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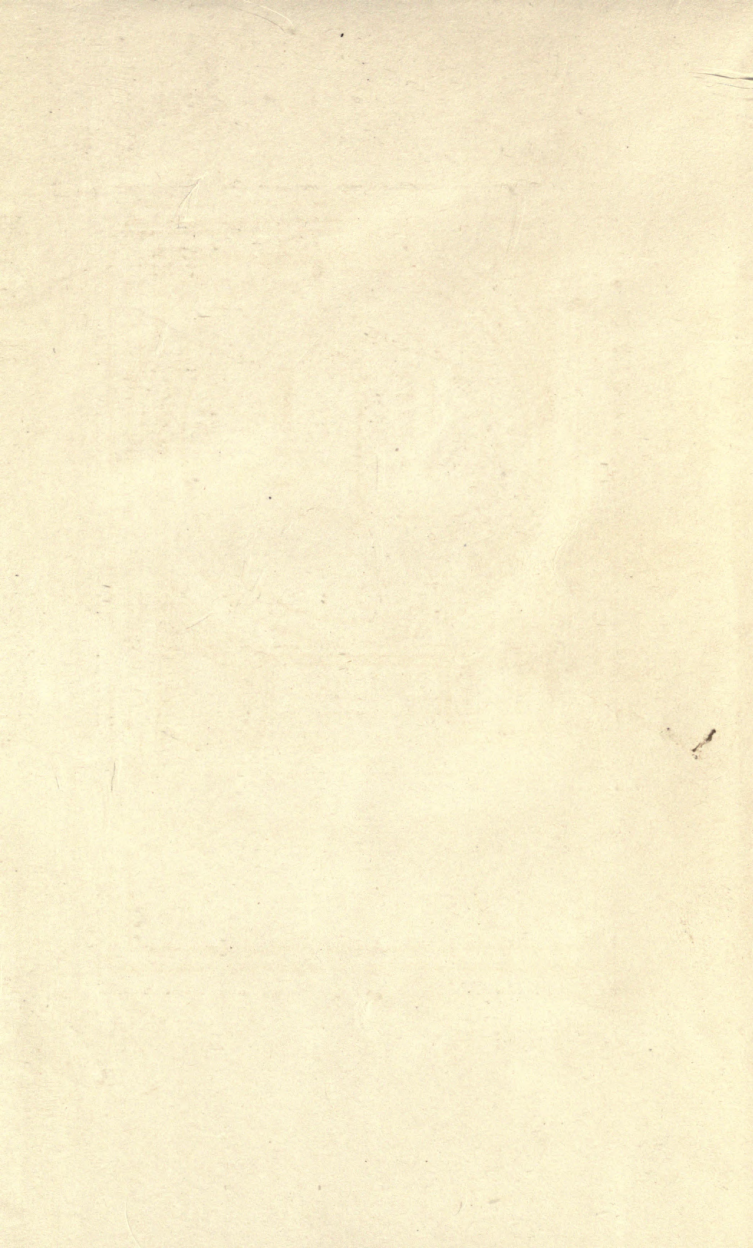


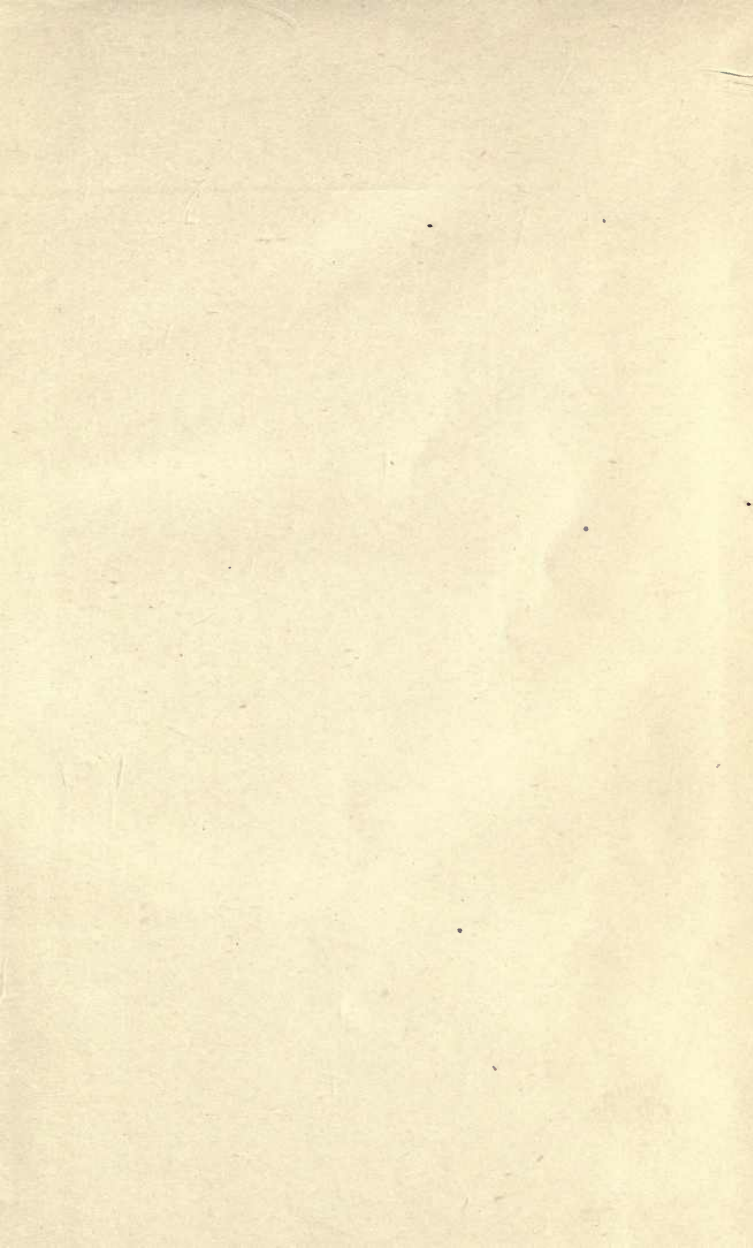
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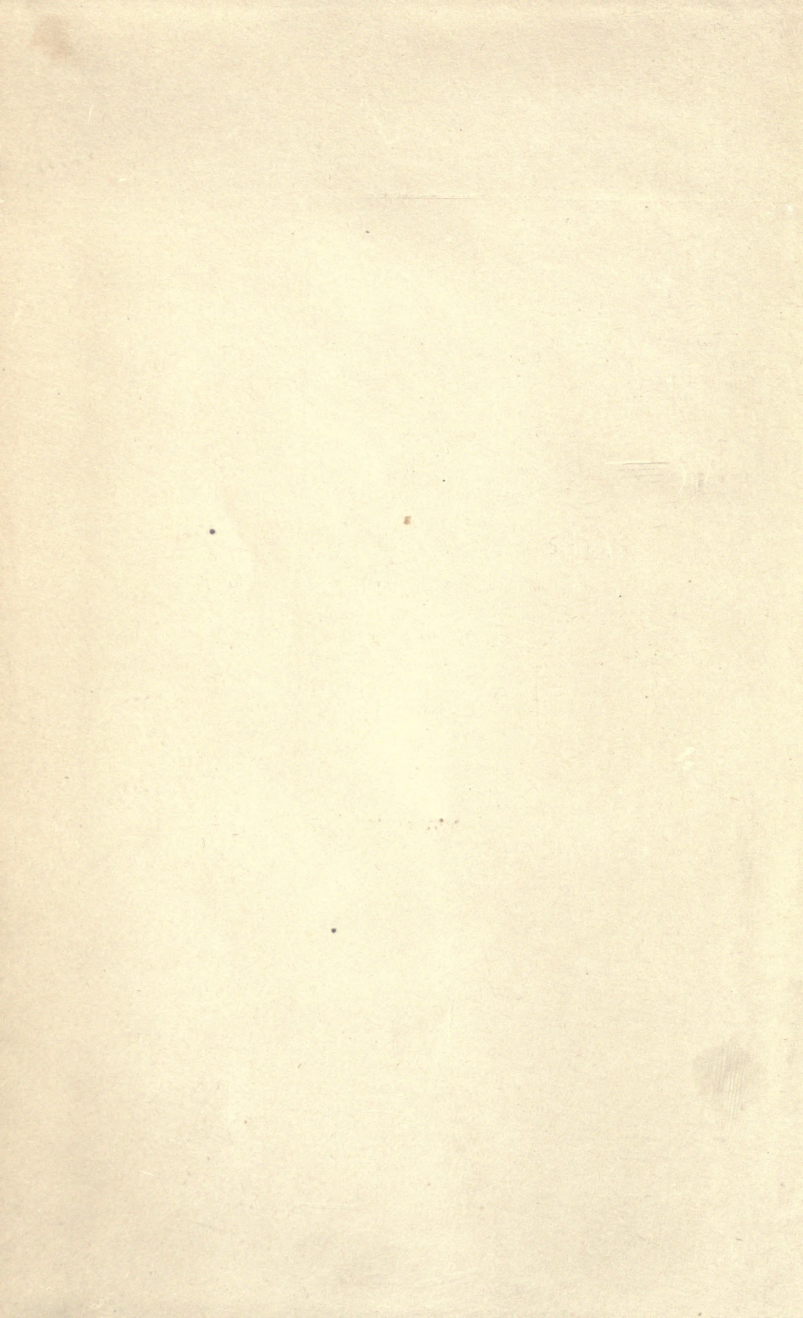


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REVISED EDITION

LESSONS

IN THE

STRUCTURE, LIFE, AND GROWTH OF PLANTS

FOR SCHOOLS AND ACADEMIES

BY

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CLASS-BOOK OF BOTANY, ETC

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EDITOR'S PREFACE.

DR. WOOD'S "**Lessons in the Structure and Growth of Plants**" was designed for an introduction to this delightful department of Natural History, and to qualify the student in Botany to make intelligent use of a **Flora**. The book is well known to educators, and the instructors in our high-schools and colleges have acknowledged its worth and conferred upon it the highest degree of approval by using it as a text-book.

It was written more than twenty years ago; since then improved methods of examination, with the aid of new microscopical appliances, have revealed much in all departments of biology, and especially in the structure and formation of *plant-tissues*.

These discoveries have introduced in some parts new and in others additional names.

To bring the work to the advanced state of the science, the chapters on **Organography** have been *revised*, and the parts on **Histology** and **Physiology** have been entirely rewritten and newly illustrated, and the whole reset in fresh and modern type.

The third chapter of the Introduction has been recast, enlarged, and newly illustrated.

In preparing the parts that are rewritten, the Editor has aimed not to enlarge, but rather to be more concise than the Author was upon the same subjects, believing that in a *text-book* brief and clear statement is more acceptable to the teacher and useful to the learner than lengthy discussion.

The chapters and sections on **Structure**, or **Organography**, have been revised as to nomenclature; but otherwise have not been disturbed, and the sequence of subjects has been preserved.

The Index and Glossary have been altered and enlarged, to suit the additional and revised matter; the words in the Glossary have been divided and accented to correspond with the latest authorities on Pronunciation.

It was the intention of the Author that this work should be a *text-book* suited to the needs of students in our **Academies, High-schools, and Colleges**, intending his "**Object Lessons in Botany**" to meet the wants of younger pupils; hence, in the changes that have been made this design has been kept in view.

The **work** now, with its revision, new matter, additional illustrations, and fresh type, is substantially a **new book**.

Its original character for educational purposes has been carefully preserved and in several features improved. It is in its new form a suitable introduction and companion to any of the manuals of the *Flora* of North America.

It affords the Editor great pleasure to record the acknowledgment of his obligations to his personal friends among the botanists of New York and vicinity for their sympathy in the work.

He is especially indebted to Dr. Geo. Macloskie, Senior Professor of Botany and Zoology in the John C. Green School of Science, at the College of New Jersey, for efficient aid and judicious criticism, upon the subjects of Histology and Physiology, where the statements are based upon microscopic examination.

His gratitude is due to Dr. John S. Newberry, of Columbia College, for his kind suggestions and encouragement.

Also to Hon. Judge A. Brown and to Mr. W. H. Rudkin, of New York, for their kind and valuable advice.

O. R. WILLIS, EDITOR.

WHITE PLAINS, NEW YORK,
March, 1889.

SUGGESTIONS TO TEACHERS.

AN enlightened instructor is disappointed, on opening a text-book, if he does not find some hint from the author as to the mode of using it.

Our best teachers of Botany differ as to what should be the subject first presented to the pupil's notice.

One would commence with the SEED; *another*, with the FLOWER; *a third*, with HISTOLOGY and PHYSIOLOGY.

These Lessons are so arranged that the learner may commence either with the Flower, which would lead through Organography, or Structural Botany, up to the Seed; or, if the teacher prefer, he can have his class commence with the Second part, which treats of the Cells and Vessels that build up plants and trees.

