many new hybrids between lily species have been developed, and many new color variations have been selected from existing forms.

L. amabile. Korea. 2 to 3 ft. June. Red flower with dark spots, reflexed petals.

L. auratum. Goldband Lily. Japan. 4 to 6 ft. July. White flowers with gold bands on the petals. Very showy, but satisfactory only if healthy stock is used.

L. canadense. Canada Lily. United States. 3 to 6 ft. July. Flowers drooping bells, yellow to orange to red, with dark spots.

L. candidum. Madonna Lily. Europe and Asia. 3 to 4 ft. June. Fragrant, white, horizontal-trumpeted flowers. August planted. Subject to botrytis blight.

L. concolor. Star Lily. China and Japan. 2 to 3 ft. June. Flowers vermilion.

L. elegans. A hybrid with many varieties. 2 ft. June. Upright flowered, yellow to orange to red. Showy and satisfactory if healthy.

L. davidi. China. 5 to 6 ft. July. Flowers nodding, red, spotted black.

L. formosanum (philippinense formosanum). Formosa. 5 to 6 ft. September. Fragrant white trumpets. Price's variety. 2 to 3 ft. July. Both bloom in one year from seed but are extremely susceptible to mosaic.

L. hansoni. Hanson Lily. Korea. 4 to 5 ft. June. Flowers orange-yellow. New shoots, unless protected, likely to freeze in spring. Apparently immune to mosaic.

L. henryi. Henry Lily. China. 5 to 6 ft. August. Flowers orange, spotted brown. Vigorous but requires staking. Resistant to mosaic.

L. martagon. Turkscap Lily. Europe. 4 to 6 ft. Flowers purplish pink. Variety *album* preferable. Marhan and Backhouse hybrids are crosses with *L. hansoni*.

L. pardalinum. Leopard Lily. Pacific coast. 6 to 8 ft. The variety *giganteum*, the Sunset Lily, preferable. Flowers orange-red, pendulous, reflexed petals.

L. regale. Regal Lily. Western China. 3 to 6 ft. June. Fragrant, white, trumpet flowers. Easily grown from seed. Vigorous and a free bloomer.

L. speciosum. Japanese Lily. Japan. 3 to 4 ft. August and September. White flowers bearded dark pink. Large, recurved petals. Satisfactory only if healthy stock is obtained.

L. superbum. American Turkscap Lily. United States. 4 to 6 ft. July. Drooping, orange-red flowers with reflexed petals. Like most native lilies it requires an acid soil.

L. pumilum (*tenuifolium*). Coral Lily. Siberia. 1 to 2 ft. June. Small, drooping, coral-red flowers with reflexed petals. Often lasts but 2 to 3 years.

L. testaceum. Nankeen Lily. Hybrid of *L. candidum* and *L. chalcedonicum*. 3 to 4 ft. June. Apricot flowers with brown stamens. August planted.

L. tigrinum. Tiger Lily. China and Japan. 5 to 6 ft. August. Orange-red flowers with dark spots, drooping. Reflexed petals.

L. umbellatum. Candlestick Lily. Hybrids. 3 to 4 feet. June. Upright, yellow to orange to red flowers. Much of present stock diseased.

L. willmottiae. China. 3 to 5 ft. July. Pendant, orange-red flowers spotted black. Recurved petals. Hybrids have larger flowers and a wide color range. Among them are Edna Keen, Brenda Watts, Lilian Cummings, Grace Marshall, Phyllis Cox, Coronation, and Maxwill.

Muscari. Grape Hyacinth. Mediterranean Region. A number of species and varieties are offered in the trade. April blooming.

M. botryoides. 8 in. Blue flowers. Variety Heavenly Blue more striking and showy bloom. 8 to 10 in.

M. comosum monstrosum (*plumosum*). 12 in. May. All petals cut and shredded.

The ordinary grape hyacinths are excellent for naturalizing and in fact for planting under all sorts of conditions. Increase rapidly.

Ornithogalum. Star-of-Bethlehem. Europe. Although the common *O. umbellatum* is a pest, *O. nutans* is showy and not a pest. 1 to 2 ft. Flowers white inside, green with white margins outside.

Scilla. Squills.

S. bifolia. Europe. 3 to 6 in. March and early April. Blue flowers.

S. hispanica (*campanulata*). Spanish Bluebell. 12 to 15 in. May. Blue, white, or pink flowers.

S. nonscripta (nutans). English Bluebell. Europe. 12 in. Very similar to *S. hispanica* except flowers are more tubular. These two large-flowered, later blooming squills should be grown far more extensively than they are.

S. sibirica. Russia. 6 in. April. Blue flowers. Very similar to *S. bifolia.*

Tulipa. Tulip. Long in cultivation, the common garden tulips are apparently all descended from *T. gesneriana* from Russia and Asia. This and other species have given rise to the following large-flowered forms.

Early Tulips. These early-flowering double and single forms are all descendants of *T. suaveolens,* a native of southwestern Asia. The colors range from white through yellow, pink, lavender, and red. Incidentally, the double forms are earlier to bloom and shorter stemmed than the single ones and unless planted with a ground cover are likely to be splashed with mud. The single early varieties grow from 10 to 18 in. high and bloom during april.

Darwin Tulips. This type of tulip is the most widely grown and ranges in height from 18 in. to 3 ft. The colors are pink, red, lavender, salmon, purple, and white. They bloom at the same time as the Cottage and Breeder. Flowers are large and broad.

Breeder tulips are similar to Darwins in shape and size but usually with different colors at the base of the petals, producing an attractive blending of two or more colors. The predominating colors are apricot, bronze, lilac, wine, rose, and yellow, in many cases suffused with bronze or buff. They are midseason in bloom.

Cottage tulips are usually characterized by large, slender flowers and thin, wiry stems. They are usually in single, clear colors. Similar to the Cottage tulips, but with gracefully curved petals, are the lily-flowered tulips. They are dainty and graceful in effect.

Parrot tulips are so-called because of the irregular, jagged edges of the petals. The older varieties had yellow and red flowers with weak stems, but the newer varieties, such as Fantasy, Gadelan, and Gemma, have much stronger stems.

Multiflowered Tulips. The other types of tulip usually have only one bloom to a stem, but these produce two to six flowers. Unless given ideal conditions they are not particularly satisfactory, producing just one flower to a stem.

Wild or Species Tulips. Of the 30 to 40 species of tulips that are found in catalogues, some are far more satisfactory than others. Unless these small-flowered tulips are early blooming, there seems to be little advantage in growing them unless completely isolated from the larger types. *T. kaufmanniana,* with primrose flowers which are pink outside, is often called the waterlily tulip. It is one of the earliest of all tulips, blooming as it does in April. Kaufmanniana hybrids give an interesting range of colors from yellow to red.

T. sylvestris, which has small, fragrant, yellow flowers is not only permanent but also multiplies rapidly.

Other species tulips worthy of trial are *T. chrysantha, T. clusiana, T. praestans, T. linifolia,* and *T. patens* (*T. persica*), which may be used in the rock garden and along the front edge of the perennial border.

OYALIDACEAE OXALIS FAMILY

Oxalis. Woodsorrel. Although usually grown as a house plant, the oxalis may be planted out in late May for summer bloom. Plant bulbs 2 in. deep and 6 to 8 in. apart. Dig and store in the same way as gladiolus. Species sometimes used—*O. bowieana*—South Africa. Flowers rose-pink.

RANUNCULACEAE BUTTERCUP FAMILY

Anemone. Although conspicuously featured in catalogues and flower shows, the various bulbous anemones are not particularly reliable in the average garden. Try these bulbs in the rock garden under thyme or sedum for protection.

A. coronaria. Poppy Anemone. Mediterranean Region. 12 in. This species and its semi-double variety St. Brigid offer brilliant color with red, blue, and white flowers from April to June.

A. apennina. Italy. 6 in. Sky blue. *A. blanda.* Greece. 6 in. Sky blue. Are usually more reliable although not of easy culture. Early fall planting is essential to secure bloom with any of these.

Eranthis hyemalis. Winter-aconite. Europe and Asia. 4 to 6 in. Yellow flowers in March. They must be planted in the early fall because the roots deteriorate quickly. Once established, they are permanent. Often selfsow. Require good drainage.

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CHAPTER XIII

THE ROCK GARDEN

Rock gardens are one of the most misunderstood and misused forms of garden. Correctly made and properly planted, a rock garden has a definite and legitimate place. Its purpose is not to have a geological collection or display but rather a place to grow rock plants. Rock gardens were originally developed in an effort to plant and beautify natural rock outcrops or possibly an accumulation of rocks left by a stream or by a glacier. Another of the original purposes was to grow alpine plants that various gardeners had seen during their travels in mountainous regions. Unfortunately many of the rock gardens that we see today have been made not for any of these reasons but simply to be in style. As such they have little or no excuse. It is just as well that the fad that swept the country but a few years ago is subsiding, for under its spell the so-called rock garden, usually a pile of miscellaneous rocks with occasional pieces of glass and shells thrown in, was found in all sorts of incongruous places.

A rock garden should be built only if it fits in with the general design of the garden, and as such it should follow all the rules discussed in the chapter on Design of Small Properties.

There are many different ideas in regard to rock gardens. Those of the English quite often differ greatly from those which we hold here in America, for we feel that above all a rock garden should look natural. This does not mean the building of a miniature Swiss Alp; for after all in planting such an artificiality the plant could not possibly be kept in scale with the rockwork, and consequently the entire effect would be thrown out of balance.

WALL GARDENS

In many ways a wall garden is the most practical form of rock garden, the type best adapted to the average yard. A wall for a rock garden is constructed without any mortar or cement and for that reason is called a *dry wall.*

A wall may be less than 1 ft. in height or 4 or 5 ft. high. It may vary from a few feet in length to 25 or 50 ft. or considerably more. More or less architectural in form, it may be fitted with a minimum of effort and obviousness into the design of our yards with rectangular boundaries and our straight-sided houses.

The construction of a dry wall is so simple that anyone can do it. Except for walls over 3 ft. in height, no foundation of any sort is needed, the bottom layer of rock being set directly on the ground. For higher walls, a foundation layer of rock should be placed beneath the surface. As it is flexible, no provision is necessary for a frostproof foundation.

The rock will naturally vary with the locality. Flat rocks should be used if possible; those from 1 to 2 in. in thickness are the easiest to lay, although thicker ones are satisfactory—whether limestone, sandstone, or slate is immaterial. In some localities only glacial boulders may be available.

A wall garden is usually built against an existing slope, or it may be used to face a fill for the development of various levels in the garden as discussed in the chapter on Design of Small Properties. If there is no variation in level, a wall can be built to be viewed from two sides. It is filled with soil in the center and is known as *free-standing*. Unless watered sufficiently, this type of wall will be limited as to the type of plants that may be used in it.

In constructing a wall, each layer or row of rock should be kept horizontal, a partial layer being put in if the base of the wall is not on level ground. As each layer of rock is put in, a light layer of soil is thrown upon it, and the next layer put in place with alternate joints. After the wall is 6 or 8 in. high, holes may be left between each two rocks or between every other rock for the insertion of rock plants. These may be put in as the wall is being built, but usually less damage is done to them if they are put in afterward. Sometimes a brick or a two-by-four is inserted to be pulled out after construction is completed and the plants are ready to be put in.

Each individual piece of rock should slope slightly toward the bank to prevent slipping out with frost action. A soil mixture of equal parts of garden loam, sand, and humus should be used for the filling. Never use heavy clay. The mixture should be tamped very firmly back of the wall, or it will slide back against the bank. The face of the wall should be set back about 1 in. for each foot of height. No rock smaller than 12 in. each way should be used, but variation in form, size, and thickness gives a more interesting effect.

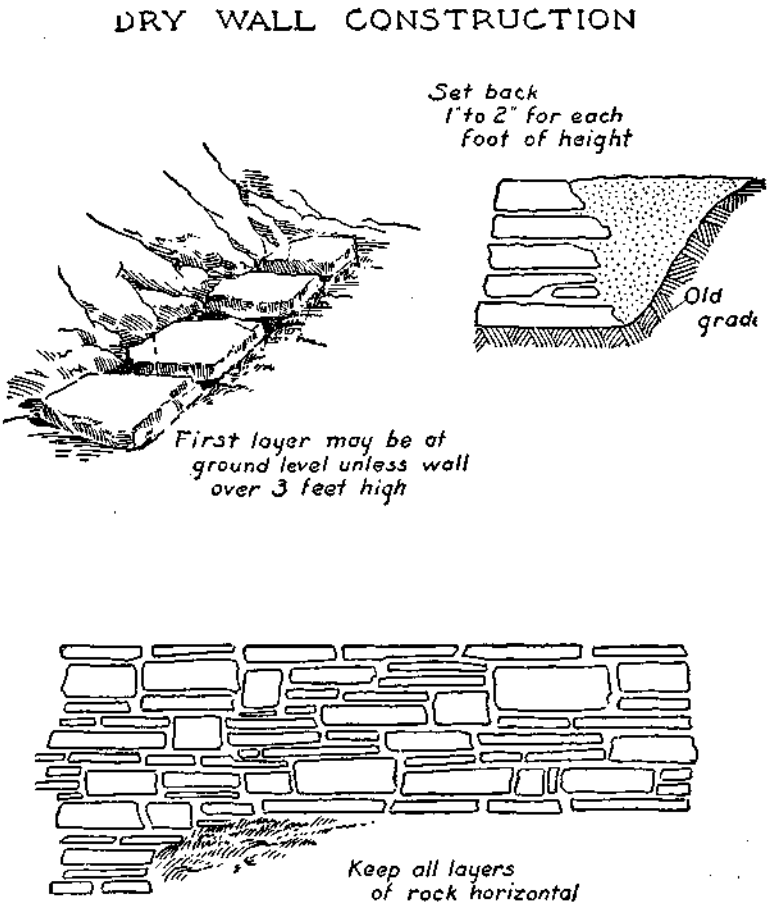

FIG. 63.

Such a wall carefully laid, with the soil well tamped, should stand for years. Dry walls may be used around terraces, along drives, or wherever there is a change of level. They are particularly satisfactory across the front of the yard along the front walk. When used along a drive, each successive layer should be set back about an inch so as to protect hubcaps and fenders.

Depending on the interest of the homeowner, a wall may be planted with the more vigorous trailing plants, which will soon cover it, or with the more restrained plants. An east or a north exposure is preferable for less hardy or alpine plants.

NATURALISTIC ROCK GARDENS

This is the type that most people think of as a true rock garden. The rock used should be well weathered and ordinarily local, although there may be times when it is possible to import weathered limestone or sandstone that will be preferable to local material.

Naturalistic rock gardens are best used on a natural slope. When artificial slopes are necessary, they should be so planted that they hide all appearance of artificiality. Likewise, even on a natural slope, the flatter the surrounding terrain the lower should be the rock garden. In fact the garden itself should not be more than a foot or at most 2 ft. above the normal level. Natural rock outcrops should be studied and imitated if possible.

In most instances the rocks should be placed in natural horizontal positions rather than vertically or at angles. Round rocks, such as glacial boulders, should be half buried to give the appearance of age and permanence. Other rocks may often be set directly on the surface without burying them. Soft dolomitic limestones with holes and pockets weathered in them give an opportunity for planting that harder limestones and other types of rocks do not. On the other hand, extremely porous rocks such as tufa, although giving ample opportunity for the insertion of plants, usually appear artificial. But only one kind of rock should be used in any one garden. Mixtures of different kinds and peculiar shapes and colors have no place. The more natural the rock garden can be made to appear before planting the more natural will be the finished effect.

For permanence, appearance, and ease of upkeep, no rocks weighing less than 25 lb. or less than 12 in. in diameter should be used. To suggest nature, considerable variety in size should prevail. For a small garden, rocks may vary from 25 to 100 lb. For larger gardens even slabs of 1 or 2 tons may be used. Even a small garden should have one large rock of several hundred pounds, although several smaller rocks may be grouped together to give the effect of one large one.

If we were to follow the instructions of English rock-garden specialists, few of us would have rock gardens, for the preparation specified is tremendous.

For the type of plants grown in the average American rock garden, $1\frac{1}{2}$ ft. of soil mixture is adequate, provided sufficient drainage is supplied if not already present. This soil mixture should be put in and around the rocks. Since it is difficult to describe accurately the construction of a rock garden, several acknowledged to be of good design and construction should be visited and studied, and several good rock-garden books read and also studied. Result of this may at first be confusion, due to the disagreement of the various authors, but the adaptation of their suggestions to our own conditions will clarify their ideas.

Although water in the form of a pool may be used in connection with the rock garden, its presence is not necessary. The prevalent idea that a cascade is necessary is erroneous. If running water is to be used, the simple geological fact that water always follows depressions and cuts its way into the rock over a period of years should not be forgotten. Thus, any cascade or waterfall should be in a recess rather than on a promontory. Running water may be kept in bounds by means of a reinforced concrete or sheet-lead trough. The latter is simpler and easier to camouflage. No concrete work should be visible. Pools should be naturalistic, with the concrete sufficiently sunken to be hidden by weathered rocks or plants.

The majority of plants grown in the rock garden require sun or at least partial sun. Plants from higher altitudes will often grow best with a north or an east exposure or where the heat of midday and the early afternoon sun is deflected by overhanging branches of a shrub or a small tree. Most of our native woodland plants are shade tolerant and should be used in such locations. The general practice of placing rock gardens in the shade or in places where other plants find it difficult to thrive is not to be recommended. Neither should rock gardens be made with the thought that they will reduce the upkeep of the garden or require less attention than other types of gardens. With the exception of perennial borders, practically no form of garden requires more care and attention than the rock garden.

MORAINE GARDENS

A moraine is a type of rock garden, with or without rocks, in which a gritty, well-drained soil mixture is underlaid by water, a foot or so beneath the surface. This water may be in the form of a running stream in a sheet-lead, concrete, or galvanized-iron trough, or it may consist of a pool in a concrete or lead tank. In either case the result is practically the same—a constant supply of moisture at the roots of the plants, with a minimum amount applied to the surface. This is an attempt to duplicate the conditions under which many alpine plants are found growing in nature where the water from melting snows flows or seeps through the rocks beneath the surface.

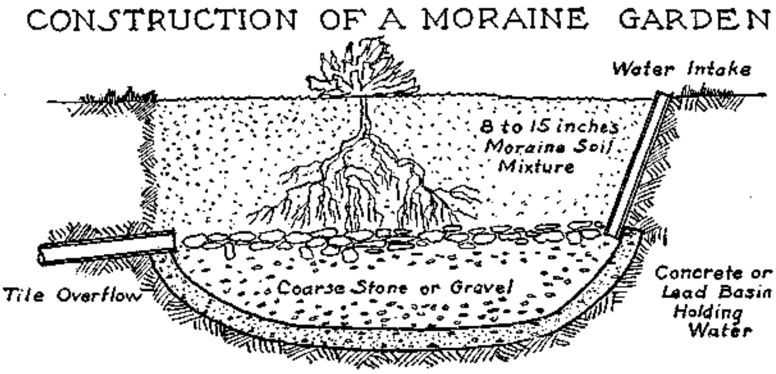

FIG. 64.

For complete drainage, the soil in the moraine should consist of equal parts of loam, leaf mold, sand, and stone chips, with a layer of ½ in. of stone chips on the surface.

A scree garden is the same as a moraine except that no water is supplied beneath the surface. Some gardeners feel that drainage should be assured by laying lines of agricultural drain tiles beneath the surface.

The **alpine meadow, or alpine lawn garden** is a modification of the naturalistic rock garden, with or without occasional rocks, in which natural alpine meadows are more or less copied. It is usually planted thickly with the more or less spreading types of plants and as such is a practical solution for planting gentle slopes or open flat areas.

SOILS

For the rock garden planted largely to dwarf perennials any good garden soil will be satisfactory. If, however, the interest in rock gardening increases, it is difficult to replace this with adequate soil for the growth of alpine plants. It therefore, may be advisable in originally constructing the rock garden to use equal parts of loam, sand, and humus, the latter in the form of peat moss or leaf mold. The soil reaction is not important for the more common types of plants. Many true alpines, however, are native in granite or other noncalcareous rock formations. It may be better in alkaline-soil sections to use sand and stone chips that do not contain limestone. They are sometimes difficult to obtain. A few drops of hydrochloric acid on sand will readily check the reactions.

Since the more choice alpines depend upon dwarf stature for effect, the presence of fertilizer is unnecessary and often a detriment. Soft, vigorous growth often increases their tendency to rot, so starvation and excessive drainage are advisable. It is difficult for the beginner to realize the almost soilless conditions under which many alpines grow in their native habitats. Therefore this point cannot be overemphasized. Heavy soil, poor drainage, and surface moisture are three conditions that frequently kill this type of plant. Alpine specialists recommend different soil mixtures for different types of alpines.

PLANTING THE ROCK GARDEN

The average small rock garden should have but few plants over a foot in height and the majority lower. Large gardens can have correspondingly higher ones. A recommendation sometimes made is that the surface of the rock garden should be one-fourth rock, one-fourth dwarf shrubs and dwarf evergreens, and one-half rock plants. Particularly necessary are the woody plants for accent, contrast, winter effect, and possibly shade and protection for alpines. Unfortunately a number of the woody plants and many of the rock plants themselves are too vigorous to be allowed unrestricted growth unless they are to take possession at the expense of less vigorous species. Therefore, the habits of each variety should be determined before its extensive use. Many so-called rock plants are best used as ground covers and will be found listed as such in Chap. XI. Above all others, *Sedum sarmentosum* and *Lysimachia nummularia* should never be planted in any rock garden.

FEATURES IN THE ROCK GARDEN

A bird bath in the rock garden, if used, should consist of a rock chiseled out to hold water. Naturally the usual type of bird bath, statuary, and gazing globes are entirely out of place.

Paths may be developed. If the garden is small, they may consist of steppingstones largely for use in its care. If for general use, they should be at least 2 ft. in width and paved with crushed stone or flat rock in keeping with the rock used in the garden itself. Likewise if steps are used in connection with the paths, the same harmony in appearance should be maintained.

PLANTS FOR THE ROCK GARDEN

To the plantsman rock plants compose one of the most fascinating groups, because no other plant group offers such variety of forms. From our nurseries and seedsmen a list of one to two thousand species and varieties may be obtained. The literature on rock plants alone is enormous. Selection of the proper kinds is therefore confusing.

For a rock garden installed of necessity or merely as a garden feature, only the most easily grown and permanent plants are recommended. These are really dwarf perennials rather than true alpines. The term *rock plant* is used to cover any plant that can be grown in the rock garden and unfortunately often includes many not entirely suitable. Alpine plants are those found in mountainous sections, usually above timber line. Horticulturally we may divide them into wall plants, moraine plants, and scree plants. A still further division should include plants too difficult to grow outdoors and cultivable only in the alpine house. Separate lists of the various types are included at the end of this chapter.

Propagation. The majority of rock plants may be grown from seed. The commoner ones may be sown in the spring and germinated without difficulty. Many of the less common, however, are often difficult to germinate, possibly because they require a low-temperature treatment. November sowing in pots is, therefore, advisable for any species whose germination is not known. Incidentally, the European idea that snow water is necessary for germination has no basis other than the low temperature, 41° or less.

Rock plants may be divided in early September and planted in cold frames, covered with sash during cold weather. This gives good-sized plants for spring planting. Cuttings may be taken during late June and July, especially of selected forms of *Aubrieta, Iberis, Campanula, Arabis, Phlox subulata,* and others. These should be potted when rooted and carried over winter in a cold frame.

Winter Protection. A large percentage of rock plants are evergreen and as such are more apt to be injured than benefited by a mulch. However, glass wool, excelsior, and oak leaves may be used for less hardy varieties. Equally important is protection against excessive moisture. A piece of glass, a stone, or a wood shingle may be held over a choice plant by a wire frame or by insertion into the soil and extending over the crown of the plant. A ½-in. layer of crushed stone on the surface of the soil is an added precaution for true alpine plants.

Pests. Slugs are one of the worst pests of the rock garden, especially if it is at all shaded. Their control is discussed in Chap. XVIII. Occasionally red spiders, aphis, and ants may become a problem. In midsummer sempervivum and other succulents may rot, a condition brought about by heavy rain during excessively high temperatures. A copper spray seems to check this somewhat.

A SELECTED LIST OF ROCK PLANTS

ARISTOLOCHACEAE BIRTHWORT FAMILY

Asarum. Wild ginger. Europe and Eastern United States. There are several evergreen species, including *A. europaeum*, that have excellent foliage throughout the year. Flowers inconspicuous. Propagation by division and seed.

BORAGINACEAE BORAGE FAMILY

Pulmonaria. Lungwort. Europe. Resembles the Virginia bluebell in its bloom. *P. saccharata* and *P. officinalis,* 8 to 12 in., with dark green leaves spotted grayish white, are used as much for their foliage effect as for their bloom. Many color variations from blue to pink. *P. angustifolia,* flowers blue, 6 to 8 in., does not have spotted leaves.

April and May blooming. Prefer partial shade.

CAMPANULACEAE BELLFLOWER FAMILY

Campula. Many of the low-growing campanulas are difficult except under wall or moraine conditions. The following are relatively easy: *C. carpatica,* 6 to 8 in.; *C. garganica,* 6 in.; *C. rotundifolia,* 8 to 12 in.; and *C. portenschlagiana* (*muralis*), 3 to 4 in. All these have white forms as well as the usual lavender-blue. May and June. Propagation by seeds or division. *C. poschscharskyana* is purple flowered, free flowering, very vigorous.

Jasione perennis. Shepherds Scabious. Southern Europe. These light, airy, blue-flowered plants are easily grown from seed.

CARYOPHYLLACEAE PINK FAMILY

Arenaria. Sandwort. Of the several species *A. montana,* Europe, and *A. verna caespitosa,* Europe and Western United States, are preferable. Sun or partial shade. Propagation by seed, division, or cuttings.

Cerastium tomentosum. Snow-in-summer. Europe. 8 to 12 in. Gray foliage, trailing. Almost too vigorous for the average rock garden. Propagation from seed, division, or cuttings. White flowers in May.

Dianthus. A large genus of many excellent plants, but others more or less worthless.

- *D. alpinus.* Often difficult. Europe. 4 to 6 in. May. Try in moraine.
- *D. caesius.* Europe. 6 in. May and June. Excellent. Select best seedlings, propagating by cuttings or division.
- *D. arvernensis.* Europe. 3 to 6 in. May. Very compact. Select best types, and propagate by division or cuttings.
- *D. neglectus.* Europe. 4 in. May. Often difficult unless in a moraine or scree garden.

Gypsophila. The following species are more or less trailing: *G. repens rosea,* 4 to 6 in., Europe, May, pink; and *G. cerastioides,* 4 to 6 in., May and June, Asia, white with pink veins.

Saponaria ocymoides. Trailing Soapwort. Europe. A trailing plant with rose-pink flowers. Most effective hanging over a rock. Propagate from seed. Often selfsows.

Silene. Among the various species of this genus offered in the trade *S. alpestris,* Alpine catchfly, Europe, white flowers, and *S. schafta,* Moss campion, Caucasian, pink flowers, are the most common. Propagation by seed or division.

Tunica saxifraga. Tunicflower. Europe. More or less continuous summer bloom. Pink flowers. Variety *florepleno,* from cuttings, is preferable.

CISTACEAE ROCKROSE FAMILY

Helianthemum. Sunrose. Mediterranean region. More or less woody plants with evergreen foliage. Inclined to be tender. Give well-drained, sunny location. Most of the named varieties were developed from *H.*

nummularium. Flowers white, yellow, pink, and red in both single and double forms. Seedlings should be selected and propagated by cutting Cut back after blooming.

COMPOSITAE COMPOSITE FAMILY

Achillea. Yarrow. Among the several dwarf species, *A. ageratifolia*, Greece, and *A. tomentosa*, Europe, Asia, and United States, are grown for their finely cut foliage and yellow flowers. About 8 in. Propagation by seed and division.

Aster. There are several varieties of the rock aster, *A. alpinus*. Europe. Cooler climates are usually preferred.

Antennaria dioica rosea. Pussytoes. 2 to 3 in. Europe, Asia. Grown partly for its gray foliage but also for its white or pink flowers.

Santolina chamaecyparissus. Lavendar-cotton. 12 to 15 in. Mediterranean region. Grown largely for its finely cut, gray foliage rather than for its small yellow flowers. It is practically evergreen.

CRUCIFERAE MUSTARD FAMILY

Aethionema. Stonecress. Asia Minor. 6 to 12 in. The more common forms are *A. pulchellum*, *A. persicum*, *A. grandiflorum*, and *A. warleyense*. They are from a few inches to a foot in height, and their grayish foliage is usually evergreen. Inferior forms are obtained from seed. Best propagated from cuttings from selected plants. Give a sunny, well-drained site.

Alyssum. Names of species other than the common *A. saxatile compactum*, Goldentuft, Europe, are often mixed in the trade. *A. montanum*, Europe, 10 in., and *A. alpestre* (*serpyllifolium*), Europe, 4 in., are probably the best of the several species.

Arabis. Rockcress. Free flowering, April blooming. Flowers usually white, but pink forms of many species are available. *A. albida*, Caucasus (usually catalogued as *A. alpina*), showier but not so permanent as *A. procurrens*, southeastern Europe. Propagated by seed, cuttings, and division.

Aubrieta. (Usually misspelled with *i* before the final *a*.) All the various forms have been developed from *A. deltoidea*, Southern Europe and Asia Minor. Plant in a sunny, well-drained situation. If difficult, cut back and mulch after blooming. Flowers pink, red, lavender, blue, or purple.

Draba. Alpine and Arctic. A number of species. White or yellow flowers. March to May. Often rather temperamental. Propagate from seed or by division.

Iberis. Candytuft. The larger types such as *I. sempervirens*, Southern Europe, may require pruning to keep in bounds. The variety Little Gem is more compact, and the variety *saxatile* even more so. Propagate by seed or cuttings. Flowers white. May and June.

CRASSULACEAE ORPINE FAMILY

Sedum. Stonecrop. The opposite of the saxifrages, the sedums can be grown in any location but preferably in the sun. Most of the native western species such as *S. spathulifolium* and *S. oreganum* are tender. Many sedums are too vigorous and spreading except for ground covers. Among the more refined kinds are *S. dasyphyllum, S. middendorffianum, S. nevi, S. rupestre,* and *S. sieboldi.* There are a tremendous number of species, many of which are misnamed in the trade.

Sempervivum. Houseleek. Hen and Chickens. Europe. A genus of over two dozen species so hybridized even in nature and so often grown from seed that names are more or less meaningless. The following will give a variety of forms: *S. arachnoideum, S. arenarium, S. globiferum, S. atroviolaceum,* and *S. tectorum.*

FUMARIACEAE FUMITORY FAMILY

Dicentra eximia. Fringed Bleedingheart. United States. 8 to 10 in. Pink flowers. May to September. Prefers slightly acid soil. Seeds should be fall sown.

GENTIANACEAE GENTIAN FAMILY

Gentiana. The alpine forms are not always permanent, preferring cool climates. Try partial shade or a moraine garden in warmer ones. *G. acaulis* and *G. septemfida* representative of genus.

GERANIACEAE GERANIUM FAMILY

Erodium. Heronsbill. There are a number of forms with finely cut foliage, often gray-green, and pink or lavender flowers. Keep dwarf by starvation. *E. chamaedryoides,* slightly tender. Most other species hardy.

Geranium. Most of this genus are rather large for the rock garden, but *G. sanguineum prostratum* (*lancastriense*), 6 in., is excellent. Light pink flowers. Seldom comes true from seed.

HYPERICACEAE ST. JOHNSWORT FAMILY

Hypericum. St. Johnswort. Yellow flowered. Summer. *H. coris,* 12 in., Europe; *H. polyphyllum,* 6 in., Cilicia; *H. repens,* 2 in., Europe. All of these tender in cold climates.

IRIDACEAE IRIS FAMILY

Iris. Among the many kinds of iris, only the most dwarf should be used in rock gardens. Among them are *I. flavissima* (*arenaria*), *I. cristata, I. pumila, I. tectorum,* and the bulbous *I. reticulata.* Propagation by division.

LABIATAE MINT FAMILY

Thymus. Thyme. The thymes must be used with discretion in the rock garden, since with few exceptions they are vigorous and spreading and will soon crowd out other plants. Many of the thymes are badly misnamed in the trade. *T. serpyllum* and its varieties *albus, coccineus,* and *lanuginosus* are among the more usual kinds.

LINACEAE FLAX FAMILY

Linum. Most of the Linums are rather large; *L. alpinum* is not. Propagate from seed. Blue flowers. June. 6 in.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Oenothera caespitosa. Western United States. 6 in. Resembles *O. missouriensis* except for smaller size and while flowers.

PAPAVERACEAE POPPY FAMILY

Papaver alpinum. Alps. Resembles a miniature Iceland poppy. Easily grown from seed but prefers a cool summer to be permanent.

PLUMBAGIACEAE LEADWORT FAMILY

Statice. Thrift. Europe, North America. *S. armeria* (formerly *Armeria maritima*) and its variety *laucheana* have pink flowers from June to August.

POLEMONIACEAE PHLOX FAMILY

Phlox. United States. Of the many kinds of phlox adapted to rock-garden use, many of the forms of *P. subulata* may be too vigorous except in large gardens. The variety Vivid is compact. *P. pilosa, P. amoena, P. divaricata,* and *P. stolonifera* can be used. The last two should be grown in the shade.

Polemonium. The native *P. reptans* and the trailing *P. humile* are good. Both have blue flowers. The latter varies greatly from seed.

PORTULACACEAE PORTULACA FAMILY

Lewisia. Native of the more or less arid regions of Western United States, they are sometimes difficult to grow with excessive watering. The foliage of *L. redidiva* and *L. oppositifolia* dies down in summer; *L. howelli* and *L. tweedyi* are evergreen. Flowers usually pink. Propagate by seed or division.

Talinum calycinum. Succulent, summer-blooming plants with pink flowers, for a sunny, well-drained location. Blooms all summer, June through August.

PRIMULACEAE PRIMROSE FAMILY

Androsace. Rock-jasmine. Europe, Asia, North America. These alpine plants are often difficult to maintain except in cooler climates. Probably best grown in a moraine garden. *A. sarmentosa* typical of genus. 3 to 4 in. Flowers pink. May to June.

Primula. Most primroses prefer a relatively cool situation, and therefore in the Midwest and South should be grown in the shade. Any of the primroses discussed in the chapter on Perennials may be used.

RANUNCULACEAE BUTTERCUP FAMILY

Anemone. *A. apennina*, Italy, and *A. blanda*, Greece. 3 to 4 in., blue flowers. *A. nemorosa*, Europe. 6 in. July, white flowers. *A. japonica* September Charm, 12 to 18 in., pink flowers, may be used in larger gardens.

Aquilegia. Columbine. Although most of the columbines are too tall for the average rock garden, *A. pyrenaica*, 8 in., blue, and *A. flabellata nana alba*, 12 in., white, are sufficiently dwarf. Propagation by seed.

ROSACEAE ROSE FAMILY

Acaena. New Zealand, South America. 3 to 6 in. Grown for small roselike foliage, bronze, green, or gray. Creeping plants for a sunny exposure. Propagated by seed or division.

Dryas. World-wide distribution in the mountains of the Northern Hemisphere. Difficult except in cool climates. Try in a moraine garden. Representative species *D. octopetala* and *D. drummondi.*

Geum. Most species of this genus are rather large for the rock garden, but *G. borisi* and *G. ciliatum* (*triflorum*) are not.

Potentilla. Cinquefoil. Of all the potentillas, many are too weedy for the rock garden. *P. verna nana* is low growing and compact. *P. tridentata*, evergreen, and *P. multifida* (*tonguei*) are the best.

RUBIACEAE MADDER FAMILY

Asperula. Woodruff. Europe, Asia. *A. odorata* is too spreading for small rock gardens. *A. cynanchica*, 1 ft., with white or pink flowers in June, is better.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Heuchera. Coralbell. United States. *H. sanguinea* and its various varieties with white, pink, or red flowers bloom from June to September. Propagated by division.

Saxifraga. A huge genus of many species of tremendous variability. The majority being difficult, they tempt the most discriminating alpine hobbyists. The commonly grown house plant *S. sarmentosa* is perfectly hardy and effective if grown on a porous rock in partial shade. The more difficult saxifrages requiring moraine treatment include *S. aizoon*, *S. cotyledon*, and their varieties *S. macnabiana*, *S. lingulata*, *S. decipiens.*

SCROPHULARIACEAE FIGWORT FAMILY

Mazus japonicus (*rugosus*). Eastern Asia. 2 in. Spreading plants with lavender, snapdragonlike flowers. They prefer shade and moisture but will stand sun if among other plants for shade. May blooming.

Penstemon. A large race of native western alpines. Usually difficult except in cool summers. Try in the moraine garden. *P. cardwelli* and *P. rupicola* are representative of the genus. Flowers blue, pink, or red. Propagate from seed or by division.

Veronica. Many of the lower growing veronicas, unless cut back after blooming, are rather ugly in midsummer. The better forms for rock gardens include *V. allioni*, *V. incana*, *V. pectinata rosea*, and *V. teucrium* (*rupestris*).

SOLANACEAE NIGHTSHADE FAMILY

Nierembergia rivularis. Cupflower. Argentina. 2 in. Flowers white, forms mats by underground stems. Often not permanent unless it has ample moisture.

VIOLACEAE VIOLET FAMILY

Viola. Although the rock-garden specialist considers pansies out of place in the rock garden, pansies and the tufted pansies, or violas, do have a place unless nothing but typical alpines are grown. *V. pedata* (*pedata bicolor*) often gives a long season of bloom. *V. rossini*, 4 in., pink, fragrant, blooms throughout the summer.

Rock-garden Plants Easy to Grow

Mat- or carpet-forming, rooting as they spread:
- Arabis alpina
- Arabis procurrens
- Campanula portenschlagiana
- Cerastium tomentosum
- Dianthus deltoides
- Gypsophila repens
- Myosotis
- Phlox subulata
- Saxifraga sarmentosa
- Sedum ellacombianum
- Sedum sexangulare
- Sedum spurium
- Thymus serpyllum
- Thymus serpyllum lanuginosus
- Veronica pectinata
- Veronica rupestris

Spreading but not forming mats:
- Achillea tomentosa
- Alyssum saxatile
- Campanula carpatica
- Dicentra eximia
- Iberis sempervirens
- Nepeta mussini
- Papaver nudicaule
- Saponaria ocymoides
- Sempervivum
- Silene alpestris
- Veronica incana
- Viola

Not spreading:
- Anemone pulsatilla
- Campanula garganica
- Campanula rotundifolia
- Heuchera
- Iris pumila
- Polemonium
- Primula
- Sedum dasyphyllum
- Sedum sieboldi
- Viola pedata

Rock Plants for Dry Walls

- Aethionema
- Alyssum saxatile compactum
- Androsace
- Arabis
- Aubrieta
- Campanula garganica
- Hedera conglomerata nana
- Heuchera
- Iberis sempervirens
- Phlox divaricata
- Phlox subulata
- Phlox subulata Vivid
- Saponaria ocymoides
- Saxifraga (encrusted varieties)
- Sedum dasyphyllum
- Sedum kamtschaticum
- Sedum sieboldi
- Sempervivum
- Silene pennsylvanica
- Thymus lanuginosus
- Veronica pectinata

Bulbs for Rock Gardens

- Allium
- Anemone apennina
- Anemone blanda
- Brodiaea
- Calochortus
- Crocus

Eranthis
Erythronium
Fritillaria meleagris
Galanthus
Hyacinthus
Iris reticulata
Muscari
Narcissus species
Narcissus triandrus hybrids
Triteleia
Scilla
Tulipa batalina
Tulipa chrysantha
Tulipa clusiana
Tulipa kaufmanniana
Tulipa linifolia
Tulipa praestans
Tulipa sylvestris

Dwarf Shrubs for Rock Gardens

Abelia grandiflora
Azalea mollis
Chaenomeles pygmea
Cotoneaster adpressa
Cotoneaster apiculata
Cotoneaster dammeri radicans
Euonymus americana
Japanese maples (keep roots and tops pruned to dwarf them)
Kerria japonica variegata
Potentilla fruticosa

Dwarf Evergreens for Rock Gardens

Azalea kurume
Berberis buxifolia nana
Berberis julianae
Berberis triacanthophora
Berberis verruculosa
Buxus microphylla koreana
Buxus sempervirens myrtifolia
Buxus sempervirens suffruticosa
Chamaecyparis obtusa compacta
Daphne cneorum
Euonymus fortunei carrierei
Euonymus fortunei (kewensis) minima
Euonymus fortunei vegeta
Hedera conglomerata nana
Ilex crenata convexa
Ilex crenata microphylla
Juniperus Bar Harbor
Leiophyllum buxifolium
Lonicera bicolor
Lonicera nitida (tender)
Lonicera pileata (tender)
Pachistima canbyi
Picea canadensis conica
Picea excelsa gregoryana
Rhododendron Cunningham's White
Santolina
Taxus cuspidata minima
Taxus cuspidata nana
Tsuga canadensis compacta

Rock Plants Difficult to Grow in Many Sections of This Country

Androsace lanuginosa
Antirrhinum asarina
Aquilegia alpina
Campanula portenschlagiana
Campanula pusilla
Campanula (other alpine species)
Dianthus alpinus
Dianthus neglectus
Draba
Dryas
Erinus
Erodium chamaedryoides
Gentiana (alpine species)
Lewisia
Linaria aequitriloba
Lithospermum prostratum Heavenly Blue
Omphaloides
Onosma
Penstemon (most alpine species)

Ramondia pyrenaica
Saxifraga (encrusted and mossy types)
Silene acaulis
Soldanella
Viola (alpine species)

ROCK PLANTS FOR SHADE

Adonis vernalis
Anemone sylvestris
Aquilegia canadensis
Asarum europea
Campanula poschscharskyana
Campanula rotundifolia
Corydalis lutea
Dicentra eximia
Epimedium
Hepatica
Hosta lancifolia
Houstonia coerulea
Mitella diphylla
Phlox divaricata
Primula
Pulmonaria
Ramondia pyrenaica
Saxifraga sarmentosa
Saxifraga umbrosa
Sedum nevi
Sedum ternatum
Tiarella cordifolia
Viola canadensis

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CHAPTER XIV

ROSES

From earliest times the rose has played a part in popular myth, legend, and literature. Its praise has been sung by poets; its perfume, adored by all; its beauty and perfection, desired by every garden lover. So popular has it become that, to supply the out-of-season demand, enormous greenhouses must be used during the winter months. The rose is the one flower that may be obtained throughout the year.

Present-day roses are useful for many purposes. The climbing forms serve as screens on porches and against buildings but more frequently on posts, fences, and arbors. Certain types are useful for mass planting and foundation borders. The newer hybrids are adapted for the production of colorful effects in the garden and for cut-flower purposes.

CLASSIFICATION OF ROSES

For proper understanding of the principles of culture it is necessary to know something about the different types and classes of rose. For convenience, they may be divided into two great groups—the bush roses and the climbing roses.

Bush Roses. These may be subdivided into (1) the landscape types (moss, damask, Austrian brier, Scotch brier, Sweetbrier, Penzance, *R. lucida*, *R. rugosa*, *R. hugonis*, *R. xanthina*), which are useful for mass effect; (2) the dwarf polyanthas, or baby ramblers (produced by hybridizing *R. multiflora* with hybrid perpetuals and hybrid teas), desirable for borders, often blooming incessantly during the season; and (3) the hybrid perpetuals and the hybrid teas, which are effective in mass and useful for cut flowers.

The large bush roses grown for mass effects are extremely hardy, floriferous, and usually free of disease. They should be used to a greater degree than at present. Although they fail to bloom except in the early summer, the ornamental seed pods, or "hips," are very attractive in the fall of the year.

Because of their hardiness and profusion of bloom, the baby ramblers and the more floriferous hybrid teas, called *floribundas,* are perfectly satisfactory, particularly for low borders.

The hybrid perpetuals and the hybrid teas form the largest group. They are extremely popular and should be grown only in special beds, not with other shrubby materials. The name *hybrid perpetual* is misleading, since this type blooms usually only once a season, although some varieties may produce a second crop in the fall. The hybrid teas are really constant bloomers if proper care is given them. Of the two, the former are more hardy and vigorous.

Climbing Roses. This group comprises forms of hybrid perpetuals and hybrid teas that have been hybridized with *R. wichuraiana* and *R. multiflora.* The rambler roses are hybrids of *R. multiflora* and are characterized by having their flowers in large clusters and blooming but once a season. Vigor of growth and bright green foliage, usually of nine leaflets, are peculiar to this type. Crimson Rambler, American Pillar, and Tausendschön are good examples.

Because of susceptibility to mildew, the ramblers are being replaced by the climbing *R. wichuraiana* hybrids, which show less tendency to disease and possess greater adaptability to locations. The best varieties belonging to this group are Dr. Van Fleet, Silver Moon, Doubloons, Excelsa, Paul's Scarlet Climber.

The species that have entered largely into the ancestry of ur present-day varieties are *R. centifolia, R. damascena, R. allica, R. moschata,* and *R. chinensis,* together with several thers of lesser importance.

R. centifolia (cabbage rose) is a native of Caucausus and 'ersia. It is characterized by large globular flowers with umerous petals which curve inward. The flowers are pink and :agrant, appearing in June or July. The leaflets are seven, ırge and wrinkled with deeply serrated margins. The plant ;self is a straggling bush, heavily thorned. It is thought to ave been described by Theophrastus about 270 B. C. as "the ɔse of sixty petals."

R. damascena (damask rose) is a native of Syria, flowering in une and July and again in the fall. The flowers are borne in arymbose clusters of red, pink, and white. Leaflets are usually ve. The plant is upright, growing to a height of 6 ft. or more.

It is quite likely that this rose appeared in Europe long before its supposed introduction in 1573 and may have been the rose described by Pliny as "rose of Paestum."

R. gallica (Provins rose). This is native to France, producing crimson flowers in June on strong, thorny stems. The leaflets are three to five, broad and doubly serrate.