In either case, we advise that the four chapters which make up the introduction be carefully studied, by using them as reading and talking lessons, with simple illustrations, until they are well understood.

TABLE OF CONTENTS:

TOGETHER WITH A SYLLABUS OF THE MORE PRACTICAL SUBJECTS, DESIGNED AS EXERCISES ON THE BLACKBOARD, PRELIMINARY TO THE LESSONS.

N. B.—We give the Syllabus of but a few Chapters, and of fewer entire, in order that the pupil may exercise his own skill in supplying deficiencies. The teacher should require this. The abbreviation (etc.) indicates a table unfinished.

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* Existence, collectively, Nature. (§ 12), etc.	
* Existence, objectively, Science. (§ 16-18), etc.	
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b With perennial stems becoming woody.	
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—By clusters.....Chorisis.

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* Irregular.

—*e* Five petals, 2 pairs and an odd one.....Papilionaceous.

—*f* Six petals, one of them lip-like.....Orchidaceous.

2, Gamopetalous, or Monopetalous. (§ 102.)

* Regular.

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—*b* Tube very short, border wide, concave, Cup-form, etc., etc.

* Irregular.

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5, Rolled <i>on</i> its axis downward.....	Circinate.
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—a From one edge into a scroll.....	Convolute.
—b From both edges inward.....	Involute.
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1, Edges meeting, Valvate.	
—With the margins straight.....	Valvate.
—With the margins involute.....	Induplicate.
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1, In feather-veined leaves.

—The chief vein forming the axis.....Mid-vein.

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* Pinni-veined Leaves.

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2, Outline of a lance, or narrow-ovate.....Lanceolate.

3, Form of the Greek letter ΔDeltoid.*b* The middle veinlets longest, lower and upper equal.

4, Circular, or nearly so.....Orbicular.

5, Outline of an elliptic spring.....Elliptical.

6, Egg-shaped, with equal rounded ends.....Oval.

7, Narrowly oval, with obtuse ends.....Oblong.

The upper veinlets longest.

8, Inversely ovate, narrower at the base.....Obovate.

9, Inversely lanceolate, narrower at the base.....Oblanceolate.

10, Obtuse at apex, narrowed to the base.....Spatulate.

11, Shaped like a wedge, the point at base.....Cuneate.

d Lowest veinlets longest and recurved.

12, A re-entering angle, or sinus, at base. Heart-shaped..Cordate.

13, Base-lobes ear-shaped.....Auriculate.

14, Base-lobes arrow-shaped.....Sagittate.

15, Base-lobes turned outward.....Hastate.

* Dissected Forms.

a Pinnately cut or divided.

1, With regular lateral segments.....Pinnatifid.

2, With segments recurved or hooked.....Runcinate.

3, Terminal segment enlarged.....Lyrate.

4, Segments many and narrow.....Pinnatisect.

5, Segments and sinuses rounded.....Sinuate.

b Palmately cut or lobed.

6, Lobes only 3	Trilobate.
7, Lobes 5 or more	Palmately-lobed.
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5, Alternate leaflets smaller.....	Interruptedly pinnate.
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* Palmately compounded, consisting of—	
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—2, Along a thick fleshy rachis.....	Spadix.
—3, On an extremely short rachis.....	Head
—4, Spike of imperfect fls. caducous together.....	Ament.
<i>b</i> Flowers borne on pedicels.	
5, Along the sides of a lengthened rachis.....	Raceme.
6, Along a short rachis, the lower pedicels lengthened.	Corymb.
7, Clustered on an extremely short rachis.....	Umbel.
<i>c</i> The pedicels themselves branched.	
—8, Loosely.....	Panicle.
—9, Compactly.....	Thyrse.

* Centrifugal, or Definite.

- 1, Clusters open, loose, of various forms.....Cyme.
- 2, Clusters compact, terminal.....Fascicle.
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INTRODUCTION.

CHAPTER I.

AIDS TO THE STUDY OF BOTANY.

1. **The proper season** for the commencement of the study of Botany in schools is late in winter, at the opening of the first session after New-Year's. The class will thus be prepared beforehand, by a degree of acquaintance with first principles, for the analysis of the earliest Spring-flowers—the Blood-root, Liverwort, Spring-beauty, Sweet Mayflower, and the Violets. We have arranged the topics of the present treatise with a special view to the convenience of the learner in this respect, beginning with that which is the first requisite in analysis—the Flower.

2. **Specimens of leaves, stems, roots, fruit, flowers, etc.,** in unlimited supply are requisite during the whole course. In the absence of the living, let the dried specimens of the herbarium be consulted. Crayon sketches upon the blackboard, if truthful, are always good for displaying minute or obscure forms. In the city, classes in Botany may employ, at small expense, a collector to supply them daily with fresh specimens from the country. Moreover, the gardens and conservatories will furnish to such an abundant supply of *cultivated* species for study and analysis, with almost equal advantage,—since the present work embraces, together with the native flora, all exotics.

3. **An Herbarium** (Latin, *hortus siccus*, or *h. s.*) is a collection of botanic specimens, artificially dried, protected in papers, and systematically arranged. *Herba-*

ria are useful in many ways:—(a) for the preservation of specimens of rare, inaccessible, or lost species; (b) for exchanges, enabling one to possess the flora of other countries; (c) for refreshing one's memory of early scenes and studies; (d) for aiding in more exact researches at leisure; (e) for the comparison of species with species, genus with genus, etc.

4. **Apparatus.**—For collecting botanic specimens, a strong knife for digging and cutting is needed, and a close tin box, fifteen inches in length, of a portable form. Inclosed in such a box, with a little moisture, specimens will remain fresh a week.

5. Specimens for the herbarium should represent the leaves, flowers, and fruit—and, if herbaceous, the root also. Much care is requisite in so drying them as to preserve the natural appearance, form, and color. The secret of this art consists in extracting the moisture from them before decomposition can take place.

6. **The drying-press**, to be most efficient and convenient, should consist of a dozen quires of unsized paper, at least 11 × 16 inches folio; two sheets of wire-gauze (same size) as covers, stiffened by folded edges; and three or four leather straps a yard in length, with buckles. When in use, suspend this press in the wind and sunshine; or, in rainy weather, by the fire. In such circumstances, specimens dry well without once changing. But if boards be used instead of wire-gauze, the papers must be changed and dried daily. Succulent plants may be immersed in boiling water before pressing, to hasten their desiccation.

7. **The lens**, either single, double, or triple, is very serviceable in analysis. In viewing minute flowers, or parts of flowers, its use is indispensable. Together

with the lens, a needle in a handle, a penknife, and tweezers are required for dissection.

8. The compound microscope is undoubtedly a higher aid in scientific investigation than any other instrument of human invention. It is like the bestowment of a new sense, or the opening of a new world. Through this, almost solely, all our knowledge of the cells, the tissues, growth, fertilization, etc., is derived. The skillful use of this noble instrument is itself an art, which it is no part of our plan to explain.

9. On the preparation of botanical subjects for examination we remark: the field of view is small, and only minute portions of objects can be seen at once; the parts must be brought under inspection successively.

10. The tissues of leaves, etc., are best seen by transmitted light. They are to be divided by the razor or scalpel into extremely thin parings or cuttings. Such cuttings may be made by holding the leaf between the two halves of a split cork. They are then made wet and viewed upon glass. The stomata are best seen in the epidermis stripped off; but in the Sorrel-leaf (*Oxalis violacea*) they appear beautifully distinct upon the entire leaf.

11. Woody tissues, etc., may be viewed either as opaque or transparent. Sections and cuttings should be made in all directions, and attached to the glass by water, white of egg, or Canada balsam. To obtain the elementary cells separately for inspection, the fragment of wood may be macerated in a few drops of nitric acid added to a grain of chlorate of potassa. Softer structures may be macerated simply in boiling water.



CHAPTER II.

DEPARTMENTS OF SCIENCE.

12. Three great departments in nature are universally recognized: the mineral, vegetable, and animal kingdoms. The first constitutes the *Inorganic*; the other two, the *Organic World*.

13. A mineral is an *inorganic* mass of matter—that is, without distinction of parts or organs. A

stone, for example, may be broken into any number of fragments, each of which will retain all the essential characteristics of the original body, so that each fragment will still be a stone.

14. A plant is an *organized* body, endowed with vitality but not with sensation, composed of distinct parts, each of which is essential to the completeness of its being. A Tulip is composed of organs which may be separated and subdivided indefinitely, but no one of the fragments alone will be a complete plant.

15. Animals, like plants, are organized bodies endowed with vitality, and composed of distinct parts, no one of which is complete in itself; but they are elevated above either plants or minerals by their power of perception.

16. Physics is the general name of the science which treats of the mineral or inorganic world.

17. Zoology relates to the animal kingdom.

18. **Botany** is the science of the vegetable kingdom. It includes the knowledge of the forms, organs, structure, growth, and uses of plants, together with their history and classification. Its several departments correspond to the various subjects to which they relate. Thus,

19. *Morphology* treats of the special organs of plants as compared with each other; it especially relates to the mutual or typical transformations which the organs undergo in the course of development.

20. *Vegetable Histology* treats of the elementary tissues—the organic units or cells out of which the vegetable fabric is constructed.

21. *Physiological Botany* is that department which relates to the vital action of the several organs and

tissues, including both the vital and chemical phenomena in the germination, growth, and reproduction of plants. It has, therefore, a practical bearing upon the labors of husbandry in the propagation and culture of plants, both in the garden and in the field.

22. *Systematic Botany* arises from the consideration of plants in relation to each other. It aims to arrange and classify plants into groups and families, according to their mutual affinities, so as to constitute of them all one unbroken series or system.

23. *Descriptive Botany*, or Phytology, is the art of expressing the distinctive characters of species and groups of plants with accuracy and precision, in order to their complete recognition. A *Flora* is a descriptive work of this kind, embracing the plants of some particular country or district.

24. Finally, in its extended sense, Botany comprehends also the knowledge of the relations of plants to the other departments of nature—particularly to mankind. The ultimate aim of its researches is the development of the boundless resources of the vegetable kingdom, for our sustenance and protection as well as education; for the healing of our diseases and the alleviation of our wants and woes. This branch of botanical science is called *Applied Botany*, including several departments—as Medical Botany, or Pharmacy; Agricultural Botany, or Chemistry; Pomology, etc.

25. The name of a plant or other natural object is twofold,—the trivial or popular name, by which it is generally known in the country; and the Latin name, by which it is accurately designated in science throughout the world. For example, *Strawberry* is the popular name, and *Fragaria vesca* the Latin or scientific name, of the same plant. In elementary treatises, like the present, for the sake of being readily understood, plants are usually called by their popular names. Yet we earnestly recommend the learner to

accustom himself early to the use of the more accurate names employed in science.

26. The Latin name of a plant is always double—generic and specific. Thus *Fragaria* is generic, or the name of the *genus* of the plant—*vesca* is specific, or the name of the *species*.

27. A **Species** embraces all such individuals as may have originated from a common stock. Such individuals bear an essential resemblance to each other as well as to their common parent, in all their parts. For example, the White Clover (*Trifolium repens*) is a species embracing thousands of contemporary individuals scattered over our hills and plains, all of common descent, and producing other individuals of their own kind from their seed.

28. To this law of resemblance in plants of one common origin there are some apparent exceptions. Individuals descended from the same parent often bear flowers differing in color, or fruit differing in flavor, or leaves differing in form, etc. Such plants are called *Varieties*. They are rarely permanent, often exhibiting a tendency to revert to their original type. Varieties occur chiefly in species maintained by cultivation, as the Apple, Potato, Rose, Dahlia. They also occur more or less in native plants (as *Hepatica triloba*), often rendering the limits of the species extremely doubtful. They are due to the different circumstances of climate, soil, and culture to which they are subjected, and continue distinct until left to multiply spontaneously from seed in their own proper soil, or some other change of circumstances.

29. A **Genus** is an assemblage of species closely related to one another in the structure of their flowers

and fruit, and having more points of resemblance than of difference throughout. Thus, the genus Clover (*Trifolium*) includes many species, as the White Clover (*T. repens*), the Red Clover (*T. pratense*), the Buffalo Clover (*T. reflexum*), etc., agreeing in floral structure and general aspect so obviously that the most hasty observer would notice their relationship. So in the genus Pinus, no one would hesitate to include the White Pine, the Pitch Pine, the Long-leaved Pine (*P. strobus*, *P. rigida*, and *P. palustris*), any more than we would fail to observe their differences.

30. Thus individuals are grouped into species, and species are associated into genera. These groups constitute the bases of all the systems of classification in use, whether by artificial or natural methods.

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CHAPTER III.

THE STAGES OF PLANT LIFE.

31. In its *earliest stage of life*, the plant is an *embryo* sleeping in the seed. It then consists of two parts, the *radicle* or rootlet, and the *plumule*. Both may be seen in the Pea, Bean, or Acorn. Besides the embryo, the seed contains also its food in some form, provided for its first nourishment.