R. moschata (musk rose) is a native of the Mediterranean region. It was introduced into England in the sixteenth century. The pink flowers are fragrant, with a distinct musk odor, and are borne in bunches. The leaves are glabrous with five to seven leaflets. Stems are quite weak.

R. chinensis (China rose) was introduced into Europe in 1789 and played an extremely important role in the development of new varieties, particularly because of its habit of almost continual flowering. The wood is bright green; leaflets vary from three to seven; and the bright red flowers appear singly or in corymbs at the end of each growth.

Among the hybrids developed from these types and others the following groups are now recognized.

Bourbons. *R. borbonica* was discovered in 1817 on Bourbon Island and introduced into France in 1822. It was thought to be a natural cross between *R. chinensis* and *R. gallica.* Bourbons have a spring- and a fall-blooming period, with especially profuse blooming in the fall. The flowers are circular, with thick, velvety petals, and the foliage is leathery. Various crosses have produced many hybrids, which, however, flower only once a season.

Gigantea Hybrids. This group is being developed from *R. odorata gigantea* and is extremely prolific in flowering and vigorous in growth but is not perfectly hardy in the northern tier of states.

Hybrid Perpetuals. Hybrid perpetuals are characterized by vigorous, hardy growth and usually a single blooming period in early summer. They resulted from crosses of hybrid Bourbons with various other types.

Hybrid Teas and Teas. *R. chinensis fragrans*, a very fragrant variety, with slender stems bearing flowers of orange, pink, yellow, and bronze, was introduced into England in 1810. The foliage is light colored, and the stems weak. It was known as the *tea rose.* Crossed with hybrid perpetuals and other types, this has become the most popular of all under the name of *hybrid* *tea* and gives us our most beautiful and satisfactory varieties of today.

Hugonis. This Chinese introduction in 1927 was found particularly desirable because of its hardiness, its fine foliage, and its large, single yellow flowers appearing early in the spring.

Multifloras. This is a group of climbing roses which was introduced into England in 1804. Crossed with hybrid teas, hybrid perpetuals, and others, it has given rise to our present group of hybrid multifloras—ramblers, with large panicles of flowers appearing at the ends of small branches which develop from buds on branches of the preceding year's growth. Long branches make these varieties useful as climbers. The leaves are soft textured and frequently wrinkled.

Noisettes. This group originated from a cross between *R. moschata* and *R. chinensis.* Crossed later with teas, hybrid bourbons, and others, they developed into our present hybrid noisettes. They are characterized by an everblooming habit, vigorous growth, and extreme thorniness. The number of leaflets is usually nine, and the flowers resemble those of hybrid teas.

Polyanthas. Crosses between *R. multiflora* and hybrid teas and hybrid perpetuals produced this dwarf group which resembles the hybrid multiflora climbing group except for its dwarfness.

Pernetianas. The first of this group was introduced in 1900 from a cross between Antoine Ducher, a hybrid perpetual, and *R. foetida* and was called "Soleil d'Or." *R. foetida* is commonly known as the *Austrian brier rose,* with yellow single flowers of unpleasant odor. The hybrid pernetianas produced by crossing with hybrid teas and hybrid perpetuals are largely in shades and tints of yellow and orange. Souvenir de Claudius Pernet and Talisman are probably the most outstanding varieties.

Rugosas. This group of roses is especially valuable for landscape plantings. The hybrids resulting from crosses with hybrid perpetuals, multifloras, and polyanthas have produced extremely fine varieties. They are very hardy and vigorous in growth with shining, thick, dark foliage above and pubescent below. The flowering habit is continuous from spring to fall, and the red hips in the fall are especially attractive. Resistance to disease is one of their specific characteristics.

Sweetbrier Hybrids. *R. rubiginosa,* commonly known as the *sweetbrier rose,* is a native of Europe. Crossed by Lord Penzance late in the nineteenth century with various hybrid perpetuals, this species developed into a group of hybrid sweetbriers, or Lord Penzance briers. They are vigorous, thorny, with fragrant foliage, and flower only in the spring.

Tender Climbers. Tender climbers have resulted from sports of hybrid teas or from crosses between hybrid teas and hybrid perpetuals.

Wichuraianas. *R. wichuraiana,* a Japanese rose, was introduced into the United States in 1893 and when crossed with hybrid teas and hybrid perpetuals has resulted in our present-day climbers known as *hybrid wichuraianas.* The varieties belonging to this group are larger flowered than the hybrid multifloras, with more persistent foliage, and are quite everblooming.

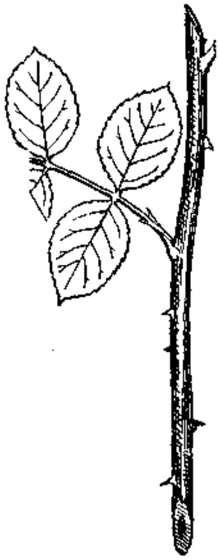
METHODS OF PROPAGATING ROSES

Roses are propagated from seed, root sprouts, suckers, layers, hardwood cuttings, softwood cuttings, budding, and grafting.

Raising Roses from Seed. Because many of our varieties are hybrids, propagation from seed will result in varying offspring. If it is desired to grow seedlings, the hips should be cut open in the fall, the seed being extracted and placed in peat or sand in a temperature of about 41°F. Left in this moist medium with cool temperature, afterripening takes place. This is a process in the life of the seed necessary for proper germination and may take from 60 to 120 days. At the end of that period the seed may be sown in soil, and germination will proceed rapidly. Seedlings will be large enough to bloom the first year from seed.

Root Sprouts, Suckers, and Layers. Many species, such as *R. rugosa, R. nitida, R. blanda, R. lucida, R. setigera, R. wichuraiana, R. carolina,* and *R. spinossisima,* are propagated by root sprouts, suckers, or layers. Sprouts and suckers may be separated and planted either in the spring or in the fall. The process of layering is simple and involves the notching of the stem on the underside, bending it to the ground, and covering with soil early in the summer. By fall of the same year these buried sections will have rooted and may be severed and transplanted then or next spring.

Hardwood Cuttings. Climbing roses, hardy landscape roses, and hybrid perpetuals are often propagated by hardwood cuttings. These are taken in the fall of the year from well-ripened wood and cut in sections 8 to 10 in. in length. The best guide to the time of taking is the dropping of the foliage after the first frost. The cuttings should be tied in bundles with a label attached and buried in a cold cellar in sand or out of doors, deeply enough to avoid freezing. The recommendation often made relative to placing of the butts up and tips down when burying outdoors is not essential. The bundles may be buried horizontally with equally desirable effect.



. 65.—A rose cutting.

In the spring of the year these cuttings should be trenched or planted out of doors 4 to 6 in. between plants and deep enough in the ground so that only 1 in. of the cutting with a single bud is above the ground. If no winter injury occurs to the wood, the same results may be obtained with hardwood cuttings taken very early in the spring instead of the previous fall. Follow the same procedure as with fall cuttings.

Softwood Cuttings (Fig. 65). These cuttings are made after blooming, from wood of the current year's growth. They should contain three buds, the leaves taken off the two lower ones and partially trimmed off the upper one. They should be inserted in sand in a hotbed and kept close and moist to hasten oting. Cold frames, forcing boxes, or even inverted mason jars d battery jars may be used for the purpose. Shading to reduce aporation, moisture to prevent wilting, and bottom heat to sten rooting are the essentials for success. Sand is preferred soil because of less danger from disease attack. After rooting, e cuttings should be potted and kept shaded and close until oper root action has taken place. Gradually these new plants ay be accustomed to conditions by giving them more air and oler temperature and in the fall or the following spring may be t out in beds.

Budding Roses (see chapter on Propagation of Plants).

Grafting (see chapter on Propagation). Grafted roses are sometimes sold. These are usually plants that have been forced in the greenhouses for a number of years and have lost much of their vitality. If they happen to have been grafted on *R. manetti*, the case is aggravated still more, and the rose enthusiast who succumbed to the lure of cheapness and bought them is often doomed to disappointment. Many failures may be attributed to such plants.

The beginner is often confronted with the question of whether to plant own-root or budded plants. By *own-root* is meant a plant that has been propagated by cuttings and develops roots from its own tissues. Many varieties do very well on their own roots, yet some can thrive only upon another stock. In such cases the stock seems to impart hardiness, a greater number of flowers, and better quality. Well-budded and properly grown plants are usually better than own-root, but their price is somewhat higher. If roses are budded on *R. manetti*, they are slow to mature in the fall and often fail to carry over winter successfully. It is well to know upon which stock the buds have been placed.

Budded and grafted stocks produce undesirable suckers which have to be watched for and removed. Otherwise, they may kill out the tops.

LOCATION SUITED TO ROSES

The rose bed or garden should be placed in an open location that gets at least half a day of sunlight. Proximity to trees should be avoided because of the loss of nutrients and moisture from the soil. The same holds true of using roses as a border for shrubbery. Well-drained land should be provided.

Plan to have the beds about 2½ to 3 ft. wide. This makes it easy to care for the plants constantly throughout the growing season and produces a better showing than narrower beds give.

PREPARING THE SOIL

Preparation of the soil is the keynote of success with roses. It should be rich and porous and well drained. A medium-heavy clay loam, containing about 20 to 30 per cent clay, seems to be preferred by most types. Heavier soils may do for hybrid perpetuals and *R. rugosa* but are apt to be poorly drained.

Cinders, gravel, or stones usually placed at the bottom of the bed and covered with a layer of manure 6 in. deep do little good. Tile laid 24 to 30 in. deep and leading into an open outlet is the only way to ensure drainage. The upper 18 to 24 in. may be prepared by mixing the loam with one-fourth manure and adding bone meal or superphosphate at the rate of 5 lb. to every 100 sq. ft. of bed.

If the soil is very heavy and shows an extreme acid reaction, lime may be applied in the form of ground limestone. The rate of application will vary with the needs but will range from 5 to 10 lb. per 100 sq. ft. This application should not be made upon soils showing a neutral or alkaline reaction, since many varieties of rose prefer a slightly acid condition. Alkaline reaction of the soil often produces flowers that turn "blue" and fade and droop quickly.

The aeration of soil is an important factor in the optimum growth of roses. It may be accomplished by the incorporation of organic matter such as peat, manure, or corncobs in the soil before planting. Organic matter has a tendency to granulate the soil particles and provide more oxygen, which is needed for root development. At the same time it reduces the carbon dioxide content of the soil, for carbon dioxide may become injurious if present in large quantities. Approximately one-fifth to one-fourth of the total volume of soil may well be made of such organic matter. In addition, fine cinders in the proportion of one-tenth to one-fifth of the volume may be incorporated, adding still greater amounts of air.

PLANTING

Time of Planting. Fall is preferable to spring for planting roses. The stock then is freshly dug, whereas spring-planted stock must have been stored over winter, with the possibility of drying and shriveling. If planted in the fall the plants become well established before spring, ready to start active growth and able to withstand our hot, dry summers. In addition, feeding may start early in the spring, but spring-planted roses must wait until summer before their roots become sufficiently vigorous to absorb the added nutrients.

Plump stock planted very early in the spring will produce good plants. Unless potted roses are used, late-spring planting is always attended with high mortality. Frequently syringing and even shading may be necessary to keep the plants alive in the early stages of late spring planting. For fall planting, the beds should be prepared in August; but for spring planting, any time in the fall will do.

When the plants arrive, they should be unpacked at once, the roots placed in water for an hour and then planted. If impossible to plant upon arrival, the roses should be heeled in a trench and covered with soil completely (roots and tops) until ready. A cool, cloudy day is the most suitable for planting.

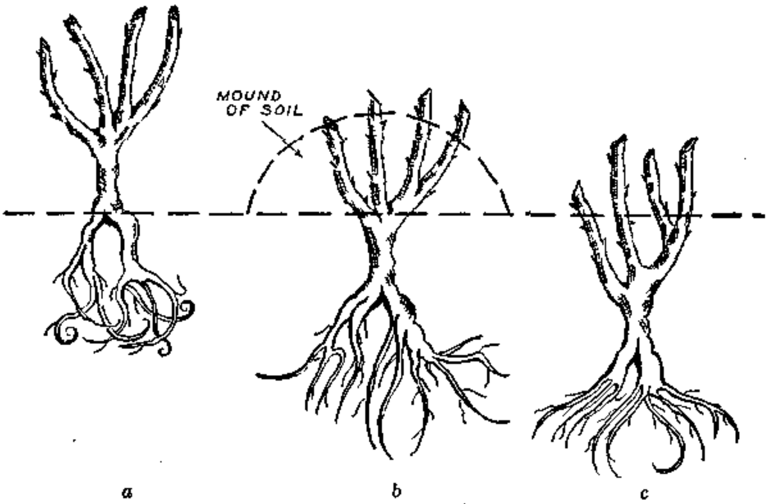


FIG. 66.—Planting: (a) improper depth, poor distribution of roots; (b) proper planting; (c) improper deep planting.

Arrangement of the Plants. Most of the hybrid teas and baby ramblers should be planted about 15 in. apart; the stronger growing hybrid perpetuals may be set 24 in. each way. Outside rows are usually 6 to 10 in. from the edge. To secure the best results and make the plants more accessible for care and cutting, without the necessity of stepping on the beds, the numbers of rows may be limited to three or four, and these staggered.

Planting consists of digging a hole or a trench large enough to permit the roots to be spread out. The plant is then pruned by trimming all bruised roots and cutting back the top in accordance with the type of rose. Hybrid perpetuals may be cut back to 8 to 12 in., with five or six stems left on each plant. Hybrid teas should be cut back more severely, 5 to 8 in. Climbers should be cut back 12 to 18 in. to force them to make heavy root systems, which in turn will produce long shoots and canes.

Each plant should be set so that the union of bud and stock is level with the surface of the ground. This depth gives the optimum results (Fig. 66). Own-root plants should be set at the same depth as grown in the nursery; deeper planting is advisable, however, in light soils. To produce intimate contact between the roots and the soil, the latter should be packed thoroughly about the roots and watered well.

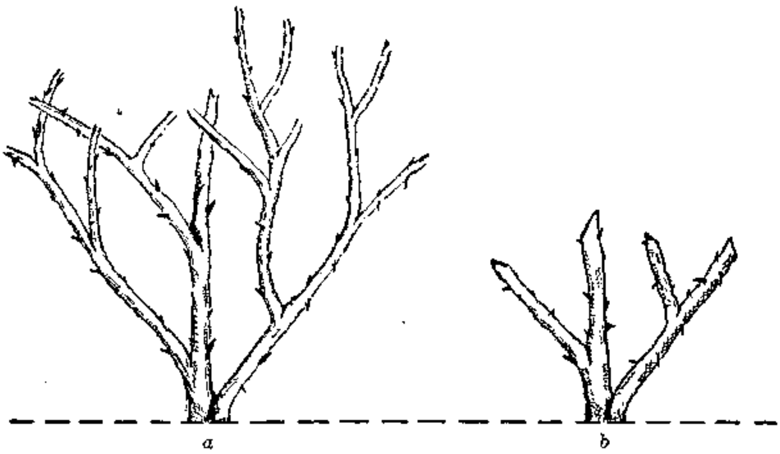


Fig. 67.—Hybrid Tea, unpruned (*a*) and (*b*) pruned.

Whether planting is done in the fall or spring, a mound of soil high around the branches prevents rapid evaporation and withering of the branches before the roots become established. This mound should be as high as the tops of the pruned branches. It should not be removed until the shoots start in the spring. A mulch of manure, leaf mold, or peat moss placed over the beds is beneficial.

PRUNING ESTABLISHED PLANTS

The pruning directions as given under Planting may also be applied to the established plants. Each spring the same procedure should be followed in the case of hybrid teas and hybrid perpetuals. Such a method may appear drastic, but in the end better flowers on longer stems will result. For those desiring a large quantity of flowers, only the dead wood and weak growths should be pruned out. Later fertilization will produce good-

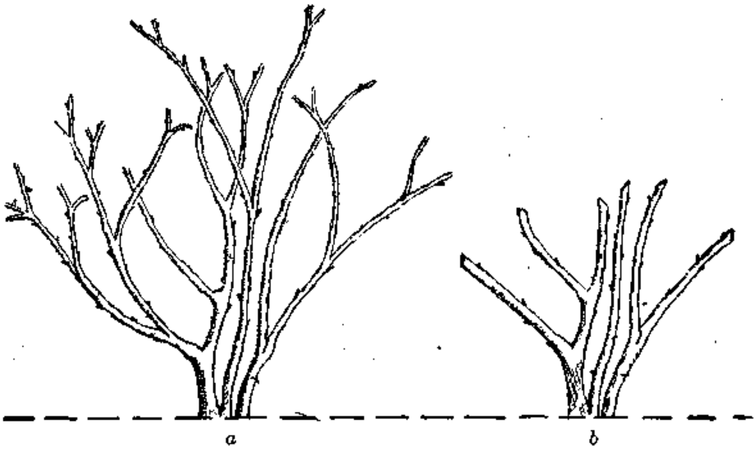


FIG. 68.—Hybrid Perpetual, unpruned (a) and (b) pruned.

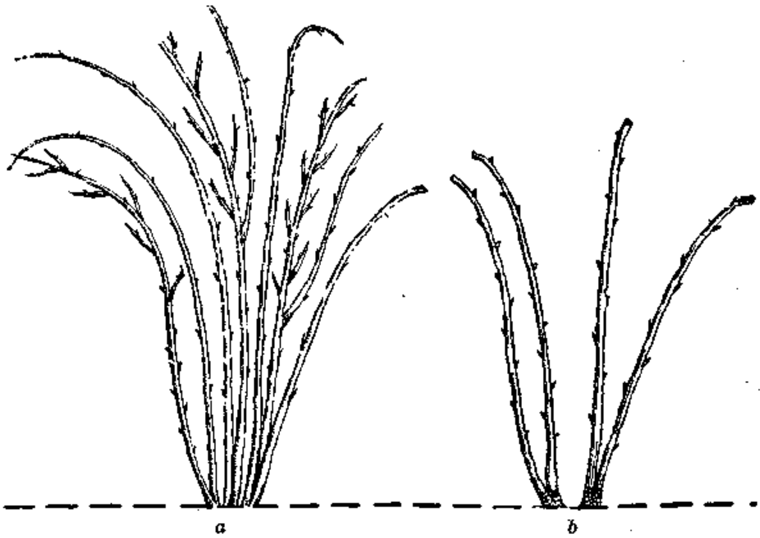


FIG. 69.—A climber before (a) and (b) after pruning.

sized flowers. The only pruning needed for bush roses in the spring is the thinning out of the older wood (Figs. 67 and 68).

Ramblers should be pruned after flowering—usually in July or August. These differ in their flowering habits from most of the other roses in that the flowers are borne upon the wood of the year previous. As a consequence, cutting back the current year's wood reduces the flowering during the subsequent season. In general all two-year-old wood should be cut out, and the tips of the current year's wood cut back about 6 in. to stop further development and induce maturity before winter. Large flowering varieties like Dr. Van Fleet and Silver Moon do not thrive under such drastic treatment. Cut out old wood every 3 or 4 years when the plants get too large for the trellis. At other times remove dead wood (Fig. 63).

FERTILIZATION

If the humus supply of the soil is deficient, stable manure, peat, manure and peat, or corncobs may be added in the spring. Peat is an excellent substitute for manure in providing all the benefits of the manure except the needed bacteria. When these are introduced by the use of a small portion of manure with peat, the latter becomes more valuable than manure. Peat contains no weed seed, has a great water-holding capacity, and is comparatively rich in nitrogen.

As soon as growth starts in the spring, superphosphate (5 lb. per 100 sq. ft.) should be applied. (If bone meal is preferred, it should be applied in the fall.) Two or three weeks later, potassium chloride or potassium sulphate should be added in dry form at the rate of 2 lb. per 100 sq. ft. or as a liquid at the rate of 1 oz. per 2 gal. of water. This amount supplies enough for 2 sq. ft. As a substitute, 2 or 3 oz. of unleached hardwood ashes may be applied to each plant.

A week later, nitrogenous fertilizer should be applied in liquid form and followed with similar doses once a week. Urea, ammonium sulphate, nitrate of soda, or potassium nitrate are all useful for this purpose. They may be added in the following doses: urea, 1 oz. per 7 gal. of water, or ¾ lb. per 100 sq. ft.; the other three, 1 oz. per 2 gal. of water, or 1½ lb. per 100 sq. ft.

To eliminate the separate applications, complete fertilizers may be used two or three times during the season. A good formula is 10–6–4, 6–8–6, or 4–12–4, at the rate of 3 lb. per 100 sq. ft. A more concentrated material is 15–30–15, which should be used in liquid form preferably at the same rate as urea. If used dry, 1 lb. per 100 sq. ft. is sufficient.

Animal manures may be applied either as a mulch or in liquid form. When used as a mulch a 2-in. coat is sufficient. The liquids are made by soaking a bushel of manure in a barrel of water for 24 hr. Liquid urea is preferable to the liquid animal manure because it is not so messy to prepare. Sheep manure and dry, pulverized cow manure are too expensive for the good that they do.

The following precautions should be observed in fertilization: Plants should be fed only when in active growth; small doses at frequent intervals are better than one single heavy application; all commercial fertilizers should be watered in; the soil should be moist before applying nutrients; to prevent late growth and immaturity, no feeding should take place later than August. Newly planted roses should receive no mineral fertilizer until thoroughly established.

SUMMER CARE OF ROSES

The success of the rose garden depends upon the care that it receives. During the summer many minor points demand attention.

Disbudding. Many varieties form several flower buds upon a single stem. The central bud of the cluster is usually the best and is the only one that should be allowed to develop. In the case of hybrid perpetuals and hybrid teas the laterals should be removed at frequent intervals. Landscape roses and polyanthas need no disbudding.

Removal of Suckers from Budded Plants. This is a very important operation. Any strong shoot that comes from below the soil surface should be regarded with suspicion. There are several ways in which the wild growth may be distinguished. The surest method is to remove the soil from about the base of the plant and trace the shoot to its origin; if it comes from below the union, you may be sure that it is wild. It should be cut off close to the bark, and even a small portion of the bark should go with it to prevent other dormant buds from developing.

Leaves of these wild suckers are usually composed of seven to nine leaflets, whereas the budded top generally has five. The color of the sucker is usually lighter, and the thorns more numerous. Unless removed, the wild shoots are apt to kill or devitalize the top.

Suggestions on Watering Roses. During dry seasons water should be applied to the rose beds but always thoroughly. Sprinkling is not advised; it brings the feeding roots to the surface and causes burning. It is well to water in the afternoon or early morning, so that the foliage is dry by night. Mildew spreads readily through the agency of water; and if the foliage is wet and the nights cold, the disease is sure to circulate unless there is a fungicide on the foliage to protect it. Other diseases may be spread in this manner.

MULCHING AND CULTIVATION

Cultivation of the soil is not necessary if a mulch of peat, leaf mold, or manure is placed over the beds. Peat is preferred. In addition to its properties mentioned previously, the brown color makes a suitable background for the green of the foliage. A 2-in. cover should be applied. If no mulch is used, frequent stirring of the ground will be necessary in order to retain moisture.

CUTTING FLOWERS

To secure continuity of bloom with the hybrid teas and perhaps a second crop with hybrid perpetuals, at least 2 in. of the lower part of the stem that bears the flower should be left when the flowers are cut. This leaves at least two buds for the development of the next crop of flowers, which will appear in about four weeks. Cutting in this fashion produces flowers on long stems, builds up a well-branched plant, and develops roses of extra quality.

After cutting, the stems should be plunged deeply in water for several hours before any arrangement in containers is attempted. This will greatly increase the keeping quality of the blooms.

WINTER PROTECTION

Because of the fact that hybrid teas cannot stand our winters, many rose lovers fail to derive the most pleasure from rose growing. It is true that many varieties will freeze within a few inches of the ground; but in spite of that, with proper protection they will bloom profusely. The popular impression is that protection is supplied to keep plants warm. Its real object is to keep them cold and to prevent their thawing and freezing during the warm spells in winter. The greatest injury occurs during such weather, because the flow of sap is started and the cold snap that follows kills the tissues that have started into activity. To secure the best results, covering must be done as late in the season as possible. Most satisfactory results are obtained by covering just before the ground becomes frozen solid.

The first requisite in carrying the plants through the winter is having the wood thoroughly ripened. Stems full of sap will not survive freezing and thawing, which expand the sap and cause bursting of the bark and exposure of the wood below. Ripening may be hastened in the fall by proper drainage, by stopping feeding in August, by elimination of cultivation early in September, and by cutting back the tops partially in October. These means are used to check growth when it is no longer advantageous.

The actual method of protection for hybrid teas and hybrid perpetuals consists of hilling the soil from the bed around each plant to a depth of 6 in., after the first hard frost. This will keep the water from collecting about the base, keep out field mice, and afford a measure of protection. Later, after the ground has frozen, a 4-in. mulch of straw or manure should be placed over the entire bed. The plants will thus remain in a dormant condition until spring.

Hardy bush roses, such as *R. rugosa*, *R. hugonis*, and *R. polyantha*, require no more protection during the winter than the shrubs planted about the grounds. In the spring the mulch should be removed, but not too early; otherwise late frosts may injure the newly formed shoots. If a mulch of peat or manure is used, it may well be incorporated in the soil for its humus value. Winter hardiness depends to some extent on the care of plants during the summer.

Rose pests and diseases are discussed in Chap. XVIII.

Recommended Varieties

12 *Hybrid Teas*

Angels Mateu (orange rose)
Charlotte Armstrong (red to rose)
Christopher Stone (scarlet-crimson)
Crimson Glory (dark crimson)
Eclipse (golden yellow)
Editor McFarland (rose-pink)
Etoile de Hollande (bright red)
Golden Dawn (light yellow)
K. A. Viktoria (white)
Mrs. Charles Bell (shell pink)
Radiance (two-toned pink)
Sister Therese (golden yellow)

12 *Polyanthas (Floribundas)*

Baby Chateau (dark red)
Dagmar Spaeth (best white)
Else Poulsen (two-toned pink)
Gloria Mundi (orange-scarlet)
Gruss an Aachen (light pink)
Improved Lafayette (cherry red)
Margo Koster (salmon, dwarf)
Permanent Wave (cerise red)
Pink Jewel (rose-pink)
Pinocchio (salmon-pink buds)
Rosenelfe (silvery-rose pink)
World's Fair (dark red)

12 *Climbing or Pillar Roses*

American Beauty (crimson-rose)
American Pillar (single, pink)
Dr. Huey (maroon red)
Dr. J. H. Nicolas (bright pink)
Doubloons (saffron-yellow)
Dream Girl (apricot)
Elegance (light yellow)
Golden Climber or Mrs. Arthur Curtis James (golden yellow)
Mary Wallace (salmon pink)
New Dawn (soft pink)
Paul's Scarlet (scarlet-red)
Silver Moon (white, single)

12 *Hybrid Perpetuals*

Baroness Rothschild (light pink)
Frau Karl Druschki (pure white)
General Jacqueminot (scarlet-crimson)
George Arends (bright pink)
Henry Nevard (scarlet-crimson)
Louise Crette (creamy white)
Mme. Albert Barbier (fawn yellow)
Mrs. John Laing (soft pink)
Paul Neyron (lilac rose)
Prince Camille de Rohan (dark crimson)
Triomphe de L'Exposition (cherry red)
Ulrich Brunner (bright carmine)

12 *Species Roses*

Rosa chinensis (old blush-pink)
Rosa Eglanteria (sweetbrier, pink)
Rosa chinensis minima (Pompom de Paris, pink)
Rosa helenae (palest yellow)
Rosa hugonis (Father Hugo's rose yellow, single)
Rosa willmottiae (purplish pink)
Rosa damascena trigintipetala (semi-double, red)
Rosa primulina (pale yellow)
Rosa voxburghi (pale pink)
Rosa rubrifolia (red-leaved rose)
Rosa rugosa (pink)
Rosa setigera (prairie rose, pink)

12 *Old-fashioned Roses*

Cabbage Rose (Centifolia) (light pink)
Capitaine John Ingram (red, moss)
Cardinal De Richelieu (velvety black)
Crested Moss (rose-pink)
Harrison's Yellow (bright yellow)
Rosa spinoissima altai single)
Lady Penzance (copper)
Lord Penzance (fawn)
Red Province (rosy-red)
Rosa damascena (Damascus rose-rose, single)
York and Lancaster (red to white)

Trailing Roses

Rose wichuraiana Rosa rugosa **Max Graf**

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CHAPTER XV

WATER GARDENING

The most charming of effects may be obtained at comparatively slight expense by the judicious use of water. Water in a small garden furnishes a cooling, refreshing, shining surface during hot summer days, duplicating and enhancing the beauty of near-by trees and shrubs and flowers. At night it will reflect the moon, multiply the stars, and create a pulsating feeling of life in the midst of the deadening effect of darkness. Water gardens, no matter how tiny, are extremely effective in beautifying the landscape. Their effectiveness is rendered more striking by the addition of a distinct and delightful class of plants embracing those submerged or floating as well as the semiaquatic used in environmental plantings.

A great diversity of color and form exists among the plants adapted to growth in the ever wet soil of the pond or pool. The hardy and the tropical lilies vie with each other for popularity, although in size and form nothing can rival the hybrid *Nymphaea* of recent development. The thick, shiny foliage of the floating water hyacinth, the enormous platter leaves of *Victoria regia*, the upstanding curiously crinkled leaves of *Nelumbo*, the sharp-pointed effect of *Sagittaria* produce a pleasing variety and withal add a touch of tropical magnificence which cannot be surpassed.

To the uninitiated such effects may seem more like a dream than possible of attainment. Actually, the construction of water gardens, their upkeep, and the cultivation of water-loving plants are comparatively easy. The simplest of water gardens may be made by sinking into the ground a wooden tub, filling it with soil and water, and placing a waterlily or two in the bottom. Situated in one corner of the back yard, flanked by a group of sweet flag and a few irises, with an uneven rim of rock jutting over the edges—and there you have the beginnings of a water garden, small but satisfying.

For larger pools or ponds greater thought should be given, and supply of water will be necessary, from either a natural or an artificial source. If a variety of water plants is desired, combining the tender as well as the hardy kinds, a sheltered location must be chosen—sheltered from winds but not from the sun. Buildings or banks located on the north side provide this needed shelter. Windbreaks, vine-covered fences, and masses of shrubbery serve the same purpose. Shade-casting trees must not be too close to the edge of the pond, for the warming rays of

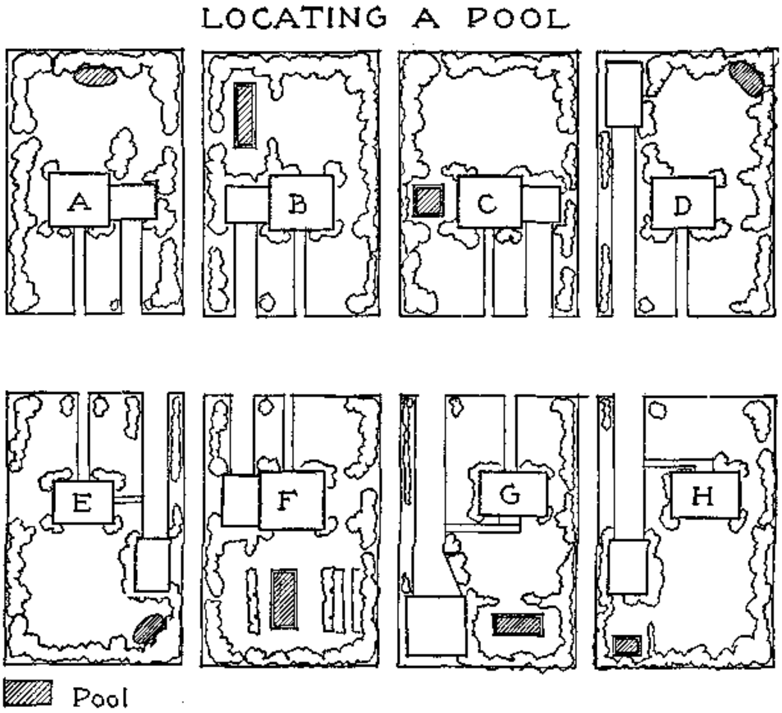

FIG. 70.

the sun are essential to proper development of the tender kinds, although the hardy water plants are not particular in this respect.

Often the type of plants growing about the site of the proposed pool determines its shape. Where informality reigns, the pool should be irregular, perhaps conforming to the contours of the established borders of trees and shrubs. On the other hand such informality would be out of place in a strictly formal layout. There, straight lines, sharp corners, and the placement upon a definite axis, as well as the length and breadth of the pool, should be carefully considered. For best effects the informal water garden should be slightly below the surrounding level, permitting the encroaching growth to hang over the edges. This, again, however, would be out of place in a formal setting where a distinct line of demarcation should be preserved between the surrounding lawn and the water area. There, too, clipped tubbed trees, statuary, and formal fountains in the center are additional attractions.

CONSTRUCTION

The pool should be excavated to a depth of 2 ft., thus allowing for a bottom covering of clay or concrete 4 in. thick, the soil medium 8 in. deep, and 1 ft. of water. If the soil is sandy or gravelly, permitting drainage and runoff, puddling with clay or the construction of a concrete basin becomes necessary. Not only is the seepage of water inconvenient, but a constant flow of fresh water reduces the temperature and checks growth. Puddling with clay is the most common method employed in construction. Heavy clay, 4 in. or more in thickness, should be cut in slabs similar to sods for the lawn, placed closely together, and tamped solidly and smoothly over the bottom and along the sides clear to the top. Pegs may have to be driven into these slabs along the sides to force them to stay in place until the pressure of water sets them permanently. If clay slabs cannot be procured readily, any heavy clay may be chopped and ground to powder, mixed with water, and in the form of paste applied to the excavated bottom and sides. Puddled ponds are very satisfactory except where crawfish penetrate and cause leakage. Clay pools require little attention. They have the advantage over concrete in that they can be remodeled or enlarged without much expense and besides are more natural in their aspect.

Although concrete pools with strongly defined sides should be used in formal surroundings only, if the side walls are sunk below the level of the lawn they will soon be obliterated by overhanging grass and other border plantings. To make a winter- and crack-proof concrete pool, disregard any recommendation to cover the bottom and sides with an inch layer of concrete. A thickness of 3 in. and preferably more should be used. Large pools should have a 6- or 8-in. wall, particularly in severe climates. Walls and bottom should be poured in one piece; otherwise cracks are sure to form. Small pools require no drain tile underneath for emptying water, since they may be filled with a hose and emptied by a siphon. For the larger water gardens 4-in. tile or a smaller water pipe should be laid underneath, with a standpipe reaching to the surface of the water and that may be unscrewed at the necessary time for draining. A good concrete mixture consists of one part cement, two parts sand, and three parts gravel or

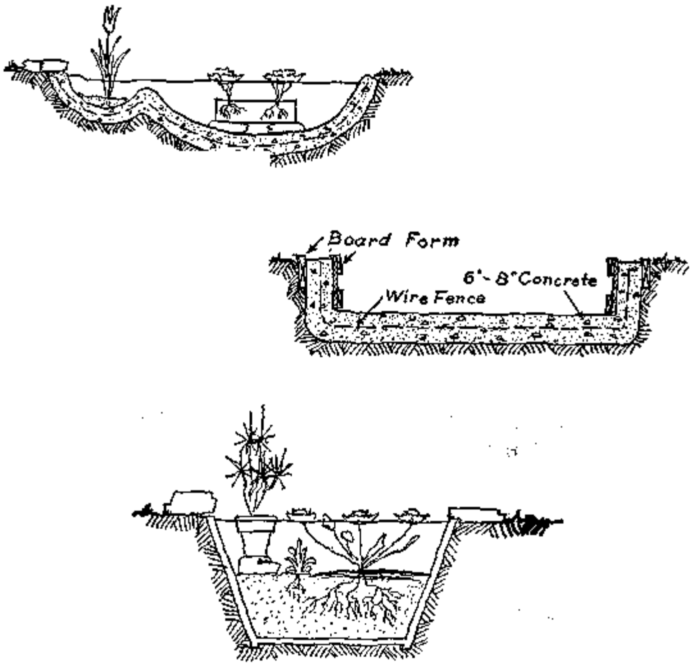

FIG. 71.—Types of pools.

crushed stone. Enough water is added to make the whole a sticky paste. If the material is too dry when poured, it will be too porous. To ensure against cracking, a network of reinforcing rods ¼ in. thick and 18 in. apart each way should be placed in the center of the concrete mass. To prevent spreading as the concrete is poured, the rods should be tied at intersections. As a further insurance against leaking, patented finish coats may be applied to the walls and bottom, preferably while the concrete is still wet; otherwise they will peel off. Once a crack appears, it is difficult to repair. Plugging with mortar is only a temporary relief. Clay may serve the purpose better. Hot asphalt is probably the best material for repair.

Formal, straight-sided ponds are constructed by means of forms made of 1-in. boards and heavily braced to prevent bulging and spreading under the weight of the concrete. Such a pond 10 ft. long and 5 ft. wide with a 4-in. bottom and tapering sides, 6 in. at the base and 4 in. at the top, will require eight bags of cement, 16 cu. ft. of sand, and 24 cu. ft. of gravel, together with 80 ft. of steel rods. In mild climates where frosts play little part in calculations, the thickness of the bottom and the sides may be reduced by half, and reinforcing eliminated. Copper, sheet lead, and alloy sheeting may likewise be used for the bottom and sides of the pools. Soldering is necessary to fasten the sheets together. These materials are expensive but long lasting.

SOIL

Fairly heavy, rich clay-loam soil is the best medium for proper growth and development of the majority of the water plants. *Nymphaea* and *Nelumbo* in particular are partial to such soil.

A compost of one-half soil and one-half cow manure may be prepared in advance by piling it in the fall and chopping and mixing it thoroughly before filling the pool in the spring. At the same time bone meal or superphosphate may be mixed with this compost at the rate of one 4-in. potful to a wheelbarrowful of soil. A complete fertilizer analyzing 4–12–4 may be substituted for the bone meal at the same rate. This will eliminate the necessity of adding potash in the form of hardwood ashes. Good sheep manure may be substituted if cow manure is not available but in much smaller quantity—one part to six of soil. This initial preparation of the soil should be supplemented each year with additions of a similar nature before planting.

PLANTING

The planting of hardy water plants can be done early in the spring and during early summer. The roots should be pressed into the soft mud, 2 to 3 in. deep, and held in place until properly established. The very vigorous among the water lilies, *e.g.*, *Nymphaea odorata*, *N. marliacea*, *N. alba*, should be planted 4 to

6 ft. apart. They will cover a water surface of about 6 ft. The less vigorous types such as *N.* James Bryden, *N. pygmaea,* and *N. fulva* should be spaced 2 to 4 ft. apart and will cover approximately that much water surface as the plants develop.

Tender waterlilies should not be planted until the temperature of the water reaches a permanent range of 65 to 70° F. They should be set 8 ft. apart, since under proper temperature and soil conditions their leaf surface may cover the space of 10 to 15 ft. Tender lilies are grown in pots, and the root balls should not be disturbed in planting.

The best method of planting waterlilies is by placing them individually in boxes or tubs and setting these 2 to 6 ft. apart in the pool according to their vigor of growth. Their roots should be planted 2 or 3 in. deep, and the water allowed to cover the crown to a depth of 4 in. This amount will suffice until the plants begin to grow, gradual additions being made until the pond is full. Hardy lilies may be left in the containers for 2 years, a top-dressing of manure being added the second spring. After 2 years, new soil should be substituted. When planted in tubs, lilies should be set with the crown even with the surface, and later covered with 1 or 2 in. of sand or gravel to keep the water from washing the soil. Eight inches of water above the crown is sufficient.

SUMMER CARE

During the season of growth all old leaves and maturing flowers should be removed, and green scum flushed off by addition of water. Algae may be destroyed by scattering copper sulphate over the surface at the rate of ½ oz. to every 125 cu. ft. of water. Plant lice often infest water plants. They may be destroyed with a spray of nicotine sulphate, at the rate of 1 tsp. to 1 gal. of water. A destructive leaf miner is eliminated by the use of arsenate of lead spray, 2 tsp. to the gallon of water. The same remedy is effective against the leaf beetles and several larvae that chew the foliage. A leaf spot sometimes causes damage but may be held in check by spraying with Bordeaux mixture. Crawfish may be poisoned by placing along the edges of the pond chopped meat impregnated with Paris green, covering it to prevent domestic animals from succumbing to the same fate.

WINTER CARE

After a frost the tropical tender lilies should be removed from ponds. If they are wanted for winter flowering in the conservatory, they may be potted and placed in tanks of water. All others should have the leaves cut back, and the tubers should be placed in a cool room away from rodent infestation. In a few weeks these roots should be cleaned and the young tubers extracted; the mother tubers may be disposed of. The new ones may be kept in damp sand or peat in a temperature of 50 to 60°F. until starting time in the spring.

The roots of hardy lilies and other hardy water plants may be left in the ponds. The water need not be drained, but a covering of boards and leaves should be placed on top to serve as a mulch and to prevent freezing. Where the concrete is thin and may crack during winter, the water should be drained and the roots covered with a mulch of straw or leaves or manure. If the roots were planted in boxes, these may be taken out, placed in a trench, and protected with a covering of sand, soil, or manure. A cool, moist basement will also serve as a storage place. Drying of the roots should be prevented under any conditions; if they dry, they will shrivel and rot.

PROPAGATION

The seeds of waterlilies lose their vitality very quickly when kept dry, owing to their thin protective covering, which permits rapid evaporation. It is therefore essential to sow them as soon as possible after maturity. For sowing, small half barrels or seed pans may be employed. The tubs should be filled half full of good sod soil, the upper surface having been covered with finely screened soil to a depth of 1 in. The seed should be sown sparingly on the surface and then covered with ¼ in. of finely screened sand. Water must be added gradually by using a sprinkling can so as not to wash off the light seeds. If seed pans are used for small quantities, these should be prepared in the same manner and then gradually immersed in a tank of water. Partial submerging the first day will be sufficient to soak the soil and seeds. The next day the whole of the pan may be immersed in the tank so that the surface of the soil is about 2 in. below the water level. The best situation for the tanks is one where the temperature ranges from 65 to 75°F., and in full sunlight germination of tender lilies takes about 10 days.

After the formation of the first floating leaf the seedlings should be potted singly in 2- or 2½-in. pots. The soil may combine a little well-decayed manure and should be fine. As soon as proper root development takes place, the plants should be shifted into 3-in. pots in a richer soil.

The seeds of hardy lilies germinate very slowly, some requiring 3 months to a year. For best results they should be sown as soon as harvested during the summer in pans or boxes and submerged in the ponds out of doors. In the fall the containers should be removed to a frostproof cellar or a greenhouse and placed in tanks of water. In the spring the seedlings may be potted and treated in the same way as those of the tender kinds. Many of the tender lilies may also be started in a similar manner, in July or August, forming small tubers before frost. Very small quantities of seed may be started in the house in pots placed in pans of water.

Hardy lilies may be divided while in growing condition, usually in the spring, although the work may also be done in August. Later division may result in winterkilling if the newly divided plants have not become properly established before freezing weather. Waterlilies of the odorata section have long roots, the growing points of which may be cut off a few inches long and planted singly in pots. None of the types that have single, thick crowns should be divided.

The lotus (*Nelumbo*) reproduces readily by small tubers attached to the base of the old root or rhizome that has completed its life cycle. These plants are lifted, and the young tubers placed in sand. In February they may be potted and placed in tanks as suggested previously.

Tender lilies are frequently raised from tuberous roots that are started into growth in January. They are placed in pots in light, screened soil. The water in which they are immersed should range from 75 to 80°. Soon the tubers begin to grow and send out runners, which leaf out and emit roots at the base of the leaves. When two leaves and a mat of roots have formed, the young plants should be separated from the parent tubers and potted singly. After removal of the new plants, the tubers will continue to produce others which are treated in a similar manner.

Constant repotting and enriching of the soil with each potting will be found necessary to eliminate checking of growth.

POLLINATION

Many of our present-day hybrid lilies are the result of chance cross-pollination by insects. To rely upon such a procedure is not satisfactory, since it is difficult to foretell what might arise from seed produced in this fashion. The better method is to go about the work of crossing systematically. It is not only a fascinating pastime but may also prove profitable if an outstanding product were secured.

Fundamentally, crossing, or hybridizing, consists of the transfer of viable or living pollen from one flower to the stigma of another. Fertilization takes place after the pollen grain germinates, sends a tube down through the style of the flower to the ovary below where the union takes place, and seed is developed. The preparation of the flowers, either pistillate or staminate, should be thorough. Plants selected for breeding should be vigorous. Consideration should be given to size, color, doubling, and leaf characters, particularly those of viviparous habit. Viviparous plants are those which develop new plants upon floating leaves during their period of growth.

The male, or pollen, parent should be covered during the bud stage to exclude insects and prevent them from depositing foreign pollen on the anthers. For this purpose a thin piece of cheesecloth or a translucent, waterproof bag may be fastened about the bud. The pollen may be collected during the second day after the flower opens, the outer whorl of stamens yielding their pollen first followed in succession by the other whorls. The female, or seed-bearing, parent should be emasculated in the bud stage. This means that all stamens and their superimposed anthers should be removed before the pollen ripens. The operation is performed by a pair of forceps reaching to the base of the stamen and plucking it out. Scissors may also be used. The emasculation is necessary to prevent self-pollination and should be done even though the stigma, or the receptive female organ, matures before the pollen. Removal of the pollen from the previously prepared flower is accomplished by the use of a camel's-hair brush or by the removal of the anthers with forceps and dragging these into the nectar that collects in the concave stigma when it becomes receptive. The petals and the sepals should be cut off partially; the flower, covered with a bag or cheesecloth tied closely about the base and fastened to a rod support. Enough twine should be left with the support to allow the seed pods to drop into the water and ripen normally. To keep a definite check of the crosses, records should be placed upon labels attached to the stake. The work of hybridizing may be done all through the summer, depending upon the flowering period of the types in question. The seeds mature usually in 3 to 4 weeks, when the seed pods should be collected, the covering removed, and the pods placed in water to allow total disintegration of the covering and thorough ripening of the seeds.