32. When placed just beneath the surface of the soil, it absorbs moisture, which, with the genial warmth of Spring, awakens the embryo, and it begins to feed and grow. The radicle protrudes (Fig. 2, *r*), turns downward, seeking the dark damp earth, avoiding the air and light, and forms the root or *descending axis*. The plumule, taking the opposite direction (Fig. 3, *p*),

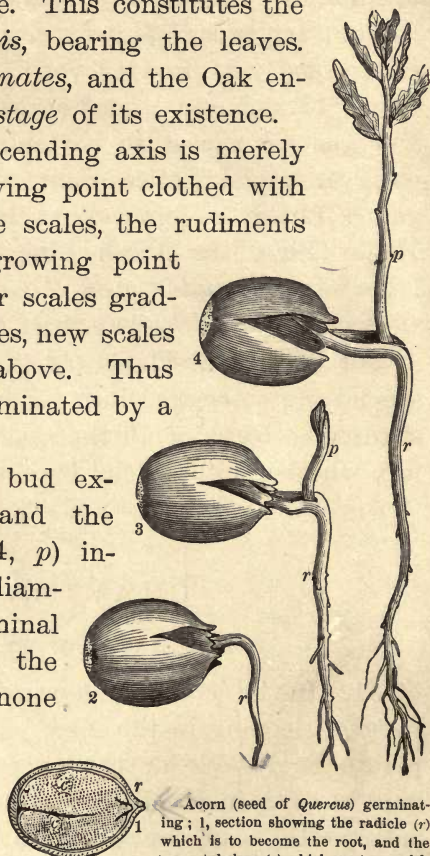
ascends, seeking the air and light, and expanding itself to their influence. This constitutes the stem or *ascending axis*, bearing the leaves. Thus the acorn *germinates*, and the Oak enters upon the *second stage* of its existence.

33. At first the ascending axis is merely *a bud*, that is, a growing point clothed with and protected by little scales, the rudiments of leaves. As the growing point advances and its lower scales gradually expand into leaves, new scales successively appear above. Thus the axis is always terminated by a bud.

34. The terminal bud expands into leaves, and the ascending axis (Fig. 4, *p*) increases in length and diameter. Besides the terminal bud, one is formed in the axil of each leaf. If none of the buds in the axils of the leaves develop, the plant at the end of the growing season will present a young oak, as

Fig. A, but if one should grow, the little tree would appear as in Fig. B.

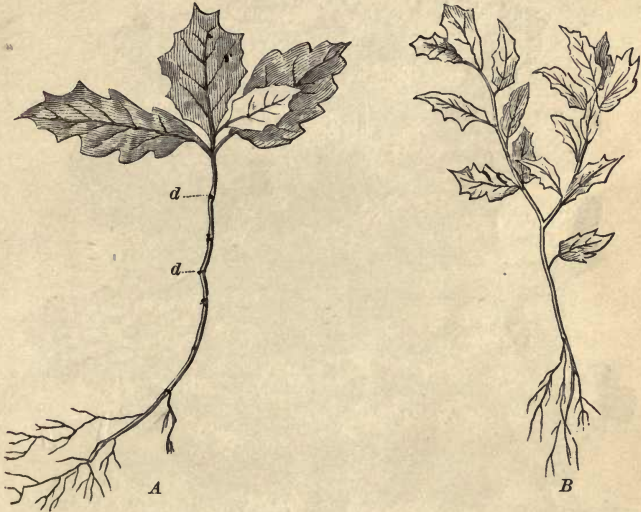
35. During successive periods of growth the lateral buds develop, forming branches and branchlets, and season after season the main axis lengthens and increases in diameter, the branches multiply and enlarge,



Acorn (seed of *Quercus*) germinating; 1, section showing the radicle (*r*) which is to become the root, and the two cotyledons (*c*) which are to nourish it; 2, the radicle *r*, descending; 3 and 4, the radicle, *r*, descending, and the plumule (*p*) ascending.

until the full-grown oak in all its beauty and majesty stands before us (Fig. *C*).

The student is struck with wonder and admiration as he watches these stages of growth; how is it, he asks, that the tiny plant which was nestling in the acorn has been changed into this gigantic oak? When he comes to study the cells and tissues of which this



A, A young oak at the end of the first season of growth, the markings on the stem, *d, d*, are the scars left by the fallen leaves; at each scar there is an undeveloped bud; some of these may grow during the next season, and develop into branches. *B*, A young oak at the end of the first season, one of the lateral buds having grown and produced a branch.

great tree is made up, his amazement will increase as he realizes the paucity of material and the magnitude of the structure; the insignificance of the beginning and the grandeur of the end. "The economy of causes and the prodigality of effects; the simplicity of laws and the complexity of results."

36. The tree is now complete, possessing the organs necessary to discharge the functions of plant growth. It has root, rootlets, stem, branches, branchlets, and

leaves. The *root* fastens it firmly in the ground; the *rootlets* take up *liquids* from the *soil*; the *stem*, *branches*, and *branchlets* are furnished with *vessels* and *passages* through which the fluids find their way to the *leaves*, where, under the influence of *air* and



C, *Quercus alba*.

sunlight, they are changed and fitted for *plant food*.

37. The next stage in the plant's life is the production of the flower. To accomplish this, a change takes place in the mode of development. Some of the buds, instead of extending the axes of the branchlets or forming new branchlets, expand their scales, producing

crowded whorls, each succeeding whorl differing from the last; some of the parts possessing great delicacy



H, young branchlet of *Q. alba*, with aments, etc. *D*, a staminate (♂) flower; *E*, the same, *F*, a pistillate (♀) flower with five stigmas; *G*, vertical section of the same; *J*, branchlet with full-grown leaves and mature fruit; *I*, section of the acorn showing the two thick cotyledons and embryo at top.

of organization, and, frequently, marked beauty of color. (See Figures *D*, *E*, *F*, *G*, *H*, *I*, *J*.)

38. The next stage is the production of fruit, in which flowering is the first step; the showy parts of the flower soon wither and fall away; the pistil, having been fertilized, is left, and continues to grow and finally matures into the ripe Fruit (Figs. *I, J*).

We found the plant slumbering in the Seed; we have followed and watched its behavior through all the stages of its Life.

39. We have seen the seed placed in the damp soil, where it absorbed moisture, enlarged, ruptured its shell, sent forth a sprout, which began to increase in two directions, one part enlarged *downwards* into the earth and formed a *root*; the other part grew *upwards* and became a *stem*. The stem clothed itself with leaves, sent forth branches, and adorned itself with flowers. These several achievements were succeeded by the crowning act of vegetable life, the production of mature *seed* in which a new Plant reposes, in embryo.



CHAPTER IV.

TERM OR PERIOD OF PLANT LIFE.

40. Flowering and fruit-bearing is an exhausting process. If it occur within the first or second year of the life of the plant, it generally proves fatal. In all other cases, it is either immediately preceded or followed by a state of repose. Now, if flowering be prevented by nipping the buds, the tender annual may become perennial, as in the florist's Tree-mignonette. We distinguish plants, as to their term of life, into the annual (①), the biennial (②), and the perennial (③). An *annual* (①) herb is a plant whose en-

tire life is limited to a single season. It germinates from the seed in Spring, attains its growth, blossoms, bears fruit, and dies in Autumn; as the Flax, Corn, Morning-glory.

41. A *biennial herb* (②) is a plant which germinates and vegetates, bearing leaves only the first season, blossoms, bears fruit, and dies the second; as the Beet and Turnip. Wheat, Rye, etc., are annual plants; but when sown in Autumn, the sudden frost prevents flowering, and they become biennials.

42. *Monocarpic herbs*.—The Century-plant (*Agave*), the Talipot-palm, etc., are so called. They vegetate, bearing leaves only, for many years, accumulating materials and strength for one mighty effort in fructification, which being accomplished, they die. In some species the term of life depends on *climate* alone. The Castor-bean (*Ricinus*) is an annual herb in the Northern States, a shrub in the Southern, and a tree of large size in its native India. So Petunia, annual in our gardens, is perennial at home (in Brazil).

43. **Perennial plants** are such as have an indefinite duration of life, usually of many years. They may be either herbaceous or woody. Herbaceous perennials, or *perennial herbs* (④), are plants whose parts are annual above ground and perennial below. In other words, their roots or subterranean stems live from year to year, sending up annually, in Spring, flowering shoots which perish after they have ripened their fruit in Autumn; as the Lily, Dandelion, Hop.

44. *Woody perennials* usually vegetate several years, and attain well-nigh their ordinary stature before flowering; thenceforward they fructify annually, resting or sleeping in winter. They are known as trees (⑤), shrubs (⑥), bushes, and undershrubs (⑦)—distinctions founded on size alone.

45. A *shrub* (⑥), is a diminutive tree, limited to eighteen or twenty feet in stature, and generally divid-

ing into branches at or near the surface of the ground (Alder, Quince). If the woody plant be limited to a still lower growth, say about the human stature, it is called a bush (Snowball, Andromeda). If still smaller, it is an undershrub (b) (Whortleberry).

46. A *tree* (5) is understood to attain to a height many times greater than the human stature, with a permanent woody stem, whose lower part, the trunk, is unbranched.

47. As to age, some trees live only a few years, rapidly attaining their growth and rapidly decaying, as the Peach; others have a longevity exceeding the age of man; and some species outlive many generations. Age may be estimated by the number of wood-circles or rings seen in a cross-section of the trunk (§ 408), each ring being (very generally) an annual growth. Instances of great longevity are on record. See Class Book of Botany, §§ 99, 100. The monarch tree of the world is the Californian Cedar—*Sequoia gigantéa*. One which had fallen measured 26 feet in diameter, and 363 in length! The wood-circles of this specimen are unusually thick, yet count up to 1,330. Among those yet standing, are many of even greater dimensions, as beautiful in form as they are sublime in height—the growth, probably, of more than 2,000 years. One of the Sequoias is estimated at 1,500 years; another of these monsters, felled in 1875, had 2,130 rings; still another was estimated by Dr. Gray to be 3,200 years old. One of these monster trees has recently been discovered, in Tulare County, California, by an engineer of the Comstock mines, that measures more than 56 feet in diameter at a point seven feet from the ground.

48. Trees are again distinguished as *deciduous* (5) and *evergreen* (5)—the former losing their foliage in Autumn, and remaining naked until the following Spring; the latter retaining their leaves and verdure throughout all seasons. The Fir tribe (Coniferæ) includes nearly all the evergreens of the North; those of the South are far more numerous in kind—*e. g.*, the Magnolias, the Live-oaks, Holly, Cherry, Palmetto, etc.

PART FIRST.

STRUCTURAL BOTANY; OR, ORGANOGRAPHY.

CHAPTER I.

THE FLOWER.

49. **The flower** is the immediate agent in the production of the seed with its embryo, and to this end its whole structure is designed. Moreover, its superior beauty attracts earliest attention, and an intimate knowledge of its organs is the *first* requisite in analysis and classification.

50. The flower may consist of the following members—the floral envelopes and the essential floral organs. *The floral envelopes* consist of one or more circles or *whorls* of leaves surrounding the essential organs. The outer of these whorls is called the *calyx*; and the other, if there be any, the *corolla*. The calyx may, therefore, exist without the corolla; but the corolla can not exist without the calyx.

51. **Calyx** is a Greek word signifying a cup. It is applied to the external envelope of the flower, consisting of a whorl of leaves with their edges distinct or united, usually green, but sometimes highly colored. The leaves or pieces composing the calyx are called *sepals*.

52. **Corolla** is a Latin word signifying a little crown, applied to the interior envelope of the flower. It consists of one or more circles of leaves, either distinct or united by their edges, usually of some other color than green, and of a more delicate texture than the calyx. Its leaves are called *petals*.

53. **Perianth** (*περι*, around, *ἄνθος*, flower) is a word in common use to designate the floral envelopes as a whole, without distinction of calyx and corolla. It is used in description, especially when these two envelopes are so similar as not to be readily distinguished, as in the Tulip, Lily, and the Endogens generally; also where only one envelope exists, as in *Phytolacca*, Elm, etc.

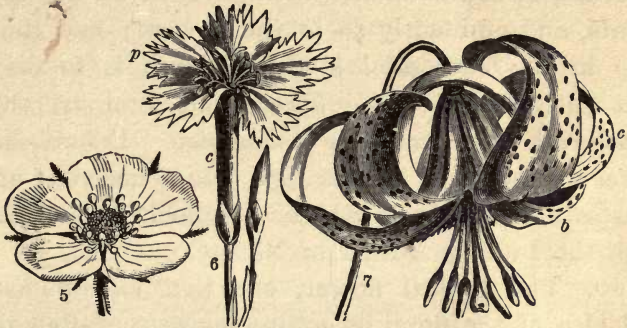
54. *The essential floral organs* stand within the circles of the perianth, and are so called because they are the immediate instruments in perfecting the seed, and thus accomplishing the final purposes of the flower. These organs are of two kinds, perfectly distinct in position and office—viz., the stamens and the pistils.

55. **The stamens** are those thread-like organs situated just within the perianth and around the pistils. Their number varies from one to a hundred or more; but the most common number is *five*. Collectively they are called the *androeceum*.

56. **The pistils** (called also carpels) occupy the center of the flower at the absolute terminus of the flowering axis. They are sometimes numerous, often apparently but one, always destined to bear the seed. Collectively they are called the *gynoeceum*.

57. **The torus** or receptacle is the axis of the flower, situated at the summit of the flower-stalk. It

commonly appears a flattened or somewhat convex disk, whose center corresponds to the apex of the axis. On this disk, as on a platform, stand the floral organs



5, Flower of the Strawberry. 6, Flower of the Pink. 7, Flower of the Lily (*Lilium superbum*). The pupil will point out the parts.

above described, in four concentric circles. The gynæceum (pistils) occupies the center; the andrœceum encircles it; the corolla is next without; and the calyx embraces the whole.



CHAPTER II.

PLAN OF THE FLOWER.

58. Such, in general, is the organization of the flower. It is simple enough in theory; and in most of the plants with which he meets, the student will easily recognize these several organs by name. But, in truth, flowers vary in form and fashion to a degree almost infinite. Each organ is subject to transformations, disguises, and even to entire extinction; so that the real nature of the flower may become an intricate and perplexing study.

59. As we shall soon see, in all these variations there is method. They are never capricious or accidental, however much they may appear so. *Unity in diversity* is characteristic of Nature in all her departments, and eminently so in the flowers; and the first step in the successful study of them is to discover that unity—that *simple, idea* of the floral structure in which all its diversities harmonize. Before flowers were created, that idea or *type* was conceived; and to possess it ourselves is a near approach to communion with the Infinite Author of Nature.

60. **The typical flower**, one that exemplifies the full idea of the floral structure, consists of four different circles of organs, as before described, placed circle within circle on the torus, and all having a common center. Such a flower must possess these five attributes—viz.: It must be

a, Complete; having the four kinds or sets of organs arranged in as many concentric circles. That it is *perfect*, having both kinds of the essential organs, is necessarily included under its completeness.

b, Regular; having the organs of the same name all similar and alike; that is, all the petals of one pattern, all the stamens alike in form, size, position, etc.

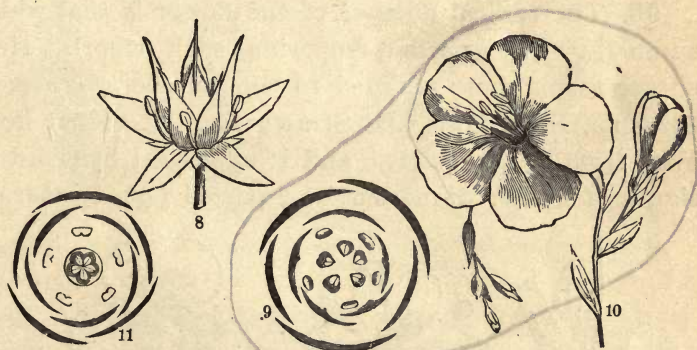
c, Symmetrical; having the same number of organs in each set or circle.

d, Alternating in respect to the position of the organs. This implies that the several organs of each set stand not opposite to, but alternating with the organs of the adjacent set;—the petals alternate with the sepals and stamens; the stamens alternate with the petals and pistils.

e, That the organs be *distinct*, all disconnected and free from each other.

61. This is the TYPE. But it is seldom fully realized in the flowers as they actually grow, although the tendency toward it is universal. Deviations occur in every imaginable mode and degree, causing that endless variety in the floral world which we never cease to admire. For example, in our pattern flowers (5, 6, 7), the pistils seem too few in the Pink and Lily, and the stamens too many in all of them.

62. The flower of the Flax (10) combines very nearly all the conditions above specified. It is complete, regular, symmetrical. Its organs are alternate and all separate; and (disregarding the slight cohesion of the pistils at their base) this flower well realizes our type. Admitting two whorls of stamens instead of one, we have a good example of our type in Stone-crop (*Sedum ternatum*), a little fleshy herb of our woods. Its flowers are both 4-parted and 5-parted in the same plant. See also the 12-parted flowers of the common Houseleek.



8, Flower of *Crassula lactea*, regular, symmetrical, organs distinct. 9, Diagram showing its plan.
10, Flower of the Scarlet Flax. 11, Diagram of its plan.

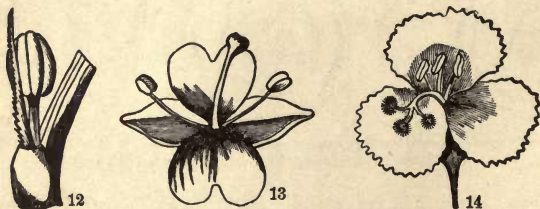
63. The flowers of *Crassula* (8), an African genus sometimes cultivated, afford unexceptionable examples, the sepals, petals, stamens, and pistils each being five in number, regularly alternating and perfectly separate.

CHAPTER III.

STUDY OF ANOMALOUS FLOWERS.

64. The true method of studying the flower is by comparing it with this type. So shall we be able, and ever delighted, to learn the nature of each organ in all its disguises of form, and to discern the features of the general plan even under its widest deviations. The more important of them are included under the following heads, which will be considered in order: 1, Variations of the radical number of the flower; 2, Deficiencies; 3, Redundancies; 4, Union of parts; 5, Irregularities of development.

65. The radical number of the flower is that which enumerates the parts composing each whorl. Here nature seems most inclined to the number *five*, as in Grassula, Flax, Rose, and Strawberry. It varies, however, from one to twelve, and is expressed by word or sign as follows: di-merous, or 2-parted ($\frac{2}{\surd}$), tri-merous

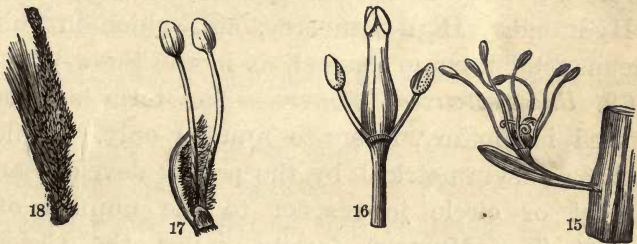


12, Flower of *Hippuris*, one-parted. 13, Flower of *Circaea Lutetiana*, $\frac{2}{\surd}$. 14, Flower of *Xyris*, $\frac{5}{\surd}$.

or 3-parted ($\frac{3}{\surd}$), penta-merous or 5-parted ($\frac{5}{\surd}$), etc. The flowers of *Hippuris* (12) are 1-parted, having but one stamen and one pistil. Those of *Circaea* (13) are 2-parted, having 2 sepals, 2 petals, 2 stamens, etc.

Those of *Xyris* (14) are $\sqrt[3]{}$, having all the parts in 3s. *Xyris* is one of the Endogens. Trimerous flowers are characteristic of this great group of Plants, while pentamerous flowers commonly distinguish the Exogens.

66. **Deficiencies** often occur, rendering the flower *incomplete*. Such flowers lack some one or more entire sets of organs. When only one of the floral envelopes, the calyx, exists, the flower is said to be *apetalous* or *monochlamydeous* (*χλαμύς*, a cloak), as in Elm, *Phytolacca*. These terms are also loosely applied to such plants as Rhubarb, Anemone, Liverwort, where the pieces of the perianth are all similar, although in two or three whorls. When the perianth is wholly wanting, the flower is said to be *achlamydeous*, or *naked*, as in Lizard-tail (15).



15, Flower of *Saururus* (Lizard-tail)—achlamydeous. 16, Flower of *Fraxinus* (Ash). 17, Flower of *Salix* (Willow), staminate—18, pistillate.

67. *Imperfect flowers* are also of frequent occurrence. They are deficient in respect to the essential organs. A *sterile* or staminate flower (denoted thus δ) has stamens without pistils. A *fertile* or pistillate flower (♀) has pistils without stamens. Such flowers being counterparts of each other, and *both* necessary to the perfection of the seed, must exist either together upon the same plant or upon separate plants of the same species. In the former case, the species

is *monœcious* (δ), as in Oak; in the latter case, *diœcious* (δ ♀), as in Willow. The term *diclinous*, denot-



19, Pistillate flower of Balm-of-Gilead. 20, Staminate. 21, Begonia—*a*, staminate; *b*, pistillate.

ing either δ or δ ♀ without distinction, is in common use.

68. *A neutral flower* is a perianth or calyx only, having neither stamens nor pistils. Such are the ray-flowers of many of the *Compositæ*, and of the cymes of *Hydrangea*, *High-cranberry*, etc., which in cultivation may all become neutral, as in the *Snow-ball*.

69. *Unsymmetrical flowers*.—The term symmetry, as used in Botany, refers to number only. A flower becomes unsymmetrical by the partial development of any set or circle in respect to the number of its organs. The *Mustard* family, called the *Crucifers*, afford good examples.

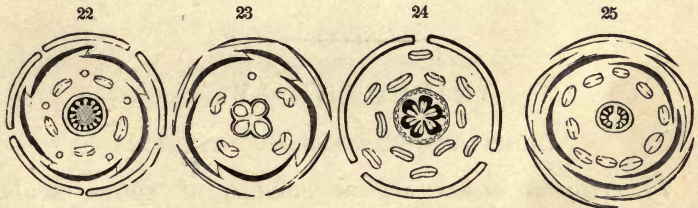
70. The flowers of *Mustard*, *Cress*, etc., are understood to be 4-merous (ψ). The sepals are four, petals four, but the stamens are six and the styles but two. The stamens are arranged in two circles, having two of those in the outer circle suppressed or reduced to mere glands. Two of the carpels are also suppressed (429). In the *Mint* family and the *Figworts* one or three of the stamens are generally abortive. Here, while the flowers are ψ , the stamens are four in some species and only two in others. The missing stamens, however, often appear in the guise of slender processes—the rudiments of stamens—proving in an interesting manner the natural tendency to symmetry.

71. In the ψ flowers of *Poppy*, the sepals are but two; in ψ *Spring-beauty* they are but two; in both cases too few for symmetry. In *Larkspur* (26) the ψ flowers have but four petals; and in *Monk's-hood* (29), also ψ , the petals

are apparently but two, strangely deformed bodies. A careful inspection, however, generally reveals the other three, very minute, in their proper places, as displayed in the cut.

72. "*Organs opposite*" is a condition much less frequent than "*organs alternate*," but is highly interesting, as being sometimes characteristic of whole families. Thus in the Primrose, Thrift, and Buckthorn families, the stamens always stand opposite to the petals!

73. How happens this? Among the Primworts this question is solved in the flowers of *Lysimachia*



Diagrams.—22, Flower of *Samolus*, showing the rudimentary stamens alternating with the perfect. 23, Flower of a Labiate plant, showing the place of the deficient stamen. 24, Flower of *Asarum*—three sepals, twelve stamens, etc. 25, Flower of *Saxifrage*—two pistils, ten stamens, etc.

and *Samolus*, where we find a circle of five teeth (abortive filaments) between the petals and stamens, alternating with both sets, thus restoring the lost symmetry. Hence we infer that in such cases generally a circle of alternating organs has been either partially or wholly suppressed. In the Buckthorn, however, a different explanation has been given.

74. **Redundancy.**—*The multiplication of organs* is exceedingly common, and usually according to a definite plan. The increase takes place, as a rule, by circles, and consequently by *multiples*. That is, *e. g.*, the stamens of a $\sqrt[3]{}$ flower, if increased, will be so by 3s; of a $\sqrt[5]{}$ flower by 5s, etc.,—sometimes to the extent of twenty such circles.

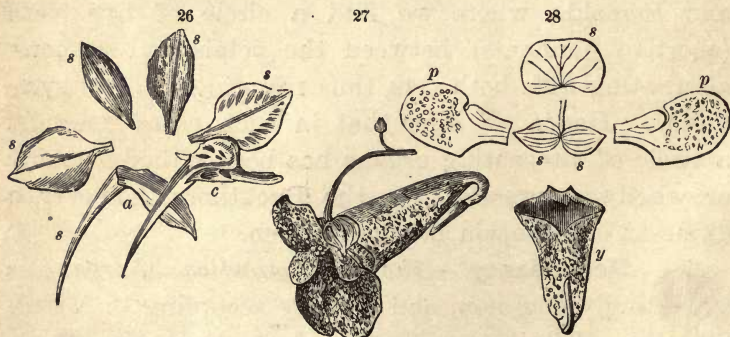
75. In the Crowfoot, Rose, and other families with numerous stamens, the arrangement is in crowded spirals, like the phyllotaxis of the plants with the internodes undeveloped. The carpels of the Crowfoot are also generally multiplied, yet often, on the contrary, diminished, as in the Pæony. In Rosaceæ, also, the stamens are generally multiplied, while the carpels exist in all conditions as to number. Thus in Strawberry they are multiplied, in the Apple they are regularly five, in Agrimony reduced to two, and in the Cherry to one. In Magnolia the $\sqrt[3]{}$ flowers have three sepals in one circle, six or nine petals in two or three circles, numerous stamens and carpels in many circles of each. In the $\sqrt[4]{}$ flowers or Blood-root there are two sepals, eight petals, twenty-four stamens, and two carpels.