THE HARDY WATERLILIES

Hardy waterlilies have a wide range of color variation and form. Some varieties have floating leaves; others project above the surface of the water; whites, yellows, pinks, reds, and intermediate shades vie with one another for dominance in the color range. Our present-day varieties are the results of crosses between *Nymphaea odorata*, *N. tuberosa* (both of American origin), and *N. mexicana*. Two European species—*Nymphaea alba* and its variety *rubra*—have also had their share in the parentage of our present-day kinds. *Nymphaea pygmaea* from China has been used as a parent in many crosses.

The following are the 10 best hardy waterlilies:

Attraction. This is the largest hardy lily, its flowers often measuring 8 in. across. The petals are red tipped with rose, flecked with white. The sepals are white with tracings of rose. As the flowers age, they become deeper and more striking in color. The stamens are of rich, unchanging, tipped yellow. A very attractive water lily.

Chromatella. This clear, canary yellow variety is among the hardy leaders; in fact it is probably the best of all yellows. The stamens are a deeper shade. Mottled browns and greens make the leaves attractive. This variety is a good propagator and a vigorous grower—so vigorous at times that it is essential to divide it every 2 years. Unless it is divided the leaves crowd and rise above the surface of the water, hiding many of the flowers.

Camanche. Camanche is a very prolific variety with brilliant apricot shades changing to coppery bronze and later to a bright red as the flower ages. The foliage is speckled with brown; the flower stems are long, standing erect well above the surface of the pool.

Gladstone. This is the best of the whites. The flowers are pure white, appearing profusely and ranging from 6 to 8 in. in diameter. Petals are broad and concave; stamens, yellow. As Gladstone is a very vigorous grower, sufficient room should be provided for its development, and division every 2 or 3 years resorted to.

Gloriosa. The double, brilliant red flower of this waterlily, floating upon the surface of the water, is extremely pleasing. The variety has all the qualities of a perfect type. The comparatively small leaf area makes it desirable for the small pool or tub. The long-lasting qualities of its cut flowers and their fragrance make it a favorite. And when it is cut frequently, greater profusion of bloom results.

Morning-glory. The flowers are of delicate shell-pink color, fragrant and large. It is a vigorous grower.

Pink Opal. Deep pink in color, the flowers are of great substance and good keeping qualities. The buds are almost round and open into a cup-shaped flower with short petals. This is a good variety for smaller pools and containers.

Rose Arey. This is a seedling from *N. odorata* of free-flowering habits with cerise-colored flowers, often reaching 8 in. in diameter. The curling of the petals and the sweet scent add to its attractiveness.

Paul Hariot. Upon first opening, the flowers are clear yellow, changing to orange-pink and deepening to reds with age. Because of this variable coloration, flowers of different ages seen together present a most striking appearance. The variety has freedom of bloom, good substance, fragrance, and vigor. The cut flowers are of lasting quality.

Sultan. This lily has large cherry-red flowers, tipped and flecked with white. It is a vigorous grower. Other good hardy lilies are listed according to color:

Copper-colored:

Aurora. Creamy yellow to red. Good for small pools

Solfaterre. Similar to Paul Hariot

Chrysantha. Very suitable for the tub garden

Pink:

Marliac pink. A popular sort
Sumptuosa. The largest of the pinks
Splendida. Deep rose—brilliant
Mrs. Richmond. A large light pink
James Brydon. A very popular rose-colored variety, free blooming, with bronze leaves
Formosa. A very large light pink

Red:

Escarboude. The most brilliant colored of all the reds. A very free grower and bloomer
Conqueror. A large flower of crimson color.
Vesuve. A very dark red and extremely prolific.
Red Laydeker. A blood red.

Yellow:

Odorata sulphurea grandiflora. This is the largest of all hardy lilies, reaching 11 in. in diameter
Yellow Pygmy. A tiny lily, ideal for tub culture. The flowers are only 1 to 2 in. across. The foliage is mottled with brown.

White:

Marliac white. Very vigorous
Richardsoni. Double large flowers. Not profuse bloomer

THE LOTUS (NELUMBO)

Nelumbo speciosum—the so-called Egyptian lotus—is misnamed, since it is native to India, where it has been held sacred by the Hindus. This species probably became naturalized in Egypt where 4,000 years ago in the sacred gardens reserved for priests and worship it grew in granite pools, lifting its foliage and blossoms as the symbol of the rise of the soul of man. Our cultivation of this beautiful plant has no doubt come about as an introduction from Egypt. Its roots and seeds are used as food by Hindus, Egyptians, Chinese, and Japanese. The seeds and tubers of our native lotus (*N. lutea*) are also edible.

The lotus commands admiration and a good deal of attention because of the stately flowers borne high above the water against the background of silvery-bluish leaves on stems as high as 8 ft. The flowers are magnificent, beginning to bloom in June and continuing until August. They open by gradual stages much as does *Nymphaea.* On the first day just a glimpse of the inner petals is to be had; on the second day the flowers open fully; and during the third they are flat and ready to shed their floral parts. The seed pods are extremely attractive. The lotus is a very vigorous grower and, unless precautions are taken, will crowd out and kill all the rest of the plant population in the pool. The so-called Egyptian lotus was first introduced upon an estate at Bordentown, N. J., and since then has become thoroughly established in that locality so that it has actually run wild. This is thought to be the only location of *Nelumbo speciosum* in America outside cultivation. Because of their tendency to spread, either a pool should be planted to them alone, or else the roots should be confined by boards or concrete partitions to prevent their filling the entire subsurface. Under proper cultivation roots have been known to run 15 ft., with leaves arising at every node.

The best time to plant lotus is in May. Care must be exercised not to injure the growing points of the roots. They are planted horizontally about 6 in. below the surface of the soil. It is best not to disturb the plants during winter, provided protection is afforded from frosts. Usually if they are planted in tubs, it may be necessary to remove them to a cool but frost-proof cellar.

The more common varieties are the following.

American Lotus (*N. lutea*). Where it grows wild, it is often known as *water chinquapin*. Flowers are yellow and often reach a diameter of 10 in.

Chinese Red Lotus (*N. pekinensis*). The growth is extremely vigorous. The flowers are large and double, of bright carmine shade.

Egyptian Lotus (*N. speciosum*). The flowers are pink. Plants are very vigorous and hardy as far north as Columbus, Ohio.

Nelumbo flavescens is creamy yellow and of very free-blooming habit.

Japanese Lotus (*N. album*). A very striking, pure-white-flowered type, fragrant and with large, light green foliage.

Shiroman. A large and double-flowered white type, the flowers sometime reaching a diameter of 12 in. Its freedom of bloom and vigor make it a very desirable addition to the large pools and particularly to natural ponds.

THE TROPICAL WATERLILIES

The geographic distribution of tropical water lilies is wide. *Nymphaea flavovirens* and *N. flava* come from Florida and Mexico.

Australia furnishes the beautiful *N. gigantea; N. zanzibariensis* and *N. stellata* are natives of Africa. The night-blooming types —*N. lotus* and *N. rubra*—are indigenous to Egypt and India. Both are held sacred by Hindus, being frequently planted about their temples.

Chinese and Egyptian literature abounds in references to the beauty and usefulness of the lily. As early as A.D. 600 a Chinese writer declared that "though it is fashionable to admire the peony, my favorite is the waterlily." In Egypt the waterlily had much to do with religious ceremonies. On many monuments and tombs two lilies were often figured—*N. lotus* and *N. coerulea,* the blue lily. White lotus was found engraved on a tomb belonging to the twelfth dynasty, or about 2500 B.C. The flowers of the lily were used as funeral offerings and emblems in later dynasties. During the reign of Rameses II, mummies were encircled with flower bands made of waterlilies. Wreathes were placed in coffins of that time.

Until recent years hybridization of the tender waterlily has not gained much headway. One of the best of the European hybrids originated in 1887 was *N. kewensis,* a cross between *N. lutea* and *N. deconensis.* In the United States many new and striking varieties have made their appearance.

The following day-blooming varieties are meritorious:

Mrs. George H. Pring is biggest and best of the white lilies in cultivation. It has been known to reach a diameter of 13 in., with a profusion of bloom and a long period of open flowers. It will bloom well in cramped quarters.

Mrs. Edwards Whitaker is the parent and counterpart of Mrs. George Pring, except for its color, which is lavender-blue, becoming pale with age. This lily is even more prolific than its white offspring.

General Pershing, as well as the other two mentioned, is the introduction of George H. Pring of the Missouri Botanical Garden. As in the case of Mrs. Pring, one of the parents of this striking pink lily is Mrs. Edwards Whitaker. The flowers are large, open early in the morning, and exude a delightful fragrance.

Blue Beauty. Deep blue flowers with yellow stamens characterize Blue Beauty lily. It is one of the best of the tender kinds for the tub garden or small pool.

St. Louis. Yellow. The only true yellow tender waterlily, introduced by G. H. Pring in 1932 from a cross between Mrs. George H. Pring and an African species *N. Burtii.*

August Koch is probably the best all-purpose tender waterlily of lavender shadings, with a great profusion of flowers. The foliage is attractive, and the habit of growth vigorous.

Mrs. C. W. Ward. Rose pink.

Panama-Pacific. Brilliant red with yellow stamens.

Dauben. The best known viviporous lily. It produces a profusion of light blue flowers. The leaf plants frequently bloom while still attached to the parent leaves.

Henry Shaw. Blue.

N. zanzibariensis. Blue.

Mrs. Woodrow Wilson. Lavender.

Col. Lindbergh. Blue, large.

Patricia Pat. Free bloomer, red, suitable for small pools.

NIGHT-BLOOMING WATERLILIES

The night-blooming waterlily opens its flowers at dusk and remains open until next morning, depending somewhat upon the brightness of the day. At the end of the summer season when the water and the air are cool, the flowers stay open after development.

Varieties. *Nymphaea lotus dentata* is the white lotus of the Nile. The leaves are dark and large, and the flowers pure white.

Mrs. George C. Hitchcock. Pink.

Frank Trelease. Crimson.

N. dealbata superba. White.

Sturtevant. Large, pink.

Missouri. White, the largest of all waterlilies. Introduced by G. H. Pring in 1932.

The majority of the tender tropical waterlilies mentioned do much better in the northern tier of states if provision is made for heating the pools. Hot-water pipes may be run on the side of the pool, or warm water may be admitted, the overflow pipe taking off the surplus. The most suitable temperature is between 80 and 90°; and until this is reached in the summer, comparatively little growth and flowering of the tender water lilies will take place. Heating the water permits of earlier planting and consequent increase of blooming period.

Victoria regia (Giant Water Platter). The first reference to this giant water lily was made by Haenke, a botanist exploring the vegetation of Peru in 1801. Ten years later M. Bonpland reported it from Argentine, and a few years afterward it was mentioned by Poepping as being indigenous to the Amazon River region. Discovered in British Guiana in 1836 by Sir Robert Schomburgh, the lily was sent to John Lindley. It was named in honor of Queen Victoria in 1837.

We read in the record of Royal Botanic Gardens at Kew:

In August, 1846, seeds of this remarkable water plant were first sent to this country by T. Bridges, a plant collector, who discovered it in Bolivia. Part of these seeds were purchased by Kew, two of which vegetated and formed leaves the size of a half crown piece, but on account of their having sprouted late in the season, and our not being acquainted with the true nature of the plant, they both died in the dull weather of November of the same year.

From that time several attempts were made to introduce it, both by roots and seeds, but both arrived dead. In February, 1849, seeds were received sent in a phial of water from Demarara by Dr. Boughton, which vegetated, and in March six plants had become fully established and grew rapidly, in May one of them filling a shallow tank 9 ft. in diameter. Application was now made to the commissioners of the woods and forests for a large tank to grow it in, and accordingly slate sides 2 ft. high were put up forming a tank on the slate floor of an orchid house. A tank was thus formed 25 ft. long by 11 ft. wide, and on the twenty-first of August mold was placed in the center and a plant planted, which grew rapidly, and on November twenty-fourth produced a flower bud, which on account of dull weather of that season of the year did not come to perfection.

This plant was the nucleus of seeds later disseminated to other parts of the world. The first plants grown in this country were by Caleb Cope of Philadelphia in 1851. At present two species are cultivated in our water gardens—*Victoria regia* and *V. cruziana*. The latter is more hardy and does not require so high a temperature for development. The plants are perennial in habit but in the northern states should be treated as annuals. Flowers often measure 15 in. across. The large, platterlike leaves measure 7 to 8 ft. across and are capable of bearing heavy weights; when a weight is applied and equalized over the entire surface, the air becomes compressed, easily supporting it. The thick veins are so arranged as to produce intercellular chambers protected by spines.

Seeds should be sown in sand in early spring and placed in heated water tanks where the temperature ranges from 75° for *V. cruziana* to 90° for *V. regia*. Germination will take place in 3 weeks. The seedlings are potted in small pots and later shifted to larger sizes. Planting should not be attempted before June. The great vegetative growth of the plants requires a large amount of nutrients in the soil which should be manured heavily before planting. Each plant requires about 3 cu. ft. of soil, 400 ft. of water surface, and a 12-in. depth of water.

Seed is collected in the fall by cutting the pods and placing them in water tanks in the greenhouse. Frequent changes of water will be needed, as the outer covering of the pods decomposes. Seeds retain their germinative powers for several years, provided they do not dry out completely.

Euryale ferox. Before the introduction of *Victoria regia*, this annual was looked upon as a giant waterlily. The leaves are round, deep green, with numerous convexities on the upper surface, and measure 4 ft. across. The underside is purple, with large veins and spines. Edges do not turn up like those of *V. regia*. The flowers are small, day blooming, and a purple color. The plant is hardy as far as Washington, reseeding itself each year.

MISCELLANEOUS PLANTS FOR THE WATER GARDEN

Although the various types of waterlily should form the basis of all attraction in the water garden, the effectiveness of the whole is enhanced by the addition of various other hardy and tender plants either growing in the soil of the pool or floating upon the surface. Striking effects are frequently produced by many of these adjuncts, and naturalness is secured through their use. Many have curious habits of growth and reproduction, making selection all the more desirable.

Azolla caroliniana is a small, floating, mosslike plant, which propagates by division.

Bladderwort (*Utricularia purpurea*). The submerged leaves of this floating plant bear bladders that trap insects. The flowers are purple and showy.

Bog Rush (*Juncus effusus*). Bog rush is desirable for the edges of ponds and marshy places. The stems are dark green, growing to a height of 4 ft.

Brooklime (*Veronica americana*). The pale blue flowers of this creeping plant make a sheet of color from April to September. It grows to a height of 4 to 6 in. and is very suitable for the edges of ponds.

Cattail (*Typha latifolia* and *T. angustifolia*). For fall effects these are excellent. They do best planted 2 ft. apart at margins of pools. Flowers are borne in dense brown spikes. *T. angustifolia* is taller and more graceful, with finer spikes of flowers. Both do best in shallow water. They spread rapidly and may become pests unless restricted in root action.

Calla (*Zantedeschia maculata*). One of the best of the spotted plants, growing along margins. Leaves are dark green with white spots. Flowers are yellow. The plants are not hardy and should be lifted after the first frost in the fall, kept dry in a cool cellar, and planted out again in the spring.

Eel Grass. A unique example of water pollination is represented by our native eel grass (*Vallisneria spiralis*). This is a grasslike, aquatic plant indigenous to small streams, where it roots in the mud. The ribbonlike leaves often measure 7 ft. in length. Staminate and pistillate flowers are produced on widely differentiated spikes. The pistillate are bladderlike, sent out from the axils of the leaves upon elongated filaments which extend them to the surface of the water. The developed flower is cylindrical, with the three petals lying flat upon the surface and enclosing the fringed stigmas, projecting over the sides. The staminate flowers are produced upon bladderlike spikes which do not elongate to the surface of the water. This necessitates the detachment of the flower buds and their ascent to the tip. The flower buds unfold their three sepals into a formation representing three connected boats which contain two heads of pollen masses. Their construction is such as to prevent the water from capsizing them and wetting the pollen grains, borne upon oblique stalks. Directed by the movement of the water, the little boats finally come in contact with a female flower and become wedged between the petals. The slanting stamens brush against the fringed stigma, leaving a few pollen grains attached for later fertilization. After fertilization the elongated filament of the female flowers coils up into a springlike arrangement, drawing the ovary down to the base where the seed are ripened. After ripening, the albuminous coating causes the seed to float to the surface, where they are disseminated by movement of water and later sink to the bottom upon disintegration of the aril.

Floatingheart (*Limnanthemum lacunosum*). This is a floating plant with ovate leaves, blotched and mottled. It bears white flowers in the summer and does best in still water 2 ft. deep.

Forget-me-not (*Myosotis palustris*). This universal favorite grows to a height of 12 in., with a mass of blue flowers in May and June. It is especially suitable for edging of informal pools and is perfectly hardy.

Hydrocharis morsus-ranae. This plant is graceful and hardy. The leaves are kidney shaped on long stems. The pollination of its white flowers is interesting. When the plant begins to ripen, small buds are formed at the end of the runners. The buds are dragged to the bottom where they remain dormant until the next season. In the spring they float to the surface and begin to grow. The old plant dies each year.

Giant Reed (*Arundo donax*) is one of the tallest of the tropical grasses for wild effects.

Horn fern (*Ceratopteris ithalictroides*) grows wild in shallow water. The sterile fronds are feathery, producing new plants as these fronds fall into the water. Horn fern is propagated by spores annually.

Iris (*I. pseudacrous* and *I. laevigata*). Good for banks and edges of ponds.

Lace Leaf (*Aponogeton fenestralis*) is a plant native to Madagascar where it is found growing in small, running streams. The leaves are oblong, 6 to 8 in. long, 2 to 4 in. broad, and peculiar in presenting a skeletonized appearance (hence the effect of lace) and floating horizontally below the surface of the water.

The plant grows from a tuber which serves as a reserve food material during the drought prevalent in Madagascar. Flower spikes appear like little brushes above the surface and contain numerous white flowers.

Lemna minor (Small Duckweed). A small, floating, light-foliaged plant with a rootlet attached to each frond.

Marshmarigold (*Caltha palustris*). A short-growing plant for banks and edges of pools, it will grow even in 4 in. of water. The flowers are yellow, blooming in May.

Papyrus (*Cyperus papyrus*). A very effective plant for height, growing 4 to 6 ft. with soft, grasslike leaves in the form of an umbrella on top of each stem. It is not hardy and should be lifted and grown in water during winter.

Parrotfeather (*Myriophyllum proserpinacoides*). A plant with feathery foliage, rooting in the soil and making a sheet of green on top of the water. It is not hardy and may be kept over winter in tanks of water.

Pickerelweed (*Pontederia cordata*) produces blue flowers 8 to 12 in. above the water and grows best in a depth of 1 ft.

Pitcherplant (*Sarracenia purpurea*) is one of our commonest of bog plants, with purple flowers on tall stalks. The leaves are tubular, pitcherlike, of green color and reddish veins. It does well in shade and very wet borders.

Sweetflag (*Acorus calamus*) is good for shallow ponds, growing to a height of 3 ft. The leaves are green or variegated. Flowers are yellow.

Sagittaria montevidensis (Giant arrowhead) is a plant with large arrow-shaped leaves. It is good for margins. The flowers are white tinged with purple. Giant arrowhead is not hardy.

Thalia dealbata is a semiaquatic plant, a native of North America, growing to a height of 4 to 5 ft. with large, lacelike leaves. The purplish flowers are borne upon tall spikes towering above the leaves. The flowers are remarkable for their peculiar mechanism. The style is held firmly by a hoodlike perianth leaf, the pollen being deposited upon a headlike stigma while still in the bud. Upon insect visitation to collect nectar, a sensitive portion of the triggerlike style causes its release with a sudden spring. This brings the stigma in contact with the stamen, affecting pollination and at the same time holding the insect imprisoned. Large black ants and smaller butterflies have been observed tightly imprisoned. The same action may be readily produced by touching the style with a needle or a hatpin.

Waterlettuce (*Pistia stratiotes*) is a perennial aquatic plant native throughout the tropics and as far north as Texas, where it is found growing in fresh water. It succeeds well as a floating plant but prefers shallow water so that the roots may become attached to the mud. The loose rosette of eight green corrugated leaves gives a striking resemblance to a floating lettuce plant. Corrugations upon the back of the leaves contain air chambers which induce buoyancy.

The plant throws numerous runners which in a short time cover a considerable area of water, producing dense masses.

Its only relation to the Jack-in-the-pulpit is observed when the minute, light green, woolly, spathelike flowers appear from the center of the rosette during the summer.

Umbrella plant (*Cyperus alternifolius*) is best used in pots set on rocks at the bottom of the pool. It is not hardy and should be taken into the house early in the fall. It is easily propagated by dividing and potting the separated clumps of roots. New plants may be produced by inserting tops with a piece of the stalk attached into wet sand or water.

Water arum (*Peltandra virginica*) has arrow-shaped, callalike leaves 6 in. long. A green spathe appears above water in May and June. The berries are green. It should be planted in soil under 1 ft. of water. It is hardy.

Water Amaryllis (*Marsilea quadrifolia*). This plant is good for edges, either growing in soil or floating. It is especially suitable for hiding pond edges.

Watercress (*Nasturtium officinale*) is useful for margins. It bears small white flowers in profusion all summer.

Water Hyacinth (*Eichhornia speciosa* and *E. azurea*). In the South this is a pest; but in ponds where its growth may be restricted it is very desirable. It floats on water, with leaves 5 in. in diameter and inflated stalks. Flowers resemble the Dutch hyacinth of blue and violet shades. The plant should be lifted in the fall.

Water poppy (*Limnocharis humboldti*). The flowers are large, poppylike, yellow, lasting all summer. The floating leaves are 3 in. wide. It is tender and should be planted in shallow water.

Wildrice (*Zizania aquatica*) is an annual that grows readily in shallow water. It reaches a height of 10 ft., with large panicles of flowers.

SUBMERGED, OR OXYGENATING, PLANTS

To have the water in the pool clear and pure a number of oxygen-releasing plants should find their place in the collection. Most of them do better when rooted in the soil, although some will live by floating on the water.

Elodea canadensis, *Cabomba*, *Ceratophyllum*, *Myriophyllum*, and *Lysimachia* may be grown either by planting in soil or as floaters. *Ludwigia, Potamogeton, Sagittaria,* and *Vallisneria* do better when planted.

SUGGESTED GROUPINGS

In order to facilitate the selection of plants for various-sized water gardens a few suggestions will be given.

The small tub garden may be placed at the base of a rock wall with irises, rockcress, sedums, *Cerastium tomentosum, Festuca glauca, Phlox subulata, Veronica rupestris,* and others forming the ground covering next to the tub. The container itself may be planted with many combinations such as one giant arrow head, one waterlily, one water hyacinth, one umbrella fern, one water-lettuce, and one parrotfeather or eel grass. The umbrella plant may be either in a pot or planted directly in the soil. Other plants may be substituted, but the number should not be increased materially, as each plant needs a chance to develop properly.

A pool 4 ft. wide and 6 ft. long may be arranged as follows: If it is to be seen from all sides, a center group of tall-growing plants will be effective. Papyrus or umbrella plants may be used for this purpose, with a group of lotuses near by. Height should be secured also at the corners. Giant arrowhead, irises, pickerel grass, and papyrus may be placed there to advantage. In the open spaces waterlilies and various floating plants will produce the desired effect. Open water should show here and there. If a pool is backed against a grouping of shrubs, height should be stressed at that end. Thalias and papyrus will serve well under such conditions.

Larger pools and those of formal settings may have to be planted to correspond to the surroundings. When the latter are informal, many miscellaneous plants are desirable; but under formal conditions, where the pool's edges are to be seen, low-growing plants are to be preferred. Lilies should predominate.

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CHAPTER XVI

WOODY PLANTS

Woody plants, including deciduous trees, shrubs, vines, and the various evergreens, are seldom appreciated and used to the extent that they could or should be. Praiseworthy as is the interest of the average homeowner or beginning gardener in flowers and roses, it is unfortunate that he chooses to plant them to the exclusion of the more necessary and permanent woody plants. Possibly this preference may be explained by quicker returns and the apparent lack of expense of the flowers, together with their often more colorful bloom. Yet flower gardens are seasonal, whereas woody plants give a year-around effect.

Any landscape plan necessarily calls for the use of woody plants for background, screen, and foundation planting. It also calls for shade and possibly windbreaks. Obviously, therefore, to comprehend the selection and use of such materials is necessary, together with a knowledge of a sufficient number of forms to fit the variety of places where they are to be used.

To meet the objection that it is not possible to learn the necessary number of plants in a short time, rather specific instructions are given in this chapter on their selection and use, together with other information in the Selected Lists of Shrubs, Trees, Small Trees, Broadleaf Evergreens, Vines, Conifers, and Ground Covers. A visual application is found in the two charts. Select your shrubs by their habits of growth. Choose your evergreens by their habits of growth. Additional information will be found in the planting problems in Chap. VII.

FACTORS TO CONSIDER IN THE SELECTION OF WOODY PLANT MATERIALS

Habit of Growth. Probably no other factor is of so much importance as that of the mature effect of a plant. This includes ultimate height and, of equal importance, ultimate width. One has but to observe the usual planting of shrubs and evergreens to know that after relatively few years either the windows are completely hidden due to excess height or the use of walks and drives is restricted due to excess width (unless severe pruning has obliterated all individual plant habits of growth.)

Although individual species and varieties will vary to some extent with sections of the country and individual location, certain definite limitations may be set. If the specifications for any individual plant for any given location are determined in advance, for its maximum desirable height and its maximum width or spread, then the necessary form may be selected to meet these specifications and seldom exceed them.

Thus tremendous amounts of pruning or, to be more accurate, beheading will be done away with. Unfortunately, even nurserymen and others normally handling these plants seldom stop to consider this factor. Although no two species will have the same habits of growth, and even any one species under different conditions will vary considerably, it is possible to generalize and classify them according to the outlines in Fig. 72.

It is recommended as a class problem that in studying the various shrubs grown locally they be classified roughly according to these various habits of growth.

Wider growing shrubs such as the Morrow honeysuckle and forsythia are obviously unsuited for planting in confined spaces a few feet in width. Similarly, shrubs with more upright habits of growth, such as *Hibiscus syriacus* and *Philadelphus lemoinei*, would not be desirable unless used in quantity for screening an undesirable object. *Philadelphus coronarius*, or even *Spiraea van houttei*, is obviously out of place when planted in front of windows or the average porch, just as the *Deutzia gracilis* or *Spiraea thunbergi* would be of relatively little value for hiding an unsightly shed. The mature heights are given in the various lists of woody plants.

Hardiness of Plants. Plant hardiness is such a variable factor that any recommendation regarding it is purely relative. Herbaceous plants tender in New Jersey, Ohio, and Missouri may be hardy farther north where they are covered with snow throughout the winter. Fall rainfall, prevailing winds, time of fall and spring frosts, soil drainage, and soil moisture are some of the more important factors to consider. Hardiness in any one locality can be determined by a knowledge of the general hardiness of the plant, by observation of other plants hardy in the vicinity, and by actual test over a variety of conditions.

Information may be obtained from bulletins of the various agricultural experiment stations and agricultural colleges. The hardi-

Rounded	Slender-erect	Broad-spreading	Broad-erect	Bare at base	Horizontal branches	Hang down over wall
Abelia grandiflora Azalea mollis Berberis mentoriensis Ceanothus Chaenomeles lagenaria Deutzia gracilis Deutzia lemoinei Hypericum patulum Indigofera kirilowi Kerria japonica Lonicera fragrantissima Rosa hugonis Salix elaeagnos Spiraea arguta Spiraea bumalda froebeli Syringa chinensis	Berberis plurifolia erecta Chaenomeles japonica Hibiscus syriacus Philadelphus lemoinei Salix discolor	Aronia Cornus stolonifera flaviramea Cotoneaster adpressa Cotoneaster apiculata Cotoneaster dielsiana Cotoneaster horizontalis Forsythia Ligustrum obtusifolium regelianum Lonicera korolkowi Lonicera morrowi Rhus aromatica Ribes alpinum Rosa rubrifolia Symphoricarpos chenaulti	Acer ginnala Cornus mas Ligustrum obtusifolium Rhamnus frangula Sorbaria aitchisoni Syringa villosa Viburnum americana Viburnum lantana Viburnum lentago	Acanthopanax Caragana arborescens Euonymus alata Euonymus europeus Hibiscus syriacus Kolkwitzia Lonicera maacki Philadelphus coronarius Spiraea vanhouttei	Crataegus Viburnum tomentosum Viburnum tomentosum sterile	Cotoneaster adpressa Cotoneaster apiculata Cotoneaster horizontalis Euonymus fortunei colorata Forsythia suspensa Hedera helix Jasminum nudiflorum Rhus aromatica

FIG. 72.—Selecting your shrubs by their habits of growth.

ness of woody plants is given by zones which are based on the average annual minimum temperature as follows:

Hardiness Zone	Temp., °F.
I (Northern Canada)	
II	−50 to −35
III	−35 to −20
IV	−20 to −10
V	−10 to − 5
VI	− 5 to 5
VII	5 to 10
VIII	10 to 20
IX	20 to 30
X	30 to 40

Unfortunately these zones do not show the amount of rainfall which is a limiting factor in the Western plains and mountain states. Plants hardy with normal soil moisture might not be under arid conditions. Excessive wind and excessive summer temperatures are also limiting factors.

Permanence. A considerable number of plant materials, including many of the most commonly used, are surprisingly short-lived when grown under normal yard conditions. This applies more to evergreens than to deciduous plants. Such evergreen forms as the Irish juniper and spiny Greek juniper, although widely used, are among the least satisfactory due to a short life. The extensive use of Arborvitae should be discouraged throughout the Midwest, where, because of red spider, lack of adequate soil moisture, and high summer temperatures, it is relatively temporary, lasting at best but a few years. Under the same conditions many of the junipers and yews would be permanent.

Other plants are short-lived because of attacks of disease or insect pests, as is demonstrated by the frequent loss of *Ligustrum vulgare* and *Symphoricarpos racemosus* through blights prevalent in some sections or of the white birch through depredations of the bronze birch borer. The use of sun-demanding plants in shade caused by large trees is ill-advised. For instance, viburnum, although shade tolerant in the shadow of a building, find difficulty in surviving under shade trees owing to insufficient moisture. Lilac, weigela, and rose may exist in shade but will not bloom adequately.

The ability or inability of woody plants to withstand the terrific heat, both direct and reflected, on the south side of buildings is another manifestation of this same problem. So we see that an adequate knowledge of the growth requirements of various plants is essential for the best results. Much can be learned only by observation and experience.

Foliage Effect. The effect caused by difference in type and size of foliage has never received the consideration that its importance warrants in the landscape plan. The size of the foliage, its color, its texture, arrangement on the stem, the time of its appearance in the spring, its condition throughout the season, the time of its fall in autumn, and autumn coloration should all be thought of. Extremely coarse-foliaged shrubs, such as *Hydrangea quercifolia,* except as foliage accents or in connection with large buildings, are not recommended, on the other hand, the use of small-foliage shrubs, *e.g., Spiraea thunbergi,* with large buildings is too great a contrast.

Shrubs with gray, red, yellow, or purple foliage except as an occasional accent are inclined to ruin the artistic effect of any planting. An exception might be an entirely gray garden in which this type of foliage would predominate. Incidentally, as stated earlier, it is possible to have a complete garden, with adequate accents and features, through the use of foliage plants alone; yet by the uninitiated, who usually feel that a quantity of bloom is necessary to make a garden, this would be considered unattractive and possibly not a garden at all.

Evergreens are another factor in foliage effect. Needled evergreens alone often contribute to an appearance of somberness and monotony. This may be changed by the addition of broadleaf evergreens where they can be grown.

Year-around Effects. Any plant, whether in leaf or not, has a definite character. The habit of branching, whether it is strikingly horizontal as in some forms of *Crataegus* and *Viburnum tomentosum* or essentially vertical as in the Bolleana poplar and *Althea,* can be used to advantage. The amount of twigs may be adequate for a screen in winter after the leaves have been shed, as in the case of the privets and most of the shrubby *Cornus;* or it may not, as in the case of *Hydrangea quercifolia,* which has but few. The winter value of twig effects is seldom appreciated to the extent that it deserves.

The colored bark of such shrubs as the *Cornus alba sibirica* and the *Kerria japonica* may be used effectively, as may the conspicuous, corky-ridged twigs of *Euonymus alatus.* In addition to seasonal bloom, ornamental fruits, not only in summer but especially in fall and winter after the leaves have been shed, contribute greatly to the landscape picture. Some of these fruits, as in most of the honeysuckles, are dropped before the leaves fall. Most, however, remain throughout the fall, and some until spring. If normal soil moisture and adequate sunlight are available, fruit production will prosper. Shade and dry soil will greatly lessen it.

The majority of shrubs bloom during May and June, many with white flowers; but by the selection of proper kinds, bloom may be obtained almost any month of the year. Here, again, evergreens, both conifers and broadleaf, may be used to advantage in the production of year-around effect.

PLANTING AND CARE

The majority of deciduous trees, shrubs, and vines may be planted any time when they are not in leaf and the soil is in satisfactory condition to work. A few for best results require spring planting. Such are, among others, fleshy-rooted plants like magnolia, cucumbertree, and tuliptree. Thin-barked plants such as *Cornus florida*, *Cercis*, *Betula alba*, and *Tamarix* do best when planted in the spring. Plants of doubtful hardiness or difficult to establish, *e.g.*, *Buddleia*, *Vitex*, *Hibiscus syriacus*, *Clematis*, and *Hydrangea petiolaris*, should be spring planted in the colder climates. Coniferous evergreens can be planted almost any time except when in active growth during June, since they are balled and burlapped. The best time, however, is during September, October, March, April, and May; the present trend in progressive nurseries is to transplant everything except large trees, even when in full leaf, by balling and burlapping. This procedure, however, requires greater care during handling and until established than does dormant stock.

Soil Preparation and Fertilization. Adequate soil preparation is not only beneficial but essential for maximum results. Although individual shrubs may be planted in pockets of good soil, complete preparation by the incorporation (plowing or spading) of organic material is better. Partially decomposed humus in the form of peat moss, rotted manure, or rotted leaves may be used. Or a green-manure or cover crop of rye, winter wheat, and soybeans may be plowed under. With this should be incorporated, before planting, a complete commercial fertilizer analyzing 10–6–4, 4–12–4, or something similar.

Holes for planting should be sufficiently large to allow all the roots to spread. Only soil of good structure and adequate fertility should be put there. All plants should be planted at the depth at which they were originally growing. Tramp the soil firmly around the roots. Water in the hole while planting is not necessary and usually is a nuisance at best. Do not mound soil around the plants; it tends to shed water. Burlap may be left on all balled plants.

Mulching. Soil between plants should not be left in sod, which is not only a nuisance to mow but detrimental to plant growth. Either smother the sod with a heavy mulch, or, better still, spade it under and apply a mulch. This mulch is especially valuable during the summer to control weeds, conserve moisture, and keep soil temperature lower for root growth. It may consist of any organic material. If not partially decomposed, as in the case of peat, it will need an application of nitrogenous fertilizer to feed the bacteria decomposing it. Otherwise nitrogen in the soil will be used at the expense of plant growth. On dormant, deciduous plants fresh barnyard manure may be used as a mulch in fall, winter, or early spring as long as it does not come in contact with the roots. Do not use it on evergreens. The second growth of alfalfa makes an excellent mulch because of its nitrogen content.

CLASSIFICATION OF WOODY MATERIALS

Several possible classifications of woody plant materials might be used. For the botanist, possibly that by families and genera within those families would be the most logical; but for the horticulturist, classification by their winter effects seems to be the most advantageous. They might also be classified according to their heights, but such a method is better adapted to one section of the country than to the country as a whole, since many species will obviously be more vigorous in warmer climates.

The usual horticultural classification groups woody material as deciduous plants, coniferous or needled evergreens, and broadleaf evergreens. The various species and varieties in each group may be classified according to their habit of growth, *i.e.*, trees, shrubs, vines. Only a part of all the plants hardy for any one locality is to be found in the nurseries, and many of the available plants are not the better varieties. The selected lists of woody plants in this chapter are those considered best for the majority of localities. It may be found, however, that other plants are

Botanical name	Common name	Height, ft.	Width, ft.	Hardiness zone	*Bloom*	*Fruit*	*Remarks*
Abelia grandiflora	Glossy abelia	3–6	3–5	V	White 6–9*	....	Blooms all summer
Acanthopanax sieboldianus (pentaphylla)	Five leaf aralia	5–8	4–6	IV	Inconspicuous	....	*Excellent for shade*
Acer ginnala	Amur maple	15–20	5–10	II	Inconspicuous	Red 7*	
Aesculus parviflora	Bottlebrush buckeye	5–10	6–12	IV	White 7	*Green 10*	
Amelanchier humilis	Low shadblow	3–4	3–5	IV	White 5	Black 8	Fruit edible
Amorpha canescens	Leadplant	1–3	2–5	V	Blue 6	....	Variable, select desirable types
Aronia arbutifolia	Red chokeberry	4–6	4–6	V	White 5	Red 9	
Azalea calendulaceum	Flame azalea	3–10	3–6	V	Yellow, orange, scarlet 5	....	Variable in color
Azalea gandavensis†	Ghent azalea	3–6	3–4	V	Yellow, orange, scarlet 6	....	Hybrids including named varieties
Azalea mollis†	Chinese azalea	2–4	2–3	V	Yellow, orange 5	....	Large flowers before leaves
Azalea obtusa kaempferi†	Torch Azalea	5–8	3–5	IV	Red, orange, pink 5	....	Brilliant autumn color
Berberis mentoriensis	Mentor barberry	2–4	2–4	V	Yellow 6	Red 9	Drought resistant
Berberis *plurifolia* erecta	Truehedge columnberry	3–5	2–3	V	Yellow 6	Red 9	
Berberis thunbergi	Japanese barberry	4–6	3–5	V	Yellow 6	Red 9	Variable from seed
Buddleia *davidi* magnifica	Orange-eye butterfly-bush	4–8	5–8	V	Lavender 7–9	....	Number of varieties available
Callicarpa japonica	Beautyberry	3–5	3–5	V	Pink 8	Lavender 10	Root hardy, but tops tender
Caragana arborescens	Pea-tree	8–15	4–8	II	Yellow 5	Green pod 8	
Caragana maximowicziana	Pea-shrub	3–4	3–4	II	Yellow 6	....	Compact growth
Ceanothus pallidus roseus	Ceanothus	2–3	2–3	V	Pink 6		
Chaenomeles japonica (maulei)	Lesser flowering quince	3–4	2–3	IV	Pink 4	Green 9	
Chaenomeles lagenaria (Cydonia japonica)	Japanese quince	5–6	5–7	IV	Scarlet-red 4	Green 9	Also white, pink, red flowers

Clethra alnifolia	Summersweet	4–8	3–5	III	White 7	....	Flowers fragrant
Cornus alba sibirica	Coral dogwood	8–10	8–10	II	White 5–6	White 8	Bright red twigs
Cornus alternifolia	Pagoda dogwood	15–20	8–15	III	White 5–6	Blue-black 8	Horizontal branches
Cornus mas	Cornelian-cherry	10–18	8–10	IV	Yellow 4	Red 8	Excellent foliage
Cornus racemosa (paniculata)	Gray dogwood	8–12	6–10	IV	White 6	White 9	Good foliage
Cornus stolonifera flaviramea	Yellowtwig dogwood	5–7	8–15	II	White 6	White 9	Yellow twigs
Cotoneaster adpressa	Creeping cotoneaster	1–2	4–6	IV	Pinkish 6	Red 8	One of hardiest, low growing
Cotoneaster apiculata	Cotoneaster	2–4	4–6	IV	Pinkish 6	Red 8	Large fruits, hardy
Cotoneaster dielsiana	Diels cotoneaster	5–7	6–8	V	Pinkish 6	Red 9	
Cotoneaster foveolata	Cotoneaster	6–8	6–8	IV	Pinkish 6	Black 9	Excellent autumn color
Cotoneaster horizontalis	Rock cotoneaster	1–3	4–6	V	Pinkish 6	Red 9	Tender in severe climates
Cotoneaster racemiflora soongarica	Cotoneaster	6–8	6–8	III	6	Red 9	Showy fruit
Deutzia carnea	Pink deutzia	2–3	2–3	IV	White-pink 5		
Deutzia gracilis	Slender deutzia	2–3	2–3	V	White 5	....	Tender in exposed places
Deutzia lemoinei	Lemoine deutzia	3–4	3–4	IV	White 5	....	One of hardiest
Deutzia scabra	Pride of Rochester	6–8	3–5	V	White 6	....	Tender in many localities
Elaeagnus multiflora (longipes)	Cherry eleagnus	6–8	5–7	IV	Yellow white 5	Red, brown flecks	Silvery-gray foliage
Euonymus alatus compactus	Winged euonymus	4–5	3–5	III	Yellow 6	Brown-orange, red 9	Brilliant autumn color
Euonymus americanus	Strawberry-bush	4–6	3–4	V	Reddish-green 6	Pink, scarlet 9	Prickly warts on fruit
Euonymus yedoensis	Yeddo euonymus	10–15	6–8	IV	Reddish-green 6	Pink, orange 9	Striking plant
Forsythia intermedia spectabilis	Showy goldenbell	6–8	8–15	IV	Yellow 4		
Forsythia suspensa	Weeping goldenbell	6–8	8–15	V	Yellow 4		
Hamamelis mollis	Witch-hazel	5–15	5–8	V	Yellow 1–3	Pod 10	

* Indicates month.

† *Azalea* is now classified as *Rhododendron* but horticulturally will still be considered as *Azalea*.

SELECTED LIST OF DECIDUOUS SHRUBS.—(*Continued*)

Botanical name	Common name	Height, ft.	Width, ft.	Hardiness zone	Bloom	Fruit	Remarks
Hibiscus syriacus	Rose of Sharon	6–8	2–5	V	Various 8	....	Erect growing
Hydrangea arborescens grandiflora	Snowhill hydrangea	3–4	3–4	IV	White 6–8	....	Prefers partial shade
Hydrangea quercifolia	Oakleaf hydrangea	4–6	3–5	V	White 6	....	Excellent autumn color
Hypericum patulum	St. Johnswort	2–3	2–3	VII	Yellow 7–9	....	Semievergreen, root hardy
Ilex verticillata	Black alder (winterberry)	4–8	3–5	III	Yellow 6	Red 9	Sexes on separate plants
Indigofera kirilowi	Kirilow indigo	3–4	3–4	IV	Pink 6		
Kerria japonica	Kerria	3–4	3–4	V	Yellow 5	....	Twigs bright green
Kolkwitzia amabilis	Beautybush	8–15	6–10	V	Pink 5		
Ligustrum amurense	Amur River privet	6–10	5–7	III	White 6	Blue-black 9	Excellent hedge plant
Ligustrum obtusifolium (ibota)	Ibota privet	6–8	5–7	IV	White 6	Blue-black 9	One of best foliage shrubs
Ligustrum obtusifolium regelianum	Regel privet	3–5	4–5	IV	White 6	Blue-black 9	One of best foliage shrubs
Ligustrum vulgare	Common privet	8–15	6–10	III	White 6	Black 9	Holds foliage late
Lonicera fragrantissima	Winter honeysuckle	5–7	5–7	V	Cream 4	....	Semievergreen
Lonicera korolkowi	Blueleaf honeysuckle	6–8	8–12	IV	Pink 5	Red 8	Leaves bluish green
Lonicera maacki	Amur honeysuckle	12–20	10–15	IV	White 5	Red 9	One of fastest growing shrubs
Lonicera morrowi	Morrow honeysuckle	6–8	8–15	III	White 5	Red 8	One of toughest shrubs
Lonicera syringantha	Lilac honeysuckle	4–7	4–7	IV	Pink-lilac 6	....	Fragrant flowers
Lonicera thibetica	Tibetan honeysuckle	4–5	4–6	IV	Pale purple 6	Red 8	
Myrica pensylvanica	Bayberry	4–6	3–5	II	Inconspicuous	Gray 9	Sexes separate; foliage aromatic
Philadelphus lemoinei	Lemoine mockorange	3–5	2–3	V	White 6	....	Erect habit of growth

Philadelphus virginalis	Virginal mockorange	5–7	3–4	V	White 6	....	Variety Argentine preferable
Photinia villosa	Photinia	8–12	5–8	IV	Inconspicuous	Red 9	Treelike
Physocarpus monogynus	Ninebark	2–3	2–3	V	Pinkish 6		
Physocarpus opulifolius luteus	Goldleaf ninebark	8–12	8–15	II	White 6	Red 8	
Potentilla fruticosa	Shrubby cinquefoil	2–3	1–2	II	Yellow 7–8	....	Select for desirable habits
Prunus tomentosa	Nanking cherry	6–8	5–7	II	White 4	Red 7	Variable
Prunus triloba	Flowering almond	6–8	5–6	V	Pink 5	Red 8	
Rhamnus frangula	Alder buckthorn	8–15	6–8	II	....	Red and black 9	Hedge or shade
Rhodotypos scandens (kerrioides)	Jetbead	4–6	4–6	IV	White 6	Black 10	
Rhus aromatica (canadensis)	Fragrant sumac	3–4	5–15	III	Green 4	Red 8	Plant aromatic
Rhus copallina	Shiny sumac	8–15	4–8	IV	Green 7	Red 9	Excellent autumn color
Rhus typhina	Staghorn sumac	8–20	5–15	III	Green 6	Red 8	Excellent autum color
Ribes alpinum	Alpine currant	5–6	6–8	II	Inconspicuous		One of best shade shrubs
Ribes odoratum	Buffalo currant	5–6	5–7	IV	Yellow 5	Black 7	Fragrant flowers
Rosa ecae	Eca rose	3–4	3–5	V	Yellow		
Rosa hugonis	Hugonis rose	4–6	4–6	V	Yellow 5	Red 8	
Rosa rubrifolia	Redleaf rose	4–6	6–8	II	Red 6	Red 7	Red foliage and stems
Salix discolor	Pussy willow	10–20	5–10	II	Catkins 4	....	Subject to borer
Salix elaeagnos (incana)	Rosemary willow	10–15	8–12	IV	....	....	Leaves gray beneath
Shepherdia argentea	Buffaloberry	6–10	6–8	II	Yellow 5	Scarlet 8	Silver-gray foliage
Sorbaria aitchisoni	Kashmir false-spirea	8–10	6–10	V	Cream 7	....	Tender but grows up again
Spiraea arguta	Garland spirea	3–5	3–5	IV	White 5	....	Should be more widely used
Spiraea billiardi	Billiard spirea	4–6	3–4	IV	Pink 6–8		
Spiraea bumalda froebeli	Froebel spirea	2–4	2–3	V	Pink 6	....	More vigorous than S. Anthony Waterer

SELECTED LIST OF DECIDUOUS SHRUBS.—(*Continued*)

Botanical name	Common name	Height, ft.	Width, ft.	Hardiness zone	Bloom	Fruit	Remarks
Stephanandra incisa (flexuosa)	Cutleaf stephanandra	3–4	3–4	V	White 6	....	Attractive foliage
Symphoricarpos chenaulti	Chenault coralberry	2–4	3–4	V	Pinkish 7	Red 9	Preferable to S. vulgare
Symplocos paniculata	Asiatic sweetleaf	8–20	8–10	V	White 5	Lavender-blue 9	
Syringa chinensis	Chinese lilac	8–12	6–10	V	Lavender 5	....	Vigorous, free blooming
Syringa villosa	Late lilac	8–12	6–10	II	Lavender 6	....	Late blooming
Syringa vulgaris	Common lilac	6–15	4–10	III	Various 5	....	Use French hybrids
Tamarix gallica	French tamarix	10–20	10–15	V	Pink 6–7		
Tamarix odessana	Odessa tamarix	6–8	8–10	IV	Pink 7–9		
Viburnum carlesi	Fragrant viburnum	4–6	3–5	IV	White 4	Black 9	Fragrant flowers
Viburnum cassinoides	Withe-rod	4–6	3–5	III	White 6	Blue 9	Brilliant autumn color
Viburnum lantana	Wayfaring-tree	10–12	6–10	III	White 6	Black 9	Holds foliage late
Viburnum lentago	Nannyberry	10–15	4–8	II	White 6	Blue-black 9	Brilliant autumn color
Viburnum opulus nanum	Dwarf European cranberrybush	1–2	1–2	IV	....	....	Dwarf compact
Viburnum prunifolium	Blackhaw	10–15	6–10	III	White 6	Blue-black 9	
Viburnum tomentosum	Doublefile viburnum	6–8	5–7	IV	White 6	Blue-black 9	Striking horizontal branches
Viburnum tomentosum sterile (plicatum)	Japanese snowball	6–8	5–7	V	White 6	....	Sterile flowers
Viburnum trilobum (americanum)	Cranberrybush	6–10	5–6	II	White 6	Red 8	
Vitex agnus-castus	Chaste-tree	5–8	4–6	V	Lilac 7–9	....	Root-hardy, but branches often winterkill
Weigela floribunda	Crimson weigela	5–7	5–7	V	Red 5		
Weigela florida (rosea)	Pink weigela	6–8	6–8	V	Pink 5	....	Many varieties

more satisfactory for certain local conditions, a matter that can be determined by checking with local plant authorities or with state agricultural colleges and agricultural experiment stations.