76. *Chrosis*.—In other cases, the organs seem to be increased in number by clusters, rather than by circles, as when in the same circle several stamens stand in the place of one—*e. g.*, in Squirrel-corn, St. Johnswort, Linden. Such cases afford wide scope for conjecture. Perhaps each cluster originates by division, as the compound from the simple leaf; or as a tuft of axillary leaves; or thirdly, by a partial union of organs.

CHAPTER IV.

ANOMALOUS FLOWERS—CONTINUED.

77. *Appendicular organs* consist of spurs, scales, crown, glands, etc., and often afford excellent distinctive marks. The old term *nectary* was indiscrim-



26, Flower of *Delphinium consolida* (common Larkspur), displaying *s, s, s, s, s*, the five sepals—*a*, the upper one spur; *c*, the corolla of four petals, here united into one and produced into a spur. 27, Flower of *Impatiens fulva* (Touch-me-not). 28, Displaying *s, s, s, y*, the four sepals, *y* being saccate and spurred; *p, p*, the two petals, both double, preserving the symmetry.

inately applied to all such organs, because some of them produced honey.

78. *Spurs* are singular processes of the flower, tubular and projecting from behind it. In Columbine each petal is thus spurred;—in Violet, one petal only; in Larkspur, two petals and a sepal, the spur of the latter inclosing that of the former. The curved spur of the Jewel-weed belongs to a sepal (27, 28).

79. *Scales* are attached to the inner side of the corolla, usually upon the claw of the petals, as in Buttercups, or within the throat of the corolla tube, as in the Borrageworts. Similar appendages, when enlarged and conspicuous, constitute a *crown* in Catchfly, Corn-cockle, Narcissus. See also the *staminal crown* of the Silk-grass (*Asclepias*).

80. *Glandular bodies* are often found upon the receptacle in the places of missing stamens or carpels, or as abortive organs of some kind. Examples are seen in the Crucifers and Grape. In Grass-Parnassus they are stalked and resemble stamens.

81. **The union of organs** in some way occurs in almost every flower; and, more perhaps than any other cause, tends to disguise its plan and origin. The separate pieces which stood each as the representative of a leaf, now, by a gradual fusion, lose themselves in the common mass. Nevertheless, marks of this process are always discernible, either in parts yet remaining *free*, or in the *seams* where the edges were conjoined. The floral organs may unite by *cohesion* or *adhesion*.

82. *Cohesion*, when the parts of the same whorl are joined together; as the sepals of the Pink, the petals of Morning-glory, the stamens of Mallows, the carpels of Poppy. *Adhesion*, when the parts of different whorls are conjoined; as the stamens with the corolla in

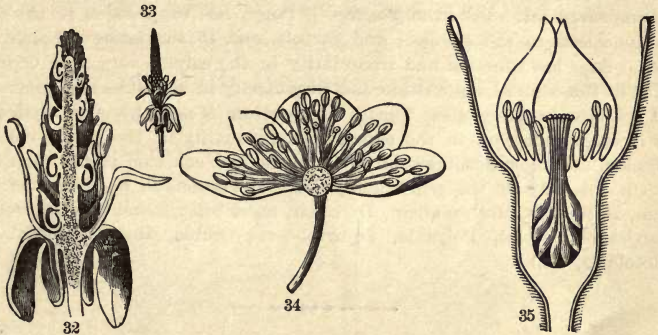
Phlox, with the pistils in Milkweed, Lady's-slipper; or calyx with ovary, in Apple or Wintergreen (Gaultheria). The adjective *free* is used in a sense opposite to adhesion, implying that the organ is inserted on (or grows out of) the receptacle, and otherwise separated from any other kind of organ. The adjective *distinct* is opposed to cohesion, implying that like organs are separate from each other. More of this in another chapter.



29, Flower of *Aconitum Napellus* displayed; *s, s, s, s, s*, the five sepals, the upper one hooded; *p, p, p*, the five petals, of which the two upper are nectaries covered by the hood, and the three lower very minute. 30, Flower of *Catalpa*, 2-lipped, 5-lobed. 31, Corolla laid open, showing the two perfect stamens and the three rudimentary.

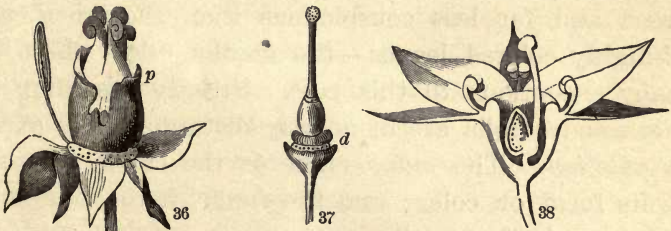
83. **Irregular development.**—Our typical flower is regular; and observation proves that all flowers are actually alike regular in the early bud. Those inequalities or “one-sided” forms, therefore, which characterize certain flowers, are occasioned by subsequent irregular growth from a regular type. The irregularity of flowers occurs in a thousand ways and modes;—in the unequal *size* of like organs; in their dissimilar *forms* and *positions*; in their unequal *cohesions*, and in their partial *suppressions*. So in the Violet (50), Monk's-hood (29), *Catalpa* (30), the Labiates (69), the Pea tribe (59), etc.

84. The torus, or receptacle, is sometimes strangely modified. In the little *Myosurus* (32), in some Buttercups, and in the Tulip-tree we find a lengthened or *spindle-shaped torus*—lengthened according to the



32, Flower (magnified) of *Myosurus*; a vertical section showing its elongated torus, etc. 33, The same, natural size. 34, Flower of *Isopyrum biternatum*; vertical section, showing the convex or globular torus, etc. 35, Flower of *Rose*, showing its excavated torus.

nature of a branch (§ 35), and all covered with the multiplied pistils. On the contrary, we have in the *Rose* (35) and *Lady's-mantle* (38), an excavated torus, within which the carpels are held, while the other organs are borne upon its elevated rim.



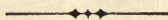
36, *Pæonia Moutan*, showing its very large disk (*d*) sheathing the ovaries (*p*). 37, Pistil of the *Lemon*, with its base surrounded by the disk, *d*. 38, Section of flower of *Alchemilla*, showing its single simple pistil, large disk, and excavated torus.

85. The **disk** is a portion of the receptacle raised into a rim somewhere in the midst of the whorls. It is found between the ovary and stamens in *Pæony*

and Buckthorn. It bears the stamens in Maple and Mignonette, and crowns the ovary in the Umbelliferæ.

86. *Combined deviations* are quite frequent, and sometimes obscure the typical character of the flower to such a degree as to require close observation in tracing it out. The study of such cases is full of both amusement and improvement. For example, the ψ Poppy has suppression in the calyx, multiplication in the stamens and carpels, and in the latter cohesion also. The ψ Sage has cohesion and irregularity in the calyx, every kind of irregularity in the corolla, suppression and irregularity in the stamens, suppression and cohesion in the pistils. The ψ Cypripedium is perfectly symmetrical, yet has irregular cohesion in the calyx, great inequality in the petals, cohesion, adhesion, and metamorphosis in the stamens, and cohesion in the carpels.

(In this way let the pupil analyze the deviations in the flower of Geranium, Hollyhock, Moth-mullein, Larkspur, Sweetbrier, Touch-me-not, Petunia, Snapdragon, Violet, Polygala, Squirrel-corn, Orchis, Henbit, Monk's-hood, Calceolaria, etc.)



CHAPTER V.

THE FLORAL ENVELOPES, OR PERIANTH.

87. In our idea of the typical flower, the perianth consists of two whorls of expanded floral leaves encircling and protecting the more delicate essential organs in their midst. As a rule, the outer circle, calyx, is green and far less conspicuous than the inner circle of highly colored leaves—the corolla. But there are many exceptions to this rule. Strictly speaking, the calyx and corolla are in no way distinguishable except by *position*. The *outer* circle is the calyx, whatever be its form or color; and the *inner*, if there be more than one, is the corolla.

88. Both blade and petiole are distinguishable in the floral leaves, especially in the petals. The blade, or expanded part, is here called limb, or lamina; the petiolar part, when narrowed into a stalk, is called the claw. In form, or outline, there is a general resem-

blance between the limb and the leaf. It is ovate, oval, lanceolate, obcordate, orbicular, etc. In margin it is generally entire. (See § 308.)

89. Some peculiar forms, however, should be noticed, as the bilobate petal of the Chickweed (44), the pinatifid petal of Miterwort (43), the inflected petal of the Umbelliferæ (42), the fan-shaped petal of Pink, the fringed (fimbriate) petal of Champion (*Silene stellata*) (40), the hooded sepal of *Napellus* (29), the saccate



Forms of petals.—39, Buttercup, showing the scale at base. 40, Mignonette, fringed at top. 41, *Silene stellata*, fringed and unguiculate. 42, Flower of *Osmorhiza longistylis*, petals inflected. 43, Flower of *Mitella diphylla*, petals pectinate-pinnatifid. 44, Petal of *Cerastium nutans*, 2-cleft.

petal of *Calceolaria*, *Cypripedium* (71). The limb is, moreover, often distorted into a true nectary, spurred (see § 78), or otherwise deformed, as in *Napellus*, *Coptis*, etc.

90. We have seen that the floral organs are often in various ways united. A calyx with its sepals united into a tube or cup was formerly said to be *monosepalous*, and a similar corolla was called *monopetalous*; *gamosepalous* and *gamopetalous* are now substituted for those words. *Polysepalous* is applied to a calyx with distinct sepals, a corolla with separate petals is *polypetalous*.

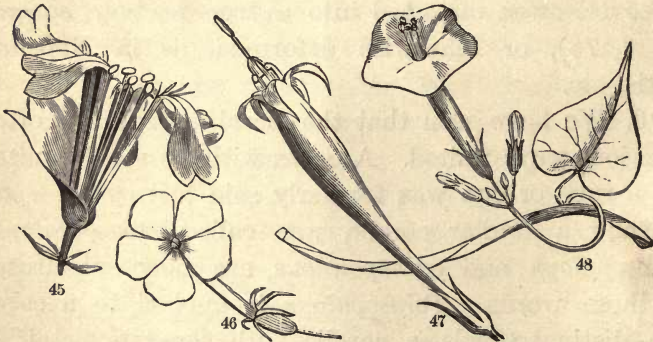
Gamosepalous and *gamopetalous* have in Germany given place to the more appropriate words *synsepalous* and *sympetalous*.

Polysepalous and *polypetalous* have also been superseded by the more accurate terms *aposepalous* and *apopetalous*.

91. The gamosepalous calyx, or gamopetalous corolla, although thus compounded of several pieces, is usually described as a simple organ, wheel-shaped, cup-shaped, tubular, according to the degree of cohesion. The lower part of it, formed by the united claws, whether long or short, is the *tube*; the upper part, composed of the confluent laminae, is the *border*, or *limb*; the opening of the tube above is the *throat*.

92. The border is either lobed, toothed, crenate, etc., by the distinct ends of the pieces composing it, as in the calyx of Pink, the calyx and corolla of Primula, Phlox, and Bellwort, or it may become, by a complete lateral cohesion, entire, as in the Morning-glory. Here the compound nature of the organ is shown by the seams alone.

93. A terminal cohesion, where summit as well as sides are joined, forming a *cap* rather than cup, rarely occurs, as in the calyx of the garden Eschscholtzia and the corolla of the Grape.

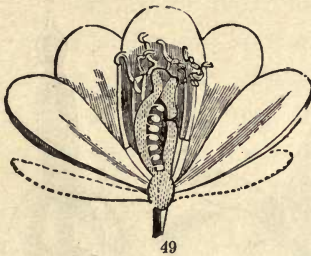


45, Flower of Saponaria (Bouncing Bet); petals and claws quite distinct. 46, Phlox; claws united, with lamina distinct. 47, Spigelia (Pink-root), petals still further united. 48, Quamoclit coccinea; petals united throughout.

94. The modes of adhesion are various and important, furnishing some of the most valuable dis-

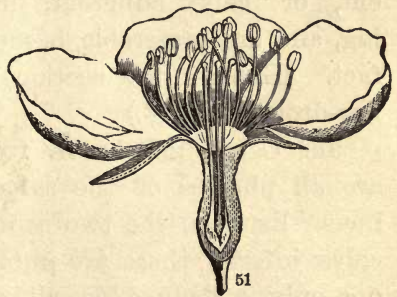
tinctive characters. An organ is said to be *adherent* when it is conjoined with some dissimilar organ, as stamen with pistil. All the organs of our typical flower are described as *free*.