When in doubt as to the use of deciduous shrubs or evergreens, consider the following facts:

1. A good evergreen planting will cost roughly ten times as much as deciduous material.

2. Deciduous plants will usually survive under much more adverse conditions than will evergreens.

How to Use Selected Shrub List

Select each plant according to the particular place where it is to be used, and decide how high it is desirable to have it grow. In front of a porch it should get no higher than the porch rail. In front of a window, if a shrub is used at all, it should get no higher than the window sill. As a border or a background planting, it may reach its normal height with no harm except the possible shading of adjacent flowers. To select a shrub according to the mature height given in the table is a simple matter.

In the same way the plant's width should always be considered. In a 5-ft. space between the house and the drive a shrub should not get wider than 3 or 4 ft. Nor should a wide-growing shrub be near a walk or in a small or very narrow yard. On the other hand, broad shrubs may be used to cover an old stump or fill in a rough corner of the yard, or banks, or where space is ample.

It is better to select a shrub that apparently will be too small than one that may become too large. Overgrown shrubs are a nuisance at best and continue to be so as long as they live. Remember that you are planting not for this year but for 10 to 25 years from now. The unnecessary care that badly chosen shrubs will demand in that length of time can be seen in the plantings around the average house throughout the United States.

The proper spacing of shrubs and other woody plants will save the labor of moving them farther apart after a few years' growth. Few gardeners or nurserymen seem to appreciate this. Deciduous shrubs are usually spaced so that after several seasons' growth they are touching each other—a distance sometimes stated as two-thirds their maximum height. An even safer basis is the minimum width given in the Selected List of Shrubs. They should be planted about two-thirds this distance from buildings or other objects.

Succession of Bloom from Trees, Shrubs, and Vines

Month	White or cream	Yellow or orange	Pink or red	Blue, lavender, or purple
February		Hamamelis mollis Hamamelis vernalis		
March	Lonicera fragrantissima	Cornus mas Jasminum nudiflora Lindera (Benzoin)		Azalea mucronulata Daphne mezereum
April	Magnolia stellata Spiraea arguta Spiraea thunbergi Viburnum burkwoodi Viburnum carlesi	Forsythia	Azalea obtusa kaempferi Cercis canadensis Chaenomeles japonica Chaenomeles lagenaria Magnolia soulangeana Magnolia soulangeana lennei	
May	Amelanchier Aronia Cornus florida Crataegus Deutzia lemoinei Halesia Malus Sorbus Spiraea van houttei Syringa	Azalea calendulacea Azalea mollis Caragana Colutea Laburnum Ribes aureum	Azalea gandavensis Daphne cneorum Kolkwitzia Lonicera tatarica Malus atrosanguinea Malus eleyi Malus floribunda Syringa	Syringa persica Syringa vulgare Wisteria
July	Abelia Aesculus parviflora Clethra Hydrangea arborescens grandiflora Oxydendron Sorbaria aitchisoni Stewartia	Hypericum Koelreuteria Potentilla fruticosa	Buddleia Hydrangea opuloides (alkaline soil) Indigofera	Buddleia Hydrangea opuloides Passiflora
August	Abelia Franklinia Hibiscus syriacus Hydrangea paniculata grandiflora Polygonum auberti	Hypericum Potentilla fruticosa	Buddleia Hibiscus syriacus	Buddleia Hibiscus syriacus Vitex
September	Franklinia Hibiscus syriacus		Buddleia Daphne cneorum Hibiscus syriacus	Buddleia Hibiscus syriacus Vitex
November		Hamamelis virginiana		

SUCCESSION OF DECORATIVE FRUITS OF TREES, SHRUBS, AND VINES

Month	White	Yellow or orange	Red	Black	Lavender	Blue-black
July–August.	Cornus racemosa	Lonicera morrowi xanthocarpa	Lonicera morrowi Lonicera tatarica	Aralia spinosa Ribes aureum Sambucus		
September–October.	Rhus radicans Rhus vernix	Malus arnoldiana Malus scheideckeri Malus theifera Malus toringoides Viburnum opulus xanthocarpum	Cotoneaster apiculata Crataegus Malus eleyi Malus floribunda Malus niedzwetzkyana Malus sargenti Viburnum sieboldi		Ampelopsis brevipedunculata Callicarpa	
September–December.	Symphorcarpos	Celastrus orbiculatus Celastrus scandens Euonymus europaeus Euonymus fortunei carrierei Euonymus fortunei vegeta Euonymus maacki Euonymus planipes Euonymus yedoensis Pyracantha Sorbus aucuparia Viburnum dilatatum xanthocarpum	Aronia arbutifolia Cotoneaster adpressa Cotoneaster dielsiana Cotoneaster divaricata Cottoneaster horizontalis Cotoneaster simonsi Crataegus cordata Euonymus americana Euonymus europaea Ilex aquifolium Ilex opaca Ilex verticillata Lindera (Benzoin) Lonicera maacki Lonicera maacki podocarpus	Cotoneaster acutifolia Aronia melanocarpa Cotoneaster foveolata Ilex glabra Ligustrum vulgare Viburnum lantana	Symplocos	Viburnum lentago Viburnum prunifolium

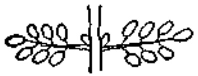
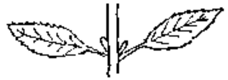
SUCCESSION OF DECORATIVE FRUITS OF TREES, SHRUBS, AND VINES.—(*Continued*)

Month	White	Yellow or orange	Red	Black	Lavender	Blue-black
September–December.			Nandina Photinia Pyracantha Rhus aromatica Rhus typhina Symphoricarpos chenaulti Taxus cuspidata Viburnum dilatatum Viburnum opulus Viburnum trilobum Viburnum wrighti			
September–February.					Symplocos	Ligustrum amurense Ligustrum obtusifolium *Ligustrum obtusifolium regelianum* Mahonia aquifolium Parthenocissus quinquefolia Parthenocissus tricuspidata veitchi Viburnum cassinoides Viburnum dentatum Viburnum lentago Viburnum prunifolium

CLASSIFICATION OF DECIDUOUS SHRUBS AND VINES

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
		Leaves alternate		
				
Amorpha	Aralia	Benzoin	Amelanchier	Althea
Caragana		Berberis	Amygdalus	Ampelopsis
Colutea	*Vines*	Cornus alternifolia	Aronia	Neillia
Potentilla	Akebia	Cotinus	Berberis	Physocarpus
Rhus	Ampelopsis	Cotoneaster	Ceanothus	Prunus triloba
Rosa		Daphne	Chaenomeles	Ribes
Sorbaria		Elaeagnus	Clethra	Stephanandra
		Myrica	Corylus	
Vines		Rhamnus	Corylopsis	
Wisteria		Salix elaeagnos	Enkianthus	
		Spiraea	Exochorda	
			Fothergilla	
			Franklinia	
			Halesia	
			Hamamelis	
			Ilex	
			Itea	
			Kerria	
			Malus	
			Myrica	
			Neviusia	
			Photinia	
			Prunus	
			Salix	
			Spiraea	
			Vitex	
			Vines	
			Actinidia	
			Celastrus	
			Symplocos	

CLASSIFICATION OF DECIDUOUS SHRUBS AND VINES.—(*Continued*)

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
		Leaves opposite		
				
Sambucus *Vines* Bignonia Campsis Clematis	Acer Aesculus Vitex	Calycanthus Chionanthus Cornus Fontanesia Hypericum Ligustrum Lonicera Shepherdia Symphoricarpos Syringa *Vines* Periploca	Abelia Buddleia Callicarpa Deutzia Euonymus Forsythia Hydrangea Kolkwitzia Philadelphus Rhamnus Rhodotypos Viburnum Weigela *Vines* Hydrangea Schizophragma	Acer Hydrangea quercifolia Viburnum opulus Viburnum trilobum

Selecting the Right Kind of Shrubs

In front of low porches and beneath low windows:
Abelia
Amelanchier humilis
Amorpha canescens
Azalea molle
Berberis mentoriensis
Cotoneaster adpressa
Cottoneaster apiculata
Deutzia carnea
Deutzia gracilis
Hypericum patulum
Indigofera kirilowi
Physocarpus monogynus
Potentilla fruticosa
Rosa ecae
Spiraea bumalda froebeli
Stephanandra incisa
Virburnum opulus nanum

In front of medium-high porches 4 to 5 ft. or windows:
Aronia arbutifolia
Azalea gandavensis
Azalea obtusa kaempferi
Berberis thunbergi
Chaenomeles japonica
Deutzia lemoinei
Kerria japonica
Ligustrum obtusifolium regelianum
Lonicera syringantha
Myrica pensylvanica
Philadelphus lemoinei
Rhodotypos scandens
Rosa hugonis
Spiraea arguta
Viburnum carlesi

Tall shrubs over 8 ft. high for screen plantings or high backgrounds:
Acer ginnala
Caragana arborescens
Cornus alternifolia
Cornus mas
Cornus racemosa
Euonymus yedoensis
Kolkwitzia amabilis
Ligustrum vulgare
Lonicera maacki
Photinia villosa
Physocarpus opulifolius luteus
Rhamnus frangula
Salix discolor
Salix elaeagnos
Sorbaria aitchisoni
Symplocos paniculata
Syringa chinensis
Syringa villosa
Tamarix gallica
Viburnum lantana
Viburnum lentago
Viburnum prunifolium
Viburnum trilobum

Shrubs 5 to 8 ft. high for backgrounds:
Acanthopanax sieboldianus
Azalea gandavensis
Cotoneaster dielsiana
Cottoneaster racemiflora soongarica
Deutzia scabra Pride of Rochester
Elaeagnus multiflora
Ilex verticillata
Ligustrum obtusifolium
Lonicera fragrantissima
Philadelphus virginalis argentine
Prunus tomentosa
Prunus triloba
Rhus copallina
Shepherdia argentea
Spiraea billardi
Viburnum cassinoides
Viburnum tomentosum
Viburnum tomentosum sterile
Weigela floribunda

Low hedges, unsheared:
Abelia grandiflora
Amelanchier humilis
Berberis mentoriensis
Berberis plurifolia erecta
Chaenomeles japonica
Deutzia carnea
Deutzia gracilis
Hypericum patulum
Indigofera kirilowi

Kerria japonica
Physocarpus monogynus
Potentilla fruticosa
Rosa ecae
Spiraea arguta
Spiraea bumalda froebeli
Viburnum opulus nanum

Low hedges, sheared—in addition to the foregoing:

Acer ginnala
Caragana arborescens
Cornus mas
Cotoneaster dielsiana
Euonymus americana
Ilex verticillata
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera fragrantissima
Myrica pensylvanica
Prunus tomentosa
Ribes alpinum
Salix elaeagnos
Syringa chinensis
Viburnum cassinoides
Viburnum lantana
Viburnum tomentosum

Tall hedges, sheared:

Acer campestre
Acer ginnala
Cornus mas
Gleditsia triacanthos
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera maacki
Rhamnus frangula
Salix pentandra
Symplocos paniculata
Syringa chinensis
Ulmus pumila
Viburnum lantana
Viburnum lentago
Viburnum trilobum

Tall hedges, unsheared:

Acer ginnala
Caragana arborescens
Clethra alnifolia
Cornus mas
Cornus racemosa
Cotoneaster dielsiana
Cotoneaster foveolata
Cotoneaster racemiflora soongarica
Elaeagnus multiflora
Ilex verticillata
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum vulgare
Lonicera fragrantissima
Prunus tomentosa
Rhamnus frangula
Ribes alpinum
Syringa chinensis
Viburnum cassinoides
Viburnum lantana
Viburnum lentago
Viburnum tomentosum
Viburnum trilobum

Shrubs for shaded locations:

Acanthopanax sieboldianus
Acer ginnala
Aesculus parviflora
Amelanchier
Aronia
Azalea
Chaenomeles
Cotoneaster
Hydrangea arborescens grandiflora
Hydrangea quercifolia
Kerria japonica
Ligustrum
Lonicera
Photinia
Rhamnus
Rhus aromatica
Ribes
Spiraea arguta
Spiraea bumalda froebeli
Viburnum (if soil is moist)

Shrubs for dry shade beneath trees:

Acanthopanax sieboldianus
Ligustrum obtusifolium
Lonicera morrowi
Rhamnus frangula

Rhus aromatica
Ribes alpinum
Ribes odoratum
Symphoricarpos chenaulti

Tall shrubs that can be trained to give shade:
Acer ginnala
Kolkwitzia amabilis
Lonicera maacki
Philadelphus coronarius
Viburnum prunifolium

Spreading shrubs for banks:
Cornus stolonifera flavirames
Cotoneaster adpressa
Cotoneaster apiculata
Cotoneaster horizontalis
Forsythia intermedia spectabilis
Forsythia suspensa
Rhus aromatica
Ribes alpinum
Symphoricarpos chenaulti

Shrubs requiring an acid soil
Azalea
Clethra
Ilex
Kalmia
Oxydendron
Rhododendron

Shrubs for wet or poorly [illegible] ground:
Cephalanthus
Clethra
Cornus alba sibirica
Cornus racemosa
Euonymus atropurpurea
Ilex verticillata
Ligustrum vulgare
Physocarpus opulifolius
Potentilla fruticosa
Ribes aureum
Salix discolor
Salix elaeagnos
Viburnum cassinoides
Viburnum dentatum
Viburnum trilobum

Shrubs for hot, dry situations:
Acanthopanax sieboldianus
Berberis mentoriensis
Ligustrum amurense
Ligustrum obtusifolium
Lonicera morrowi
Rhamnus frangula
Rhus aromatica
Shepherdea argentea
Tamarix

Shrubs with fragrant flowers:
Abelia
Clethra
Daphne cneorum
Elaeagnus angustifolia
Lonicera fragrantissima
Lonicera syringantha
Philadelphus (most varieties
Ribes aureum
Syringa chinensis
Syringa vulgaris
Viburnum burkwoodi
[illegible]urnum carlesi

[illegible] planted in the spring:
[illegible]elia
[illegible]ddleia
[illegible]llicarpa
[illegible]lycanthus
[illegible]biscus
[illegible]agnolia
Tamarix
Vitex

Should be balled and burlapped when transplanted:
Abelia
Acer palmatum
Cornus florida
Cotoneaster
Magnolia

Foliage small:
Abelia
Amorpha
Berberis (most varieties)
Caragana
Cotoneaster adpressa
Cotoneaster apiculata
Cotoneaster horizontalis
Hypericum (most varieties)
Indigofera
Lonicera korolkowi
Lonicera syringantha

Rosa ecae
Rosa hugonis
Spiraea arguta
Spiraea thunbergi

Foliage large:
Calycanthus
Chionanthus
Hamamelis
Hydrangea arborescens grandiflora
Hydrangea quercifolia
Syringa josikaea
Syringa villosa
Viburnum lantana
Viburnum sieboldi
Viburnum tomentosum
Viburnum trilobum

Autumn color—red:
Acer ginnala
Amelanchier
Aronia
Azalea kaempferi
Cornus
Cotoneaster
Euonymus alatus
Euonymus (deciduous,
Hydrangea quercifolia
Rhus aromatica
Spiraea bumalda froebeli
Viburnum carlesi
Viburnum cassinoides
Viburnum prunifolium

Autumn color—yellow:
Acanthopanax
Aesculus parviflora
Caragana
Hamamelis
Hypericum
Ribes alpinum
Spiraea thunberg
Zanthorhiza

Shed leaves early in fall:
Acer ginnala
Callicarpa
Caragana
Chionanthus
Crataegus
Euonymus
Lonicera tatarica
Philadelphus
Syringa

Hold foliage late in fall:
Abelia
Cotoneaster (most varieties)
Forsythia
Ligustrum amurense
Ligustrum obtusifolium
Ligustrum obtusifolium regelianum
Ligustrum vulgare
Lonicera fragrantissima
nicera maacki
nicera maacki podocarpa
nicera standishi
yrica
ibes alpinum
lix discolor
lix elaeagnos
Spiraea arguta
Spiraea bumalda Anthony Waterer
Spiraea bumalda froebeli
Viburnum lantana
Viburnum tomentosum
Viburnum trilobum

Twigs few—poor winter screen:
Chionanthus
Hibiscus syriacus
Hydrangea quercifolia
Philadelphus virginalis
Syringa josikaea
Syringa vulgaris
Viburnum burkwoodi
Viburnum carlesi

Colored twigs for winter effect:
Cornus alba sibirica (red)
Cornus stolonifera flaviramea (yellow)
Kerria japonica (green)
Rosa rubrifolia (red)

DECIDUOUS TREES

The proper selection and planting of trees for shade, ornamental purposes, and other uses deserve far more careful con sideration than they generally receive. Note the shade trees along the average city street. Often there is no uniformity of variety, no proper care in regard to pruning and pest control, and usually they are planted too close together. Besides, many of those planted are not desirable varieties, being either short-lived and brittle or messy because of flowers, fruit, or seeds. The trees in any one block and preferably any one stretch of street should be of the same variety. They should be planted sufficiently far apart to allow for growth without crowding. If possible, their planting and care should be supervised by the municipality under the direction of a trained arborist.

Street trees should be planted 40 to 75 ft. apart, depending on the mature size of the variety. As they grow, the lower branches should be removed to prevent interference with traffic.

All trees should have adequate root systems when planted—at least 1 ft. of root spread for each inch of trunk diameter. They should be planted in topsoil preferably of a light loam nature rather than heavy clay. If the drainage is not adequate, tile should be installed as described in Chap. IX. Trees should be planted at the same depth at which they were originally growing. If not purchased from a nursery, they may be collected from fields or fence rows but never from the woods.

Immediately after planting, wrap the trunk with burlap or tree-wrapping paper from the branches down to the ground. This serves as a protection against borers as well as sun scald. After two seasons' growth, a tree should have sufficient vigor to resist borers and adequate foliage to guard against sun scald.

Injury to the new roots by wind movement may be prevented by using three guy wires, which may be attached to the tree with screw eyes in the branches or run through rubber garden hose and put around the trunk or the main branches. They should remain for 2 years.

The common practice of burying organic material beneath the root ball is likely to cause damage through the liberation of gases of decomposition. An adequate mulch over the entire root system is beneficial (see Chap. II).

After planting, approximately one-third of the smaller branches may be removed, always maintaining the natural shape and outline of the top.

SELECTED LIST OF LARGE SHADE TREES

Botanical name	Common name	Height, ft.	Hardiness zone	Remarks
Acer campestre	Hedge maple	20–35	IV	Small-leaved, attractive tree
Acer platanoides	Norway maple	35–50	III	
Acer saccharum	Sugar maple	35–60	III	Brilliant autumn color
Betula papyrifera	*Canoe birch*	35–60	II	Subject to borers
Betula pendula gracilis	Cutleaf European birch	30–50	II	Subject to borers
Celtis occidentalis	Hackberry	40–75	II	Vigorous, hardy tree
Fagus sylvatica	European beech	40–60	IV	Requires light, well-aerated soil
Fraxinus excelsior	European ash	40–75	III	Good tree but subject to oyster-shell scale
Fraxinus quadrangulata	Blue ash	40–75	III	Good tree but subject to oyster-shell scale
Ginkgo biloba	Ginkgo	50–75	IV	Excellent tree, free from pests. Plant male only
Gleditsia triacanthos inermis	Thornless honeylocust	40–75	IV	Should be more widely used
Gymnocladus dioica	Kentucky coffeetree	40–60	IV	A striking tree
Larix decidua	European larch	40–60	IV	A conifer; handle as evergreen
Liquidambar styraciflua	Sweetgum	35–50	IV	Brilliant autumn color
Liriodendron tulipifera	Tuliptree	50–75	IV	Spring plant, one of best shade trees
Magnolia acuminata	Cucumbertree	40–60	IV	White flowers in May, leaves large
Nyssa sylvatica	Tupelo, sour gum	40–75	IV	Black fruit, brilliant autumn color
Phellodendron sachalinense	*Sakhalin corktree*	30–40	III	Broad-spreading tree, black fruit
Platanus occidentalis	Buttonwood	50–75	IV	
Platanus orientalis	Oriental planetree	40–60	V	*Highly tolerant of city conditions*
Populus alba pyramidalis	Bolleana poplar	40–60	III	Use in preference to Lombardy poplar
Quercus borealis	Red oak	40–75	IV	One of best shade trees
Quercus coccinea	Scarlet oak	40–75	IV	One of best shade trees
Quercus imbricaria	Shingle oak	35–50	V	Small leaves
Quercus palustris	Pin oak	40–60	IV	Prefers acid soil
Quercus phellos	Willow oak	35–50	V	Small leaves
Salix pentandra	Bay willow	35–50	IV	Glossy, dark green leaves
Sophora japonica	Japanese Pagoda-tree	35–50	IV	Flowers white, graceful tree
Tilia cordata	European linden	35–50	IV	Flowers fragrant
Tilia euchlora	Crimean linden	35–50	IV	Flowers fragrant
Ulmus americana	White elm	50–75	II	
Ulmus carpinifolia (campestris)	Smoothleaf European elm	40–75	IV	Many varieties
Ulmus carpinifolia sarniensis (wheatleyi)	Jersey elm	40–60	IV	Upright type
Ulmus moline	Moline elm	40–50	II	Upright, narrow habit
Ulmus pumila	Siberian elm	50–75	IV	Small leaved, quick growing, wood very brittle

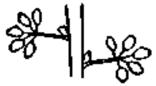
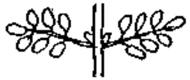
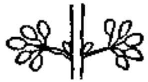
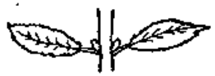
Small trees have a relatively wide range of use, not only as shade in restricted areas such as terraces and outdoor living rooms but as accents in the shrub border, as specimens around the edges of large lawns, as screens and backgrounds for the yard, all in addition to the decorative, showy bloom produced by most of them and the decorative fruits of some.

Selected List of Small Trees

Botanical name	Common name	Height, ft.	Hardiness zone	Remarks
Amelanchier laevis	Allegheny shadblow	20–25	IV	White flowers 5,* purple-black fruit 6
Carpinus betulus fastigiata	Columnar European hornbeam	20–40	V	Columnar tree
Cercidiphyllum japonicum	Katsura-tree	20–30	IV	Grown for foliage, variable habit
Cercis canadensis	Redbud	15–25	V	Red-pink flowers 4
Cladrastis lutea	Yellow-wood	15–25	III	Fragrant white flowers 6, yellow foliage autumn
Cornus florida	Flowering dogwood	15–25	IV	White blooms 5, red berries 9–12
Crataegus intricata (coccinea)	Cockspur thorn	8–10	V	Flowers white 5, fruits red, leaves glossy
Crataegus phaenopyrum (cordata)	Washington thorn	15–25	IV	Flowers white 5; fruits small, red, fall and winter
Elaeagnus angustifolia	Russian-olive	15–25	IV	Gray foliage; flowers yellow, fragrant 6; fruit silver 8
Franklinia alatamaha	Franklinia (Gordonia)	10–25	V	Large white flowers 9, 10; autumn color
Halesia carolina	Silverbell-tree	15–25	IV	Showy white flowers 5, fruits 4-angled brown
Koelreuteria paniculata	Goldenrain-tree	15–25	V	Yellow flowers 7, fruits brown balloonlike 9–11
Laburnum watereri (vossi)	Goldenchain	15–20	V	Yellow flowers 5
Magnolia soulangeana	Soulange magnolia	15–25	V	Flowers pink 5
Malus arnoldiana	Arnold flowering crab	15–25	IV	Flowers pink 5, fruit yellow
Malus floribunda	Japanese flowering crab	15–25	IV	Flowers pink 5, fruits red
Malus sargenti	Sargent flowering crab	6–8	V	Flowers white 5, fruits dark red
Oxydendron arboreum	Sorrel-tree	20–30	IV	Flowers white 6, 7; leaves brilliant red in autumn
Prunus newporti	Newport purpleleaf plum	15–20	IV	Flowers white 5
Sorbus aucuparia	European mountain-ash	20–30	II	Flowers white 5, fruit orange-red 8, 9
Stewartia koreana	Stewartia	15–35	V	Flowers large, white 6, 7; autumn color

* Indicates month.

Classification of Deciduous Trees

Pinnately compound	Palmately compound	Simple, margin entire	Simple, margin toothed	Simple, margin lobed
Leaves alternate				
				
Ailanthus Albizzia Aralia Cladrastis Gleditsia Gymnocladus Hicoria Juglans Koelreuteria Laburnum Maackia Robinia Sophora Sorbus	Ptelea	Cercis Elaeagnus Maclura Magnolia Nyssa Quercus imbricaria Salix	Alnus Amelanchier Betula Carpinus Castanea Celtis Crataegus Halesia Malus Morus Ostrya Oxydendron Populus Quercus Salix Tilia Ulmus Zelkova	Pointed lobes Liquidambar Malus Morus Platanus Quercus Rounded lobes Ginkgo Liriodendron Populus alba Quercus Sassafras
Leaves opposite				
				 Rounded lobes
Acer negundo Fraxinus Phellodendron Staphylea	Acer palmata Aesculus	Catalpa Cornus florida Paulownia	Acer	

TREES FOR VARIOUS USES

Street plantings:
- Acer platanoides
- Acer saccharum
- Ginkgo biloba
- Gleditsia triacanthos inermis
- Liriodendron
- Nyssa
- Platanus orientalis
- Quercus borealis
- Quercus coccinea
- Quercus palustris
- Ulmus americana

Erect growing:
- Carpinus betula fastigiata
- Liriodendron tulipifera
- Populus alba pyramidalis

Usually none too permanent because of disease or insects:
- Betula
- Populus
- Sorbus

Too brittle and soft to be planted if other trees available:
- Acer negundo
- Acer saccharinum
- Populus eugenei
- Ulmus pumila

Small trees to shade outdoor living room and terrace:
- Amelanchier laevis
- Cercis canadensis
- Cornus florida
- Crataegus phaenopyrum
- Elaegnus angustifolia
- Halesia carolina
- Malus arnoldiana
- Sorbus aucuparia

Showy flowers:
- Amelanchier
- Cercis
- Cladrastis
- Cornus
- Crataegus
- Franklinia
- Gleditsia triacanthos inermis
- Halesia
- Koelreuteria
- Laburnum
- Liriodendron
- Magnolia acuminata
- Magnolia soulangeana
- Malus
- Oxyendron
- Paulownia
- Sophora
- Stewartia

Autumn color—red-orange:
- Acer ginnala
- Acer rubrum
- Acer saccharum
- Cornus florida
- Liquidambar
- Nyssa
- Oxydendron
- Quercus borealis
- Quercus coccinea
- Quercus velutina
- Rhus

Autumn color—yellow:
- Acer campestre
- Amelanchier
- Betula
- Celtis
- Cladrastis
- Fraxinus
- Ginkgo
- Gleditsia
- Hicoria
- Koelreuteria
- Liriodendron
- Platanus
- Ulmus

CONIFEROUS EVERGREENS

Because of their year-around effect, coniferous evergreens have a universal appeal. Usually, however, no effort is made to distinguish the desirable from the undesirable forms. To most

Selecting Evergreens by Their Habits of Growth

						
Conifers						
Juniperus chinensis sargenti Juniperus horizontalis Bar Harbor Juniperus horizontalis *douglasi* Juniperus horizontalis plumosa	Juniperus chinensis pfitzeriana Juniperus sabina tamariscifolia Juniperus virginiana *kosteri* Taxus canadensis Taxus cuspidata thayeri Taxus cuspidata andersoni	Taxus cuspidata columnaris Taxus media hatfieldi Thuja occidentale	Juniperus virginiana globosa Pinus mugo mughus	Juniperus hibernica Taxus media hicksi Thuja occidentalis doublasi Thuja occidentalis *pyramidalis*	Abies nobilis glauca Abies nordmanniana Abies veitchi Picea abies Picea omorika Picea *orientalis* Taxus cuspidata Thuja plicata Tsuga canadensis Tsuga caroliniana	Pinus nigra Pinus resinosa Pinus strobus Pinus sylvestris
Broadleaf						
Daphne cneorum Euonymus fortunei Euonymus fortunei radicans Euonymus fortunei colorata Leiophyllum Pachistima Pachysandra Vinca	Cotoneaster floccosa salicifolia Euonymus fortunei carrierei Euonymus fortunei vegeta Mahonia aquifolium Pyracantha coccinea		Berberis verruculosa Buxus sempervirens Ilex crenata convexa Ilex crenata helleri Ilex glabra Lonicera nitida Rhododendron caroliniana		Ilex aquifolia Ilex opaca	Buxus arborescens Buxus sempervirens Euonymus japonica Rhododendron maximum Viburnum rhytidophyllum

SELECTED LIST OF CONIFEROUS EVERGREENS

Botanical name	Common name	Height, ft.	Hardiness zone	Fruit	Remarks
Abies concolor	Colorado fir	30–40	IV	Cone	Bluish green
Abies nordmanniana	Nordmann fir	50–60	IV	Cone	Dark green
Abies veitchi	Veitch fir	50–60	III	Cone	Dark green
Cedrus atlantica glauca	Atlantic cedar	25–75	VI	Cone	Bluish green
Chamaecyparis lawsoniana	Lawson cypress	30–50	V	Cone	Bright green
Chamaecyparis obtusa compacta	Dwarf Hinoki cypress	2–3	III	Cone	Dark green, dwarf, compact
Chamaecyparis obtusa gracilis	Hinoki cypress	4–6	III	Cone	Dark green, upright
Chamaecyparis pisifera filifera	Thread Sawara cypress	6–15	III	Cone	Dark green (best of the many varieties of this species)
Juniperus chinensis columnaris	Columnar Chinese juniper	20–25	IV	Blue berry	Green, upright
Juniperus chinensis pfitzeriana	Pfitzer juniper	3–5	IV	Blue berry	Gray-green, broad spreading
Juniperus horizontalis Bar Harbor	Bar Harbor juniper	½–1	II	Blue berry	Blue-green, creeping
Juniperus horizontalis douglasi	Waukegan juniper	1–2	II	Blue berry	Green, bronze in winter
Juniperus horizontalis plumosa	Andorra juniper	2–3	II	Blue berry	Green, bronze in winter
Juniperus sabina tamariscifolia	....	2–3	IV	....	Blue-green, broad spreading
Juniperus virginiana burki	Burk juniper	10–15	II	Blue berry	Blue-green, upright
Juniperus virginiana canaerti	Canaert juniper	10–15	II	Blue berry	Dark green, upright
Juniperus virginiana globosa	Globose Redcedar	4–5	II	Blue berry	
Juniperus virginiana keteleeri	Keteleer juniper	10–15	II	Blue berry	Dark green, upright
Libocedrus decurrens	Incense-cypress	40–60	V	Cone	Bright green, broad tree
Picea abies (excelsa)	Norway spruce	50–75	II	Cone	Light green
Picea abies gregoryana	Gregory spruce	2–3	II	Cone	Bright green, dwarf, compact
Picea glauca conica	Arrowhead Norway spruce	4–6	II	Cone	Light green, erect, compact
Picea omorika	Serbian spruce	40–60	IV	Cone	Slender, erect tree
Picea orientalis	Oriental spruce	30–50	V	Cone	Bright green, slow growing
Pinus cembra	Swiss stone pine	10–20	IV	Cone	Bright green
Pinus koraiensis	Korean pine	40–60	III	Cone	Green

SELECTED LIST OF CONIFEROUS EVERGREENS.—(*Continued*)

Botanical name	Common name	Height, ft.	Hardiness zone	Fruit	Remarks
Pinus mugo mughus	Mugho pine	3–6	II	Cone	Green, dwarf, compact
Pinus nigra	Austrian pine	40–60	IV	Cone	Dark green
Pinus resinosa	Red pine	40–60	II	Cone	Dark green
Pinus strobus	White pine	40–60	III	Cone	Bright green
Pinus sylvestris	Scotch pine	40–60	II	Cone	Light to gray-green
Pseudotsuga taxifolia (douglasi)	Douglas-fir	60–75	V	Cone	Green or blue-green
Sciadopitys verticillata	Umbrella-pine	20–30	V	Cone	Dark green
Taxus baccata repandens	Spreading English yew	2–3	VI	Red berry	Dark green, broad spreading
Taxus baccata stricta (fastigiata)	Upright English yew	6–9	VII	Red berry	Dark green
Taxus cuspidata (capitata)	Japanese yew	15–25	IV	Red berry	Dark green
Taxus cuspidata columnaris	Adams yew	6–9	IV	Red berry	Dark green, broad, upright
Taxus cuspidata nana	Dwarf Japanese yew	2–3	IV	Red berry	Dark green, upright
Taxus media andersoni	Anderson yew	4–5	IV	Red berry	Dark green, broad-spreading
Taxus media hatfieldi	Hatfield yew	4–5	IV	Red berry	Dark green, upright
Taxus media hicksi	Hicks yew	6–9	IV	Red berry	Dark green, narrow, upright
Thuja occidentalis douglasi pyramidalis	Douglas arborvitae	10–20	V	Cone	Bright green
Thuja occidentalis pumila	Little Gem arborvitae	2–3	V	Cone	Bright green
Thuja occidentalis rosenthali	Rosenthal arborvitae	6 9	V	Cone	Bright green
Thuja occidentalis woodwardi	Woodward arborvitae	2–3	V	Cone	Bright green, compact
Thuja plicata	Giant arborvitae	30–50	V	Cone	Bright green, upright
Tsuga canadensis	Common hemlock	40–75	IV	Cone	
Tsuga canadensis compacta	Cople · pyramidal hemlock	10–20	IV	Cone	Dark green
Tsuga caroliniana	Carolina hemlock	35–50	IV	Cone	Dark green

people all evergreens are pines or cedars, and all are thought to be equally satisfactory for landscape use. The first step, then, is to learn to distinguish the different genera, to learn the difference between pines, spruces, firs, and hemlocks. The key to common conifers makes that relatively easy. Added to this key should be the two conifers that are deciduous, the larch (*Larix*) and the bald cypress (*Taxodium*).

Conifers have many and varied uses, the most common being in foundation plantings. Others include screens and windbreaks, backgrounds for flower borders and gardens, hedges,

Coniferous Evergreens for Various Uses

Windbreaks:
- Picea abies
- Pinus nigra
- Pinus resinosa
- Pinus sylvestris

Tolerant of shade, provided soil is not robbed of moisture by tree roots:
- Taxus
- Tsuga

Attractive when purchased but usually short-lived in many sections of country:
- Juniperus squamata meyeri
- Thuja occidentalis and most varieties
- Thuja occidentalis pyramidalis
- Thuja orientalis and varieties

Requiring protection from strong winds:
- Tsuga

Specimens for large lawn areas:
- Abies
- Cedrus atlantica glauca
- Chamaecyparis lawsoniana
- Picea omorika
- Pinus koraiensis
- Sciadopitys
- Tsuga

Well adapted to use in foundation plantings:
- Chamaecyparis obtusa gracilis
- Chamaecyparis pisifera filifera
- Juniperus chinensis pfitzeriana
- Juniperus chinensis sargenti
- Juniperus horizontalis douglasi
- Juniperus horizontalis plumosa
- Juniperus virginiana burki
- Juniperus virginiana canaerti
- Juniperus virginiana globosa
- Pinus cembra
- Pinus mugo mughus
- Taxus cuspidata and varieties
- Taxus media and varieties
- Thuja plicata (only if kept pruned)
- Tsuga canadensis compacta
- Tsuga caroliniana (only if kept pruned)

specimen evergreens in large lawns, accents in the flower garden, and evergreen effects in the rock garden.

Before considering the individual species and varieties, it may be well to take up their habits of growth, both natural and artificially produced. The average layman's natural tendency in purchasing evergreens seems to be toward compact, formal types such as globes and pyramids and, if informal types are purchased, to prune them to produce formal, sheared types. Forms like these, except in the hands of professionals, tend to make the evergreens themselves too conspicuous, each plant standing out as an individual from all its neighbors. Unfortunately most evergreen plantings found around American houses are better examples of lack of taste than of good taste.

In general, evergreens should be of the informal types which blend together. With them should be combined broadleaf evergreens to produce foliage and form contrasts. Coniferous evergreens planted alone are inclined to be too somber and rather monotonous in effect. Newly made plantings of relatively small plants may be tied together in effect by the use of an evergreen ground cover such as English ivy or wintercreeper. Care must be taken with these two vines that they do not climb onto the evergreens. Evergreen ground covers that avoid this difficulty include *Pachysandra, Vinca minor, Sedum album, S. acre, Phlox subulata,* and *Iberis sempervirens.*

BROADLEAF EVERGREENS

The broadleaf evergreens are seldom appreciated to the extent that they should be. They include all evergreens except the conifers. Although some kinds are widely used throughout the South and a few kinds throughout the North, a variety of forms is available, but these forms are adopted only by the more progressive landscape architects. Used alone, in combination with coniferous evergreens, or blended with deciduous shrubs, the broadleaf evergreens give a luxurious effect and a year-around attractiveness found in no other group of woody plants. Their winter color is usually far more attractive than that of most conifers.

A few precautions must be observed. Because of their large leaf surface, extremely windy locations should be avoided. Wind in winter is especially injurious to them. Injury due to lack of sufficient soil moisture can be overcome partially by a liberal mulch with peat moss, rotted leaves, rotted sawdust, or similar material. If sufficient soil moisture is not available in the fall, heavy watering with soft water is advisable before the ground freezes.

Adequate drainage is essential. In poorly drained, heavy clay oils a line of agricultural drain tile may be necessary. A rel-tively light loam is preferable, but clay soil may be adequately repared. In preparing heavy soils care must be taken not to ise alkaline sand. Contrary to popular belief, many materials upposedly acid in nature are not, *e.g.*, pine needles, oak leaves, nanure with shavings as bedding, weathered or rotted sawdust, eaf mold, and rotted apple pumice. Fresh oak sawdust may iave a slight acidifying affect. Most broadleaf evergreens espond to adequate organic material in the soil even to the extent f mixing equal parts with the top foot or two of soil. Cultiva-ion is apt to be detrimental because of surface roots. Partial hade seems to be beneficial especially in the Midwest.

Broadleaf evergreens requiring acid soils include rhododendron, zalea, mountain laurel, heather, leucothoe, arbutus, partridge erry, wintergreen, and some wild flowers.

The hollies will often grow better in a slightly acid soil. Al-hough many broadleaf evergreens are found growing naturally n sunny slopes, when grown under cultivation partial shade is eneficial.

Many soils are naturally acid so no extra chemicals need be dded to grow acid-soil plants. Other soils are neutral or alkaline o that they require a special treatment to grow acid-soil plants atisfactorily. The only way to determine the reaction of a soil, *.e.*, whether it is acid, neutral, or alkaline, is by means of a soil est. The presence of moss, the color or odor of the soil, the resence of certain weeds such as sorrel are no indication what-oever of an acid soil (see Chap. II).

The latest recommendation for acidifying soil is a mixture of qual parts of:

Powdered sulphur—need not be so fine as dusting sulphur
Iron sulphate (copperas)
Aluminum sulphate
Ammonium sulphate

)ne pound scattered over 100 sq. ft. will lower the pH ½ point own to a pH of 6. Below this point it takes less to increase the cidity. This is scattered over the surface of the ground. It nay be raked in if desired, but it is not necessary. For full enefit, it may be applied in the early spring. Otherwise it

SELECTED LIST OF BROADLEAF EVERGREENS

Botanical name	Common name	Height, ft.	Spread, ft.	Hardiness zone	Remarks
Azalea obtusum japonicum	Kurume azalea	2–4	2–4	VI–VIII	Flowers yellow, red, orange
Berberis julianae	Wintergreen barberry	3–5	3–5	V	Hardiest of evergreen barberries
Berberis triacanthophora	Threespine barberry	2–4	2–3	V	Flowers white-pink; fruit blue-black; small leaves, bronze in winter
Berberis verruculosa	Warty barberry	2–4	3–4	V	Flowers yellow, fruit black, small holly-like leaves gray beneath
Bignonia capreolata	Crossvine	25–50		V	Flowers orange, vigorous clinging vine
Buxus microphylla koreana	Korean box	1–2	2–3	IV	Hardy, but foliage unattractive, green
Buxus sempervirens	Common box	6–8	5–8	V	Young plants more tender. Protect until foot high. May be grown in sheltered locations in zone IV
Buxus *sempervirens* handsworthi	Handsworth box	5–10	5–8	V	
Buxus sempervirens rotundifolia	Roundleaf box	5–15	8–10	V	
Cotoneaster salicifolia floccosa	Willowleaf cotoneaster	3–6	5–10	VI	White flowers June, red fruit October, worth trying in zones IV and V
Daphne *cneorum*	Garland flower	1–2	2–3	IV	Flowers pink May–June. Often short-lived. Shade in winter
Elaeagnus pungens	Thorny eleagnus	6–10	6–10	VII	Flowers white, fruits red, worth trying in zones V and VI
Euonymus fortunei (radicans acuta)	Sharpleaf wintercreeper	1	Spreading	IV	Seldom blooms, essentially a vine
Euonymus fortunei carrierei	Glossy wintercreeper	2–4	3–5	IV	Flowers white June, fruit yellow-orange, becomes vine if support available
Euonymus fortunei colorata	Wintercreeper	1	Spreading	IV	Seldom blooms, essentially a vine, faster growing
Euonymus fortunei radicans	Wintercreeper	1–2	Spreading	IV	Seldom blooms, essentially a vine, many variations
Euonymus fortunei vegeta	Bigleaf wintercreeper (evergreen bittersweet)	2–3	3–5	IV	Becomes vine if support available
Euonymus kiautschovica (patens)	Spreading wintercreeper	3–6	3–5	V	Flowers white August, fruits pink-orange. Becomes vine if support available
Hedera helix	English ivy	1	Spreading	V	Evergreen vine
Hedera helix baltica	Baltic English ivy	½–1	Spreading	V	Evergreen vine, hardier than common
Ilex aquifolium	English holly	15–40	10–25	VI	Fruits red
Ilex crenata	Japanese holly	10–15	5–8	VI	Fruits black, small leaved
Ilex crenata convexa	Japanese holly	4–6	3–5	V	Fruits black, leaves convex, hardier than crenata
Ilex crenata helleri	Heller Japanese holly	1–2	2–3	VI	Dwarf, compact, fruits black
Ilex crenata latifolia	Largeleaf Japanese holly	10–15	5–8	VI	Fruits black, larger leaves than type. All hollies have sexes on separate plants. Buy according to sex
Ilex glabra	Inkberry	6–8	4–6	III	Fruits black.
Ilex opaca	American holly	15–40	10–25	V	Fruits red. Named varieties of I. opaca and I. aquifolium are available
Ilex pedunculosa	Longstalk holly	8–25	8–12	IV	One of hardiest.

SELECTED LIST OF BROADLEAF EVERGREENS.—(*Continued*)

Botanical name	Common name	Height, ft.	Spread, ft.	Hardiness zone	Remarks
Kalmia latifolia	Mountain-laurel	5–10	3–5	IV	Flowers white-pink May–June
Leiophyllum buxifolium	Box sandmyrtle	1	1–2	V	Flowers white May–June, small leaves
Leucothoe catesbaei	Drooping leucothoe	3–5	2–4	IV	Flowers white April–May, leaves medium to large
Lonicera nitida	Evergreen honeysuckle	3–6	2–4	VII	Small leaves, root hardy in zone IV
Lonicera pileata	Privet honeysuckle	3–6	3–5	VII	Small leaves, root hardy in zone IV
Magnolia grandiflora	Bullbay	40–75	20–40	VII	Flowers white May–July, large leaves. Try in sheltered location in zone V
Mahonia aquifolium	Oregon hollygrape	3–5	3–4	V	Flowers yellow May, fruits blue-black. More evergreen in shade
Mahonia bealei	Leatherleaf hollygrape	3–8	3–5	V	Flowers yellow May, fruits blue-black, large leaves
Nandina domestica	Nandina	3–5	2–4	VI	Flowers white June, fruits red
Pachistima canbyi	Pachistima	1–2	1–2	IV	Small leaves
Pachysandra terminalis	Japanese spurge	6–8	Spreading	IV	Evergreen ground cover, prefers shade
Pieris floribunda	Mountain andromeda	3–5	2–4	IV	Flowers white April–May
Pieris japonica	Japanese andromeda	5–8	4–6	V	Flowers white April–May
Pyracantha coccinea	Scarlet firethorn	4–6	5–8	V	Flowers white May, fruits red September–February
Pyracantha coccinea lalandi	Laland firethorn	6–8	4–6	VI	Flowers white May, fruits red September–February
Rhododendron carolinianum	Carolina rhododendron	3–6	3–5	V	Flowers rosy-purple May–June
Rhododendron catawbiense	Catawba rhododendron	4–6	3–5	IV	Flowers purple May–June
Rhododendron maximum	Rosebay rhododendron	10–20	5–15	III	Flowers rose-lavender June–July. A number of named hybrids available. Usually more profuse bloomers
Viburnum burkwoodi	Burkwood viburnum	5–8	4–6	IV	Flowers white May. Semievergreen in cold climates
Viburnum rhytidophyllum	Leatherleaf viburnum	6–8	3–5	V	Flowers white May–June, fruit black, large leaves, prominent veins.
Vinca minor	Periwinkle	6–8	Spreading	III	Flowers blue June; Bowls variety slightly preferable
Yucca filamentosa	Common yucca	2–3	2–3	III	Flowers white July, 5–6 ft.

may be applied any time the soil is found to be insufficiently acid.

The aluminum sulphate will produce acidification in 10 to 14 days; iron sulphate but slightly longer. Powdered sulphur requires 3 to 6 months. The ammonium sulphate, although producing no appreciable soil acidity, speeds up the process.

Although special fertilizers have been recommended for acid-soil plants, it is questionable if their use is necessary. Neither is it necessary to use only organic fertilizers such as soybean meal. If the necessary soil reaction is obtained by applying the above mixture, any complete fertilizer may be used.

In those sections of the country having hard water it is very important that acid-soil plants be watered as little as possible. An insufficiently acid soil may do more harm than lack of ample soil moisture. Water from water softeners is just as harmful.

A Few Hints on Maintaining Soil Acidity

Do not apply lime.

Do not apply bone meal.

Do not apply wood ashes.

Do not apply sand unless you are sure it contains no limestone.

Broadleaf evergreens are best transplanted with a ball of earth. September, early October, April, and May are the best seasons. Early spring planting is not recommended, nor is the late fall a good time.

In addition to the list below, many broadleaf evergreens may be used in the milder climates and include evergreen forms of the privets and viburnums, camellia, Osmanthus, Stransvaesia, Sarcococca, Lyonia, Eleagnus, Aucuba, Pittosporum, Nandina, Laurel cherries, Laurus, Ilex aquifolium, Pyracantha, Euonymus japonica.

Broadleaf Evergreens for Various Uses

Hedges, sheared or unsheared:
- Berberis julianae
- Buxus sempervirens
- Euonymus fortunei carrierei
- Euonymus fortunei vegeta
- Euonymus kiautschovica
- Ilex aquifolium
- Ilex crenata
- Ilex crenata latifolia
- Ilex opaca

Kalmia latifolia
Pyracantha
Screen planting:
Ilex aquifolium
Ilex opaca
Rhododendron maximum
Background planting:
Buxus sempervirens
Buxus sempervirens handsworthi
Euonymus kiautschovica
Ilex crenata
Ilex crenata latifolia
Ilex glabra
Kalmia
Pyracantha coccinea lalandi
Rhododendron
Viburnum rhytidophyllum
Rock gardens:
Buxus sempervirens
Buxus sempervirens suffruticosa
Daphne cneorum
Euonymus fortunei carrierei
Euonymus fortunei vegeta
Leiophyllum
Lonicera nitida
Lonicera pileata
Pachistima
Foundation plantings:
Berberis julianae
Berberis triacanthophora
Buxus
Euonymus fortunei carrierei
Euonymus fortunei vegeta
Euonymus kiatschovica
Ilex crenata and varieties
Kalmia
Leucothoe
Mahonia
Nandina
Pieris
Pyracantha
Rhododendron
Viburnum
Yucca
Specimen plants on lawn areas:
Buxus
Cotoneaster
Ilex aquifolium
Ilex opaca
Pyracantha
Rhododendron
Viburnum rhytidophyllum
Ground covers and grass substitutes:
Euonymus fortunei
Euonymus fortunei colorata
Euonymus fortunei radicans
Hedera helix and varieties
Pachysandra
Vinca minor
Banks and slopes:
See ground covers
Tolerant of shade:
Buxus
Euonymus
Hedera
Ilex
Kalmia
Mahonia
Pachyandra
Rhododendron
Viburnum
Vinca
Yucca
Preferring shade in summer except in cool climates:
Hedera
Pachysandra
Rhododendron

VINES

Vines serve many purposes in landscape planting yet are seldom used to the extent that they should or could be around the average home. In selecting a vine for any particular reason it is

SELECTED LIST OF WOODY VINES

Botanical name	Common name	Height, ft.	Hardiness zone	Exposure	How climbs	Remarks
Actinidia arguta	Actinidia	25–50	IV	Sun or shade	Twining	Excellent foliage, fruit edible
Akebia quinata	Akebia	10–20	IV	Sun or shade	Twining	Semievergreen
Ampelopsis brevipedunculata maximowiczi (heterophylla)	Porcelain ivy	25–50	IV	Sun or shade	Tendrils	Lilac, blue-green fruit
Aristolochia durior (sipho)	Dutchmans-pipe	25–50	IV	Sun	Twining	Large foliage
Bignonia capreolata	Crossvine	25–50	V	Sun	Clings	Evergreen, orange flowers June
Campsis (Bignonia) tagliabuana Mme. Galen	Mme. Galen trumpet vine	25–50	V	Sun	Clings	Large orange flowers June
Celastrus orbiculatus	Oriental bittersweet	15–40	IV	Sun or shade	Twining	Orange-red fruit
Celastrus scandens	American bittersweet	15–40	II	Sun or shade	Twining	Orange-red fruit
Clematis jackmani	Jackman clematis	10–20	V	Sun	Tendrils	Purple flowers June. Also many named varieties
Clematis montana	Anemone clematis	15–25	V	Sun	Tendrils	Pink flowers June
Clematis paniculata	Japanese clematis	15–25	V	Sun or shade	Tendrils	White flowers. Holds foliage late
Clematis texensis (coccinea)	Scarlet clematis	15–25	IV	Sun	Tendrils	Red flowers
Euonymus fortunei (radicans acuta)	Sharpleaf wintercreeper	25–50	IV	Sun or shade	Clings	Evergreen
Euonymus fortunei colorata	Purpleleaf wintercreeper	25–50	IV	Sun or shade	Clings	Evergreen
Euonymus fortunei radicans	Wintercreeper	15–30	IV	Sun or shade	Clings	Evergreen
Euonymus fortunei vegeta	Bigleaf wintercreeper	25–50	IV	Sun or shade	Clings	Evergreen, orange-yellow fruit
Euonymus kiautschovica (patens)	Spreading wintercreeper	25–50	VI	Sun or shade	*Clings*	*Evergreen, orange-yellow fruit in mild climates*
Hedera helix	English ivy	25–50	IV	Shade	Clings	Evergreen, many varieties
Hedera helix baltica	Baltic English ivy	25–50	IV	Shade	Clings	Evergreen, hardiest
Hydrangea petiolaris	Climbing hydrangea	25–50	IV	Sun	....	White flowers
Jasminum nudiflorum	Winter jasmine	8–10	V	Sun	Prostrate	Yellow flowers early spring
Lonicera japonica halliana	Japanese honeysuckle	25–50	IV	Sun or shade	Twining	White flowers summer
Parthenocissus quinquefolia	Virginia creeper	25–50	III	Sun	Tendrils	Blue fruit, autumn color
Parthenocissus quinquefolia engelmanni	Engelmann ivy	25–50	III	Sun	Clings	Blue fruit, autumn color
Parthenocissus tricuspidata lowi	Geranium creeper	5–20	V	Sun	Clings	Small leaves
Parthenocissus tricuspidata veitchi	Boston ivy	25–50	IV	Sun	Clings	Autumn color
Passiflora incarnata	Passionflower	15–50	V	Sun	....	Lavender flowers, fruit edible herbaceous in cold climates
Polygonum auberti	Chinese fleecevine	25–50	V	Sun	Twining	White flowers late summer
Rosa wichuraiana	Memorial rose	6–8	V	Sun	Prostrate	White flowers, semievergreen
Wisteria floribunda	Japanese wistaria	25–50	IV	Sun	Twining	Lavender flowers, get grafted plants

necessary to know something of its habits—whether it is large and vigorous or small with more or less restricted growth. Its method of climbing is important. Vines that climb by rootlike holdfasts are used for growing on brick, stone, or stucco buildings; walls; chimneys; telephone poles; and possibly tree trunks. Supports of some sort must be supplied for those which climb by twining or by tendrils. As it is difficult to remove vines from wooden or wire trellis or wire netting when pruning, a few galvanized-iron wires are recommended.

The idea of roses near buildings appeals to the layman, but care should be taken to have only the newer varieties with mildew-resistant foliage and even then to apply necessary fungicides to keep the plant healthy. Additional summer bloom may be obtained by sowing a few seeds of annual vines such as hyacinth-bean or Heavenly Blue morning-glories at the base of climbing roses and other vines. A more complete list of annual vines will be found in Chap. X. Perennial vines such as cinnamon-vine or kudzu may be used to advantage in place of the woody ones.

VINES FOR VARIOUS USES

Shaded locations:
- Akebia
- Celastrus orbiculatus
- Celastrus scandens
- Euonymus
- Hedera helix
- Lonicera japonica halliana
- Parthenocissus quinquefolia

Showy flowers:
- Bignonia
- Campsis
- Clematis
- Hydrangea
- Jasminum
- Lonicera
- Passiflora
- Polygonum
- Rosa
- Wisteria

Ornamental fruits:
- Ampelopsis brevi-pedunculata
- Ampelopsis tricuspidata veitchi
- Celastrus
- Clematis
- Euonymus fortunei carrierei
- Euonymus fortunei vegeta
- Euonymus kiautschovica
- Parthenocissus quinquefolia

Evergreen:
- Bignonia capreolata
- Euonymus fortunei and varieties
- Hedera helix and varieties

Clinging to wood, stone, brick, or stucco:
- Bignonia capreolata
- Campsis
- Euonymus
- Hedera
- Hydrangea
- Parthenocissus quinquefolia engelmanni
- Parthenocissus tricuspidata veitchi

For covering telephone or electric poles:
Any clinging vines
Euonymus
Hedera helix
Parthenocissus quinquefolia engelmanni
Parthenocissus tricuspidata lowi
Parthenocissus tricuspidata veitchi

Along base of walls to climb and cling:
Bignonia capreolata

Hanging down over walls or steep banks:
Celastrus orbiculatus
Celastrus scandens
Euonymus fortunei colorata
Hedera helix
Jasminum nudiflorum
Lonicera japonica halliana
Rosa wichuraiana

For small archways or small porches:
Akebia
Clematis jackmani
Euonymus fortunei vegeta

For fences or trellis:
Actinidia
Ampelopsis brevi-pedunculata
Bignonia
Campsis
Celastrus
Clematis
Euonymus
Hydrangea
Jasminum
Polygonum
Wisteria

Between house and sidewalk in 1- to 3-ft. space:
Euonymus fortunei
Euonymus fortunei colorata
Euonymus fortunei radicans
Euonymus fortunei vegeta
Hedera helix

Covering old sheds and buildings:
Actinidia
Ampelopsis brevi-pedunculata
Bignonia
Campsis
Celastrus
Hydrangea
Polygonum
Wisteria

Banks and slopes:
Celastrus scandens
Euonoymus fortunei colorata
Lonicera japonica halliana
Parthenocissus quinquefolia
Rosa wichuraiana

WOODY PLANTS AS GROUND COVERS

The various vines and trailing shrubs are well adapted to ground coverage. Some are rather extensively used for this, but many are not. Since it is not always possible to determine in advance which ones will thrive, it may be well to try at least several kinds before making extensive plantings. Some forms are evergreen, others deciduous. A few, such as English ivy, are most satisfactory in shade in hot summer climates. Others, such as the roses, demand at least a half day of sun.

In planting banks and slopes erosion may be controlled previous to coverage by the plants with a straw mulch. A light application of a complete commercial fertilizer will counteract the nitrogen starvation caused by bacteria using nitrogen while decomposing the mulch

SELECTED LIST OF WOODY GROUND COVERS

Botanical name	Common name	Height as ground cover, inches	Hardiness zone	Remarks
Akebia quinata	Akebia	6–8	IV	Vine, nearly evergreen
Arctostaphylos uva-ursi	Bearberry	8–12	IV	Prostrate, roots as it spreads
Euonymus fortunei	Sharpleaf wintercreeper	12–18	IV	Vine, evergreen
Euonymus fortunei colorata	Wintercreeper	8–12	IV	Vine, evergreen. Bronze-red in winter
Euonymus fortunei radicans	Wintercreeper	12–18	IV	Vine, evergreen
Euonymus obovatus	Running Strawberrybush	12–18	IV	Prostrate shrub, deciduous
Hedera helix	English ivy	8–12	V	Vine, evergreen
Hedera helix baltica	Baltic English ivy	6–10	V	Vine, evergreen
Hedera helix self-branching	Self-branching English ivy	6–12	V	Vine, evergreen
Hypericum bucklei	Mountain St. Johnswort	8–12	V	Low shrub, deciduous
Lonicera japonica halliana	Japanese honeysuckle	12–18	V	Vine, evergreen in south
Mahonia repens	Creeping hollygrape	12	V	Low, stoloniferous shrub, evergreen
Parthenocissus quinquifolia	*Fiveleaf ivy*	12	IV	Vine, deciduous
Parthenocissus tricuspidata lowi	Geranium creeper	6	V	Vine, deciduous
Rosa rugosa Max Graf	Max Graf rose	18–24	IV	Low shrub, deciduous
Rosa wichuraiana	Memorial rose	12–18	IV	Prostrate vine, deciduous, holds *foliage late*
Zanthorhiza apiifolia	Yellowroot	12–18	IV	Low shrub, spreads by underground stems, deciduous

STUDY AND IDENTIFICATION OF DECIDUOUS PLANTS

A detailed study of the individual characters of each plant makes its identification more accurate. It is far more certain than the formation of mental pictures of each, as is practiced by the average plantsman. Flower structure cannot be used advantageously, since identification is often desired when bloom is not available. This is the difficulty that horticulturists have in using the average botanical key based primarily on flower and fruit structure. The study of woody plants by families together with family characteristics is recommended. Horticultural keys for deciduous woody plants are based primarily on leaf arrangement, leaf type, and leaf margin. The outline on page 386 is suggested in studying woody materials. Dormant twig and bud characters make winter identification possible. Several keys are available, but it is not within the scope of this book to provide for the identification of every species and variety of woody plant.

SIMPLIFIED WINTER KEY TO SOME OF THE MORE COMMON SHRUBS

1. Leaves alternate, see 1, p. 412
 2. Twigs with thorns
  3. Twigs scaly
   4. Twigs thorn tipped. Hippophae—sea **buckthorn**
   4. Twigs not thorn tipped
    5. Decurrent lines present, plant drooping. Lycium—**matrimony-vine**
    5. Decurrent lines absent. Elaeagnus
  3. Twigs not scaly
   4. Inner bark yellow. Berberis—barberry
   4. Inner bark not yellow
    5. Leaf bases persistent through winter. Rubus
    5. Leaf bases not persistant
     6. Bundle scars about 20. Aralia spinosa—devils-walkingstick
     6. Bundle scars less than 20
      7. Bundle scars 5 to 10. Acanthopanax—fiveleaf aralia
      7. Bundle scars 3
       8. Stipule scar present, thorns few. Chaenomeles—**flowering quince**
       8. Stipule scar absent, thorns many. Rosa—rose
 2. Twigs without thorns
  3. Catkins present
   4. Buds stalked, catkins two sizes. Alnus—alder
   4. Buds not stalked, catkins one size
    5. Twigs aromatic
     6. Catkins ¼ in. long, buds very small. Myrica—**sweetgale**

6. Catkins $\frac{1}{2}$ in. long
7. Leaf scars nearly circular. **Rhus aromatica—fragrant sumac**
7. Leaf scars not circular. **Comptonia asplenifolia—sweetfern**
5. Twigs not aromatic. **Corylus—hazelnut**
3. Catkins absent
4. Twigs aromatic when bruised
5. Pith hollow, plant vine. **Solanum dulcamara—bitter nightshade**
5. Pith not hollow
6. Leaf scar almost circular, nearly surrounding bud. **Ptelea—hoptree**
6. Leaf scar not circular
7. Buds often superposed
8. Bundle scars 3. **Lindera—spicebush**
8. Bundle scars 1. **Daphne mezereum**
7. Buds not superposed. **Myrica—bayberry**
4. Twigs not aromatic when bruised.
5. Stipule line extending around the stem. Bud pubescent. **Magnolia**
5. Stipule line not extending around the stem
6. Bud scales 1. **Salix—willow**
6. Bud scales not as above
7. Twigs green or nearly so
8. Decurrent lines present
9. Stipules prominent. **Caragana—Siberian pea-tree**
9. Stipules not prominent. **Kerria japonica**
8. Decurrent lines absent. **Laburnum—goldenchain**
7. Twigs not noticeably green
8. Stipules or scars present
9. Bundle scars distinct, 3 or more present
10. Buds at end of twig. **Hibiscus—rose-of-Sharon**
10. Buds not at end of twig
11. Buds stalked. **Hamamelis—witch-hazel**
11. Buds not stalked
12. Leaf scar strongly decurrent. **Physocarpus—ninebark**
12. Leaf scar not as above
13. Twigs zig-zag. **Stephanandra**
13. Twigs straight
14. Buds borne near upper end of twig. **Rhamnus frangula —Glossy buckthorn**
14. Buds scattered up and down twigs
15. Buds clustered, 3 or more. **Prunus—flowering plum, cherry, almond**
15. Buds solitary or occasionally in pairs
16. Leaf scar large, large twigs. **Sorbaria—false spirea**
16. Leaf scar and twig not as above. **Chaenomeles—flowering quince**
9. Bundle scars indistinct, crowded or 1
10. Bark conspicuously shreddy, fruit not a berry
11. Stipules persistant and sheathing stem. **Potentilla—shrubby cinquefoil**

11. Stipules not as above, fruit a papery pod. **Colutea**—bladder-senna
10. Bark not shreddy, fruit a berry. Ilex—winterberry
8. Stipules or their scars absent
9. Leaf scar U shaped or circular, tending to surround the bud
10. Twigs hairy. Rhus—staghorn sumac
10. Twigs not hairy
11. Twigs flexible, leathery. Dirca—leatherwood
11. Twigs not as above
12. Bundle scar 1, twig slender. Symplocos—sweetleaf
12. Bundle scars many. Rhus—sumac.
9. Leaf scar not U shaped
10. Bundle scars many, leaf scar inside twig. **Zanthorhiza**—yellowroot
10. Bundle scars 3 (see 10 below)
11. Leaf scar broad triangular. Rhus—smoketree
11. Leaf scar narrow, lens shaped
12. Buds stalked. Ribes—currant
12. Buds sessile
13. Buds elongated
14. Bud scales finely toothed. Pith white in young twigs. Aronia—chokeberry
13. Buds globose or ovate, stems brown
14. Lenticels conspicuous and abundant, bark bitter, pith white. Exochorda—pearlbush
14. Lenticels few, pith green, bark not bitter. Photinia
10. Bundle scars 1 or not distinct
11. Twigs and leaves pinkish and glaucous, leaves partly persistent. Zenobia
11. Twigs *granular* or hairy (under lens) (see 11 below)
12. Fruit berrylike. Cotoneaster
12. Fruit a dry capsule. Clethra
11. Twigs not as above, twigs brownish. Spiraea
1. Leaves opposite
2. Twigs spicy, buds hidden by brownish hair. Calycanthus—sweetshrub
2. Twigs with conspicuous corky ridge. Euonymus—winged euonymus.
2. Twigs not as above
3. Branching sympodial, *i.e.*, side bud continually taking the lead. Cornus florida, Cornus kousa
3. Side buds hidden
4. Buds sunken in bark above leaf scars. Cephalanthus—Buttonbush
4. Buds hidden beneath leaf scars. Philadelphus—Mockorange
3. Side buds near end of twigs foliate, *i.e.*, outer pair of bud scales like immature leaves
4. Bark on older twigs peeling off
5. Decurrent lines present on one-year twigs. Hypericum—St. Johnswort
5. Decurrent lines absent, twigs stout. Hydrangea quercifolia

4. Bark on older twigs not peeling off, fruit berrylike
5. Buds and twigs hairy, pith two-year twigs white. Viburnum
5. Buds and twigs scaly, pith two-year twigs brown. Shepherdia—buffaloberry
3. Side buds near end of twig valvate; *i.e.*, outer pair of bud scales entirely enclose bud
4. Terminal bud absent on vigorous end shoots
5. Leaf scars connected directly by horizontal line
6. Conspicuous fringe of hairs at base of each bud, twigs dark glossy red color. Acer palmatum—Japanese maple
6. Plant not as above
7. Older twigs striped
8. Leaf scar narrow, bundle scars 3. Acer pennsylvanicum—striped maple
8. Leaf scars broad, bundle scars more than 3. Staphylea—bladdernut
7. Older twigs not striped
8. Bark on older twigs shredding off. Lonicera—honeysuckle
8. Bark on older twigs not shredding off. Viburnum
5. Leaf scars not connected directly by horizontal line. Cercidiphyllum—Katsura-tree
4. Terminal bud present on vigorous end shoots
5. Leaf scars raised and black. Cornus
5. Leaf scars neither raised nor black. Viburnum
3. Side buds not as above
4. Bark on older branches shredding off
5. Two-year twigs hollow
6. Two-year twigs white inside
7. Leaf scar raised, bundle scars 1. Symphoricarpos—snowberry.
7. Leaf scar not raised, bundle scars 3. Deutzia
6. Two-year twigs brown inside
7. Buds superposed. Lonicera—honeysuckle
7. Buds not superposed
8. One-year twigs brown
9. One-year twigs very slender, usually pubescent. Symphoricarpos—coralberry
9. One-year twigs glabrous, not slender. Deutzia
8. One-year twigs gray
9. One-year twigs glabrous, very slender. Symphoricarpos—snowberry
9. One-year twigs velvety or hairy. Lonicera maacki podocarpa
5. Two-year twigs solid
6. Bundle scars 3, usually very distinct. Hydrangea
6. Bundle scars 1 or indistinct
7. Pith brown in two-year twigs. Symphoricarpos—coralberry
7. Pith white in two-year twigs. Kolkwitzia—beautybush
4. Bark on older branches not shredding off
5. Each twig ends in short thorn. Rhamnus—buckthorn

5. Twigs not ending in thorn
6. Bundle scars 3 to 7, usually very distinct
7. Decurrent lines where leaf scars meet. **Weigela**
7. No decurrent lines
8. Bundle scars 5 or more. Sambucus—elderberry
8. Bundle scars 3, or in three groups
9. Fruit persistant over winter, black seeds. **Rhodotypos**-jetbead
9. Fruit not as above
10. Leaf scars large and deep, twigs stout. Aesculus—bottle-bush buckeye
10. Leaf scars not large and deep
11. Outer scales of end buds, three to five pairs. Acer—maple
11. Outer scales of end buds, only two pairs. Viburnum
6. Bundle scars 1 or indistinct
7. Pith solid continuously
8. One-year twigs green, without lenticels. Euonymus
8. One-year twigs gray or brown, lenticels present
9. Buds loose scaly, large in comparison to slender twigs. Syringa chinensis, Syringa persica
9. Buds not as above
10. Terminal bud absent, *i.e.*, two buds not one or three at end of twigs. Syringa vulgaris, Syringa japonica—lilac
10. Terminal bud present
11. One-year twigs stout, bundle scars, slightly concave line. Syringa josikaea, Syringa villosa
11. One-year twigs stout, bundle scars almost a complete circle Chionanthus—fringetree
11. One-year twigs slender. Ligustrum—privet
7. Pith not solid continuously. Forsythia—goldenbell

KEY TO COMMON BROADLEAF EVERGREENS

This key does not contain some of the evergreen perennials

Start with 1. Your specimen will be described by one of two descriptions. **Then go to numbers as instructed at the end of each line.**

1. Leaves opposite **2**
1. Leaves alternate **9**
2. Leaves aromatic when bruised **3**
2. Leaves not aromatic when bruised **5**
3. Leaves narrow, less than ½ in. wide .... Thyme
3. Leaves broader **4**
4. Margin of leaves toothed .... Teucrium
4. Margin of leaves not toothed .... Box
5. Margin of leaves entire, not toothed **6**
5. Margin of leaves toothed **8**
6. Twigs rough, undersides of leaves pubescent .. Viburnum rhytidophyllum
6. Twigs not rough, undersides of leaves not pubescent **7**

7. Leaves small, less than ¼ in. long, arranged in 4 rows on twig........ Leiophyllum
7. Leaves small, less than ¼ in. long, arranged in 2 rows on twig..Lonicera
7. Leaves larger, ½ in. or longer..................................Box
8. Leaves small, less than ½ in., sides of leaves nearly parallel, low shrub. Pachistima
8. Leaves small to medium, width at least ½ of length, shrub or vine.... Euonymus
8. Leaves large, at least 1½ in. long, shrub..........Viburnum burkwoodi
9. Leaves compound....................................Mahonia
9. Leaves not compound....................................10
10. Plant with spines....................................11
10. Plant without spines....................................12
11. Leaves with spiny edges....................................Barberry
11. Leaves without spiny edges....................................Firethorn
12. Leaves with spiny edges....................................Holly
12. Leaves without spiny edges....................................13
13. Plant a vine....................................English ivy
13. Plant shrubby, not a vine....................................14
13. Plant not as above, a low spreading plant............Japanese spurge
14. Leaf margin not entire, toothed, sometimes very finely............15
14. Leaf margin entire, not toothed at all..........................17
15. Teeth few at tip only....................................Holly
15. Teeth more or less all along margin..............................16
16. Leaves not over ¾ in. in length, rather thin..................Azalea
16. Leaves 1 to 1½ in. long, leathery..........................Pieris
16. Leaves 2 in. or over in length, leathery....................Leucothoe
17. Leaves less than ¾ in. wide, not over 2 in. long..Cotoneaster salicifolia
17. Leaves ¾ to 1½ in. wide, about 2 in. long......................18
17. Leaves over 1 in. wide, at least 3 in. long..............Rhododendron
18. Leaves pointed at tips............................Mountain-laurel
18. Leaves blunt tipped......................Rhododendron carolinianum

SIMPLIFIED KEY TO COMMON KINDS OF NEEDLED EVERGREENS (CONIFERS)

1. Leaves in clusters or groups, at least ½ in. in length; fruit a cone.....2
1. Leaves not in clusters....................................3
2. Leaves in clusters of 2 to 5............................Pinus—pine
2. Leaves in clusters of more than 5.....................Cedrus—cedar
3. Leaves opposite, in pairs, usually small, not over ¼ in. in length......8
3. Leaves alternate or scattered along twig..........................4
4. Bark on one-year-old twigs uniformly green, leaves at least ½ in. long, fruit fleshy, red....................................Taxus—yew
4. Bark on one-year-old twigs not uniformly green....................5
5. Winter buds conspicuously long and pointed with many scales, not sticky. Leaves dark or bluish green, ¾ to 2 in. long..Pseudotsuga—Douglas fir
5. Buds not long pointed....................................6

6. Older twigs smooth with no projections where leaves were attached..... Abies—fir
6. Older twigs rough from small projections where leaves were attached..7
7. Leaves usually flat, with light lines on under surface, twigs only slightly roughened.......................................Tsuga—hemlock
7. Leaves usually 4-sided, twigs very rough after leaves fall..Picea—spruce
8. Leaves sharp and harsh to touch, fruit berrylike.....Juniperus—juniper
8. Leaves not sharp or harsh, fruit a cone..........................9
9. It is extremely difficult to differentiate between the remaining two genera, Retinospora and Arborvitae. Leaves with white lines X or Y shaped, or streaks on undersurface of leaves. Leaves usually extending out from branchlet rather than pressed against it and sharp pointed............. Chamaecyparis—retinospora
9. Leaves without white markings, leaves usually pressed against the branchlets, leaves round pointed....................Thuja—arborvitae

PRUNING

Pruning is the removal of undesirable or surplus growth at the proper time. As such it may be used more or less to control the habits of growth into desired forms. Much of the pruning usually done would not be necessary if the proper trees, shrubs, or evergreens had been chosen to fit the site, and unfortunately much of it does more harm than good. Pruning should be confined to the following.

Removal of Dead Wood. Sooner or later most trees, shrubs, evergreens, and vines will have one or more dead branches. These may have been killed by natural causes such as crowding and shade, by disease or insect pests, or possibly by some such mechanical injury as the copper wire of a plant label or rubbing against another branch. This dead wood should be removed as soon as possible, not only to prevent the entrance of decay into the healthy wood but also because it is a potential source of disease and insect pests.

Removal of Disease- and Insect-infested Branches. Branches infected with fire blight or other disease should be removed as soon as possible to prevent its spreading to the rest of the plant. They should be cut well below the point of infection, and the pruning tool sterilized by immersion in corrosive sublimate, 1 part to 1,000, after each cut. Lilacs and other plants heavily infested with oyster-shell scale may well have the old severely weakened wood completely removed. Shrubs like pussy willow infested with borer can be cut to the ground to allow new growth from the base. Branches infected with canker should be removed. All material such as the foregoing should be burned.

Removal of Excess Growth. Even though care has been exercised in selecting plants that will not become too large, occasionally branches may grow out beyond normal limits. These are best pruned not by cutting back to the desired length but by cutting to a point considerably lower. Shrubs and other plants that are too large for their location, if it is impossible to move and replace them with lower growing ones, may be somewhat lowered in height and lessened in width by the removal of the oldest wood at the ground. The common practice of pruning back to a definite height is not recommended. Heading back trees, particularly soft maples, not only destroys their natural beauty but allows the entrance of decay through the stubs of the branches which can never heal properly.

Control of Undesirable Growth Habits. Certain plants, such as the forsythia with its long arching branches and the Pfitzer juniper with its vigorous horizontal growth, may call for correctional pruning by tipping the longest branches. Low-hanging branches of trees and shrubs interfering with the space beneath may call for removal. Weak crotches in trees may require the removal of one branch.

Removal of Injured and Broken Wood. After high winds, wet snows, or sleet storms, broken and injured branches may have to be removed. In every case pruning should be carried out so that the wound will heal naturally.

For the Development of Desired Growth Habits. Where formal effects are wanted as in hedges or occasionally individual shrubs, pruning is necessary to develop the desired shape or habit of growth. Certain evergreens, such as Cannart juniper and the many varieties of the Japanese yew, will undoubtedly require regular and severe pruning to keep them from developing into open and scraggly plants. Shrubs or evergreens grown in restricted areas may demand a certain amount to keep them within the desired limits of growth.

The common practice of shearing all shrubs, regardless of kind and place, into round-headed forms, as is so often done around schoolhouses, public buildings, and cemeteries, is to be deplored. The beauty of most shrubs lies in their normal, natural habit of growth.

Rejuvenation of Old Plants. The average shrub requires little or no pruning for the first 5 to 6 years, but after that the more vigorous will often need a partial rejuvenation each year by the removal of a quarter to a third of the oldest branches clear to the ground. In this way the effect of removing the tops all at once and the consequent gap in the planting are avoided. Severe pruning is best done in the spring just before growth starts.

Reduction of Root Growth. Certain fast-growing shrubs may often be materially slowed in their rate of growth by a yearly root pruning. A spade will serve to cut the roots at an appropriate distance from the trunk, the amount naturally varying with the size and nature of the plant. This method may be used for such plants as firethorn, pines, spruces, or even hedges of Chinese elm —in fact for most fast-growing plants.

Principles of Pruning

An understanding of some of the fundamental principles of pruning is necessary to avoid injury to plants and to achieve the desired results. In all pruning every effort should be made to permit the wound's natural healing, which is accomplished by the growth of bark over the area. This will take place only when the wound is flush with the side of the branch. Any projection, even as little as ⅛ in., may be sufficient to prevent natural healing. When healing does not occur, the entrance of decay into the wound is more or less a matter of course. Where the wound is an inch or more in diameter, additional protection is necessary, since healing will not occur before decay has a chance to enter. All wounds larger than this should be treated with a wound dressing, the best of which is asphalt emulsion. If regular house paint is used, it should be kept ¼ in. away from the edges of the wound to prevent any possible injury to the active cambium layer.

Cutting back any branch stimulates the development of those buds nearest the wound. Consequently, the cutting back of the tops of such shrubs as Vanhoutte spirea in an attempt to lessen their height actually results in increasing the terminal growth, and they grow higher than before.

Where bloom is desired, pruning should be performed just following the blooming period to allow the development of new flowering wood for the next season. Where growth alone is the object, as in the case of shrubs with colored bark, pruning may take place at any time before growth starts in the spring.

Except for blooming shrubs, pruning, as in the case of shade trees, may take place at any time.

Tree Pruning

Trees, because of their size and use, present certain pruning problems not found in other plants. Newly planted trees should have approximately one-third of the smaller branches removed to reduce the tops in proportion to the root system. At all times, however, the natural shape of the tree should be maintained. It may be advisable to leave some of the lower branches temporarily to furnish adequate leaf surface for the manufacture of food. These can be removed in a few years' time.

With the exception of maples, which bleed profusely when late winter or early spring pruned, pruning may take place at any time. Care should be exercised during winter, however, to prevent injury when branches are frozen. Rubber soles for climbing will protect the bark.

Although normally the average shade tree requires but little pruning, when a greater amount of light is desired the branches may be thinned. Branches interfering with buildings or even with traffic on the street are naturally removed. Growth may be restricted by pruning the ends of the more vigorous branches each year.

It is especially necessary in connection with trees, because of the larger wounds involved, to cut all branches off flush with the next larger branch. So that the falling branch may not tear the bark, a cut should first be made underneath the branch a few inches from where it is to be removed.

Evergreen Pruning

Much unnecessary pruning of evergreens may be prevented by the selection of proper varieties. However, even when the proper ones have been selected, a small amount of restrictive pruning will occasionally be necessary.

Pines, spruces, and firs are usually pruned by pinching back the new growth in June. The amount left will, of course, depend on the size of the plant desired. Occasionally the above-mentioned evergreens can be cut back into two- or three-year-old wood and under optimum growing conditions will develop adventitious buds. Normally, however, when growing under yard conditions they cannot be expected to do this.

Yew, juniper, arborvitae, and hemlock may be pruned at any time although preferably in the spring before growth starts. These varieties possess a greater ability to produce new buds from two- and three-year-old wood and also have a greater number of side branches that will grow on. The more vigorous junipers, such as Pfitzer and *J. horizontalis* and its varieties, and the yews may need severe pruning to keep them within bounds.

Old plants of pine, fir, spruce, and hemlock are difficult if not impossible to reduce greatly in size, whereas many of the junipers and yews may be cut back severely and develop into good plants.

Shrub Pruning

Shrubs, as a rule, demand greater attention in regard to pruning than do trees or evergreens. To avoid the disappointment and dissatisfaction so prevalent after pruning at improper times, the following suggestions are offered:

Shrubs Requiring but Little Pruning

Aesculus parviflora
Azalea
Clethra
Cornus alternifolia
Cornus florida
Cornus mas
Crataegus
Euonymus
Hamamelis
Hypericum
Kalmia
Mahonia
Rhododendron
Rhus
Viburnum carlesi
Viburnum tomentosum
Viburnum tomentosum plicatum

Shrubs Best Pruned Just after They Have Finished Blooming

Abelia
Caragana
Cercis
Chaenomeles
Deutzia
Exochorda
Kolkwitzia
Lonicera
Philadelphus
Prunus
Rhodotypos
Ribes
Rosa (species)
Salix discolor
Spiraea
Syringa
Tamarix
Viburnum
Weigela

Shrubs Requiring Heavy Pruning, Particularly Removal of Surplus Branches at the Proper Time

Cornus alba sibirica	Lonicera
Cornus amomum	Philadelphus
Cornus sanguinea	Physocarpus
Cornus stolonifera	Rhodotypos
Deutzia (tall varieties)	Rosa (species)
Forsythia	Sambucus
Ligustrum	Tamarix

Berried Shrubs Whose Fruits Are Desired Following Bloom Should Be Pruned Sparingly Each Spring

Aronia	Euonymus
Berberis	Ligustrum
Cotoneaster	Viburnum

Shrubs That May Be Winter or Early Spring Pruned

Amorpha	Hibiscus syriacus
Buddleia	Hydrangea
Callicarpa	Ligustrum
Colutea	Lonicera
Cornus alba sibirica	Lycium
Cornus amomum	Rosa
Cornus sanguinea	Sorbaria
Cornus stolonifera	Symphoricarpos

TREE CARE

A. Every tree with a trunk diameter of an inch or more should be wrapped with burlap or tree-wrapping paper from the branches to the ground as soon as planted. This keeps out borers, prevents the trunk from drying out, and prevents sun scald. In addition three guy wires should hold the tree firmly in place. Attach them to heavy screw eyes or lag bolts in the trunk or the large branches. This is preferable to wire through a garden hose.

B. Fertilize trees from Feb. 1 to July 1 or from Sept. 1 to Dec. 1, using 3 to 5 lb. of a 10–6–4 complete commercial fertilizer to each inch of trunk diameter. Place in holes 12 to 15 in. deep and 15 to 18 in. apart from trunk to tip of branches and half as far beyond.

C. Weak crotches may be braced by wire cables fastened to eyebolts through branches. Braces, to be effective, should be at least one-half the distance from the crotch to the top of the tree. Chains or braces but a few feet above the crotch are not satisfactory.

D. Soil filled over tree roots even if only 4 in. thick may
sufficient to kill the tree slowly by smothering the roots. A we
built around the trunk, as at *E*, is useless in preventing t

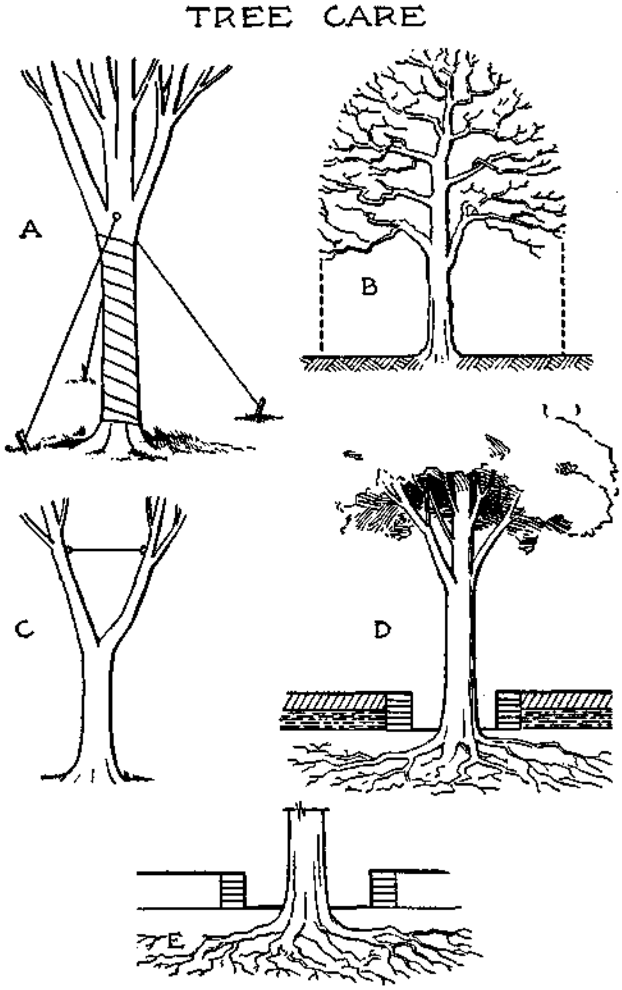


FIG. 73.

damage. Depending on depth of fill, 4 to 24 in. of coarse gravel or coarse crushed stone should be spread over the entire root area for aeration. Four or more lines of agricultural tile should be placed from the well around the trunk to the outer edges of the fill.

F. To remove a branch from a tree, first make a cut on the underside at 1 to prevent the falling branch from tearing the bark on the main trunk. Then cut through at 2.

G. Long stubs not only will not heal over but are unsightly.

H. Even small stubs as short as ¼ or ⅛ in. may prevent proper healing and allow decay to start.

I. A properly made wound flush with the surface and protected by an asphalt wound dressing will eventually heal over. Other dressings are less satisfactory. Some even retard proper healing.

J. Split crotches, especially in elm trees, should be drained. Drill a ½-in. hole halfway into the tree at the base of the crack. Insert an iron pipe an inch or so into the tree and extending sufficiently far out to drip clear of the trunk. The slime flux

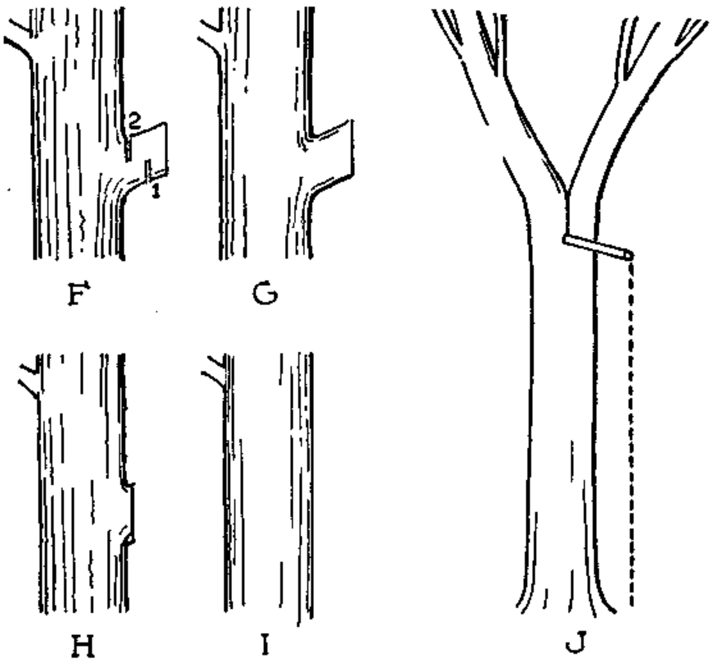


FIG. 73.—(*Continued*)

resulting from algae and bacteria growing in the sap is extremely toxic to plant tissue.

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CHAPTER XVII

HOUSE PLANTS

House plants might be said to be those pot plants which are able to exist and grow under adverse conditions. The average modern house, with its relatively high temperatures, its low degree of atmospheric humidity, does not provide the most favorable conditions under which to grow plants. The problem becomes more complex due to the presence of illuminating gas from heating and cooking equipment, for even such a minute quantity that it cannot be detected by its odor can seriously injure plants. The question of watering naturally involves the human element.

Many of these drawbacks, however, can be greatly reduced so that the culture of house plants is not impossible—in fact, under more ideal conditions may be highly successful. Light may be controlled by the use of south, east, or west windows for plants requiring a maximum amount of it. North windows or those not receiving a normal amount of sunlight and points away from sunny windows are best for plants which grow under conditions of reduced light. Where natural sunlight is not available in sufficient quantities, additional light may even be supplied through the use of electric light.

By various means humidity may be greatly increased and otherwise made more advantageous to plant growth. In houses heated by hot air, the maintenance of sufficient water in the humidifying attachment of the furnace will aid materially. In houses heated by other means this necessary increase in the humidity is probably easiest to accomplish with shallow, galvanized pans filled with water above which the plants may be set so that the pots are not directly in the water. Coarse gravel in the pans, with the pots set on top of it, may serve the purpose. Small dishes or small pans of water are not practical, since fairly large amounts must be evaporated daily to maintain relative humidity. If one of the several types of humidigraph now availible is used, a relative humidity of 40 to 60 per cent should be naintained.

The proper temperature of the air is important, together with reedom from sudden changes. Most house plants will give etter results when grown at 70 than at 80°. A night tempera-ure of 60° should be maintained if possible.

Watering. Soil requirements were discussed in Chap. IV, yet pplication of this knowledge is not always easy. Aside from gas njury, watering is the major difficulty in the successful growing f house plants. A general tendency is to underwater rather han overwater, but plants should be watered daily if necessary, r at least they should be checked every day to see if they need it. Those with considerable foliage, *e.g.*, primrose and cyclamen, will aturally require more water than the succulents with greatly educed leaf surfaces or the type of foliage from which there is a ninimum loss of water vapor through transpiration.