95. The term *hypogynous* (ὑπό, under, γυνή, the pistil) is an adjective in frequent use, denoting that



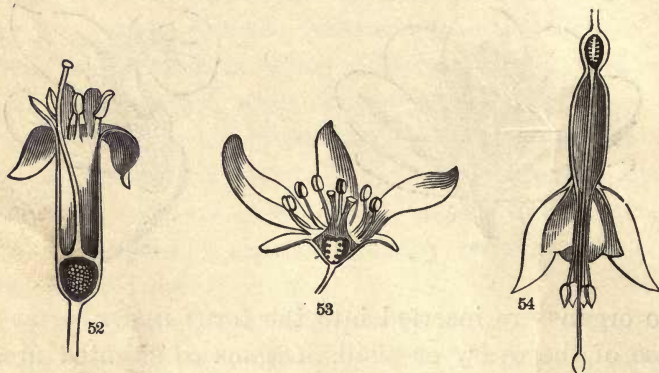
the organs are inserted into the torus *under*, or at the base of the ovary or pistil. Organs so situated are, of course, in the normal condition and *free*, there being no adhesions. Observe and explain the sections of *Jeffersonia* and *Violet* (49, 50).

96. *Perigynous* (περί, around) is a term applicable to the stamens and petals only, and implies that they are (apparently) inserted on the calyx or corolla *around* the free ovary. In *Phlox*, the stamens are perigynous on the corolla-tube. In *Cherry* and *Plum*, the petals and stamens are perigynous on the calyx-tube. (See 51.)



97. *Epigynous* (ἐπί, upon) denotes that the organs

are inserted (apparently) *upon* the ovary, as appears in Apple, Pear, Caraway, Sunflower. (See cuts 42, 51.) The common phrases "calyx superior," "ovary inferior," have the same signification as "calyx epigynous," all implying the apparent insertion of the organs upon or above the ovary. In this condition



52, *Ribes aureum* and (54) *Fuchsia gracilis*; ovary inferior or adherent, stamens and petals epigynous (above the adherent ovary). 53, *Saxifraga Virginiensis*; ovary half-superior.

all the organs, or at least the calyx, are blended with the ovary to its top. Hence the phrases "ovary adherent," or "calyx adherent," have also the same meaning, and are preferable, because in accordance with the fact. (Explain the sections of Golden Currant and Ear-drop — 52, 54.)

98. Calyx inferior or free, ovary superior or free, are all phrases of the same import as calyx hypogynous. Between the two conditions, calyx superior and calyx inferior, there are numerous gradations, of which one only is defined, to wit, calyx half-superior, as exemplified in the Mock-orange and Saxifrage (53).

X CHAPTER VI.

FORMS OF THE PERIANTH.

99. The innumerable forms of the perianth, whether calyx or corolla, or both, are first to be distinguished as POLYPETALOUS or GAMOPETALOUS, and secondly, as *regular* or *irregular*. The POLYPETALOUS-*regular* forms are typified by the four figures below, and described in the following paragraphs.

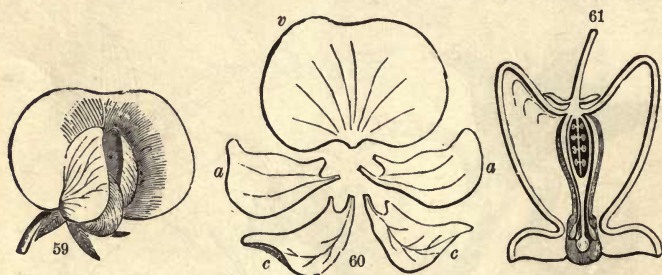


Forms of corollas.—55, *Cheiranthus* (Stock). 56, *Silene regia* (Scarlet Catchfly). 57, *Pyrus coronaria*. 58, *Amaryllis* (Atamasco Lily).

100. First, *Cruciform* (*crucis*, of a cross) or cross-shaped corollas consist of four long-clawed petals, placed at right angles to each other, as in Mustard, Wall-flower (55). 2d, *Caryophyllaceous* or pink-like corollas consist of five petals with long, erect claws, and spreading laminae; as in the Pink (56). 3d, *Rosaceous* or rose-like corollas are composed of five short-clawed open petals; as in the Rose (Fig. 57). 4th, *Liliaceous* flowers, like the Lilies, consist of a

six-leaved perianth; each leaf gradually spreading so as to resemble, as a whole, the funnel-form (58).

101. **Polypetalous-irregular** forms (59, 71) may generally be referred to these two types—the papilionaceous and the orchidaceous. The *Papilionaceous* (*papilio*, butterfly) corolla or flower may consist of five dissimilar petals, designated thus: the upper, largest, and exterior petal is the banner (*vexillum*); the two lateral, half-exterior, are the wings (*alæ*); the two lower, interior petals, often united at their lower margin, are the keel (*carina*). The flowers of the Pea,

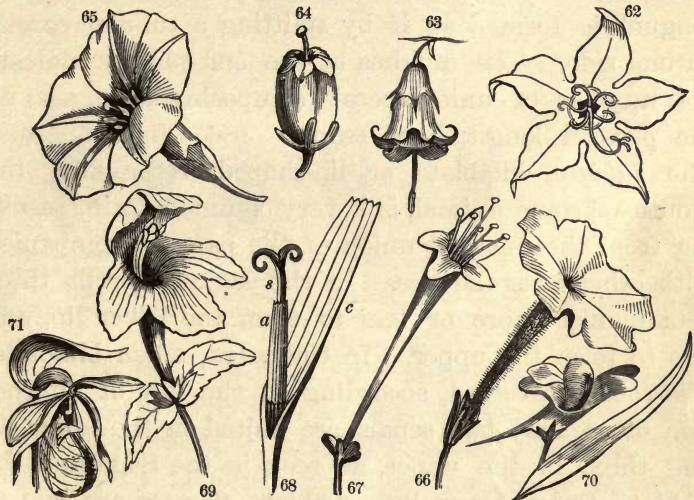


59, Papilionaceous flower of the Pea. 60, Displayed: *v*, the vexillum; *a*, *a*, the alæ; *c*, *c*, the carina. 61, Section of flower of *Dicentra Cucullaria*.

Locust, Clover, and of the great family of the Leguminosæ in general are examples. The *Orchidaceous* is a form of the perianth peculiar to the Orchis, and to that large and singular tribe in general. It is a 6-parted double perianth, very irregular, characterized chiefly by its *lip*, which is the upper petal (lower by the twisting of the ovary) enlarged and variously deformed.

102. **Gamopetalous-regular** perianths (62–67) may include mainly the following forms, although some of them may become irregular. First, *Rotate*, wheel-shaped, or star-shaped, is a form with tube very short,

if any, and a flat, spreading border; as the calyx of Chickweed, corolla of *Trientalis*, Elder. It is sometimes a little irregular, as in Mullein. 2d, *Cup-shaped*, with pieces cohering into a concave border, as in the calyx of Mallows, corolla of *Kalmia*, etc. 3d, *Campanulate*, or bell-shaped; when the tube widens abruptly at base and gradually in the border, as in



Forms of corollas.—62, *Campanula Americana*; rotate. 63, *Campanula divaricata*. 64, *Andromeda*; urceolate. 65, *Convolvulus* (Morning-glory). 66, *Petunia*. 67, *Lonicera sempervirens* (Honeysuckle). 68, Dandelion; ligulate corolla (c), 5-toothed; a, five anthers united into a tube around s, the style. 69, *Synandra grandiflora*, ringent, upper lip 2-lobed, lower 3-lobed. 70, *Linaria* (yellow Snapdragon), personate. 71, *Cypripedium acaule*, orchidaceous.

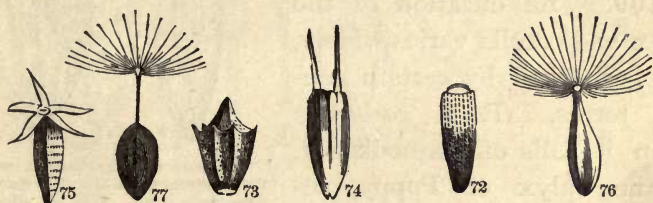
the Harebell, Canterbury-bell. 4th, *Urceolate*, urn-shaped; an oblong or globular corolla with a narrow opening, as the Whortleberry, Heath. 5th, *Funnel-form* (infundibuliform), narrow-tubular below, gradually enlarging to the border, as Morning-glory. 6th, *Salver-form* (hypocrateriform), the tube ending abruptly in a horizontal border, as in Phlox, *Petunia*, both of which are slightly irregular. 7th, *Tubular*, a

cylindraceous form spreading little or none at the border; as the calyx of the Pink, corolla of the Honey-suckle. It is often a little curved. Tubular flowers are common in the Compositæ, as the Thistle, Sun-flower, when they are often associated with the next form, the *ligulate*.

103. **Gamopetalous - irregular** perianths may be either ligulate or labiate. The *ligulate* corolla (*ligula*, tongue) is formed as if by splitting a tubular corolla on one side. The notches at the end plainly indicate the number of united petals composing it, as also do the parallel longitudinal seams. (See Figs. 68, 69.) The *labiate*, bilabiate or lip-shaped, resembling the mouth of some animal, is a very common form, resulting from the unequal union of the parts, accompanied with other irregularities. In the labiate corolla three petals unite more or less to form the lower lip, and two to form the upper. In the calyx, when bilabiate, this rule is reversed, according to the law of alternation of organs; two sepals are united in the lower lip and three in the upper, as seen in the Sage and the Labiate Order generally. Labiate flowers are said to be *galeate* or helmeted when the upper lip is concave, as in Catmint; *ringent* or gaping when the throat or mouth is wide open (69); *personate* or masked when the throat is closed as with a *palate*, like the Snap-dragon (70).

104. Certain *reduced forms* of the perianth should be noticed in this place. The *Pappus* (πάππος, grandfather, alluding to his gray hairs) is the hair-like calyx of the florets of the Compositæ, and other kindred Orders. The florets of this Order are collected into heads so compactly that the calyxes have not room

for expansion in the ordinary way. The pappus is commonly persistent, and often increases as the fruit matures, forming a feathery sail to waft away the seed through the air, as in the Dandelion and Thistle. It varies greatly in form and size, as seen in the cuts; sometimes consisting of scales, sometimes of hairs, again of feathers or bristles. Sometimes it is mounted on a stipe, which is the beak of the fruit.



Cypselæ (incorrectly called akenium) of the Compositæ, with various forms of pappus. 72, *Ecripta procumbens*, no pappus. 73, *Ambrosia trifida*. 74, *Helianthus grosse-serratus*, pappus 2-awned. 75, *Ageratum conizoides*, pappus of five scales. 76, *Mulgedium*, capillary pappus—cypselæ slightly rostrate. 77, *Lactuca elongata*, rostrate cypselæ.

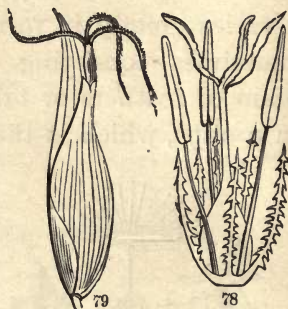
105. Again: the calyx, or the limb of the calyx, is reduced to a mere *rim*, as seen in the Umbelliferæ. In the Amentaceous Orders, the whole perianth diminishes to a shallow cup, as in the Poplar and Willow, or altogether disappears, as in the Birch, Ash, and Lizard-tail (15, 16).

106. **Setæ**, meaning bristles in general, is a term specifically used to denote the reduced perianth of the sedges. In the Bog-rush (*Scirpus*) there is, outside the stamens, a circle of six setæ, representing a 6-leaved perianth (78). In the Cotton-grass (*Eriophorum*) the setæ are multiplied and persistent on the fruit, becoming long and cotton-like.

107. **Perigynium** is the name given to the urceolate perianth of *Carex*, investing the ovary, but allowing the style to issue at its summit. It is composed

of two united sepals, as indicated by the two teeth at the top (79).

108. **Glumes and pales** represent the floral envelopes, or rather the involucre of the Grasses (436). Their alternating arrangement clearly distinguishes them from a perianth.



78, Flower of *Scirpus lacustris*, magnified; consisting of six stamens, three pistils united, except the stigmas.
79, Flower of *Carex rivularis* ♀, with *g*, its glume, *p*, its bottle-shaped perigynium, 2-toothed at top, enveloping the triple ovary; stigmas, three.

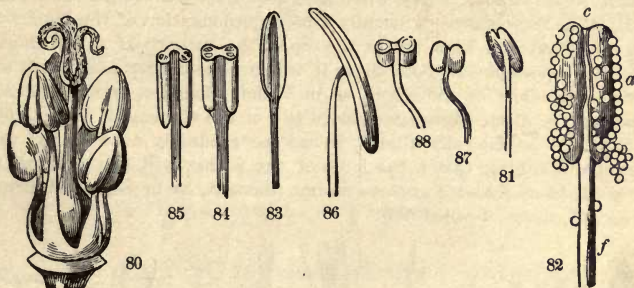
109. **The duration** of the calyx and corolla varies widely, and is marked by certain general terms. It is *caducous* when it falls off immediately, as the calyx of Poppy, corolla of Grape; *deciduous* when it falls with the stamens, as in most plants; and *persistent*, if it remain until the fruit ripens, as the calyx of Apple. If it continue to grow after flowering, it is *acrescent*; and if it wither without falling off, it is *marescent*.