Soil aeration has been discussed. With the need of it in mind, water should be applied only after the soil has begun to dry out. Overwatering, and the consequent prevention of soil aeration, will be as harmful to growth as underwatering. Plants in small ots usually require more frequent watering than do those in arger containers. Plants in porous clay pots, which allow for vaporation through the sides, will need more than those in glazed containers. Indeed, glazed containers, with or without drainage holes in the bottom, are often more satisfactory than the standard clay pot for house plants when the latter are watered ndividually. Usually, however, it is necessary to learn how to water plants in such containers, since, with the loss by evapora-tion greatly reduced, much less water is required.

Whether the water is applied from the top of the pot or by setting the pot in water is immaterial. If the latter method is used, the pot should remain in water only until saturated. The need of any individual pot plant for water can be determined only by experience, since it is impossible to describe it.

Soils.—The type of soil for pot plants is not nearly so important as is generally believed. If it is in sufficiently good physical condition and contains adequate plant nutrients, then intricate and individual soil mixtures are not necessary. Any good garden oam may be used as a basis, modified if necessary by the addition of organic matter such as peat moss or leaf mold, its drainage perhaps slightly increased by the incorporation of sand. A good mixture is half garden loam, a quarter humus, and a quarter sharp sand.

The use of woods soil as commonly practiced by the layman is not advisable, since it is often lacking in mineral material adequate to give good growth. The often recommended practice of incorporating charcoal in the soil is of no value, either, except for drainage. In place of the usually recommended bone meal, a complete commercial fertilizer with an analysis such as 4–12–4 may be mixed in at the rate of a 3-in. flower pot full to each bushel of soil. Plants such as fern and begonia, that prefer a more porous type of soil, may be potted in a mixture of equal parts of garden loam, humus, and sand.

Most house plants will respond to regular fertilization during their active growing periods, but it should be withheld during December, January, and February when the light intensity does not warrant application of additional nutrients. Fertilization may be at the rate of one level teaspoonful, 4–12–4, to a 6-in. pot every month; less for smaller and more for larger pots. In place of the commonly recommended liquid manure as a stimulant, its modern equivalent, 1 oz. of ammonium sulphate dissolved in 1 gal. of water, should be used. Plants may be watered every 2 to 4 weeks with this solution. The various soluble fertilizer tablets offered for sale should be used according to the instructions furnished with them. Lime should be added to the soil only when necessary to counteract excess acidity. Most house plants prefer a slightly acid soil with a pH of 6.0 to 7.0. Acid-soil plants such as hydrangea, azalea, and gardenia may require iron sulphate as described under Gardenias. Methods of determining soil reaction are discussed in Chap. II and should be studied before either lime or iron sulphate are applied.

Potting. House plants should be grown in pots no larger than absolutely essential to contain their root systems. A general tendency is to have them too large. Rooted cuttings should be potted in 2½- or at most 3-in. pots. Plants should be repotted only when there is a more or less solid mass of roots around the outside of the ball of earth and always to the next size larger pot, as from a 3- to a 4-in. pot, from a 4- to a 5-in. pot, and so on.

Although the use of pieces of broken pot over the drainage hole is necessary in the culture of greenhouse plants where they are hose watered, it is not necessary in house plants where individual plant watering is practiced. In repotting, the new soil should be completely firmed around the old ball of earth so that no air pockets are formed. Potting is best done just previous to the normal active period of growth for each particular kind of plant. Repotting usually decreases the amount of bloom until the plant is again pot bound. Repotting once a year is usually ample. Regular fertilization is often preferable to repotting unless difficulty is encountered in the maintenance of sufficient soil moisture.

A practical and satisfactory application of soilless culture is found in a type of flower pot now on the market under the name of Mineral Maid. The chemical nutrient solution is contained in the lower part and transferred by a porous wick to the plant growing in silica sand in the upper part of the container.

Insect Pests. Common insects attacking house plants are aphis, red spider, mealy bug, white fly, thrip, mite, nematode, and the various scale insects. Their control is discussed in Chap. XVIII.

Common plant diseases attacking house plants are relatively few. They include leaf spots, mildews, and root rots. The many physiological conditions often considered as diseases are also discussed in Chap. XVIII.

Summer Care. House plants are often difficult to care for in the summer, particularly during vacations. There is no reason why they should not be planted out of doors with their pots plunged into the ground up to the rims in partial shade. Many of the foliage plants may be plunged in on the north side of the house. Blooming plants, such as Fuchsia, *Impatiens*, *Begonia semperflorens*, and gardenia, may be put directly in the ground in partial shade. Geranium and calla will thrive in full sun. Saintpaulias are one of the few house plants that are probably best kept indoors. All these plants should be removed to the house in September before frost. Many may be repotted, and all fertilized, at this time.

AQUARIUMS

Aquariums are an interesting addition to the window garden and to the house. If properly planted with an adequate number of oxygenating plants for the benefit of the fish, they are relatively permanent and require little care. With fish but no oxygenating plants the water must be changed regularly, and the aquarium becomes rather a nuisance. An often encountered difficulty is the use of too many fish for the size of the aquarium and too few plants to give an adequate oxygen supply. The better oxygenating plants include the following.

Vallisneria (Eel Grass). With ribbonlike leaves. There are dwarf varieties.

Elodea. A rapidly growing plant requiring the frequent removal of excess growth.

Sagittaria. Similar to *Vallisneria* but coarser.

Cabomba (Water Shield). Finely divided foliage. Rather fast growing.

Myriophyllum. Finely divided foliage. Even faster growing than *Cabomba,* requiring removal of surplus.

All these plants require sunlight or an amount of light equal to it supplied by an electric bulb.

The various floating plants such as *Salvinia, Lemna* (duckweed), and *Pistia* (water lettuce) are of no value in oxygenation.

It is difficult to give a specific formula for the number of fish to be used, but roughly 2 in. of goldfish is ample for each gallon of water. If tropical fish such as guppies, swordtails, and moons are desired, double this amount of water may be used. If the number of fish is no greater than this and the quantity of oxygenating plants is ample, the water need be changed but once a year, provided the excess food is removed if not eaten immediately, together with any sediment.

The oxygenating plants should be planted in an inch or so of sand in the bottom of the container. In changing the water care must be taken to have the fresh water at the same temperature as that which is removed, as all fish are extremely sensitive to changes in water temperature, even a few degrees being sufficient to kill them.

TERRARIUMS (WARDIAN CASES)

The Wardian case, as developed in the early nineteenth century for growing and shipping the more difficult tropical plants, has been popularized in the present-day terrarium, which may be a fish bowl, a large glass candy jar, a battery jar, or an aquarium.

A thin layer of a loose soil mixture is placed in the bottom of the container. It may be above a layer of gravel, broken crocks, or charcoal. Watering will vary with the type of plants used. For succulents little moisture should be applied. For other plant materials sufficient moisture is introduced to maintain a fairly high degree of humidity.

Single plants such as *Selaginella* are popular, but a complete landscape may be developed with the use of clinkers or stones, small figures, and structures. In this case only plants that will maintain their small stature are included. Cuttings of box, Japanese yew, and juniper and seedlings of hemlock, pine, and spruce may do for trees. Mosses, lichens, and ferns such as ebony spleenwort may be used. Such plants as wandering-jew and helxine, which have a vigorous nature, soon fill the bowl unless constantly pruned. Partridge berry is an excellent subject.

When the humidity becomes too high, the glass lid must be removed; otherwise mold and even decay may start. Extra moisture is added only when needed to maintain the necessary humidity.

PROPAGATION

The same principles are followed in the propagation of house plants in the house as for all plants in the greenhouse. A shallow box may be filled with sand in which the cuttings can be inserted. To maintain the necessary humidity four pieces of glass may be inserted vertically around the sides of the box, with the fifth on top. Another satisfactory method is to use a shallow pan filled with sand, with a drainage hole 2 to 2½ in. from the top. The excess from water applied two or three times per week drains out through this hole into the saucer in which the pan is set. As soon as the cuttings have roots ½ in. in length, they should be potted in a loose soil mixture.

Leaf cuttings may be made of *Begonia, Sansevieria, Crassula, Sedum, Saintpaulia, Bryophyllum, Kalanchoe,* and *Gloxinia;* stem cuttings, of *Impatiens, Fuchsia, Gardenia, Euphorbia, Begonia, Geranium, Chrysanthemum, Cissus, Crassula, Hedera,* and *Peperomia.*

A SELECTED LIST OF HOUSE PLANTS

ACANTHACEAE ACANTHUS FAMILY

Beloperone guttata. Tropical America. Although vigorous plants 15 to 20 ft. high in Florida, when grown as pot plants they seldom exceed 18 to 24 in. The white flowers with reddish-brown bracts give it the name "shrimp plant." Propagated by cuttings. Blooms even as a small plant.

AMARANTHACEAE AMARANTH FAMILY

Iresine.

I. herbsti. South America. Leaves broad, red or green with yellow veins, notched at top.

I. lindeni. Ecuador. Bloodleaf. Leaves narrow, sharp pointed, dark red. Plants somewhat similar to the *Coleus* in foliage character, grown for their foliage effect.

AMARYLLIDACEAE AMARYLLIS FAMILY

Clivia. Kafirlily.

C. miniata. South Africa. Leaves 1½ ft. long, flower stalk 2 ft. Flowers upright, salmon-orange in color. Easily grown plants with dark-green, strap-shaped leaves and compact heads of brilliant flowers. Require repotting but seldom. Fertilize frequently as recommended for *Calla.* Propagate by division.

Hippeastrum (*Amaryllis*). Most of the *Amaryllis* grown today are hybrids of the various South American species. The large, showy blooms are not difficult to produce if properly grown. They seldom bloom, however, if not given a rest period. Pot the bulbs in the fall, and keep dry until December. Then water and fertilize as any other plants. Remove from pots and plant in full sun in garden until early fall.

ARACEAE ARUM FAMILY

Aglaonema simplex. Borneo. 3 ft. Commonly called the "Chinese evergreen." Grows equally well in water or soil, in full sun, or in greatly reduced light. Propagated by division or cuttings. Other species of this genus are sometimes available.

Dieffenbachia picta (*brasiliensis*). South America. There are a number of varieties having green leaves with various markings of white or yellow. Like many tropical foliage plants, it becomes leggy with age. The old stems can be layered in sphagnum moss or cut to 2- or 3-in. pieces and rooted in sand.

Monstera deliciosa. Mexico and Central America. Huge leaves perforated with large holes. With age produces flowers with white spadix 1 ft. long. Edible fruit. Satisfactory only in large houses.

Philodendron. Devils Ivy. Tropical America. A vigorous vine with heart-shaped leaves. Not inclined to branch unless tip pinched at regular intervals. Withstands greatly reduced light. Grown frequently in water.

Scindapsus (*Pothos*). Ivy-arum, Hunters Robe.

S. pictus. East Indies. A vigorous vine with oblique leaves. Variety *argyraeus* leaves are spotted silver white. Is more often grown than the type. This genus is usually catalogued as *Pothos.* Will grow readily in water.

Zantedeschia. Calla (improperly called "calla lily").

Z. aethiopica. South Africa. Common Calla. 2½ ft. Flowers white.

Z. elliottiana. South Africa. Golden Calla. 1 ft. Flowers yellow. Leaves spotted. The dormant roots are planted in September in a rich soil. After growth has started, feed once a month with ammonium sulphate, 1 oz. to 2 gal. of water. The following June put the pots on their sides out of doors until September. Although callas are not free blooming as house plants, they are sometimes satisfactory.

ARALIACEAE ARALIA FAMILY

Hedera helix. English Ivy. Europe, Asia, and North Africa. Evergreen plants, usually a vine climbing by holdfasts. There are a great many varieties, many of them hardy. Can be grown in a sunny window or where there is very little direct light. Red spider, mealy bug, and scale may be serious pests. Some of the newer, self-branching varieties are more compact for pot culture. Ivy may be grown in water.

ASCLEPIADACEAE MILKWEED FAMILY

Hoya carnosa. Waxplant. China and Australia. Fleshy-leaved vine with fragrant cluster of white flowers during the summer. Propagated by cuttings.

Stephanotis. Madagascar and Malaya. Usually sold as cut flowers but occasionally as pot plants. Vigorous vines with fragrant white flowers. Summer blooming.

BALSAMINAE BALSAM FAMILY

Impatiens. Touch-me-not.

I. holsti (usually listed as *I. sultani*). Zanzibar. 2 ft. Hybrid forms of this have white, pink, salmon, lavender-pink, and red flowers with succulent, light green stems and foliage. One of the best flowering pot plants. Excellent for summer bloom in shaded gardens. Any good garden soil will do. Needs full sun during the winter months. Propagation by seed or cuttings.

BEGONIACEAE BEGONIA FAMILY

Begonia. A large genus with several hundred species, many of which have been hybridized, producing innumerable varieties. Although all are flowering, the following are equally attractive when grown for their foliage effect alone: Rex hybrids *B. feastii, B. argentea-guttata, B. coccinea, B. fuchsioides, B. evansiana, B. haageana, B. heracleifolia, B. picta, B. rajah, B. thurstoni,* and *B. manicata.*

The following begonias are grown essentially for their bloom:

B. semperflorens. Brazil. Many varieties. Some of the hybrid forms are not practical in the average home except for a short period after purchasing. The same applies to hybrids of the bulbous types, such as *B. socotrana* Gloria de Lorraine.

Others grown for their bloom include *B. coccinea* from Brazil and *B. dregei* from South Africa.

The tuberous-rooted types, most of which are hybrids, are summer blooming only, resting during the winter. Dormant plants may be put indoors in April; but growing seedlings, usually obtainable in 3-in. pots, may be purchased in June.

Begonias for the most part prefer reduced light rather than full sun. They should be potted in a porous soil with ample humus and some sand. Most begonias are propagated by stem cuttings; some, by leaf cuttings. Some of the semperflorens forms may be grown from seed.

CACTACEAE CACTUS FAMILY

The recent increased interest in cacti has brought into use many of the 1,300 species of this family. Their study is complicated by a wide range of forms.

Selenicereus. Night-blooming Cereus. A group of 16 species from Southern United States and South America, all of which are night blooming. Properly grown in good soil and with adequate watering, these plants should bloom each year. Since many of them are vigorous vines—some up to 25 ft. in height—severe pruning may be necessary.

Zygocactus truncatus (usually sold as *Epiphyllum truncatum*). Christmas Cactus. Brazil. Flowers red. There are a number of different color forms, some with pink flowers. Propagated by cuttings. If amply fertilized and properly watered, should bloom regularly each winter.

COMMELINACEAE SPIDERWORT FAMILY

Tradescantia. Spiderwort.

T. fluminensis. Wandering-jew. South Africa. There are white and yellow variegated varieties as well as the green type. The purple and green forms are properly *Zebrina.* Will grow in soil or water. Several larger forms of *Tradescantia* are occasionally sold as pot plants.

Zebrina pendula. Wandering-jew. Mexico. Vine, rooting at the nodes, foliage green and purple.

COMPOSITAE COMPOSITE FAMILY

Chrysanthemum morifolium. Hybrids, probably of Chinese origin. Plants of chrysanthemums may be kept growing in the house over winter, divided and repotted in February or March, and, if pot grown (the pots plunged into the ground over summer and brought indoors before freezing weather), may produce some bloom. This method is best used with the early-blooming kinds.

Senecio cruentus. Cineraria. Canary Islands. Large, daisylike flowers in white, lavender, pink, purple, and red. The taller, smaller flowered sorts, such as the variety *stellata*, are more open in growth. Grown from seed each year. Their large leaf surface requires copious watering with excellent drainage. Overwatering will produce wilting.

Senecio mikanioides. German Ivy. China. Vine with thin, pointed-lobed, dark green leaves. Requires considerable sun. Very susceptible to plant lice. Propagated by cuttings. Will root and grow in water.

CORNACEAE DOGWOOD FAMILY

Aucuba japonica. Himalayas and Japan. Shrub. Leaves green, spotted yellow. Hardy in the south and on the Pacific coast. Showy plants. There are several varieties.

CRASSULACEAE ORPINE FAMILY

The various genera of this family often difficult to distinguish from one another. All are fleshy leaved. Some grown for foliage; others, for flowers.

Bryophyllum pinnatum. Air Plant. East India, escaped to Florida. 3 to 5 ft., flowers greenish, purple tinted. Adventitious plants develop along edges of leaves.

B. daigremontianum. See *Kalanchoe.*

B. tubiflora. See *Kalanchoe.*

Crassula arborescens. South Africa. Sometimes called the "jade plant." Thick, fleshy, ovate leaves. Flowers rose-red. Easily propagated from stem or leaf cuttings. Seldom gets over 2 to 3 ft. high as a pot plant, usually much smaller. Used in dish gardens extensively to simulate a tree. Other species often grown include *C. portulacea* and *C. lycopodioides.*

Kalanchoe blossfeldiana (*globifera coccinea*). Madagascar. 8 to 12 in. Grown for red flowers during winter.

K. daigremontiana. Madagascar. 2 to 3 ft. Similar to *Bryophyllum,* plantlets developing along edges of fleshy triangular leaves with purplish marks on undersurface. A showy plant.

K. tubiflora. South Africa. 2 ft. Leaves cylindrical, producing plantlets on tips.

Also included in the 20 genera of this family are *Sedum, Echeveria, Sempervivum, Rochea,* and *Cotyledon.* Most of these are propagated by leaf cuttings.

CYPERACEAE SEDGE FAMILY

Cyperus alternifolius. Umbrella-plant. Africa. Stems 2 to 6 ft. in length, the leaves in an umbrellalike whorl at the top. May be grown as a pot plant in soil or as an aquatic plant with the pot submerged in water. The papyrus of ancient Egypt is *C. papyrus,* often used in outdoor pools. Propagated by division or leaf cuttings.

EUPHORBIACEAE SPURGE FAMILY

Acalypha wilkesiana. Copperleaf. South Sea Islands. A shrub 15 ft. high grown for its foliage. There are many varieties with brown, red, and bronze mottled leaves. Grown outdoors extensively in the tropics. Propagated by cuttings.

Codiaeum variegatum. Croton. Old World tropics. There are a tremendous number of varieties of this foliage plant. The colored leaves come in yellow, red, brown, and pink, singly or in combinations. Although often sold as a house plant and extensively grown in the tropics, the atmosphere of most houses is usually too dry to grow it successfully.

Euphorbia pulcherrima (*Poinsettia pulcherrima*). Poinsettia. Tropical America. The color is supplied by the red, white, or pink bracts beneath the inconspicuous flowers. A number of named varieties. Difficult to keep in the home because of drafts, lack of sufficient humidity, and irregular watering. Should be watered daily but never allowed to become waterlogged. Sudden changes of temperature, low temperatures, and gas must be avoided. After the leaves begin to dry in January or February, cut off one-half of the growth. Put in the cellar, and water every few weeks, just enough to prevent the wood from shriveling. In early June cut back severely, repot, and plant out of doors in partial shade. After growth starts, fertilize once a month with a solution of 1 tbsp. of 4–12–4 fertilizer to 1 qt. of water, using one-half cup per 6-in. pot. Bring indoors in early September. Place in a sunny window where the night temperature does not go below 60°. Mealy bugs are often a serious pest.

GERANIACEAE GERANIUM FAMILY

Pelargonium. South Africa.

P. hortorum. Common Geranium. Hybrids of various species, including many named varieties with white, pink, salmon, and red flowers. They are used extensively for outdoor bedding in the summer and as house plants in winter. They prefer full sun and heavy soils and as pot plants must be well root bound for good bloom.

P. domesticum. Lady Washington Geranium or Pelargonium. Usually larger flowered than the common geranium, with the upper petals blotched. A number of named varieties. More showy in form but usually more difficult to grow. Prefers a cooler, more humid atmosphere.

P. peltatum. Ivy Geranium. Trailing plants with fleshy leaves and dark rose flowers, much used for porch boxes and hanging baskets.

There are a number of other species grown for variously scented foliage. All geraniums are propagated by cuttings.

GESNERIACEAE GESNERIA FAMILY

Saintpaulia. African-violet.

S. ionantha. Tropical Africa.

The species itself is seldom grown. The 100 or more varieties include Blue Boy, Blue Girl, Pink Beauty, White Lady, Dupont Blue, Redhead, Double Duchess, Bicolor, Orchid Beauty. Colors range from white to pink, lavender, plum, orchid, lavender blue, and purple. There is no yellow variety. Foliage shape and habit of growth vary with varieties.

Saintpaulia requires relatively little light. It can withstand the dry atmosphere of the average home, blooming over long periods throughout the year. An east or a north window is preferable, although a south or a west window may be used during the winter.

Water may be applied from top or bottom of pot. Cold water below room temperature and too much sun cause light disfiguring spots on foliage.

If potted in porous soil, it may be watered frequently and heavily. Mix equal parts of garden loam, sand, peat moss, and rotted manure. In heavier soils overwatering may cause trouble. Keep in relatively small pots. Saintpaulia is very susceptible to gas injury, which causes dropping of the flowers. Propagation is by leaf cuttings, usually rooted in sand or vermiculite but may be rooted in water.

Sinningia speciosa (*Gloxinia speciosa*). Gloxinia. Brazil. Summer-blooming plants with large, bright, bell-shaped flowers and succulent leaves. Store in pots kept dry from September until February. Do not overwater. Propagation from seed and by leaf cuttings. Although gloxinia can with care be grown in the house, most houses are too warm for satisfactory results.

IRIDACEAE IRIS FAMILY

Marica.

M. northiana. Brazil. 3 ft. Flowers white with violet markings at the base. Irislike foliage in a flat, fan-shaped spray. Adventitious plants develop on flower stalks. Easily grown house plants. Quite common through the Middle West although seldom sold by florists. Each flower lasts but one day, but several buds on each stalk prolong the blooming period.

LABIATAE MINT FAMILY

Coleus blumei. Java. 3 ft. There are many varieties of this colorful species. They prefer full sun whether in the house or out of doors. In summer best to grow young, vigorous plants rather than old ones. Usually propagated by seed or cuttings. The variety Trailing Queen may be used in hanging baskets, along the front part of the flower border, or even in the rock garden. Will grow in water.

LILIACEAE LILY FAMILY

Aspidistra elatior (*lurida*). China. One of the toughest of all house plants. The large leaves 1 to 2 ft. in length, seemingly unaffected by drying out or overwatering. Full sun or no sun. The flowers are inconspicuous on the surface of the ground. The variegated foliage forms are more interesting than the type. Propagate by division.

Asparagus.

A. plumosus. South Africa. A climbing plant with dark green, needlelike leaves. Also a dwarf variety. Propagated by seed or division.

A. sprengeri. South Africa. Climbing or trailing plants with light green leaves. Propagate from seed or by division.

A. falcatus. Asia and Africa. Climbing plants much coarser than the preceding species. Dark green leaves at least ¼ in. wide and 1 in. or more in length. Makes an excellent house plant.

Chlorophytum elatum (*Anthericum variagetum*). South Africa. Leaves variegated green and white to 1 ft. in length. Flower stalks 2 ft. or more in length. Flowers white. Adventitious plants produced in axils of inflorescence. Fleshy roots. Propagated by division and by plantlets. Usually listed in catalogues as *Anthericum*.

Convallaria. Lily-of-the-valley.

- *C. majalis*. Europe, Asia, and North America. Used for winter forcing from special pips from cold storage. Blooms in 3 weeks in sand or soil. Home-grown pips will not force until after low-temperature treatment.

Cordyline terminalis. Asia. Many varieties, often with combinations of rose and green stripes.

- *C. indivisa*. New Zealand. Long, slender leaves. Often used for cemetery urns. Most cordylines are propagated by layering old stems.

Dracaena. Dracena.

- *D. fragrans*. Upper Guinea. Plain green leaves. Varieties *lindeni* and *massangeana* with variegated stripes. Inclined to get leggy with age unless rerooted in sphagnum and repotted.
- *D. godseffiana*. Guinea. Smaller leaves than *D. fragrans*. Spotted with white.
- *D. sanderiana*. Cameroons. Leaves with white margins. Most forms propagated by layering old stems. Most other plants commonly called *Dracaena* are *Cordyline*.

Lilium longiflorum. Easter Lily. Japan. Although this lily is often hardy in mild climates, it should not be planted in the garden for the simple reason that most florists' stock is infected with mosaic and would infect other lilies in the garden. If desired for garden use, grow it from seed.

Sansevieria zeylanica. Bowstring-hemp. Ceylon. 2 to 3 ft. Common spotted variety roots readily from leaf cuttings.

- *S. trifasciata laurentii*. Belgian Congo. 2 to 3 ft. Similar to *S. zeylanica*, but yellow margin to leaves. Propagate by division only.
- *S. cylindrica*. Africa. Tubular leaves. 10 to 12 in. Several other species are occasionally found in cultivation.

MORACEAE MULBERRY FAMILY

Ficus. Fig. A large genus of tropical plants, including the various edible figs. Propagation is by cuttings.

- *F. elastica*. Rubber Plant. India and Malaya. Once popular but seldom grown today. There is a variegated variety.
- *F. retusa* (*nitida*). Indian and Malay. A smaller leaved species, making a very attractive plant. Used as a shade tree in Florida.
- *F. pumila* (*repens*). China, Japan, and Australia. A vine clinging by rootlike holdfasts. May be grown on the walls in a conservatory or merely trailing over the surface of the pot.
- *F. lyrata* (*pandurata*). Africa. A large-leaved plant sometimes grown in pots. A shade tree in Florida.

ONAGRACEAE EVENING-PRIMROSE FAMILY

Fuchsia. Native of South America, Mexico, and New Zealand. Most of the cultivated forms are hybrids. For winter bloom dry off in October:

prune back. Start into growth in January or February. For summer bloom in shaded gardens, store more or less dry in the cellar over winter. Propagate by cuttings. White fly is a serious pest indoors.

OXALIDACEAE OXALIS FAMILY

Oxalis. These vigorous little bulbs, with many three-parted leaves, may be planted in pots or hanging baskets for winter and spring bloom.

O. cernua. Buttercup Oxalis. South Africa. Flowers yellow.

O. bowiei. South Africa. Flowers rose-purple.

The pots may be put in the cellar at the end of their spring-blooming period; the plants, repotted and started into growth again in the fall.

PANDANACEAE SCREWPINE FAMILY

Pandanus veitchi. Screwpine. Polynesia. Leaves green and white striped. Sharp-toothed edge. Usually produces a number of suckers at the base of the plants by means of which it is propagated. One of the most showy and satisfactory foliage plants.

PIPERACEAE PEPPER FAMILY

Peperomia.

- *P. crassifolia.* Tropical Africa. 8 to 12 in. Round, dark green leaves. Also a variegated form. Easy to cultivate. Very satisfactory. Will grow in water.
- *P. sandersi argyreia.* Brazil. Erroneously called "watermelon begonia." Although more showy with white areas between the veins, it is not usually so satisfactory as a house plant. May be used in terrariums.

POLYPODIACEAE COMMON FERN FAMILY

Asplenium.

- *A. nidus.* Birdsnest Fern. Asia. Leaves entire, bright green, upright.
- *A. viviparum.* Bourbon, Mauritius. Bronze leaves. Plantlets develop on the leaves.

Cyrtomium falcatum. Hollyfern. Asia. Fronds dark glossy green. Exceedingly durable.

Davallia bullata. Squirrels-foot Fern. Malaya, India, and Japan. Finely divided fronds from creeping brown rhizomes. Withstands house conditions excellently.

Nephrolepis exaltata. Swordfern. Florida, South America, Asia, and Africa. A rather stiff, narrow-leaved fern. From the variety *bostoniensis* there are a great many variations, both dwarf and otherwise. Some of the better kinds are *elegantissima, whitmani,* and Teddy Junior. Do not grow too close to radiators or hot-air openings.

Polypodium aureum. Hares-foot Fern. Tropical America. Coarse fronds 3 to 4 ft. long from creeping rhizomes.

All ferns may be propagated by spores, a slow process. Most of them are propagated by division of the plants or of the rhizomes. Ferns grow best in a light, porous soil with ample organic matter. Soil drainage should be excellent.

Pteris. Brake.

P. cretica. Tropics. Fronds to 1 ft. There are a number of varieties, including *albo-lineata,* and *cristata.*

P. serrulata. China and Japan. There are many varieties, including *cristata.*

PRIMULACEAE PRIMROSE FAMILY

Cyclamen.

C. indicum. Greece and Syria. Grown anew each year from seed sown 18 months before blooming, they demand a very cool, humid atmosphere, which makes them difficult to maintain in the home. Occasionally they may be dried off during the summer, started into growth in September, and made to bloom a second time successfully. When watering avoid getting crown wet, as rotting may result.

Primula obconica. Primrose. China. Flowers white or pink. Rather large-leaved, coarse plants requiring copious watering. Grown anew from seed each year. Foliage causes dermatitis on many people.

P. malacoides. Fairy Primrose. China. A dainty plant with rose flowers and relatively small leaves. Free flowering. There are several varieties.

RUBIACEAE MADDER FAMILY

Gardenia jasminoides. Cape Jasmine. China. Many varieties including *veitchi.* Belmont and Hadley are larger flowered than the type. Requires warm, sunny, humid conditions which are difficult to supply in the average house. To maintain soil moisture place the pot in a larger pot with at least 1 in. of space filled with sphagnum or peat moss. Soil, one-half acid peat and one-half garden loam, must be kept acid. Lack of acid is indicated by chlorosis. Correct by the application of iron sulphate at the rate of 1 tbsp. to 1 qt. of water, ½ cup to 6-in. pot, less for smaller pots. Nitrate nitrogen in the form of a complete fertilizer is injurious. Always apply nitrogen in the form of ammonia, as ammonium sulphate, 1 tbsp. to 1 qt. of water, using ½ cup of this per month for a 6-in. pot, less for smaller pots. No repotting should be done after Sept. 1.

Plants should be set out in half shade in the garden in early June. Prune back two to three pairs of leaves on each stem. Best to repot to the larger size pot at this time. Mulch with acid peat out of doors in summer. Bring indoors in September. Mealy bugs and nematodes are often serious pests.

SCROPHULARIACEAE FIGWORT FAMILY

Calceolaria. Slipperwort. Mexico to Chile.

C. herbeohybrida (hybrida). Pouched flowers, yellow, orange, and red, usually spotted. Most varieties grown anew each year from seed, but a few smaller flowered types are grown from cuttings. Purchased from florists are difficult to grow in average home.

URTICACEAE NETTLE FAMILY

Helxine soleirolii. Commonly called "baby's tears." Corsica and Sardinia. A small-leaved, trailing plant forming dense mats. Used in combination with other plants in pots as a ground cover or by itself. Grows in full sun or part shade. Is hardy out of doors in mild climates. Propagation is by division.

Pilea microphylla. Artillery Plant. Southern Florida, tropical America. 1 ft. Small, succulent leaves. Propagation by cuttings.

VITACEAE GRAPE FAMILY

Cissus rhombifolia (*Vitis rhombifolia*). Commonly called "grape ivy." South America. Leaves with three leaflets. Brown hairs on veins on lower side of leaves. One of the most satisfactory of all house plants, thriving in full sun or with no direct light and with normal or heavy watering. Will also grow in water alone. Propagated by cuttings.

C. antarica. Java. Large individual leaves 3 to 4 in. long. Darker green than preceding species. Vigorous grower.

SAXIFRAGACEAE SAXIFRAGE FAMILY

Saxifraga sarmentosa. Mother of Thousands Eastern Asia. Erroneously called a begonia. Leaves striped with silver. Runners produce plantlets. Flowers white. This plant is perfectly hardy. May be grown out of doors in partial shade.

Tolmeia menziesi. Pick-a-back Plant. Alaska to California. 2 ft. The foliage resembles the native *Tiarella.* Grown because of the adventitious plants produced at the base of the leaf blades.

Plants That Can Be Grown in Water without Soil

Aglaonema simplex
Cissus rhombifolia
Dieffenbachia
Euonymus fortunei (E. radicans) and its varieties
Hedera helix
Pachysandra terminalis
Pedilanthus
Peperomia crassifolia
Philodendron
Rhektophyllum mirabile (Nephthytis picturata)
Scindapsus (Pothos)
Tradescantia
Vinca minor

To this list might be added certain vegetables such as sweet potato, carrot, and beet. A pinch of complete fertilizer, *e.g.*, 4–12–4, ½ tsp. to 1 cup of water, will be an aid.

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CHAPTER XVIII

INSECT PESTS AND PLANT DISEASES

DIAGNOSIS

Accurate diagnosis of garden troubles, whether they are caused by insect pests, plant diseases, cultural practices, or internal disturbances within the plant, is one of the essentials of intelligent gardening. Before a specific pest is accused of being the source of the difficulty, even though its presence has not been observed, it is always well to check over the growth requirements of the particular plant or plants and make sure that they are being adequately met.

Effects of Improper Amounts of Sunlight. The light requirements of plants have already been discussed in detail. Application of the principles, however, is often ignored. When plants that require practically full exposure to sun are grown under partial or complete shade, unsatisfactory growth will be the result. This may be indicated by the lack of bloom; by lack of the production of fruit in the case of plants with ornamental berries; by spindly, weak growth; or even by the gradual deterioration of the plant. A common example of this is the Pfitzer juniper in shaded locations. It may exist for several years but becomes more and more anemic in appearance. On the other hand, woodland plants such as ferns and evergreens such as rhododendrons, if placed in full sun, often have the foliage scorched.

Quite often the factor of soil moisture is closely associated with shade if the plants are in the vicinity of trees. For instance, viburnum will grow well in the shade of a house but often suffer in that of trees, not because of the shade but because of the severe reduction of soil moisture.

Effect of Improper Soil Moisture. It is surprising how often other factors are blamed for the failure of adequate plant growth when the moisture supply is the immediate cause of the difficulty. Usually, particularly around houses, this is due to changes in grade and the movement of relatively large masses of soil together with the burying of rocks and rubbish, which prevent the normal upward movement of the moisture in that soil. Trees, shrubs, flowers, and lawns often suffer, even though apparently adequate amounts of water are applied artificially. If plants in one part of the yard grow satisfactorily, whereas in other spots they do not thrive, deficiency in water may be suspected, and the same may be said of house plants.

Occasionally the effects of overdoses of moisture, usually due to lack of adequate drainage, are observed. Excessively heavy losses of roses, perennials, and bulbs can often be traced to it. Trees and evergreens can be killed in a single season by sudden accumulations of soil moisture. Contrary to popular belief, placing plants on a slope or at the top of a hill does not necessarily mean that drainage will be adequate. The installation of agricultural drain tile 18 in. to 2 ft. beneath the surface and 20 to 30 ft. between lines may be necessary to carry the water to a lower level or into a drain. A 1-in. drop in 100 ft. is sufficient.

Effect of Improper Temperature. Each plant has a certain optimum temperature requirement, with a limiting maximum and minimum, and within this range will make satisfactory growth. When winter temperatures go below the minimum, winterkilling can be expected. There are, however, a number of factors that enter into this, such as the degree of maturity before winter and the time, the amount, and the speed of the temperature drop, coupled often with soil moisture. Many coniferous and broadleaf evergreens if excessively dry in the fall, with low temperatures in the winter, may be expected to suffer injury. Sudden freezes in the late autumn or early winter before the plants are thoroughly matured may produce injury. Excessive wind, which dries out the foliage and the twigs, is also to be considered. Once plants are established, they can often survive when unestablished plants would be killed. Adequate forms of winter protection such as windbreaks, shade, and mulches can be applied to tender or doubtful cases.

On the other hand, during excessively hot seasons certain plants may be severely injured. Not only their foliage but also their stems and possibly even their roots may be affected. The use of mulches of peat moss, or a similar material, to lower the soil temperature will often prove beneficial. Lowering the temperature through shading by means of lath, cloth, or even near-by trees may be used to advantage. This brings us directly to the problem of the selection of those plants which can withstand the temperatures of the particular climate in which they are to be grown. If adequate lists are not available for any particular section, extensive trials together with observation will be the determinants.

Effects of Improper Soil Nutrients. The nutrient requirements of plants were discussed in Chap. II. However, lack of them is seldom appreciated in the home garden. Tests of yard soils indicate that in the majority of instances an inadequate amount of fertilizer, if any, has been applied. Poor growth, lack of bloom, and complete death of plants are some of the more common indications.

It must also be remembered that in the use of modern commercial fertilizers overdoses may cause destruction of the roots and consequent death of the plant. Careless application, especially in contact with the foliage, may cause local damage to the leaves.

Effects of Improper Soil Preparation. The soil around the average house is of notoriously poor structure and nutrient content, being usually composed largely of subsoil from the cellar excavation or, at best, of meager topsoil of worn-out farm land. Although the average garden plant is highly tolerant of the soil in which it is grown, that soil must be in good physical condition.

Roots require air the same as the leaves so that the lack of sufficient air in the soil retards plant growth. Sandy loam soils naturally have this aeration if properly drained. Heavy clay soils, unless thoroughly prepared by the addition of adequate amounts of organic matter, do not. In the same way soils compacted through traffic, such as by walking or by automobiles, are usually insufficiently aerated to give satisfactory root growth. Unless this condition is corrected by the incorporation of organic matter, the plants will be unhealthy. A temporary correction may be made by the application of a 2-in. mulch of undecomposed organic matter in the spring; chopped corncobs, straw, fresh manure with straw bedding, alfalfa chaff, clover chaff, and similar materials meet this requirement. Organic matter being unavailable, the incorporation of a 2- to 4-in. layer of coal ashes mixed with the top 8 to 12 in. of soil will give surprising results.

Acid-soil plants such as *Rhododendron* and mountain-laurel will show all the symptoms of disease when grown in a soil insufficiently acid. This is indicated by the yellowing of the foliage, scorching of the leaves in the sun, nonblooming, and poor growth. Soil acidification is discussed in Chap. II.

Effects of Mechanical Injury. Although mechanical injuries are relatively rare, such factors as hail and wind on foliage and flowers must be considered. The mechanical injury of the bark of trees, shrubs, and evergreens by garden tools and lawn mowers is often overlooked. Human beings and animals rubbing against new growth may cause serious injury. Moreover, the amount of damage done to plants by livestock and even squirrels and rabbits is not always realized. The girdling effect of wire fencing, wire clotheslines, and radio aerials is often unsuspected. Even the copper or iron wire of a plant label may girdle smaller branches or trunks of nursery stock. Damage from illuminating gas from a broken main is usually indicated by the dying of foliage which remains on the plant, and it may occur 1,000 ft. or more from the break if the ground is frozen.

Injury Due to Spray Materials. Improper or careless application of spray or dust materials may cause injury to foliage. This is usually indicated by scorched spots around the edges of the leaves and occasionally elsewhere. The use of any such materials when the temperature is over 80°F. is inadvisable, particularly when synthetic preparations are used. Even the application of small amounts of water, as by a light shower, may cause scorching during droughts or periods of high temperature. Likewise the application of pesticides when plants are wilted may cause damage that would not occur if the plants were in their normal state of turgidity. Other injuries such as stunting may occur. Research now underway indicates that insecticides and fungicides, with but few exceptions, all have injurious effects on plants, possibly serious if applied at too frequent intervals.

METHODS OF CONTROL

One of the first requirements for the control of plant pests is adequate equipment with which to apply the necessary chemicals.

The usual means of application are dusting, spraying, and fumigation.

Advantages of Dusting. Dusting is usually quicker than spraying, if for no other reason than that the dusts are usually prepared and ready, requiring no measuring and mixing. Applied with an adequate dust gun, they are usually more efficient, particularly in the hands of a novice, because of the fineness of the particles which whirl in all directions through the air. Dusting, however, must be done when there is absolutely no wind. However it may be done at any hour of day or night. Contrary to popular belief, the foliage should be dry when dust is applied, not wet with dew or rain. Moisture on the foliage may bring about concentration of the dusting material in drops of water. This is often followed by burning.

Dusting equipment is usually less expensive than satisfactory spray apparatus and therefore offers another advantage, especially from the standpoint of the home gardener. Dust guns with 2-qt. capacity are often more satisfactory than the smaller sizes. A handle on the top to keep the dust gun right side up may prevent uneven application of dust. A crank or bellows type of dust gun should be used when larger areas are to be dusted. The shaker type of dust gun sold with certain mixed dusts seldom does an efficient job of dusting. In applying the dust, only a microscopic film is necessary. Disfiguring overdoses are no more efficient and may injure foliage.

Advantages of Spraying. A few pesticides are available in liquid form but not in dusts. Spraying may be done when foliage is wet. It can also be done, although not so effectively, in a light wind whereas dusting cannot. On the other hand there is always the nuisance of having to mix a fresh batch of spray material each time since most sprays lose toxicity on standing. Furthermore, sprayers must be thoroughly cleaned after being used, and they cost more in the first place. But by the use of a hose and extension spray rods, larger plants may be covered with smaller equipment than by dusting.

Fumigation. Fumigation is limited to enclosed structures such as greenhouses or on a smaller scale to the treatment of individual plants or small quantities of plants in a box. Some of the newer chemicals, such as DD and chloropicrin, can now be used for outdoor soil sterilization.

SPRAY EQUIPMENT

Unless spray equipment is adequate, it is more or less useless. The inexpensive atomizers with quart cans or Mason jars as containers are seldom satisfactory except for individual plants. Compressed-air knapsack sprayers with 2- to 5-gal. tanks are all right when limited quantities of material are to be applied, but the old-style knapsack sprayer, pumped while operating, is not recommended. Bucket pumps and barrel pumps are relatively inexpensive but will do. Mounted on wheels or on a cart with an extra length of spray hose and 4 to 6 ft. of spray rod, they can be used for small trees as well as for the garden in general. Fifty- to a hundred-gallon sprayers with gasoline or electric motors are available. So are smaller portable electric and gasoline pumps with 20- to 25-gal. tanks. For liquid spray materials containing no solid ingredients small fuel-oil pumps driven by ¼-hp. motor may be used.

The present trend is toward power-driven equipment because it will develop a pressure of 100 or 150 lb. or more, as opposed to the average hand pump, which develops only 25 to 35 lb. pressure. It is therefore much more efficient, because it breaks up the spray into very fine particles. It is also more economical, using far less material. All small sprayers should have a 45-deg. elbow on the end of the spray rod to give adequate underfoliage application.

Dust Guns. Any dust gun to be effective should have a 2- or 3-ft. extension tube, equipped with a deflector on the end for the application of the dust beneath the leaves as well as on top. The smaller ones operated by a plunger are effective for small plants. For larger plants and larger areas a crank type or a bellows type is necessary.

When dusts are being diluted or mixed the diluent must be selected with care. Recent research indicates that talc, gypsum, infusorial earth, and diatomaceous earth are safe, having no effect on plants, whereas lime and bentonite have a stunting effect.

Spreaders. The leaves of many ornamental plants are covered with a waxy bloom. Most spray materials do not wet their surface but collect in droplets and run off, leaving them entirely free of spray. A spreader is therefore necessary to release the surface tension of the solution so that it will wet and cover the leaves. Soap, soap substitutes, calcium caseinate, and oil emulsions are used.

As they usually destroy the color effects of ornamentals, oils are not desirable. Soaps, especially in hard waters, tend to gum up the sprayer. The alkaline effect of soap is necessary with Black Leaf 40.

The soap substitutes are excellent spreaders or wetting agents. For home use Dreft, Swerl, Vel, Tide, and others may be used. Commercial spray spreaders include Santomerse S, Grasselli spreader, Tergitol No. 7.

Mixing Spray Materials

It is essential in the mixing of spray materials that all measurements be carefully and accurately made. Use soft water if possible. The best results will be obtained when the spray itself and the atmosphere are between 60 and 80°F. in temperature. Only standard measuring spoons and cups should be employed. The following table may be helpful:

3 tsp.	1 tbsp.
2 tbsp.	1 fl. oz.
4 tbsp.	¼ cup
16 tbsp.	1 cup
32 fl. oz.	1 qt.

To determine the amount of spray material to use when only the rate of dilution is given, use the following table:

Dilution	Tsp. per gal.	Tbsp. per 5 gal.	Oz. per 25 gal.
1 part to 1,000	¾	1¼	3⅓
1 part to 800	1	1½	4
1 part to 600	1½	2	5⅓
1 part to 500	1¾	2½	6½
1 part to 400	2	3⅕	8
1 part to 200	4	6⅖	16
1 part to 100	8	12½	32

PESTICIDES

There is unquestionably more carelessness and waste effort in pest control than in any other phase of gardening. All too many gardeners fail to distinguish between an insecticide and a fungicide. They fail to realize that Black Leaf 40 may kill aphis but be absolutely worthless in the control of plant diseases. Added to this are the often overly optimistic claims of some spray material manufacturers as to the merits and efficiency of their products.

The whole field of pest-control materials has been completely revolutionized by wartime developments and the use of new chemicals for both insecticides and fungicides. So many have been introduced that considerable confusion exists. Many pests heretofore difficult or even impossible to control can now be killed, and others previously controlled are better controlled. But with the new chemicals there are also new problems. For instance DDT is so effective that beneficial insects which have kept harmful species under control are themselves killed. This permits a few, such as red spider, to increase as it never before had the opportunity to do. And contrary to what might be expected the new pesticides are often more limited in the range of pests they control than some of the older but less efficient ones. All of this tends to make present-day pest control more complicated rather than simplified.

With the wealth of new compounds developed and being developed many of the chemicals now used may be discarded for others more efficient or in some cases less injurious to plants. Any material that is sufficiently active to kill a pest must necessarily affect the plant itself. It is therefore a problem to have a sufficiently wide margin of safety between a concentration strong enough to kill a pest and yet not strong enough to damage the plant itself seriously. For instance Bordeaux mixture is an effective fungicide, but it usually retards plant growth to such an extent that the yield is reduced. Pesticides should therefore be applied only when necessary and not as a habit.

Difficulty is encountered in making recommendations for the use of many of the new materials. As formulations and dosages have not been standardized, the directions on each individual container must be followed as has been the case in the past with many brands of rotenone and combinations of materials.