CHAPTER VII.

X OF THE ESSENTIAL ORGANS.—THE STAMENS.

110. Within the safe enclosure of the floral envelopes stand the essential organs—the stamens and pistils—clearly distinguishable from the perianth by their more slight and delicate forms, and from each other by various marks. In the complete flower the ANDRŒCEUM next succeeds the corolla in the order of position, being the third set, counting from the calyx.

111. A. perfect stamen consists of two parts—the *filament*, corresponding with the petiole of the typical leaf; and the *anther*, answering to the blade. Within the cells of the anther the *pollen* is produced, a substance essential to the fertility of the flower. Hence the anther alone is the essential part of the stamen.



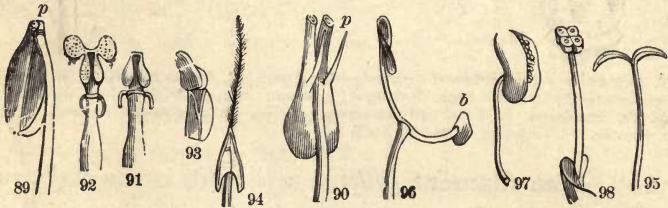
80, Androecium and gynoecium of Frankenia (after Peyer). 81, Stamen (adnate) of Morning-glory. 82, Same enlarged, with pollen grains discharged; *f*, filament; *a, a*, anther, 2-lobed; *c*, top of the connectile. 83, Ranunculus. 84, Same, cut transversely. 85, Iris, cut transversely (extrorse). 86, Amaranth, versatile. 87, Larkspur, innate. 88, Same, cut.

112. The filament (*filum*, a thread) is the stalk supporting the anther at or near its top. It is ordinarily slender, yet sustaining itself with the anther in position. Sometimes it is *capillary*, and pendulous with its weight, as in the Grasses.

113. The anther is regularly an oblong body at the summit of the filament, composed of two hollow parallel lobes joined to each other and to the filament by the *connectile*. In front of the connectile, looking toward the pistil, there is usually a furrow; on its back a ridge, and on the face of each lobe a seam, the usual place of *dehiscence* or opening, all running parallel with the filament and connectile.

114. The stamen, as thus described, may be considered regular or typical in form, and is well exemplified in that of the Buttercup (Fig. 83). But the variations of structure are as remarkable here as in other organs, depending on such circumstances as; 1st, The attachment of filament to anther. This

may occur in three ways. The anther is said to be *innate* when it stands centrally erect on the top of the filament; *adnate* when it seems attached to one side of the filament; *versatile* when connected to the top of the filament by a single point in the back. 2d, The modes of *Dehiscence*, or opening, are also three—viz., *valvular*, where the seam opens vertically its whole length, which is the usual way; *porous*, where the cells open by a chink or pore, usually at the top, as in *Rhododendron* and *Potato*; *opercular*, when by a lid opening upward, as in *Sassafras*, *Berberis* (92). 3d, The facing of the anther is also an important character. It is *introrse* when the lines of dehiscence look toward the pistil, as in *Violet*; *extrorse* when they look outward toward the corolla, as in *Iris*. 4th, The *connectile* is usually a mere prolongation of the filament, terminating, not at the base, but at the top of the anther. If it fall short, the anther will be *emarginate*. Sometimes it outruns the anther, and tips it with a terminal appendage of some sort, as in *Violet*, *Oleander*, and *Paris*. Again, its base may be dilated into spurs, as in two of the stamens of *Violet*. 5th, If the connectile be laterally dilated, as we see gradually done in the various species of the Labiate Order, the lobes of the anther will be separated, forming two *dimidiate* (halved) anthers on one filament, as in *Sage* and *Brunella*. Such are, of course, 1-celled (96).



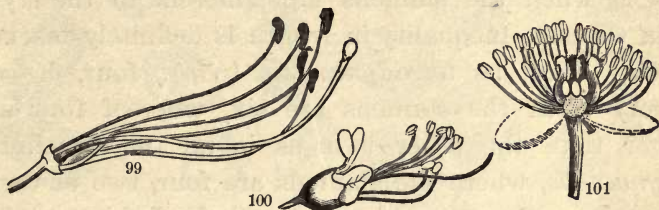
Peculiar forms of stamens.—89, *Pyrola rotundifolia*; *p*, dehiscence by pores at top. 90, *Vaccinium uliginosum*; *p*, dehiscence. 91, *Berberis aquifolium*, anthers opening (92) by valves upward. 93, Anther of *Violet*, introrse, with an appendage at top. 94, *Oleander*, sagittate, appendaged. 95, *Catalpa*, lobes of anther separated. 96, *Sage*, lobes of anther widely separated, on stipes; *b*, barren lobe without pollen. 97, *Malva*, anther 1-celled. 98, *Ephedra* (after Peyer), anther 4-celled.

115. The cells of the anthers are at first commonly four, all parallel, becoming two only at maturity. In some plants the four are retained, as in the anthers of *Ephedra* (98). In others, as *Mallows*, all the cells coalesce into one (97).

116. *Appendages* of many kinds distinguish the stamens of different species. In the *Ericaceæ* there are horns, spurs, tails, queues, etc. In *Onions* and *Garlic*, the filament is 2 or 3 forked, bearing the anther on one of the tips. Sometimes a pair of appendages appear at base, as if stipulate. It is often conspicuously clothed with hairs, as in *Tradescantia*. (See 89-94.)

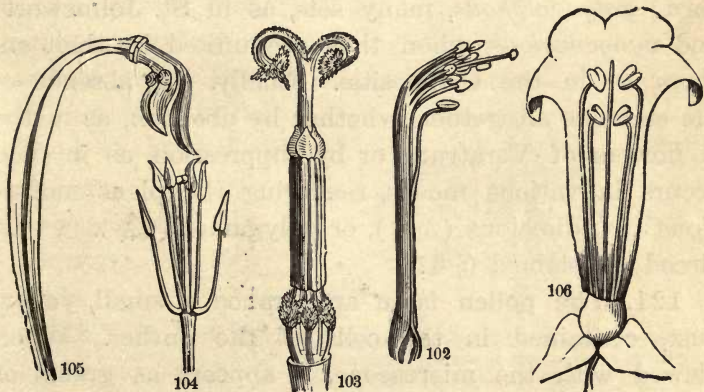
117. *Staminodia*, or sterile filaments with abortive anthers or none, occur singly in many of the *Figworts* and *Labiates*, or in entire whorls next within the petals, alternating with them, as in *Loose-strife*. The curious fringes of the *Passion-flower* are regarded as composed of staminodia (112).

118. The number of the stamens is said to be *definite* when not exceeding twenty, as is sometimes definitely expressed by such terms as follow, compounded of the Greek numerals—viz., *monandrous*,



Essential organs.—99, *Rhododendron*, five stamens (*s*), one pistil (*p*), oblique or slightly irregular. 100, Flower of *Æsculus* (Buckeye), regular, 5-toothed calyx (*c*), very irregular 4-petalled corolla, seven stamens unequal, one style (*s*). 101, Flower of *Hydrastis*; *s*, sepals deciduous.

having one stamen to each flower; *diandrous*, with two stamens; *petandrous*, with five stamens. If the number exceeds twenty, it is said to be *indefinite* (denoted thus, ∞) or *polyandrous*.



102, Stamens (diadelphous) of a Leguminous plant. 103, Stamens (syngenesious) of a Composite; *f*, filaments distinct; *a*, anthers united; *s*, stigmas revolute, etc. 104, Tetradynamous stamens of a Crucifer. 105, Gynandrous column of *Cypripedium*; *o*, ovary; *r*, torus; *s*, sterile stamen; *a*, two pollinia; *c*, stigma. 106, Didynamous stamens of *Lophospermum*.

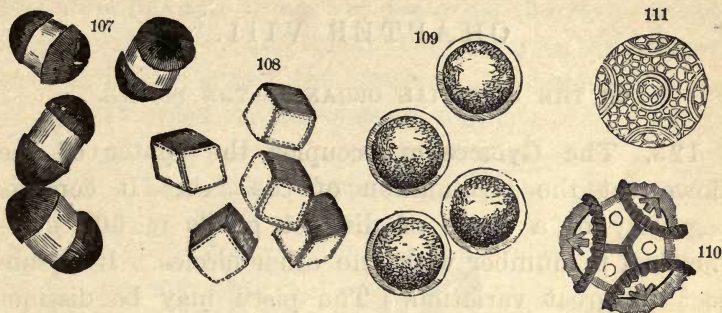
119. The position or insertion of the stamens (§ 55) may be more definitely stated here as *hypogynous*, on

the receptacle below the ovaries; *perigynous*, on the calyx around the ovary; *epipetalous*, on the corolla, as in Phlox; *epigynous*, on the ovary at its summit, and *gynandrous* (γυνή, pistil, άνδρες, stamens) on the pistil, that is, when the stamens are adherent to the style, as in Orchis. Inequality in length is definitely marked in two cases, as *tetradynamous* (τέτρας, four, δύναμις, power) when the stamens are six, whereof four are longer than the other two, as in all the Crucifers; *didynamous*, where the stamens are four, two of them longer than the other two, as in all the Labiates (104, 106).

120. **Cohesion** is as frequent with stamens as with petals. They are *monadelphous* (άδελφός, a brother) when they are all united, as in Mallow, into one set or brotherhood by the filaments; *diadelphous* in two sets, whether equal or unequal, as in Pea, Squirrel-corn; *polyadelphous*, many sets, as in St. Johnswort; and *syngenesious*, when they are united by their anthers, as in the Compositæ. Finally, the absence of the stamens altogether, whether by abortion, as in the ♀ flowers of Veratrum, or by suppression, as in Oak, occurs in various modes, rendering the plant monœcious (♂), dioecious (♂ ♀), or polygamous (♂ ♀ ♀), as already explained (§ 67).

121. **The pollen** is in appearance a small, yellow dust, contained in the cells of the anther. When viewed with the microscope, it appears as grains of various forms, usually spheroidal or oval, sometimes triangular or polyhedral, but always of the same form and appearance in the same species. Externally they are curiously, and often elegantly figured with stripes, bands, dots, checks, etc. Each grain of pollen is a

membranous cell or sac containing a fluid. Its coat is double—the outer is more thick and firm, exhibiting

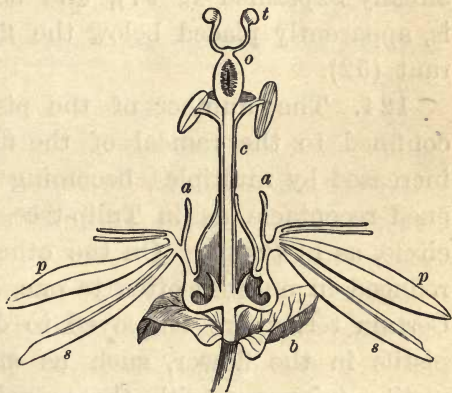


Pollen grains.—107, *Pinus larico*. 108, *Basella rubra*. 109, *Ranunculus repens*. 110, *Scolymus grandiflorus*. 111, *Passiflora incarnata*.

one or more breaks where the inner coat, which is very thin and expansible, is uncovered. In the fluid are suspended molecules of inconceivable minuteness, said to possess a tremulous motion. When the membrane is exposed to moisture, it swells and bursts, discharging its contents.

122. In the Orchids and Silkweed tribe, the pollen

grains do not separate as into a dust or powder, but all cohere into masses called POLLINIA, accompanied by a viscid fluid.



112, Section of the Passion-flower (*Passiflora cœrulea*); *b*, bracts of the involucre; *s*, sepals; *p*, petals; *a, a*, staminodia or sterile filaments; *c*, stipe; *o*, ovary; *d*, stamens; *t*, stigmas.

CHAPTER VIII.

OF THE ESSENTIAL ORGANS.—THE PISTILS.