INSECTS

The term "insect" is loosely used since many, which are not true insects with six legs, are included. These are mites, centipedes, red spiders, sowbugs, slugs, and others.

The standard classification of insects into chewing and sucking means but little with the present-day control materials. It is more important to know what specific insecticides should be used. However a knowledge of the life history of each insect is helpful in determining the method of control.

In the past many insects could be killed only by stomach poisons taken in with their food; however, these poisons had no effect whatsoever on sucking insects. Today many of the newer insecticides not only kill by contact rather than as stomach poisons but have considerable residual effect. This gives a far wider range of use with fewer applications. On the other hand many of the new materials have a rather narrow range of effectiveness. They will control many pests but have little or no effect on insects apparently easier to kill.

The more important insecticides include DDT, B.H.C., H.E.T.P., Methoxychlor, Chlordane, Rotenone, Elgetol, and miscible oil. Others are listed in the alphabetical list of pest-control materials.

PLANT DISEASES

A plant disease may be caused by a parasite such as fungus, by bacteria, or by a virus. From the standpoint of the application of fungicides for their control, only those diseases which are specifically caused by an external organism can be considered, but it must not be forgotten that the various environmental factors previously discussed in this chapter are just as important in the cause of trouble as are specific organisms.

Fungi and bacteria of the type that develop on the outside of the plant as represented by leaf spots, rusts, and mildews are usually relatively easy to control. When, however, they are internal—entirely within the tissues of the plant—as is the case of blights, wilts, and the various mosaics produced by viruses, little or nothing can be done. If the infection is localized, in a branch or other part of the plant, it may sometimes be removed and destroyed before it spreads to the remainder of the plant. All diseases, but particularly those of the latter type, may often be controlled by the following methods.

Sanitation. This includes the clearing and burning of all diseased plants and rubbish and the planting of only healthy, disease-free plants if possible.

Disease Resistance. It is possible to obtain disease-resistant strains of a few garden plants and also a number of disease-resistant types of vegetables. Among the former are the wilt-resistant aster and rust-resistant snapdragon. Some rose varieties are more resistant to black spot than others.

Protection. Specific chemicals, or fungicides, may be applied to prevent disease organisms from entering the plant. Complete coverage is necessary for efficient control. In recent years cloth houses to protect growing asters from yellows and lilies from mosaic, carried from diseased to healthy plants by insect vectors, have proved practical. Even more recently the use of DDT to control leaf hoppers can be used to keep asters healthy without cloth protection.

Fungicides. For many years the common fungicides contained either a copper compound or sulphur. To these have been added new organic compounds including thiocarbamates, dinitro compounds, carbonyl compounds, and organic mercury compounds.

Thiocarbamates include Fermate, Zerlate, Parzate, Karbam, Zincate, Zimate, Dithane, Arasan, Tersan.

Dinitro compounds include elgetol and DN.

Organic mercury compounds include Puratize, Puraturf, Ceresan, Semesan, G.G.G., and DuBay.

Carbonyl compounds include formalin, Spergon, Phygon.

Inorganic mercury compounds include corrosive sublimate, calomel.

Copper compounds include copper oxide, copper carbonate, copper sulphate, basic copper chloride, copper oxychloride sulphate, tribasic salt of copper sulphate, copper phosphate. These are sold under a variety of trade names.

Sulphur is used in various forms as dusting sulphur, wettable sulphur, flotation sulphur, micronized sulphur, lime sulphur, and others under various trade names.

Unfortunately no one material has yet been found that is effective in the control of all diseases or satisfactory on all plants. Thoroughness is extremely important in applying all sprays and dusts; the entire surface must be covered. Fungicides are usually more effective when applied before a rain rather than after. Spores germinate during wet periods, and unless the plant is protected by a fungicide, it may become diseased.

LIST OF PESTICIDE MATERIALS

Aerosol Bombs. Some of the newer insecticides and combinations of them are put into special greenhouse fumigation bombs.

Arasan. A thiocarbamate dust used to treat lily bulbs and some cuttings. Tersan is same except it is for liquid treatment.

Azobenzene. Used as a dust or fumigant in greenhouses for red spider and mite control. Burns some foliages. Does not always give satisfactory control.

Benzene Hexachloride, B.H.C., 666. Except in purified form, the gamma isomer, it has a very disagreeable odor. Used for control of grasshoppers, wire worms (larva of click beetle), lace bugs, white flies, sowbugs, symphilids, millipedes, spittle bugs, red spider, mealy bug, leaf hoppers, and cockroaches. It has no residual effect, must be applied frequently until control obtained. 3 oz. to 100 sq. ft. of 25 per cent wettable powder is applied for soil insects.

Bordeaux Mixture. See Copper.

Calcium Arsenate. Has never been used to any extent on ornamentals.

Carbon Bisulphide. Highly inflammable, formerly used for fumigation of stored seeds and injection into anthills. Now replaced by DDT for seed storage and chlordane for ant control.

Calcium Cyanide. Now replaced by aerosol bombs for greenhouse fumigation.

Ceresan. An organic mercury compound used for seed and bulb treatment. New improved Ceresan is less toxic than regular Ceresan.

Chlordane. Originally called "1068." One of the newer materials especially effective against chewing insects. Available as 50 per cent wettable powder, in liquid form and as a 5 per cent dust for dusting. Sold under various trade names. Is better than DDT for control of grasshoppers, ants, and grubs in the soil. Also used for control of leaf miners. It does not however have as great a residual effect as DDT so that more frequent applications may have to be made. Do not apply to members of Cucurbit group. Apply as a 5 per cent dust, 20 lb. to the acre for grasshoppers. One pound to 2,000 or 3,000 sq. ft. ground area gives nearly 100 per cent kill of Japanese beetle grubs. For ants, $\frac{1}{8}$ tsp. of 50 per cent wettable powder is washed into each hill or dust surface of hills with 5 per cent dust three or four times.

Cryolite. A fluorine compound (sodium fluosilicate) formerly used for the control of blister beetles, now replaced by DDT. To dust, mix with 1 to 2 parts of a diluent but do not use lime.

Chloropicrin. Teargas, Larvacide. Used as a soil fumigant to kill soil insects and nematodes. Controls weeds only after seeds have started to germinate. Has but slight fungicidal value. Must not be used in soil in which plants are growing.

Copper. Bordeaux mixture is the oldest form but, because of stunting effect of the soluble copper in it and unsightliness on plants, it has been replaced by newer insoluble copper compounds. These include Cupro-K (basic copper chloride), Coposil (copper ammonium silicate), and Basi-Cop (basic copper sulphate), and others. In each case instructions on container should be followed.

Ammoniacal Copper Carbonate. Is sometimes recommended in place of Bordeaux mixture, since it does not stain the foliage, but it is not nearly so effective as the other copper sprays.

DD. Used as a soil fumigant for control of nematodes and other soil pests. Has no effect on soil-born diseases. No plants can be in ground when used and 2 weeks must be allowed before planting or sowing seed. Other materials now available for this same purpose include Iscobrome, Dowfume MC2, and Dowfume G. Be careful to follow instructions given for each particular material.

DDT. A general-purpose insecticide highly efficient for a wide range of insect pests. Has to a large extent replaced arsenate of lead. Gives efficient control of thrips, leaf hoppers, flea beetles, and spittle bugs. In ordinary form is not effective against red spider, nematodes, and many aphids. DDT has the disadvantage of killing insect parasites of some of these pests and beneficial insects depending on them so that its use increases the numbers of these pests. Aerosol grade of DDT is effective against many aphis. This form does not injure members of cucurbit family or young plants of tomatoes and beans as does regular DDT. DDT is also used for control of plant bugs in place of rotenone and for chinch bugs in lawns. Used in place of tartar emetic for gladiolus thrips on the growing plants and in place of napthalene on the corms. Better than molasses and nicotine for control of box leaf miner.

Other difficult pests now controlled by it are Holly leaf miner, lacewing fly, rose midge, and sowbugs. It has possibilities for control of crawling stage of many scale insects. Present indications are that the aerosol form of DDT (do not confuse with aerosol bombs) may give it even greater effectiveness. One advantage of DDT over other contact poisons is its residual effect of 10 days to 6 weeks or more depending on the degree of sunlight reaching and effecting it. Its use on plants usually infested with red spiders may cause difficulty. This would include, among others, garden roses, evergreens, phlox, garden chrysanthemums, and hardy primroses.

Earthworms and grubs are controlled by application of 1 lb. 50 per cent DDT or its equivalent to each 1,000 sq. ft. ground area. Apply with water or mixed with dry sand.

Diluents. Materials used to dilute chemicals to usable strengths in dusts. Includes talc, bentonite, hydrated lime, gypsum, diatomaceous earth, fuller's earth, kaolin, walnut-shell flour.

Dinitro Compounds. Elgetol and Dow Dormant are used as dormant sprays for the control of scale insects and aphis eggs. Must be used while plants are completely dormant or damage will result. Another DN compound is mixed with walnut shell flour to make DN dust for summer control of red spider. Elgetol is claimed by some to be superior to miscible oils for dormant control of oyster-shell scale. Also used for Euonymus scale. Elgetol has fungicidal value for turf diseases, peony blight, and other leaf diseases. Disadvantage is the yellow stain on operator's hands.

Dithane. A thiocarbamate fungicidal spray with some insecticidal value. Unless used with caution may burn foliage. Used on azaleas and camellias.

Dithiocarbamates. See Thiocarbamates, Fermate, Zerlate.

DN. See Dinitro Compounds.

Elgetol. See Dinitro Compounds.

Ethylene Dichloride. Used as a fumigant for seeds and bulbs. Emulsified form has replaced P.D.B. for control of peach-tree borer.

Fermate. An iron thiocarbamate. A black powder disfiguring to foliage unless mixed with other materials to lighten its color. One of best controls for rose blackspot and many other surface foliage diseases. Not effective against mildew.

Fish-oil Soap. Once widely used as spreader with insecticides and as a mild contact spray for some aphis and some scale insects. Largely replaced.

Fluorine Compounds. Once extensively used to control blister beetles, flea beetles, and other insects difficult to control otherwise. Now largely replaced by DDT. One of these fluorine compounds is Cryolite.

Formaldehyde. A carbonyl compound used as fungicidal disinfectant for bulbs and tubers. Used 1 part to 50 parts water. Soak ½ to 1 hr. Formerly used extensively in dust form to treat seedbeds until the use of a seedbed surface of sand, vermiculite, or sphagnum moss did away with need.

Fumigants. For greenhouse use, see Azobenzene, Aerosol Bombs, H.E.T.P., T.E.P.P., and Parathion. For soil fumigants see Formaldehyde, DD, and Chloropicrin.

Glue. Once used for red spider control. Now replaced by Dowspray 17, DN dust, H.E.T.P., and Parathion.

Hexaethyl Tetraphosphate (H.E.T.P.). An extremely poisonous material which must be used freshly mixed, if sprayed. Not usable as dust because of instability. If sprayed on soil, has stunting effect on plants. It has but little residual effect. Used chiefly for the control of red spider, mealy bug, mite, and aphis. Used as a fumigant for red spider. May be mixed with DDT but not compatable with Bordeaux or other alkaline materials. Present indications are that this may be replaced by other materials. See Parathion.

Lead Arsenate. Has long been one of the standard stomach poisons but is fast being replaced for use on ornamental plants by DDT and other of the newer insecticides, except for control of bagworms on evergreens. As a spray, arsenate of lead should be used at the rate of 9½ level teaspoonfuls to 1 gal. of water, or 1½ lb. to 50 gal. As a dust 1 lb. of it is combined with 10 lb. of an inert dust, preferably talc, but hydrated lime or even flour will do.

Lime Sulphur. Used as a dormant spray for scale insects and fruit diseases. Because of disagreeable odor and blackening of paint is seldom used on ornamentals.

Mercuric Chloride. Corrosive to metal, use only in earthenware, wood, or enameled metal containers. Used as disinfectant for gladiolus corms, calla corms, and pruning tools. Besides being very poisonous has disadvantage of retarding growth of treated plants. Used 1 part to 1,000 parts of water for dormant material, 1 part to 2,000 parts for growing material. Sometimes used for worm control in lawns, but DDT is safer.

Metaldehyde. A sulphonated alcohol used in commercial ant and slug baits. It is difficult to purchase except in prepared baits. See DDT and Chlordane.

Methoxychlor. Marlate. Similar to DDT but said to be less toxic to warm-blooded animals. Used as spray or dust. Has same residual effect as DDT but a quicker knockdown effect according to the manufacturer. Is effective against Mexican bean beetle, cucumber beetles, and leaf hoppers.

Methyl Bromide. Used as a fumigant for nursery stock and bulbs. Because of poisonous nature, proper equipment is absolutely necessary.

Napthalene. Formerly used for control of thrip on gladiolus corms and as a cyclamen mite repellent around Delphinium. Now replaced by DDT and other materials.

Nicotine. Is being rapidly replaced by newer materials. In the form of nicotine sulphate, usually sold under the trade name Black Leaf 40. Has long been the standard contact insecticide. It is used at the rate of ½ pt. of nicotine sulphate and 2 lb. of laundry soap to 50 gal. of water or 1½ tsp. of nicotine sulphate and 1 oz. of soap to 1 gal. of water. More difficult insects may require nearly double this amount, or 2½ tsp. of nicotine sulphate to 1 gal. of water. Nicotine is also used in dust form. For a 2 per cent dust use ¾ oz. of nicotine sulphate to 1 qt. of hydrated lime, or 2½ lb. of nicotine sulphate to 50 lb. of lime. For a 3 per cent dust, use 1 oz. of nicotine sulphate to 1 qt. of hydrated lime, or 3¾ oz. of nicotine sulphate to 50 lb. of hydrated lime. A 3 per cent dust is usually recommended. It is best to mix it fresh at frequent intervals. Black Leaf 155 is a 14 per cent fixed nicotine dust used primarily for root aphis.

Oil. Is largely for the control of scale insects but also for the winter control of aphis eggs. There are two types, miscible oils and oil emulsions which have been treated to be safe on growing tissue. Because of greater stability and therefore less danger, the former are preferable, but they should not be applied less than 6 weeks apart, or stunting may follow. They should not be sprayed on blue evergreens or on plants with glaucous foliage, for they will ruin the color effect. Dormant oil sprays can be used on woody plants only when the plants are completely dormant. So prepared that they will mix with water, they should never be applied when the temperature is below 40°F. or when it is likely to freeze before the spray material has had an opportunity to dry. Instructions must be followed. As a rule, 1 qt. of oil to 5 gal. of water (in summer, usually 1 pt. of oil to 5 gal. of water). Many of the cheaper, or quick-breaking, oils available for orchard work and those to which thiocyanates have been added are not safe for ornamental plants. Oil should never be sprayed on sugar maple, Norway maple, Japanese maple, beech, walnut, hickory, or magnolia.

Paradichlorobenzene (P.D.B.). Once widely used for peach-borer control. Has now been replaced by ethylene dichloride.

Parathion. Thiophos; 3422; Vapophos. A new material closely allied to H.E.T.P. Is extremely toxic to humans. Wear a mask when using indoors or when dusting outdoors. When spraying outdoors, avoid inhaling fumes. A 2 per cent dust effective in control of red spider. For spray, use 1 oz. of wettable powder in 25 gal. of water. Probably best spray for summer control of crawling stage of scale insects. Also controls aphis.

Paris Green. Although once widely used, this material is now obsolete.

Phenothiazine. Long used as a worm poison in livestock, but used in one all-purpose dust as a nonpoisonous substitute for DDT.

Phygon. A carbonyl compound used as a fungicidal spray largely for fruits and vegetables.

Puratize. An organic mercury compound used as a fungicidal spray for leaf and fruit diseases. So far has been used mainly on fruit trees. Puraturf is used for control of lawn-grass diseases.

Pyrethrum. Nonpoisonous to warm-blooded animals. Once widely used for contact spray for aphis. Often combined with rotenone. Now mainly used in combination with DDT in aerosol bombs for fly and mosquito control.

Red Squill. A rat poison not poisonous to other animals.

Rotenone. A contact spray or dust derived from derris and cube roots. Has some residual effect. Used in many mixed general-purpose dusts. Also available as a spray. Is a good aphicide.

Ryanex. Insecticide derived from a plant, Ryania, replaced by newer chemicals.

Sapodilla. An insecticide that came into prominence during the war for control of chinchbugs, tarnished plant bugs, and others. Replaced by newer materials.

Selenium. Used in form of sodium selenate as soil application to be absorbed by the plants. Can be used for control of red spider, mite, foliar nematode, and chrysanthemum midge on herbaceous plants. Gives only fair control of aphis. It should never be used on food plants because of its poisonous nature. It should be applied only to well-established plants, and the solution should be kept off the foliage as it will injure it. Dissolve 1 lb. in 4½ gal. of water or 1.5 oz. in 1 qt. of water. Make final solution with 1 qt. of this in 25 gal. of water. This treats 100 sq. ft. 2½ pt. in 6 gal. of water treats 25 sq. ft. Do not mix in any food utensils. Overdoses can be corrected by applying 5 lb. of gypsum per 100 sq. ft., or 1 lb. to 25 sq. ft.

Semesan. Largely replaced by Ceresan for bulb treatment and Spergon for seed treatment of ornamentals.

Spergon. A carbonyl compound used for seed treatment of flowers and vegetable seed. Has a far wider range of use than most seed treatments.

Sulphur Dusts. Must be sufficiently fine to pass through a 300-mesh screen. In general, the finer the sulphur, the more effective it is as a fungicide. When mixed, 9 parts of sulphur to 1 part of arsenate of lead (Massey dust), it may be used as a combined fungicide and insecticide. Best results are obtained if the temperature is between 70 and 90°F. Above 90°F. the foliage may be burned.

Sulphur Sprays. Call for the use of a specially prepared type of sulphur that will mix with water. This is called "wettable sulphur." The flotation type of sulphur, sold under trade names such as Flotox and Ultrafine, is finer in texture and, therefore, stays in suspension better than ordinary wettable sulphur, which is sold under such trade names as Mike, Sulfuron, Kolofog, Magnetic, Catalytic, Mulsoid, Mistbrand, and Micronizer. All these should be applied at the manufacturer's recommended strength.

Tartar Emetic. Once used for thrip control on gladiolus and as an ant poison. Now replaced by DDT and Chlordane.

INSECTS AND OTHER PESTS

Name	Description	Remedy
Lawns		
Ants	Needs none	Wash ⅛ tsp. 50 per cent wettable powder chlordane into each hill or dust 5 per cent chlordane over surface of soil. Repeat 3 or 4 times
Earthworm	Needs none	1 lb. 50 per cent DDT or 2 oz. 50 per cent wettable chlordane powder per 1,000 sq. ft. Apply dry mixed with sand, or mixed with water
White grub	White larva living in soil	Same as earthworm
Mole	Needs no description	Control grubs and earthworms, no mole food, no moles
Sod webworm	Larva ½–1 in. in length. Just beneath surface of lawn	Use DDT or chlordane. Dust or spray
Army worm	Brown-striped caterpillar. Eats entire lawn usually midsummer	Use DDT or chlordane
Chinch bug	Small, black, ⅛ in. long	Dust with 56 per cent DDT
Garden Flowers		
Slug	Slimy, snail-like. Feeds at night. Hides under leaves and lumps of soil during day	Dust soil and foliage with 5 per cent DDT or spray with DDT. Use metaldehyde bait
Grasshopper	Needs no description	Apply 5 per cent chlordane dust
Cutworm	Caterpillar. Hides by day. Cuts plants off at surface of ground at night	Apply chlordane to surface of soil Dust or spray
Sowbug	Gray, ¼–⅜ in. long. Rolls up when disturbed. Injurious around seedbeds	Dust or spray with DDT
Tarnished plant bug	Grayish bug, red or yellow spots, ¼ in. long; punctures leaves, buds, and petals of variety of plants	Dust or spray with DDT
Aphis	May be various colors, *e.g.*, green, red, black, gray; also various sizes	Black Leaf 40 spray, rotenone dust, or spray with B.H.C., H.E.T.P., or parathion
Cyclamen mite	Tiny mite causing blacking of delphinium flower stalks	DN dust, Dowspray 17 spray, parathion, dusting sulphur or B.H.C.
Red spider	See evergreens	H.E.T.P., T.E.P.P., or parathion
Phlox plant bug	Small bug ⅛ in. long. Punctures growing tip	Dust or spray with DDT
Japanese beetle	White grub in soil Adult—green and bronze beetle	Treat soil as for earthworms Adult dust or spray with DDT
Blister beetle	Gray-black beetle, ½ in. long, on flowers	Dust or spray with DDT
Thrip	Slender insect $\frac{1}{16}$–⅛ in. long. Difficult to reach in sheaths of leaves	5 per cent DDT dust, or spray with wettable DDT

INSECTS AND OTHER PESTS.—(*Continued*)

Name	Description	Remedy
Garden Flowers (*Continued*)		
Leaf hopper	Small, green insects on undersides of leaves. Leaves become curled, often grayish	Spray or dust with DDT
Root aphis	Bluish-green aphis on roots. Stunts growth, foliage yellows	Control ants which spread aphis Apply Black Leaf 155
Striped cucumber beetle	Yellow and black stripes. Eats holes in leaves	Spray or dust with aerosol form of DDT or methoxychlor
Stalk borer	Larva bores in stalks of various plants	Clean up and burn all rubbish in fall. Inject few drops rotenone in entrance hole, and plug
Columbine borer	Borer starts in stem, enters roots	Dig plants, and burn or cut out borer. Occasionally plant will live
Iris borer	Eggs laid on leaves in fall. Borer tunnels into rhizomes	Cut off leaves, and burn in early spring. Apply DDT as new growth starts
Columbine leaf miner	Tunnels visible as light lines in leaves	Try DDT or chlordane
Waterlily leaf miner	Tunnels visible as light lines in leaves	Cut off leaves, and burn
Flea beetle	Small black beetle eating small holes in leaves. Jumps when alarmed	Spray or dust with DDT
Woody Deciduous Plants—Trees, Shrubs, Vines		
Aphis	See Garden-flower Pests	
Red spider	See Evergreens Pests	
Leaf hopper	See Garden-flower Pests	
Canker worm	Females wingless, emerge from ground, caterpillars about 1 in. long, yellow-brown to black	Apply tanglefoot on paper band around trunk, October through April for fall and spring control. Or apply DDT as leaves start
Bagworm	Larva in bag 1 in. long covered with bits of leaves. Eats foliage	Pick and burn bags if only a few. Or spray with arsenate of lead or parathion as soon as they start feeding in spring
Borer (roundheaded)	Bores into trees near base of trunk; sawdust is indication	May sometimes be speared with wire or killed by carbon tetrachloride injected into holes
Rose-stem girdler	Swelling of branches by tunneling of larva	Cut and burn infested branches
Lilac borer	Tunnels near base of main branches	Same as roundheaded borer
Leopard moth	Bores in twigs and branches. Commonest on elms and maples	Cut and burn infested twigs in summer
Flatheaded borer	White borer just beneath bark of newly planted or weakened trees. Adult a grayish beetle	Wrap all trees with burlap or paper from branches to ground as soon as planted. Leave on for 2 years

INSECTS AND OTHER PESTS.—(*Continued*)

Name	Description	Remedy
Woody Deciduous Plants—Trees, Shrubs, Vines (*Continued*)		
Magnolia scale	Large, soft scales ¼–½ in. in diameter	Lime sulphur dormant spray. For small plants use stiff brush any time
Scurfy scale	Scurfy, whitish scale	Dormant spray with miscible oil
Euonymus scale	Female resembles oyster-shell scale. Male small and white	Thorough dormant spray with miscible oil. DDT or parathion every 10 days, June 1–Aug. 1
Oyster-shell scale	Small oval scales. Winters as eggs beneath scale. Hatches May or June	Dormant oil or Elgetol spray, or DDT or parathion, as eggs hatch in spring
San José scale	Small, dark gray, circular scale	Dormant oil spray
European elm scale	Large, soft scale on undersurface of branches	Dormant oil spray or summer contact spray. Easily controlled
Terrapin scale	Large scale, with strong odor. Found on maples	Oil is dangerous on sugar maples, use DDT or parathion as young emerge in June or July
Cottony maple scale	Attacks variety of plants, cottony mass on each scale	Early spring application of miscible oil except on hard maples. Use DDT or parathion as young emerge in July
Sawfly	Light-colored caterpillar eating foliage	DDT, applied immediately
Norway maple aphid	On undersurface of leaf. Gives copious honeydew	Spray in early summer with Black Leaf 40, rotenone, or parathion
Japanese beetle	See Common Garden Pests	
Elm-leaf beetle	Beetle yellowish ¼ in. long, eats holes in leaves early spring; larva eats undersurface of leaf	DDT when leaves half grown for beetles
Tussock moth	Larva red head, yellow-black markings	DDT on undersurface of leaves for larva
Boxelder bug	Gray, black, and red bug, ½ in. long	Remove all pistillate boxelder trees
Evergreens		
Bagworm	See Woody Plants	
Red spider	Almost invisible mite	Parathion, DN dust, Dowspray 17, B.H.C., or dusting sulphur
Arborvitae leaf miner	Brown tips to twigs	Remove and burn infested twigs in winter. 3–5 per cent DDT dust or spray wettable DDT, late May to early July
Holly leaf miner	Fine tunnels beneath upper surface of leaves	Remove and burn all infested leaves. Treat same as arborvitae
Box leaf miner	Very fine tunnels beneath upper surface of leaf	Dust with 5 per cent DDT or spray wettable DDT at weekly intervals, mid-May to mid-June
Pine sawfly	Light-colored caterpillar	Dust or spray with DDT

INSECTS AND OTHER PESTS.—(*Continued*)

Name	Description	Remedy
	Evergreens (*Continued*)	
Box psylla	Small, gray insect causing cupping of leaves	Apply contact spray in spring
Juniper scale	Small, light scale	Miscible oil 1 part to 20 parts water, early spring. Or dry lime sulphur 1 lb. to 3 gal. water
Euonymus scale	See Trees, Shrubs	
Juniper webworm	Needles webbed together	Spray before May 15 with 3 oz. arsenate of lead, 1 oz. dry lime sulphur, 5 gal. water. Use force in spraying
Pine leaf scale	Light-colored scale on needles	Spray when young hatch in June or later with DDT or parathion
Pine bark aphid	Wooly aphid on twigs and branches	Spray with contact spray
Spruce gall aphid	Swelling at base of new growth	Apply contact spray just before growth starts
Pine shoot moth	Larva burrows into new growth	Pick and burn infested tips. Apply contact spray three weekly intervals beginning late June
Rose slug	Greenish slugs skeletonizing leaves	Dust or spray with DDT
Rose chafer (rose bugs)	Yellow-brown beetles	Dust or spray with DDT
Leaf roller	Caterpillars within rolled leaves	Dust or spray with DDT
	House and Greenhouse Plants	
Aphis	See Garden-flower Pests	
Mealy bug	White, cottony masses	Spray with H.E.T.P.
Red spider	See Evergreen Pests	
Earthworm	Needs no description	Dust surface of soil with DDT
Sowbug	See Garden-flower Pests	
White fly	Tiny white insect on under-surface of leaves	Dust or spray with DDT or B.H.C.
Scale	Small scale insect found frequently in ferns, English ivy, and other house plants	For single plant scrub off with soft brush and water. Otherwise spray with Volck or dust with 5 per cent DDT

DISEASES OF GARDEN FLOWERS

Name of plant	Disease	Effect	Remedy
	Damping-off	Seedlings fall over, injured at surface of soil	Use seedbed of sand, vermiculite, or sphagnum moss
	Mildew	Grayish-white spots on leaves	Apply sulphur immediately

DISEASES OF GARDEN FLOWERS.—(*Continued*)

Name of plant	Disease	Effect	Remedy
	Leaf spot	Spots or blotches on leaves	Apply sulphur or fermate
	Leaf scorch	Margin of leaves injured from excessive heat or water on foliage in hot sun	Shade during excessive heat
	Root rot	Plant gradually wilting and dying	Remove and burn plant
	Wilt	Plant wilting	Remove and burn plant. Asters, grow wilt-resistant varieties
Cosmos..........	Stem blight	Small brown spots on stems, enlarge and girdle stem	Remove and burn plant
Clematis.........	Leaf spot, stem rot	Girdles stem at ground level	Burn all diseased parts. Apply fermate
Dahlia...........	Stunt	Plants stunted and dwarf	Destroy plants
Dahlia..........	Blossom blast	....	May be hot weather
Dahlia...........	Mildew	....	Dust or spray with sulphur
Delphinium......	Bacterial leaf spot	Irregular black spots on upper surface of leaves	Cut off and burn tops in fall. Drench ground with corrosive sublimate 1:2,000
Delphinium......	Crown rot and root rot	Yellowing of lower leaves, wilting and dying of entire plant	Remove all diseased plants. Drench ground with corrosive sublimate 1:2,000
Hollyhock.......	Rust	Brown spots on lower leaf surface	Remove old leaves before growth starts in spring. Apply fermate
Aster............	Yellows	Leaves yellow, flowers distorted	Lives over winter on perennial weeds. Carried by leaf hoppers. Apply DDT every 10 days
Aster............	Wilt	Plants wilt. Brown streaks on stems. Entire plant dies	Use only wilt-resistant seed
Iris.............	Rot	Rhizomes soft, smelly	Cut out diseased parts, allow sun to reach rhizomes
Phlox...........	Leaf blight	Lower leaves die, partly due to red spider	Dust sulphur or fermate June, July, August. Water well during dry spells
Sweet pea.......	Anthracnose	Leaves have white areas. Tips of shoots wilt	Worse near orchards. Treat seed 5 min. 5 per cent formaldehyde solution before planting. Burn all plants in fall
Sweet pea.......	Bacterial streak	Red-brown streaks on stems and leaves	Soak seeds few minutes in corrosive sublimate 1 tablet in 1 pt. water

DISEASES OF GARDEN FLOWERS.—(*Continued*)

Name of plant	Disease	Effect	Remedy
Tulip	Botrytis blight (fire)	Dark spots on leaves and flowers. May kill entire plant	Remove and burn bulbs. Plant in new ground
Tulip	Breaking (virus)	Flowers striped or streaked color	Remove and burn
Vinca	Leaf and twig blight	Kills leaves and twigs	Apply fermate. Propagate new stock from cuttings
Narcissus	Basal rot	Foliage yellowing prematurely. Base of bulb rotten	Dig and burn
Narcissus	Buds blast	Common with double-flowered varieties	No control except possibly more moist location
Snapdragon	Rust	Dark brown spots on lower leaf surface	Grow rust-resistant varieties
Aquilegia	Root rot	Plants yellow and die	No control. Keep new plants coming from seed. *A. canadensis* more or less resistant
Canna	Bud rot	Buds destroyed. Spots on foliage	Worse in some varieties. Select those which are resistant
Golden glow	Mildew	Gray spots or areas on foliage	Dust with sulphur in July; repeat
Peony	Nonblooming	May be due to shade, too deep planting, competition of tree roots, or botrytis blight	
Peony	Botrytis blight	Young growth wilts, or stems and foliage turn black, or buds turn brown	Cut off and burn in fall. Have soil clear of debris before growth starts in spring

DISEASES OF WOODY DECIDUOUS TREES, SHRUBS, VINES

Name of plant	Disease	Effect	Remedy
Ash	Flower gall	Staminate flowers greatly deformed. Unsightly but not serious	Dormant oil spray for mites
Beech	Die-back	Trees gradually die from top down. Due to lowering of water table and soil compacting	No control except loosening soil, mulching, and applying large amounts of water
Catalpa	Twig blight	Branches of *C. bungei*, wilting	No control. Cut out
Elm	Dutch elm disease	Withering and dying of branches and tree	Remove tree, and burn. Fertilize healthy trees, and maintain vigor
Elm	Phloem necrosis	Withering and dying of branches and tree	Control leaf hopper with DDT. Apply every 10 days, June 1–Sept. 1

DISEASES OF WOODY DECIDUOUS TREES, SHRUBS, VINES.—(*Continued*)

Name of plant	Disease	Effect	Remedy
Elm.	Slime flux	Exudation of sap from injuries	Insert drainage pipe at bottom of crack or injury to drip clear of trunk
Maple.........	Wilt	Wilting of leaves. Green streaks in wood	Cut off infected branches, and burn. Fertilize
Maple.........	Spray-oil injury	Sugar maples, many branches and even entire tree killed by oil spray	Apply fixed copper or fermate as leaves develop. Repeat at intervals of several weeks
Maple.........	Anthracnose	Irregular dead areas on leaf margins	No practical control
Poplar.........	Canker of branches	Areas of bark die, eventually killing branch	Avoid Lombardy poplars. Bolles poplar somewhat resistant
Willow.........	Twig blight	Bark on twigs and trunk newly planted trees, probably sunscald	Wrap trunk with burlap as soon as planted
Oak...........	Chlorosis	Yellowing of leaves	Increase soil acidity and available iron. Spray foliage with iron sulphate 16 lb. to 300 gal. water with spreader added. Or ½ lb. iron sulphate, ½ lb. powdered sulphur for each inch of trunk diameter. Apply in holes 12 in. deep, 12–18 in. apart, under branch spread of tree
Sycamore......	Leaf blight	New leaves blighted	Spray fixed copper or fermate as buds open, again as leaves develop
Horsechestnut..	Leaf blotch	Edges of leaves brown in midsummer	Rake and burn leaves in fall. Apply fixed copper or fermate as leaves develop in spring. Repeat several times
Lilac..........	Blight	Brown spots in early spring on leaves or stems of new growth	Remove and destroy diseased branches. Spray with fixed copper or fermate when open and again when fully open
Snowberry.....	Anthracnose	Dying of twigs and leaves, browning of fruit	Apply fixed copper or fermate several times during summer
Sumac.........	Twig blight	Branches wilt and die	Cut out and burn
Rose..........	Mildew	Dusty white spots on surface of foliage	Dust or spray with sulphur early June to September
Rose..........	Blackspot	Irregular black spots, often surrounded by yellow. Leaves eventually drop off	Dust or spray with fermate early June to September. Apply once a week and after each rain

DISEASES OF WOODY DECIDUOUS TREES, SHRUBS, VINES.—(*Continued*)

Name of plant	Disease	Effect	Remedy
Rose..........	Brown canker	Small reddish-purple spots on stems, leaves, or petals. Stem cankers later enlarge, sometimes girdle twigs	Prune heavily in spring, removing all cankers. Additional summer pruning may be necessary. Use dormant lime sulphur 1 lb. to 3½ gal. water before growth starts
Rose..........	Stem canker	Small yellow or reddish spots which turn brown as they enlarge. Cankered wood dries; bark cracks	Same as brown canker
Rose..........	Crown gall	Infection through wounds	When pruning, leave no stubs. Destroy infected plants

DISEASES OF EVERGREENS

Name of plant	Disease	Effect	Remedy
Rhododendron.	Phytophora Die-back	Dead leaves and twigs brown with cankers on twigs	Cut out and burn. Destroy diseased lilacs near by
Rhododendron.	Leaf spot and die-back	Dead leaves and twigs brown	Rose and currant cane blight same. Remove and burn diseased parts. Apply fixed copper or fermate
Kalmia........	Kalmia leaf spot	Light spots with darker margins on leaves	Destroy fallen and infected leaves. Spray several times with fermate June 15–Sept. 1
Rhododendron.	Leaf scorch	Due to excessive sun, lack of sufficient soil acidity	Plant in partial shade; maintain soil acidity
Ivy...........	Leaf spot	Brown spots on leaves	Hand pick, or use fermate
Euonymus.....	Crown gall	Enlarged growth on main branch	Destroy plants
Box...........	Winter injury	Twigs and main branches dying, sometimes not until summer	Remove injured branches. Water heavily in fall and winter
Box...........	Canker wilt	Attacks bark on branches; wood turns dark	Thin plants to allow sunlight to enter
Juniper........	Twig blight	Tips of twigs and entire branches dying	Cut out and burn. Spray or dust several times a season with fermate

DISEASES OF EVERGREENS.—(Continued)

Name of plant	Disease	Effect	Remedy
Juniper	Rust	Enlarged growth on branches of *J. virginiana*	Remove and burn infested twigs. One stage occurs on apple, pear, and flowering crab
Privet	Anthracnose	Twigs and branches wilting	Fixed copper or fermate in spring before buds open
Hemlock	Wind injury	Needles dropping off tips of branches	Protect from strong wind
Arborvitae	Unsatisfactory growing conditions	Leaves and twigs browning	Plant more satisfactory evergreens
Juniper (Irish, spiny Greek).	Unsatisfactory growing conditions	Lower branches and needles dying	Plant more satisfactory variety of juniper

DISEASES OF HOUSE PLANTS

Begonia	Leaf nematodes	Irregular brown spots between veins	Keep water off foliage. Remove and burn infected leaves
Gardenia	Bud drop	Buds drop when half developed	Proper culture, difficult in house
Gardenia	Chlorosis—may be due to alkaline soil or nematodes or lack of ammonium nitrogen	Foliage light color or yellowish	Apply ammonium sulphate and iron sulphate 1 tsp. to 1 qt. of water, give ½ cup to 6-in. pot
Geranium	Leaf spot	Brown spots on leaves	Destroy infected leaves. Apply fungicide
Paper-white narcissus	Gas in atmosphere	Buds develop but dry up and blast	Keep away from gas if possible
Hydrangea	Chlorosis	Yellowing of foliage	Apply aluminum sulphate ½ tsp. to 6-in. pot
Saintpaulia (African-violet).		Leaves with irregular yellow marks.	Keep cold water off foliage. Keep out of hot sun

T.E.P.P. Tetraethyl pyrophosphate is the active ingredient in H.E.T.P. Sold as Tetracide. Used as a spray or fumigant for control of red spider, mealy bugs, mite, and aphis.

Thiocarbamates. A relatively new group of fungicides including Arasan, Tersan, Fermate, Karbam, Parzate, Methasan, Zerlate, Zincate, Zimate, Dithane, and others. Some of these are available only in liquid form, others may be used for dusting or spraying. May give better control than sulphur or copper compounds. Apparently thiocarbamates have a tendency to irritate mucous membranes and cause sneezing, making their use for dusting disagreeable to many.

Thiocyanates. Includes Loro and Lethane. Formerly used in greenhouses for control of mealy bug and other insects. Danger of burning foliage at high temperatures. Now largely replaced by newer materials.

Toxaphene. Chlorinated camphene. Another insecticide, used for control of grasshoppers and boll weevils on cotton.

Wax Emulsions. Used to spray new plants to reduce water loss through evaporation. Dowax is one of the brands.

Zerlate. A zinc carbamate similar to fermate. Tends to burn foliage of apples and roses.

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CHAPTER XIX

GREENHOUSE MANAGEMENT

Plant requirements are the same in a greenhouse as they are outdoors; but the greenhouse, with its gradually evolving, automatic means of supplying conditions artificially, is becoming better and better equipped for plant growth.

For example, light, so necessary for photosynthesis, may be reduced in the summer by shading the glass with whitewash or shades, and in the winter electric light provides additional illumination. Temperature is automatically controlled by thermostats regulating the steam or hot-water circulation through pipes; ventilation, by similar controls attached to the ventilating apparatus. By means of air conditioning, which is finding its way into greenhouse management, both humidity and temperature may be controlled during either the summer or the winter. (Cold water flowing over tight greenhouse roofs during the summer is, of course, the simplest way to reduce temperature and increase humidity.) In some instances typical home air-conditioning units will serve. Watering, fertilization, and cultivation are taken care of by soilless culture, so that uniformity of growth is obtained and considerable labor saved. With crops growing in soil, automatic watering devices are gradually coming into use in the form of tensiometers and subirrigation for potted plants. Thus in a modern greenhouse practically every phase of the necessary factors of growth may be regulated or will be as greater perfection in methods and equipment is developed.

FACTORS

Light. Since many plants grown in the greenhouse are indigenous to climates of varying nature, light regulation is necessary. In the winter time its inadequacy is the greatest of problems because crop maturity must be secured at that time. Artificial light provides the answer except that the needed high intensity is extremely expensive. However, many crops respond to very low amounts of additional light.

In the summer excessive amounts of light must be reduced to secure proper development, as in the case of *Saintpaulia*, *Cyclamen*, and various tropical foliage plants. To a lesser degree this is true of rose and carnation, where reductions of light serve to keep the growth soft and flower color of higher intensity.

Humidity. Because of the artificial conditions that obtain in the greenhouse, the air is usually too dry for the majority of crops, and regulation of humidity is needed. It is provided by keeping the walks wet, sprinkling them by hand or irrigating them by systems that throw a fine mist on them or in the air. Humidiguides make it possible to determine the relative percentage of humidity, and such instruments should be employed where automatic regulation is not yet practiced. Crops vary in their humidity requirements, which should be learned if perfection is to be attained. For example, rose, gardenia, and orchid need relative humidities ranging from 60 to 90 per cent, especially during the warm seasons, whereas carnation, stock, and the various succulents grow much better at 25 per cent. Regulation of humidity is likewise essential in the control of various bacterial and fungous pests as well as in fumigation and spraying practices. The most common and universally used method of humidity increase is syringing the foliage with water. This practice is avoided, however, with crops possessing hairy foliage, *e.g.*, saintpaulia, tuberous-rooted begonia, and gloxinia, to prevent leaf damage. For instance, it has been found that the yellow ring spots in *Saintpaulia* Blue Boy are apparently due to the application of cold water when the intensity of light is high.

Moisture. Regulation of moisture in the soil is extremely important when plants are grown in the greenhouse. On the ability to water depends one of the major factors of success, and here to a large extent the structure of the soil and the adequacy of drainage enter in. With perfect drainage (in most greenhouses it is not adequate) and a uniform supply of moisture, good growth is assured, provided all other factors are controlled. The actual practice of watering usually depends on heavy drenching to provide the moisture and a subsequent partial drying to provide the air. Various "breakers" are attached to the hose to reduce pressure without sacrificing volume and thus supply the moisture without packing the surface of the soil. Crops vary considerably in their soil water requirements, so general rules cannot be made. Furthermore, it is important to realize that in bench-grown crops spot watering after planting young or dormant plants is essential. Spot watering refers to the application of moisture to the area around the plants and not the whole bench, until such time as root extension spreads into the soil between the plants. Plants with large root systems require more moisture than those with small ones. Those with fine roots demand less moisture than the coarse-rooted kinds. For example, rose requires more moisture than carnation, saintpaulia less than hydrangea and cineraria. Dormant plants like bulbs, hydrangea in the winter, and rose in pots started for Easter are provided with small amounts of water at first until root action develops. The season of the year likewise has its effect; obviously, during the winter waterings are fewer than in the spring and summer.

Temperature. Optimum temperatures for various greenhouse crops are determined by the natural habitat from which the plants come. Ordinarily greenhouse crops are divided into warm and cool sections. The warm crops require a temperature of 60° or higher at night with a corresponding rise of 5 to 10° during the day on cloudy days and even higher than that on sunny days. The cool crops are grown in temperatures varying from 45 to 55°F. at night with corresponding rises during the day.

The initiation of buds in the different crops depends on temperature. Many of the plants mentioned as cool will grow but fail to flower in higher temperatures; such is the case with stock, cineraria, calceolaria, primrose. As a consequence, the requisite temperatures should be adhered to.

Precooling of bulbs is based on the specific temperatures required to initiate flower-bud formation and secure earlier flowering. Narcissus, tulip, lilies, and bulbous iris are treated in this fashion. On the other hand, preheating of gladiolus corms, yellow calla, etc., causes earlier initiation of buds.

CROP TEMPERATURE

Cut flowers	Temperature	Pot plants	Temperature
		Warm	
Rose	58–62	Poinsettia	60–65
Euphorbia	60	Hydrangea	60–65
Gardenia	60–65	Kalanchoe	60–65
Gerbera	60	Rose	60
Lily	60–70	Saintpaulia	60–70
Lily-of-the-valley	75	Azalea (when forced)	60
Poinsettia	60–65	Gardenia	60–65
Orchid	60 and up	Bedding plants	60
		Tropical plants	60–70
		Cool	
Carnation	46–48	Hydrangea (at start)	55
Chrysanthemum	50	Calceolaria	55
Snapdragon	50	Cineraria	45–50
Stock	45–50	Primrose	50
Calendula	45–50	Chrysanthemum	50
Aster	50	Camellia	40–45
Bouvardia	55	Genista	50–55
Sweet pea	50	Azalea (at start)	45–50
Bulbs	50 and up	Lily (at start)	50
Annuals (miscellaneous)	50	Geranium	50
Violet	45		
Stevia	50		

Ventilation. The greenhouse ventilators are provided for the purpose of admitting the needed carbon dioxide from the outside and the regulation of heat and moisture. They should be raised or lowered to avoid sudden changes of temperature and too rapid circulation of air.

Opening ventilators should be a practice during the winter as well as summer. It is better to waste some heat in the winter than to exclude the outside air. Caution should be observed, however, in order to avoid the sudden changes that occur in winter from temperature drops.

During the summer, conservation of humidity may necessitate the closing of all side ventilators and the reduction of air through the top ones, especially when roses are being started back after being dried off in order to keep the stems soft and cause development of new buds or when carnations are first benched and until they become established, etc.

Nutrition. In soilless culture fertilizers may be applied automatically, but the subject of nutrition calls for careful consideration when crops are grown in soil. Usually if bench or potting soils are properly prepared, with good structure, sufficient organic matter, and adequate nutrients, the problem of further fertilization will depend largely upon soil tests, which are sufficiently indicative so that they may be followed successfully. Likewise visual symptoms of deficiency and overdoses are fairly well known and may be used as guides.

Soils should be fertilized only when the need arises, when the plants are large enough to absorb the needed nutrients, when they are vigorous and not diseased, when the season of the year warrants. Then fertilizers should be given in proper proportions and adequate doses and always when the soil is moist; damage is apt to occur from high concentrations.

CROPS

The many flowering crops grown in the greenhouse for commercial and private purposes require specific conditions for successful development. Obviously it is impossible to discuss these in detail in the space of one chapter, but the essential points of culture will be given.

Rose

Roses grown under glass belong to the hybrid tea group and are usually budded or grafted on *R. manetti* or *R. odorata* understocks, although in some cases own-root plants are employed. The usual planting time for own-root and grafted roses is in May and June out of 4-in. pots, the plants having been propagated during the winter and spring, preceding the planting. Budded roses, either dormant buds or started eyes, are best planted in a dormant state, out of cold storage in January or February. They may be planted later, however, provided they are first potted and are thus planted in a growing condition.

Any soil with one-fourth to one-third organic matter, preferably manure, of good physical structure, with a pH of 6.5 and a content of nutrients of nitrogen (25 p.p.m.), phosphorus (10 to

15 p.p.m.), potassium (30 to 50 p.p.m.), and calcium (150 p.p.m.), and well drained will grow roses satisfactorily. Steam-sterilized soil is to be preferred, largely because of its more suitable structure. The amount in the bench need not be over 5 in.

Planting distance is usually 12 in. each way. After planting, spot watering is practiced until the root system develops, and it is important, since most failures occur from an improper growing start. During the initial period of development, high humidity is desirable. As soon as possible after planting, roses should be staked, using 5-ft. galvanized No. 9 wire stakes, one to a plant. These are attached by clips to a No. 18 wire stretched above the plants and fastened to supports at the end of the bench or bed. As the new shoots develop, each is tied to the stake with white string, loosely enough to allow proper aeration and at points where the string will not interfere with the cutting.

Temperatures maintained vary from 56 to 62°F. at night. The cool varieties belonging to the Talisman group should be grown at 56 to 58°; others are best grown at 58 to 60°F. Day temperatures may be 10 to 15° higher.

General cultural practices call for adequate ventilation at all times and high humidity, particularly during the summer. Watering should be thorough, so that the water drains through the openings in the bench bottom or through tile in V-shaped beds. Improper drainage with subsequent lack of aeration causes loss of roots. The easiest method to determine the need of water is by means of trowel insertion. If the trowel has no moisture or particles clinging to it when withdrawn from the soil, water is needed. At present, attempts are being made to provide automatic equipment to regulate watering.

Fertilization should depend upon soil tests. Higher nitrogen content is needed during the extremely active periods of early fall and late spring. During winter, because of lack of light, and during the summer, because of extreme heat, the supply should be reduced. Medium-high phosphorus and high potassium, particularly during the winter, are essential.

Once planted, rose plants usually remain in the same soil for a period of 4 years. During that time two methods of procedure are employed to check growth. One consists of a definite rest period given by reducing the soil moisture to a point of almost complete drying and yet not shriveling the bark. This is done during the early summer months and requires about 10 to 15 days. After the drying period, the plants are cut back and started into growth again by applying water to the soil and keeping the humidity high in the greenhouse. No applications of fertilizers should be made until proper foliage development has taken place.

The second method consists of cutting each stem back into harder wood below the normal cut. By starting in late spring or early summer and cutting each stem back, in the course of two or three months the plants are in a condition to continue growth. Reduction of moisture during this cutting-down period provides a partial rest period. Thus the grower is enabled to continue cutting throughout the year, although the difference in the total cut for the year between the two systems will not be significant.

Roses should be cut with stems as long as possible, the cut being made to the first five-leaflet leaf above the emergence of the stem being cut. However, variations are used, depending upon the time of the year and the variety. Usually new stock after planting is allowed to produce as many shoots from the bottom as possible to build a strong plant. This is accomplished by soft pinching the new shoots. Soft pinching means the removal of the terminal buds close to the tip.

Roses may be cropped by pinching. During the spring and summer approximately six weeks is needed to develop a crop from a pinch. During the winter eight weeks is needed. Cropping is practiced for such holidays as Christmas, Easter, and Mother's Day to supply the heavy demand.

Stem length determines the grading system. The more common grades are 9 to 12, 12 to 15, 15 to 18, 18 to 21, 21 to 24 in. To secure these in some varieties, soft pinching of the terminals is necessary because of a tendency to produce short stems. For exhibition purposes, three and four such pinches are made, taking 25 to 40 weeks to produce a flower on a 4- or 5-ft. stem. Average production is approximately 25 flowers per plant, and on such a basis rose growing is profitable. Higher averages may be secured if optimum conditions are obtained.

The most serious troubles of the rose are the mildew and blackspot diseases which are controlled by proper ventilation and the use of sulphur dusts on the foliage and sulphur fumes from heating pipes. Red spider, thrips, midge, and aphids constitute the major pests, control measures for which consist of the proper spray applications and heavy syringing with water in the case of red spider.

Carnation

Cool nights, abundance of sunshine, care in disease control, and knowledge of watering are the factors in successful carnation culture.

Carnation is propagated by stem cuttings taken from growing tips or from side shoots growing from the axils of the leaves of flowering stems from December to March.

After potting the cuttings, two principal methods are used in carrying them on. One consists of growing them in pots or planted closely in benches of soil and the placement in their permanent locations during early summer. The second method calls for planting the young stock out in the field as soon as weather permits and then benching these developed plants in the greenhouses in July or August. In either case constant pinching of the terminal growth is necessary to produce bushy plants. Final planting distances are either 7 by 7 or 8 by 8 in.

Any well-drained soil with an organic content of about one-fourth will grow good carnations. The pH range of the soil is between 6.0 and 7.5. Steam-sterilized soil has proved very effective. High calcium content as well as high potassium are conducive to stiff stems. The nutrient relations may be expressed as nitrogen, 5 to 15 p.p.m.; phosphorus, 2 to 10 p.p.m.; potassium, 15 to 25 p.p.m.; and calcium, 200 p.p.m.

The carnation is a cool crop and grows best in temperature ranges of 46 to 48°F. at night. The humidity should be low, and the soil kept on the dry side, particularly in the fall and winter. At planting extreme care in watering is essential to develop a good root system and prevent accumulation of moisture at the base of the stem, since this leads to a very destructive disease known as *stem rot*.

Carnations are supported by wire and string and by a new wire mesh that fits over the bench, eliminating the string.

Fertilization should follow a soil-testing routine.

The most serious troubles that develop are calyx splitting, which is usually hereditary and is intensified by high amounts of fertilizers, overabundance of water, and fluctuations of temperature; fungous disturbances, which can be held in check by spraying with Fermate or Zerlate; such pests as red spider, thrip, and aphids. Azobenzine or Parathion fumigation is an efficient remedy for red spider, and the others may be readily controlled by proprietory sprays or Parathion.

Carnations are graded by the size of the flower and the length of the stem. The production per plant varies from 10 to 20 per year.

Chrysanthemum

The chrysanthemum is a cool crop grown with fair success in almost every greenhouse. A fibrous loam soil, neutral in reaction and well drained, should produce a good crop. New plants are propagated by cuttings taken in the spring from stock plants carried over winter in cold houses in well-drained raised benches.

Several classes of chrysanthemum are used: the incurved, or globular; the reflexed, where the florets curve away from the center; the anemone, with high centers and regularly arranged ray florets; the singles, composed of a cushion of disk florets surrounded by one row of ray florets; and the pompons, which may be flat flowered, globular, single, or anemone. The last are distinguished by shorter, well-branched habit and numerous flowers on each plant.

A further subdivision may be made by classifying these groups according to habit of growth—the standards, the disbuds, and the spray or pompons. The standards comprise the large-flowered types, which are grown to one, two, or three stems. The disbuds are smaller flowered types grown with several stems per plant, each stem disbudded to a single flower. The pompons produce several flowers to each stem, and from 6 to 10 stems or even more may be produced on each plant.

Planting takes place from May until July, the plants being spaced about 8 in. apart. Cuttings produced either are potted far enough in advance of planting to ensure a well-rooted plant or else are benched directly from the propagating bench into the soil. Those which are to be shaded should be planted in May, but the later flowering varieties need not be benched until July.

During the early period of growth, the most desirable temperature of 50 to 60°F. cannot be maintained, but later in the fall it should be used. General care consists of the maintenance of comparatively low levels of nutrition—nitrogen, 10 to 15 p.p.m.; phosphorus, 5 to 10 p.p.m.; potassium, 10 to 15 p.p.m.; and calcium, 150 p.p.m. Thus fertilizer additions need not be frequent and should be discontinued when the color shows in flowers. A mulch of acid peat is beneficial. Standard varieties of chrysanthemum are supported by stakes or by white strings attached to the base and to a wire strung lengthwise above. Pompon varieties are wired and strung in squares like carnations.

In case of the standards and disbuds, vigorous growth results in the appearance of side shoots in the axils of the leaves. These should be removed religiously just as soon as they appear. In the same manner all basal shoots should be kept down. Pompons and disbuds are pinched in the early stages to provide several stems, the former allowed to develop without disbudding, whereas the disbuds are kept to a single flower bud.

Another process known as *taking buds* is practiced with standards. Standards produce two types of buds, the crown and the terminal. The first to appear is the crown bud, and it is distinguished by being surrounded by vegetative shoots. Usually it is removed, and one of the vegetative shoots is allowed to elongate. Later in the season this shoot produces a cluster of flower buds—the terminal buds. One of them is selected as the final flowering bud; the rest are removed. This selection of the final bud is known as *taking the bud*.

Chrysanthemum responds to the reduction of daylight period by the use of black cloth to ensure earliness and likewise to additional illumination to produce late flowering. Proper manipulation of lighting and shading will produce the crop the year around.

Sweet Pea

Winter-flowering sweet pea is characterized by the development of vegetative growth first, flowering, and then branching. Winter production is profitable only if optimum conditions of light and soils are provided. At best, bud drop will occur during the winter, so every precaution should be used to provide maximum quantities of light. Additional light has to date proved too expensive.

Well-drained, deep soils of good crumb structure are needed for sweet pea. Because of its deep-rooting propensity, deeply worked ground beds are desirable. Raised benches may be used but require greater care in watering and fertilization. In gravel culture sweet peas do extremely well in raised benches. Steam-sterilized soils are good.

Very little fertilization is needed in the fall and winter, provided that phosphorus, potassium, and calcium are supplied at the beginning. Nitrogenous applications are not needed until spring. Watering by subirrigation has proved satisfactory in the lighter soils and where the subsoil is hard enough to prevent runoff.

Seed of sweet pea is usually sown in double rows, 6 in. apart, and spaced in beds 24 to 36 in. If planted directly in the soil, 1 oz. of seed will cover 30 ft. of row. Instead of direct planting, seed may be started in sand or in 2½-in. pots and transplanted later. Starting in August and planting successively in September, October, and December, a continuity of cropping will result from Christmas until May.

Abundance of water, temperatures of 48 to 50°F., and free ventilation are essential. Supports consist of wire and string.

The most important difficulties arise from bud drop, usually due to poor light and succulent growth; damping-off; mildew; and streak. Soil sterilization and dusting seeds with copper compounds reduce damping-off; sulphur dusts check mildew; and high potassium is thought to correct streak. Red spider, aphids, thrips, and nematodes are the most serious pests.

Snapdragon

Snapdragon is propagated by seed sown in succession from June on and planted in August or later. The soils most satisfactory should be of high organic content, coarse structure, comparatively low nitrogen content, and pH of 6 to 7.0. While in pots before planting in benches, which are preferable to ground beds, the plants should be pinched to produce well-branched specimens. Planting distance is usually 8 by 8 in.

High humidity during the summer and spring and low humidity during winter are advisable. Temperatures of 45 to 48°F. are best, together with adequate ventilation at all times.

The most serious diseases are rust, bacterial blight, and damping-off. Aphids, mites, leaf tyers, and sow bugs constitute the worst pests. Blasting of buds is usually due to cyanide fumigation.

Orchid

The majority of orchids may be divided into two classes—the terrestrial and the epiphytic. The former grow in soils composed of organic matter deposited on forest floors; the latter, on branches of trees in tropical regions where a part of the year is unfavorable to vegetation, so that special structures called *pseudobulbs* terminate each season's growth. Nutrition is secured by absorption of moisture and through accumulation of organic matter about the fleshy roots. Among the more common genera *Brassocattleya, Cattleya, Dendrobium, Laelia, Laeliocattleya, Miltonia, Oncidum, Phalaenopsis,* and *Vanda* are epiphytic, whereas *Calanthe, Cymbidium,* and *Cypripedium* are semiterrestrial.

According to their mode of growth, orchids fall into two groups—the monopodial and sympodial. In the monopodial group the growth of the main stem is continued indefinitely by the terminal bud. This bud growth may be interrupted by periods of rest, but this rest is not manifested on the stem by the formation of scales. *Vanda* is typical of this group. The sympodial orchids terminate the growth of each shoot after one or two years. Growth of plant is continued by buds originating in the axils of the creeping stems. One or more buds may develop in this fashion at a time.

Orchids are propagated by division or seeds. All genera that develop pseudobulbs are propagated by division of the rhizome into sections, each containing several pseudobulbs. Terrestrial orchids like *Cypripedium* are likewise divided into sections.

There is no mystery about the matter of orchid-seed germination or the process of seed sowing. Numerous failures have resulted solely from faulty technique in one or several steps of the procedure. The process is not difficult if adequate equipment and conditions are provided. A knowledge of bacteriological technique, however, is a decided advantage.

Orchid seeds are undeveloped embryos. Unlike most seeds they do not possess sufficient stored food for seed germination and subsequent development. Experimental research has demonstrated that an outside supply of food must be supplied. Whether this food is supplied directly as in the case of sugar in a nonsymbiotic medium or by the reduction of organic materials to simple sugars by the so-called symbiotic fungi, the final result is the same. Available sugar, chemical salts, water, and a proper hydrogen-ion concentration (pH) in connection with proper light and temperature are all necessary for success.

Preparation of Mediums. *Culture Flasks.* Erlenmeyer flasks are most suitable as culture containers. Some prefer the 1-l. capacity for extensive work, but the 500-cc. size is easier to handle.

Clean Glassware. The flasks and all other glassware used should be cleaned with the following solution:

40 g. commercial potassium dichromate
150 cc. of tap water
230 cc. of commercial sulphuric acid

Heat water; dissolve the potassium dichromate; and allow to cool. After cooling, add acid in small quantities *slowly* until all has been added. Use care in this procedure, as the heat generated may break the glass container. *Never use a metal container for this solution.* To clean, pour the mixture into glassware; turn flasks, tubes, and other glass equipment, covering all surfaces. Handle with care. Pour off the liquid, which may be saved and used again. Rinse glassware in water, thoroughly removing all acid.

Culture Mediums. Knudson's solution B has proved very satisfactory. The formula is recommended as follows:

Stock Solutions

Salt	Amount
$Ca(NO_3)_2$ (calcium nitrate)	50.0 g. in 950 cc. of water
K_2HPO_4 (potassium phosphate)	12.5 g. in 988 cc. of water
$MgSO_4.7H_2O$ (magnesium sulphate)	12.5 g. in 988 cc. of water
$(NH_4)_2SO_4$ (ammonium sulphate)	25.0 g. in 975 cc. of water

Prepare these stock solutions in separate bottles for future use.

In making the mediums use 20 cc. of each of these stock solutions in 920 cc. of water for 1 l. of solution, as suggested in the following table.

Material	1 l.†	2 l.	5 l.	10 l.
Calcium nitrate	20 cc.	40 cc.	100 cc.	200 cc.
Potassium phosphate	20 cc.	40 cc.	100 cc.	200 cc.
Magnesium sulphate	20 cc.	40 cc.	100 cc.	200 cc.
Ammonium sulphate	20 cc.	40 cc.	100 cc.	200 cc.
Iron phosphate	0.05 g.	0.10 g.	0.25 g.	0.5 g.
Agar-agar	18 g.	36 g.	90 g.	180 g.
Dextrose* (sugar)	20 g.	40 g.	100 g.	200 g.
Water	920 cc.	1,840 cc.	4,600 cc.	9,200 cc.
Number of 500-cc. flasks	6	13	33	66
Number of 1-l. flasks	4	8	20	40

* Maltose is reported to be as effective.
† 3.78 l. = 1 gal.

1. Add agar to water, and melt over a slow fire. Melting at too high a temperature scorches the agar and darkens the solution. Agar melts at approximately 95°F. and solidifies at 45°F. A pressure cooker, autoclave, or large double boiler may be used for melting it. If a pressure cooker or autoclave is used, do not place a lid tightly over the container of agar and water, because unequal pressures will cause the solution to boil over if the container is nearly full.

2. After melting, filter the solution through a double thickness of cheesecloth with a pad of *absorbent* cotton between the layers. This will remove all foreign material. This step may be omitted if a clear agar solution is not desired.

3. Add the chemical solutions and the sugar. Stir well.

4. After all ingredients have been added and thoroughly mixed, check the pH of the solution for acidity. Its range should be between 4.5 and 5.2. This is important because outside this range orchid-seedling growth will be very poor.

For checking the pH a potentiometer is by far the most accurate instrument. However, it is expensive and not easily accessible. The Soiltex colorimetric method will therefore be accurate enough. This consists of a colorimetric indicator and a color chart. A few drops of the indicator on a few drops of the solution will result in a color change of the solution. The color is then matched on the color chart, which indicates the approximate pH.

If the pH of the solution is above 5.2, it may be reduced by the addition of 0.1*N* hydrochloric acid. To prepare 0.1*N* hydrochloric acid, add 1 cc. of concentrated acid (35 per cent) to 99 cc. of distilled water. If distilled water is inaccessible, tap water will do. Add enough acid to reduce the pH to approximately 4.7, because, after autoclaving and cooling, the final pH will be around 5.0. Use extreme care in adding the acid; it is easy to add too much and reduce the pH below the optimum. This technique is best worked out on a trial sample of water or other liquid, so that one may become familiar with the reactions.

In extreme cases the initial pH may be below 4.5. Then $0.1N$ sodium hydroxide is used to adjust the pH. This is prepared by dissolving 4 g. of stick sodium hydroxide in enough water to make 1,000 cc. Add the solution in the same way in which the acid is handled, but remember that the pH increases with the addition of alkali and decreases with that of acid.

The agar solution must remain in a liquid state during the period of pH testing and subsequent pouring into the flasks. To be on the safe side it may be best to leave the sugar out of the solution until the proper pH is adjusted, to prevent carmelization. After the adjustment add the sugar.

5. After adjusting the pH the solution is ready to be poured into the flasks. Use 150 cc. of medium for a 500-cc. flask and 250 cc. for a liter flask.

6. Plug the flask openings with *nonabsorbent* cotton, and cover with a square of brown paper to keep the cotton clean and reduce the chances of contamination by microorganisms.

7. Steam sterilize the flasks in an autoclave for 30 min. at 15 lb. pressure. If a pressure cooker is used and 15 lb. pressure cannot be maintained, increase the time to 1 hr.

8. Remove the flasks from the sterilizer, and set upright so that the agar will solidify in a level position. This is a decided advantage in seed sowing. Some prefer to slant flasks on an angle; but special racks are necessary, and contamination from microorganisms is much more likely than when placed upright.

9. If seed sowing is not to be done for several days, place the flasks in a place free of air currents and drafts, and cover with a clean cloth. They may be put in a refrigerator, but the reduction of moisture is sometimes a disadvantage.

Seed Sowing. This procedure demands the utmost care and attention. Poor technique will result in complete failure, but an observation of several cardinal points will help greatly in overcoming difficulties so often encountered.

Cleanliness is absolutely essential. The air is full of micro-organisms which float around on particles of dust, and it takes only *one* mold spore or bacterium to ruin an otherwise sterile culture.

Seed sowing should be done in a room or culture chamber free of air currents.

Procedure. *Seed Sterilization.* 1. Sterilize orchid seeds with calcium hypochlorite solution, 10 g. in 140 cc. of water. Add enough water to make a thick paste. Mix thoroughly. Add the remainder of the water, and stir. Allow to stand 15 min., and filter off the liquid. It will smell of chlorine. Pour it in a flask, and stopper. It should not be prepared until seed sowing is to be done, as it loses its strength within 2 days.

2. Sterilize seeds in *small* vials or test tubes. Put a small clump of seeds in the vial, and then half fill it with the calcium hypochlorite solution. Shake thoroughly to separate all the seeds; they have a tendency to stick together, and if not separated some of the mold spores or bacteria may not be killed. After thorough shaking allow to stand 15 min. Shake frequently, as seeds tend to float to the surface. NOTE: Usually the seeds turn a bright orange color, then become white or light tan. This is merely an oxidizing reaction of the hypochlorite solution with the fatty material on the seeds and in no way hinders germination.

3. After the seeds are thoroughly sterilized, they are ready to be planted. Sterilize a platinum loop, as used by bacteriologists, by passing it over an open flame. Cool, and pick up a clump of the seeds. Remove the cotton plug carefully, and flame the neck of the flask. Hold the plug between the second and third fingers, never touching the part that was inserted in the flask. Then hold the flask with the thumb and forefinger of the left hand. Tilt the flask slightly, and insert the loop with the seeds with the right hand. Be careful not to touch the inside wall of the flask with the loop. Place the seeds in the moisture of condensation collected on the surface of the agar. Remove the loop; flame the neck of the flask; and insert the cotton plug. Rotate the flask slightly, spreading the seeds evenly over the surface. Do not sow seeds too thickly.

Instead of using a platinum loop, a sterile pipette may be used to advantage. Place the rubber bulb of a medicine dropper over the end to pull the seeds up into the tube. Do not use a larger bulb, because too much vacuum pulls the seeds into the bulb and many are wasted. It is best to have at least one pipette for each variety of seeds to be planted to eliminate chances of mixing the varieties. Pipettes must be sterile.

4. After all seeds are sown, it is best to place over the *non-absorbent* cotton plug a square of *absorbent* cotton 6 by 6 in. that has been soaked in a 1:1,000 solution of bichloride of mercury. Squeeze out excess mercury solution; cover the cap with a square of moistureproof cellophane, and wrap it tightly with copper wire or an inverted jelly glass. The latter procedure is an added precaution against contamination after the flasks have been placed in the incubator.

Caution: Bichloride of mercury is poisonous and is best handled with rubber gloves. Do not place the solution in metal containers—it will corrode them. Glassware or graniteware is satisfactory.

5. Flasks may be properly labeled on the ground-glass area on each flask or by individual celluloid or pyralin labels tied on with copper wire.

Care of Flasks. For best germination, seed flasks should be placed in a somewhat shaded area of a greenhouse or in a special incubator. The temperature should never get below 70 or above 95°F. The relative humidity should be approximately 75 per cent. Place the flasks in an area where they will remain clean, where no drafts occur, and not too close to the heating pipes. Avoid excessive handling; it is best never to pick up the flasks, because this merely increases opportunities for contamination.

A small percentage of contamination may be expected. In such cases remove the contaminated flasks unless the seedlings have developed to a stage in which they may be transplanted. Seedling development is usually arrested by competition of the microorganisms and is likely to become stunted. The most common contaminating organisms are the molds. Bacteria are rarely severe, because they grow best on an alkaline medium and the acid medium optimum for orchid seedlings is unsuitable.

Transplanting. In 3 to 9 months' time after sowing seeds the seedlings will have developed a root system, strong enough for transplanting. This is shown by the appearance of several white roots. The medium for transplanting is clean osmunda peat, packed into 2½-in. pots, with about 50 seedlings pricked in each. These are kept in Wardian cases with high humidity and a temperature of 75°. In 9 months' time the second transplanting takes place, this time 25 seedlings to the pot. These are again transplanted, and finally they are set in individual pots about a year or longer after germination. Transplanting from the culture-medium flasks does not differ essentially from the method described, except that the seedlings are larger when removed from the flask and do not require so many transplantings. When grown in peat and sand mixtures, the young plants are first transplanted to larger flasks and then to pots as in previous cases.

Potting Mediums. The potting medium for orchids depends in composition upon their habits of growth.

Terrestrial orchids, like *Calanthe,* require a medium composed of one-half fibrous loam, one-fourth leaf mold, one-fourth sand.

Semiterrestrial (*Cypripedium*) need a medium of one-third chopped sod, one-third leaf mold, one-third osmunda peat.

Epiphytic—(*Cattleya* and others). Osmunda peat makes the best medium for this group.

Potting. Special orchid pots with holes on the sides are no longer used for the majority of commercial orchids. Neither are baskets. Hard-baked, 5- or 6-in. pots are used instead. One-fourth of the pot is filled with broken crocks, on top of which a little of the potting mixture is spread. The plant is then set on top of this, roots spread out, and the potting mixture tamped very firmly into the pot, working it toward the center with a stick. Care should be taken not to break the roots and also to have the rootstock always near the top. The season for potting depends on the genus and the potting is usually done just before active growth begins or when the terminal buds break.

General Culture. Watering, ventilation, and temperatures are extremely important phases of orchid culture. After repotting, little watering is given until growth starts; then the maximum amount should be used until the flower sheaths are well developed; after that it should be reduced. Frequent syringing and wetting of walks is needed throughout the growing period. After flowering, when most genera are in a state of rest, watering and syringing should be at a minimum. Free circulation of moist, warm air is also necessary. Temperatures vary with the genera, from the cool temperatures of 50°F. for *Odontoglossum* to 65 to 70° for some species of *Vanda, Oncidum,* and *Miltonia.*

GRAVEL CULTURE

Although osmunda has been the standard potting medium for orchids for many years, potting in it is a slow operation even where hydraulic dibbles are used. It also dries out unevenly because of uneven potting and different degrees of decomposition of the osmunda. This results in a lot of uncertainty in watering.

With the discovery of haydite as a medium for growing plants, attempts were made to grow orchids in this medium. Tests have been running for the past 8 years. During that time, haydite has proved itself to be a very satisfactory potting medium for orchids.

Haydite is an inert medium of clay and shale fused together at high temperatures. Two grades are being used: FF, which is a fine grade, the particles ranging in size from 1/16 to 1/8 in.; and B, which is a coarse grade, the particles ranging in size from 1/4 to 3/8 in. The fine grade is suitable for seedlings in 2½- to 3-in. pots. The coarse grade is recommended for larger plants. Haydite provides anchorage, excellent drainage, and excellant aeration, all of which are very important for good growth.

Upon receipt of haydite, examine it for dust particles and wash it to remove this fine material. If this is not done, the fine particles cake in the bottom of the pot, resulting in poor drainage.

Some support is necessary in haydite to hold the plant until it becomes established in the pot. This may be taken care of very satisfactorily by using No. 9 wire, and bending it as illustrated in Fig. 74. The wire clamps down over the rim of the pot and is held there with a small ring. A clamp of this type can easily be made with the aid of a vise, wire shears, and a hammer. It not only is a good support and stake for the plant, but also can be used for hanging the plants when necessary.

Vermiculite has been used as a potting medium for both seedlings and flowering plants. It is not a satisfactory medium for orchids. Quartz gravel can be used as a potting medium. It does not dry out as quickly as haydite, however, and watering must be watched.

Subirrigation. Subirrigation in the next few years may become the cheapest and the best methods of growing orchids. Experiments have been running for about 5 years at both Missouri Botanical Gardens and Ohio State University. Several commercial growers are well satisfied with the results obtained.

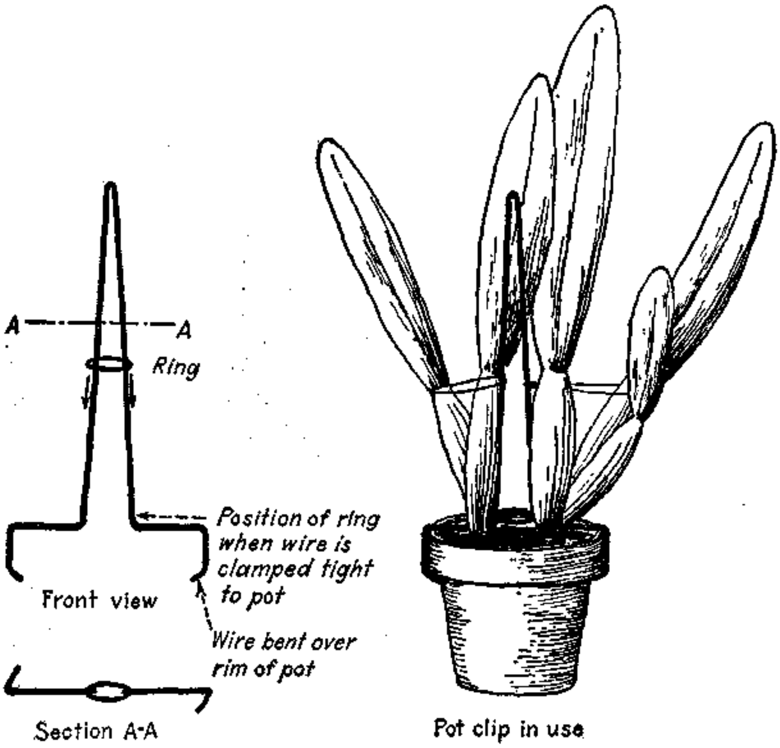

Fig. 74.—Orchid pot clip.

Young plants may be planted directly in haydite or quartz gravel, but should be potted before root systems become tangled. Mature plants should be grown in pots and plunged in haydite.

The requirements for subirrigation are a watertight bench, intake and outlet valves, a tank for nutrient solution, and a pump. The best method of subirrigation is to plunge the pots in B-grade haydite up to the rim of the pot. The benches are then flooded approximately once in 2 weeks, depending on climatic conditions and the condition of the plant. Water should stand in the bench for about 6 hr. to get proper absorption. This method may be used for orchids planted in haydite or in osmunda. Plants in osmunda should not be watered so frequently as those in haydite.

Fertilization. It is advisable to fertilize plants in osmunda, but it is not absolutely necessary, since there are some nutrients in the osmunda. With haydite, however, it is imperative. Fertilization must be practiced for best results. In the case of subirrigation, the nutrient solution can be pumped up into the bench each time the plants are watered. When watering overhead in haydite, it is advisable to fertilize every other time watering is done. Ohio WP solution used at half strength is very good. The pH should range between 5.0 and 5.5 for best results.

OHIO WP

Chemicals	Per 1,000 Gal. of Water
Potassium nitrate, KNO_3	5 lb. 13 oz.
Ammonium sulphate, $(NH_4)_2SO_4$	0 lb. 15.5 oz.
Magnesium sulphate, $MgSO_4 \cdot 7H_2O$	4 lb. 8 oz.
Monocalcium phosphate, $CaH_2(PO_4)_2 \cdot H_2O$	2 lb. 6.5 oz.
Calcium sulphate, $CaSO_4 \cdot 2H_2O$	10 lb. 12 oz.

Manganous sulphate should be added to all solutions each month. One ounce of manganous sulphate is dissolved in 1 gal. of water acidified with 3 to 5 drops of commercial sulphuric acid. All this solution should be used for 1,000 gal. of nutrient solution. Iron should be added weekly in the form of ferrous sulphate at the rate of 4 oz. per 1,000 gal.

Various trade-marked soluble fertilizers have not proved so satisfactory as the one-half WP solution.

Transplanting. When possible, it is best to shift from community pots to fine haydite. Use coarse haydite when shifting into 4-in. pots or larger. The reason for this is that, when small, the plants require more moisture. The fine haydite retains moisture longer. Then, too, fine haydite gives more anchorage for the small plants which do not have much of a root system when young.

When transplanting from osmunda to haydite, do not leave any osmunda around the roots. This procedure in repotting will save a lot of trouble. The osmunda becomes saturated with water, while the haydite is dry. As a result, the roots in the osmunda rot off and the growth is retarded.

Pests. Comparatively few pests attack the orchids. Scales, thrips, and snails are their worst enemies, for which DDT and Parathion are effective.

Miscellaneous Crops—Cut Flowers

Crop	Soil	Fertilizer	Temperature	Propagation	Planting and remarks
Calendula officinalis.....	Any well-drained, fibrous loam. pH6–7	Superphosphate in soil. Ammonium sulphate when needed	45–48	Seed. September sow for January benching	12 by 12 in.
Aster (Callistephus hortensis).	Any well-drained, fibrous loam. pH6–7	Superphosphate in soil. Ammonium sulphate when needed	50	Seed. Sow in July, bench in August for January with additional light. Bench in February for May with additional light	10 by 10 in. Use light from time of potting—4 hr. per day, 25-watt lamps
Bouvardia humboldti and hybrida.	Add leaf mold. pH7–7.5	High potassium. Light application of nitrogen	55	*B. humboldti*—cuttings in spring. *B. hybrida*—root cuttings March	12 by 12. May or June. Shading will bring crop in early
Buddleia asiatica.......	Any good soil	Light nitrogenous applications	50	Cuttings—March	Use 7-in. pots. Dry off after March. Start old plants into growth in August
Boston yellow daisy (Chrysanthemum frutescens).	Any good soil. Aeration important	Nitrogenous applications helpful	50	Cuttings in August. Plant in November	12 by 12. Additional light beneficial. Exceptional growth in gravel culture
Candytuft (*Iberis amara*) Centaurea cyanus Clarkia elegans Chrysanthemum coronarium Didiscus coeruleus Larkspur (Delphinium ajacis) Salpiglossis sinuata	Any good soil. pH6–6.5	No additions *necessary* after initial soil preparation	50	Sow seeds in January for late spring or in November if lighted	8–10 in. apart. Additional light causes considerable earliness. Do well in gravel culture
Euphorbia fulgens......	Heavy soil, well drained. pH6.5	Light nitrogenous applications in fall to produce longer *stems*	60 but may be grown in lower for late bloom	April from cuttings. Bench in July. Pinch*ing necessary*	10 by 10 in. Shading helpful. July 15, *flower September*. September, flower in December. Does well in gravel culture

Crop	Soil	Fertilizer	Temperature	Propagation	Planting and remarks
Feverfew (Matricaria capensis).	Fibrous loam. pH7	Little needed	50	Seed or cuttings January planting, flowers in late May. Additional light on October-benched plants—flower in February	12 by 12 in. Additional light exceptionally satisfactory. Exceptional in gravel culture
Gypsophila elegans......	Shallow benches or flats—good loam	Little nitrogen—otherwise stems lodge	45–50	Seed sown in succession directly in rows	Rows 6–8 in. apart. Additional light helpful
Gardenia veitchii and grandiflora.	Well drained. No fresh manure. One-third acid peat. pH5.5–6.5. Shallow soil. Do not overwater. Use peat mulch	Inorganic best. Nitrogen—not too high. Ferrous sulphate needed	50–55 in September for bud set. 60°. Humidity high. Good ventilation	Cuttings, November–March either in sand or in pots of peat. Use grafting case. Temperature, 75–85°	May—18 in. apart. Additional light of 20 ft.-candles or more increase production and earliness. Bud drop—over fertilization, poor aeration, poor drainage. Temperature too high. Good in gravel culture
Gerbera...............	Light loam, one-fourth manure. pH7–7.5. Ground beds preferred	Fall and spring. Light nitrogenous application	55–60	Seed or division.	Early fall. Crowns above soil. Does well in gravel
Pansy (Viola tricolor)...	Light, well-limed soil	Light nitrogenous applications needed	45–50	Seed in July, bench in October	10 in. apart. Light increases production. Does well in gravel culture
Stevia (Piqueria trinervia)	Light loam. Good drainage. One-fourth organic matter	Little	45–50	Cuttings from stock in January	Pot in 7 in. Keep out in frames. Bring inside in September. Shaded in September will flower in November
Statice suworowii	Light loam	Little	45	Seed in October	8 by 8 in.
Stock (Matthiola incana)	Light loam. Best in beds	Little. Some lime needed	45–48	Seed in succession, either direct in bench or from pots from August on	3 in. in row, 6 in. between rows for nonbranching. Branching—6 by 8 in. Precooling in fall brings about earliness. Doubles identified by indented leaves

BULBS, CORMS, AND TUBERS

Crop	Propagation	Time to start	Conditions at start	Maturity
Achimenes	Rhizomes in leaf mold and sand	March and April	Grow in 65° in moist house. Shade glass to avoid sunscald	Summer and fall
Amaryllis hybrids	Seeds or offsets	Pot in heavy loam in October	Rest in summer. Grow in 65–70°. After flowering fertilize with 4–12–4	January
Anemone coronaria	Seed or root division	Pot in October in shallow pans	Grow in 50°	January to March
Calla (Zantedeschia aethiopica).	Offsets	Pot in August–October in 6- or 7-in. pots in light, well-drained soil with one-fourth manure. Use bichloride of mercury treatment before potting	Grow in 55°. Abundance of water	Flower from December to May. Dried off completely in May and until planting
Lily-of-the-valley (Convallaria majalis)	Offsets from pips or crowns	Any time of the year	Set pips in closed shaded case in sand closely together—rows 2 in. apart. Bottom heat 80°, top heat 75°. First 2 weeks little air or light. Harden after that	Will mature in 3 weeks
Freesia refracta alba	Cormlets	Plant in flats, benches, or pots, closely. Use soil—3 parts loam; 1 part leaf mold, manure, or peat	Plant in August, 55°F.	Christmas or later. Browning of tips due to early overwatering, later underwatering, fumigation
Gladiolus hybrids	Cormlets	December and January 2 in. apart in rows spaced 6–8 in.	Light, medium-fertile soil, high phosphorus. 50°. Preheating for 3 weeks 80° in moist atmosphere will cause early flowering	May and June. Additional light too costly because of high intensity required
Hyacinth (Hyacinthus orientalis).	Bulblets—by scoring or scooping	Pot in September or October 1 to 4-in. pot; 3 to 5-in. pot; 4 to 6-in. pot. Well-drained, porous soil	Place in cold storage at 45–50° or outdoors with a covering of soil and straw. Prepared, bring in late November. Place in 70–75°	Prepared—Christmas. Normal flowering requires 3 weeks in 60–65°
Iris (bulbous)	Bulblets	Flat in September, deep flats, light soil	Bulbs 1½ in. apart. Keep cool until November, then grow in 50–55°	Normally bloom in January. For Christmas use precooled. Bring in greenhouse in November. Keep at 50°F.

BULBS, CORMS, AND TUBERS.—(*Continued*)

Crop	Propagation	Time to start	Conditions at start	Maturity
Ixia	Cormlets	September or October. In flats 1 in. apart	Keep cool. Bring to greenhouse in December. 50–55°. Plant in frames and cover	March and April. Bloom in May
Lilium longiflorum erabu, giganteum and varieties.	Bulb scales	Pot in 5–6-in. pots all year for succession. For Easter pot in December.	7–9- and 8–10-in. bulbs most common sizes. Keep in 50° until 6–8 in. high. Then raise temperature to 56° and later 60° or higher	Takes 13–14 weeks after tips show above pot during spring. Less time later. After buds show—6 weeks to maturity. High humidity, high temperature reduce forcing time. Additional light is helpful. Do exceptionally well in gravel culture
Lilium speciosum	Bulb scales	Pot in January. Pot in July. Pot in May. Pot in November. Use 8–9 in. bulbs	55° 55°	June, July, August. Christmas. September. February–March. May be grown under lath during summer
Narcissus (various species) Tazetta hybrids require no outdoor storage.	Slabs from bulbs	Pot or flat in September or October. Set closely together	Storage at 45–50° or outdoors covered. For normal bring in January, and force at 55–60°. Precooled bring in November, and force at 50°	Normally February and later. Precooled Christmas
Ornithogallum lacteum	Bulblets	Pot in October or November	55°	March or April
Tulip	Bulb slabs	Pot or flat in September or October.	Storage at 45–50° or outdoors	January on. Precooled for Christmas

Potted Plants

Crop	Propagation and time	Soil	Special treatment	Maturity and remarks
Astilbe japonica	Division of clumps in spring	Light, fertile, porous. Nitrogenous applications needed while forced	Pot in fall after frost. Temperature 55–60°F. Abundance of water needed. Hot-water treatment at 110°F. for 1 hr. in October	14 weeks from potting. Used for Easter 40–60 days earliness
Azalea indica and kurume types.	Cuttings and grafting	One-third acid peat, one-third acid sand, one-third loam. Use acid-forming fertilizers such as cottonseed meal and ammonium sulphate. pH5	In autumn pot and place 45° until March. Later raise to 50°. Early forcing 45° to November, then 60–65°. In January 60–65°	Easter. Christmas. Valentine's Day
Begonia Melior	Leaf cuttings. November–December	Soil should contain one-third leaf mold or peat and sand. Add 4–12–4 and well-rotted manure to potting soil. pH6	Temperature 58–60°. During summer shade glass and provide humidity. Staking necessary	Christmas. Do not syringe overhead to avoid foliar nematode spread
Begonia semperflorens	Seed in fall	Fibrous soil and peat. pH6	Temperature 62°	May and June
Calceolaria hybrida and integrifolia.	*C. hybrida* by seed in August. *C. integrifolia* by cuttings in August	pH6. One-fourth manure added to loam. 4–12–4 should be used in potting soil	55°. In December in 3-in. pots. In January in 5-in.	April. Additional light will bring plants into flower in February
Camellia japonica	Cuttings and grafting during fall and winter	One-third acid peat and loam. Good aeration and drainage. pH 4–5. Repot only after finish flowering	November until flowering temperature 42–45°. After flowering raise to 60°. Summer under lath with pots plunged or in greenhouse with shade on roof. Prune after flowering	November to March, depending on variety
Chrysanthemum hortorum	Cuttings in May or June	Well-drained, fibrous soil. pH6.5	Pot 3 cuttings in 5- or 6-in. pot or pan in July. Pinch until late August. For shading pot in May or June. Shade July 1 for Sept. 1 bloom	October to November

POTTED PLANTS.—(*Continued*)

Crop	Propagation and time	Soil	Special treatment	Maturity and remarks
Cineraria cruenta	Seed from June on	One-fourth manure with sandy loam. Later shifts *should have 4–12–4 added.* Nitrogenous applications will help size	Use pans instead of pots, better aeration. Tempera*ture 45–50°F.*	From Christmas to Mother's Day
Cyclamen persicum	Seed from August to December. Germinate in 4–5 weeks in 60°F.	One-third well-rotted manure one-third loam, one-third leaf mold. Good drainage. pH6.5. Add horn shavings later	Keep cool in summer. Shade roof and ventilate. General winter temperature 50°F. Require abundance of water	Christmas to April
Fuchsia hybrida	Cuttings in November–March from stock plants rested in August and started into growth in September	Fibrous, porous loam, one-fourth manure. Respond to complete fertilizer. pH6.5–7	Temperature 55–60°. 2½-in. plants panned in 6-in. pans in January	Make excellent Mother's Day plants
Gardenia veitchii	Cuttings in December–March	One-half acid peat in soil. Little fresh manure. Use ammonium sulphate in liquid form. pH5.5–6.5	Pinch until Aug. 15. During summer high temperature and humidity. Set buds in August and September for Christmas by dropping tem*perature to 50°. Later* when buds set 60–62°. For Easter drop temperature and keep on dry side in January	All year, starting with Christmas
Geranium (Pelargonium hortorum).	Cuttings in fall from stock plants grown indoors or out	Firm soil with one-fourth sand for drainage. Little nitrogen until final shift in April—then use 2–10–10. pH7	Pinch to produce bushiness. Keep on the dry side. Buds should show 5 weeks before flowering. General temperature 55°	Mother's Day, Memorial Day
Gloxinia (Sinningia speciosa).	Seeds January or February	3 parts loam, 2 parts manure, 1 part sand. pH6.5	Careful watering. Keep foliage dry. Shade needed. Good ventilation	July and August
Hydrangea hortensis	Cuttings in February	3 parts loam, 1 part manure, 1 part peat. Keep in pots all summer or in beds. pH6–6.5. Ammonium sul*phate is useful*	Pinch after setting in field in July. Lift from field in September. Keep cool until Dec. 26 for Easter forcing. *Use aluminum sul*phate for bluing—1 lb. to 5 gal. water. Use of ferrous sulphate 4 oz. to 5 gal. clears the blue color	Start forcing at 54–56° in late December. Keep on dry side. Raise temperature later to 60° or higher de*pending on Easter date.* Old plants may be carried over for next year

POTTED PLANTS.—(*Continued*)

Crop	Propagation and time	Soil	Special treatment	Maturity and remarks
Kalanchoe blossfeldiana......	Seeds and leaf cuttings in January	Fibrous, well-drained soil with little nitrogen	Pan 2¼-in. plants three to a 6-pan. Keep on dry side. Humidity low. Temperature 60–65°	October to May. Shading will bring plants in early. September to October 20. Shading, will flower at Christmas
Lantana camara.............	Cuttings in fall	Medium-heavy soil	60°F.	May on
Pelargonium domesticum.....	Cuttings in fall	Light, fibrous soil	50°F.	April, May
Petunia hybrida............	Single varieties—seed in January. Double varieties—cuttings in September	Light, fibrous soil. Little nitrogen	45–50°F.	May
Poinsettia (Euphorbia pulcherrima)	Cuttings in May–August, from stock plants started in April. Take soft cuttings between nodes. Immerse in water 5 min. Close atmosphere first 5 days	3 parts loam, 1 part manure. pH6.5. Little fertilizer until after panning in the fall	Pan in October, 3 plants to a 6-in. pan. 60–65°. Do not overwater. Lower temperature a week before Christmas	Christmas. Affected by artificial illumination
Primula obconica, malacoides.	Seed from February to June	3 parts loam, 1 part manure, pH6.5–7	45°F.	Christmas and spring
Rose......................	Budded plants. Field grown	Heavy, fibrous soil. One-fourth manure. pH6–6.5	Trim and pot in November. Keep in cold house or cold frame until January. Syringe canes, and gradually raise temperature to 60°F.	Easter and May. Buds should show 2 weeks before needed
Saintpaulia ionantha and hybrids.	Leaf cuttings rooted in sand or sand and peat or potted in sandy soil. Bottom heat of 65–70°. Any time of year	3 parts sandy loam, 1 part leaf mold, 1 part well-rotted manure. No further fertilization needed	Make small shifts or grow in bench and pot in 3-in. pots. Heavy shade needed. Between 350–800 ft.-candles sufficient for growth and flowering. 60–62°. Good ventilation	6–9 months from cutting to 4-in. pots. Subirrigation is a satisfactory method of watering. Mite a serious pest
Solanum pseudocapsicum.....	Seed in January	Fibrous loam, little nitrogen	55°. Plunge pots outdoors during summer	Christmas

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