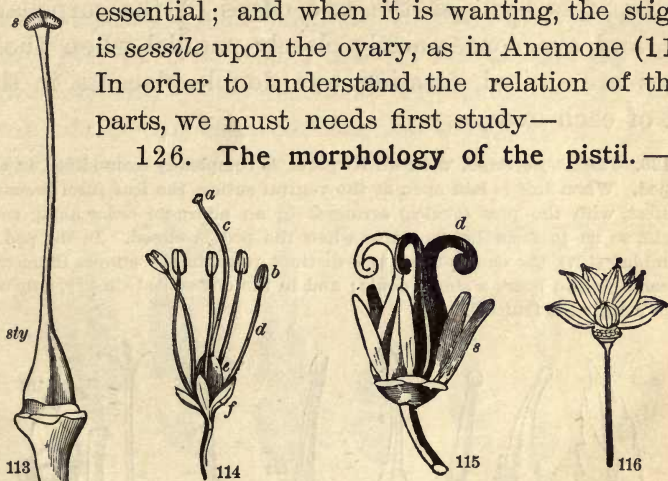
123. The Gynæceum occupies the center of the flower, at the termination of the axis. It consists regularly of a circle of distinct pistils (§ 60), symmetrical in number with the other circles. It is subject to great variation. The pistil may be distinct and *simple*, as in Columbine, or coherent in various degrees into a *compound* body, as in St. Johnswort. Also instead of being free and superior, as it regularly should be, it may adhere to the other circles, as already explained (§ 97), and become *inferior*; that is, apparently placed below the flower, as in the Currant (52).

124. The number of the pistils is by no means confined to the radical of the flower. They may be increased by multiples, becoming a *spiral* on a lengthened receptacle, as in Tulip-tree, or still remaining a circle, as in Poppy. On the other hand, they may be reduced in number often to one, as in Cherry and Pea. Certain terms are employed to denote the number of pistils in the flower, such as *monogynous*, with one pistil; *trigynous*, with three; *polygynous*, with many, etc.

125. The **simple pistil** may usually be known from the compound, by its one-sided forms—having two sides similar and two dissimilar. If the pistils appear distinct, they are all simple, never being united into more than one set, as the stamens often are. The

parts of a simple pistil are three—the *ovary* (*o*, 113) at base, the *stigma* (*s*) at the summit, and the *style* (*sty*) intervening. Like the filament, the style is not essential; and when it is wanting, the stigma is *sessile* upon the ovary, as in Anemone (116). In order to understand the relation of these parts, we must needs first study—

126. The morphology of the pistil.—As

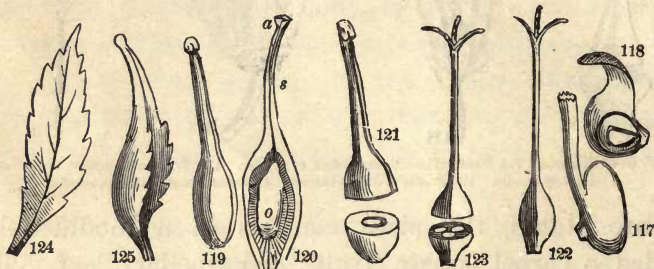


113, Pistil of Tobacco. 114, Pistil, stamens, and calyx of Azalea. 115, Trillium—stigmata (*d*) and anthers (*s*) nearly sessile. 116, Pistils of Rue Anemone (*A. thalictroides*)—stigmata sessile.

before stated, the pistil consists of a modified leaf called a carpel (*καρπός*, fruit), or carpellary leaf. This leaf is folded together toward the axis, so that the upper surface becomes the inner, while the lower becomes the outer surface of the ovary. By this arrangement two sutures or seams will be formed—the dorsal, at the back, by the midvein; the ventral, in front, by the joined margins of the leaf. This view of the pistil is remarkably confirmed and illustrated by the flowers of the Double Cherry (124, 125), where the pistil may be seen in every degree of transition, reverting toward the form of a leaf. This carpellary leaf stands in the place of the pistil, having the edges infolded toward each other, the midvein prolonged and dilated at the apex, as shown in 125.

127. The *placentæ* are usually prominent lines or ridges extending along the ventral suture within the cell of the ovary, and bearing the ovules. They are developed at each of the two edges of the carpellary leaf, and are consequently closely parallel when those edges are united, forming one double placenta in the cell of each ovary.

128. The *simple carpel*, with all its parts, is completely exemplified in the Pea-pod. When this is laid open at the ventral suture, the leaf form becomes manifest, with the peas (ovules) arranged in an alternate order along each margin, so as to form but one row when the pod is closed. In the pod of Columbine (127), the ovules form two distinct rows, in the simple Plum carpel, each margin bears a single ovule; and in the one-ovuled Cherry, only one of the margins is fruitful.

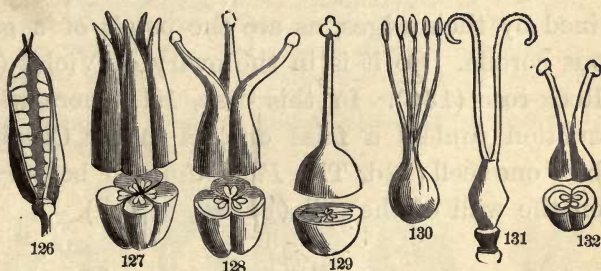


117, Simple pistil of Strawberry, the style lateral. 118, Simple pistil of Crowfoot, cut to show the ovule. 119, Simple pistil of the Cherry. 120, Vertical section showing the ovule (*o*), style (*s*), stigma (*a*). 121, Cross-section of the same. 122, Compound pistil of Spring-beauty. 123, Cross-section of the same, showing the three cells of the ovary. 124, Expanded carpellary leaf of the Double Cherry. 125, The same partly folded, as if to form a pistil.

129. The *stigma* is the glandular orifice of the ovary, communicating with it either directly or through the tubiform style. It is usually globular and terminal, often linear and lateral, but subject to great variations in form. It is sometimes double or halved, or 2-lobed, even when belonging to a single carpel or to a simple style, as in Linden, where these carpels are surmounted by three pairs of stigmas.

130. The *compound pistil* consists of the united circle of pistils, just as the monopetalous corolla con-

sists of the united circle of petals. The union occurs in every degree, commencing at the base of the ovary and proceeding upward. Thus in Columbine, we see the carpels (pistils) distinct; in early Saxifrage, cohering just at base; in Pink, as far as the top of the ovaries, with styles distinct; in Spring-beauty, to the top of the styles, with stigmas distinct; and in Rhododendron, the union is complete throughout.



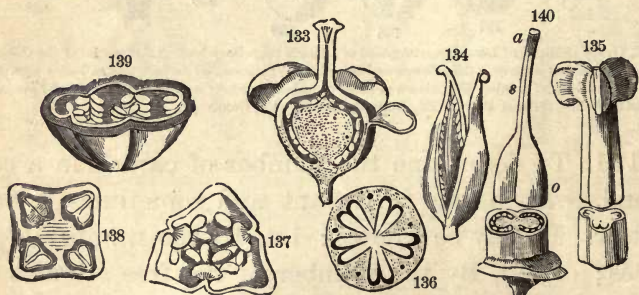
126, Ovary (follicle) of Larkspur, composed of a single carpellary leaf. 127, Ovaries of the Columbine, five, contiguous but distinct. 128, Compound ovary of Hypericum, of carpels united below with distinct styles. 129, Ovary of another Hypericum of three carpels completely united. 130, Ovary of Flax; carpels five, united below, distinct above. 131, Dianthus (Pink). 132, Saxifraga.

131. To determine the number of carpels in a compound ovary is an important and sometimes difficult matter. It may be known: 1st, By the number of the styles; or, 2d, By the number of the free stigmas (remembering that these organs are liable to be halved — § 129); or, 3d, By the lobes, angles, or seams of the ovary; or, 4th, By the cells; or, 5th, By the placentæ. But in Dodecatheon, etc., all these indications fail, so perfect is the union, and we are left to decide from analogy alone.

132. The student will notice two very diverse *modes of cohesion* in the carpels of the compound ovary. First and regularly, the carpels may each be closed, as when simple, and joined by their sides and

fronts; as in St. Johnswort (129) and Lily (171). In this case, he may prove the following propositions. 1st. The compound ovary will have as many cells as carpels. 2d. The partitions between the cells will be double, and alternate with the stigmas. 3d. A partition dividing the cell of a single carpel must be a *false* one; as occurs in Flax (136). 4th. The PLACENTÆ, as well as the ventral suture, will be *axial*.

133. Again: the carpels may each be opened and conjoined by their edges, as are the petals of a gamopetalous corolla. So it is in the ovary of Violet (137) and Rock-rose (139). In this case, 1st. There will be no partition (unless a false one, as in the Crucifers), and but one cell; 2d. The *Placentæ* will be *parietal*, *i. e.*, on the wall of the cell (*paries*, a wall).



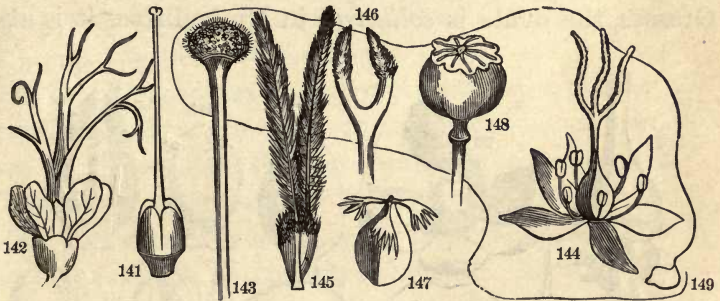
133, *Samolus Valerandi*, section of flower showing the free axial placentas. 134, Ovary of *Scrophulariaceæ*. 135, Ovary of Tulip. 136, Cross-section of ovary of Flax, 5-celled; falsely 10-celled. 137, Ovary of Violet, 1-celled. 138, Ovary of *Fuchsia*, 4-celled. 139, Ovary of Rock-rose, 1-celled, 5-carpelled. 140, *Gentianaceæ*, 2-valved, 1-celled.

134. Between the two conditions of *axial* (or central) and *parietal placentæ*, we find all degrees of transition, as illustrated in the different species of St. Johnswort and in Poppy, where the inflected margins of the carpels carry the placentæ inward, well-nigh to the axis. Moreover, the placentæ are not always mere marginal lines, but often wide spaces covering large portions of the walls of the cell, as in Poppy and Water-lily; in other cases, as *Datura* (168), they become large and fleshy, nearly filling the cell.

135. A *free axial placenta*, without partitions, occurs in some compound one-celled ovaries, as in the Pink

and Primrose orders (133). This anomaly is explained in two ways—first, by the obliteration of the early-formed partitions, as is actually seen to occur in the Pinks; secondly, by supposing the placenta to be, at least in some cases, an *axial* rather than a marginal growth—that is, to grow from the point of the axis rather than from the margin of the carpellary leaf, for in Primrose no partitions ever appear.

136. A few peculiar forms of the style and stigma are worthy of note in our narrow limits, as the *lateral* style of Strawberry; the *basilar* style of the Labiatae and Borrageworts; the branching style of Phyllanthus, one of the Euphorbiaceae; also the globular stigma of Mirabilis; the linear stigma of Mediola; the feathery stigma of Grasses; the filiform stigma of Indian corn; the lateral stigma of Aster; the petaloid stigmas of Iris; the capitate and perforated stigma of Violet (141-149).



Pistils.—141, Symphytum, basilar style, ovary 4-parted. 142, ♂ Flower of Phyllanthus (Euphorbiaceae), branching styles. 143, Mirabilis Jalapa, globular stigma. 144, Flower of Luzula, stigmas linear. 145, Feathery stigmas of a Grass. 146, Stigmas of Aster. 147, Rumex. 148, Poppy. 149, Filiform stigma of Zea Mays (Corn).

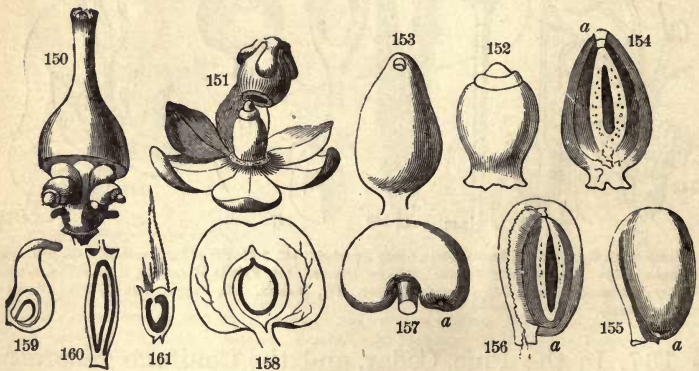
137. In the Pine, Cedar, and the Coniferæ generally, both the style and stigma are wanting; and the ovary is represented only by a flat, open, carpellary scale, bearing the naked ovules at its base.

CHAPTER IX.

THE OVULES.

138. The ovules are understood to be *transformed buds*, destined to become seeds in the fruit. Their development from the margins and inner surface of the carpel favors this view; for the ordinary leaves of Bryophyllum and some other plants do habitually produce buds at their margin or on their upper surface; and in the Mignonette, ovules themselves have been seen transformed into leaves.

139. The number of ovules in the ovary varies from one to hundreds. Thus, in Buttercups, Compositæ, and Grasses, the ovule is *solitary*; in Umbelliferæ it is also



150, Pistil of Celosia; the pericarp detached, showing the young ovules. 151, Flower of Rhubarb, pericarp removed, showing the young ovule. 152, A similar ovule (orthotropous) of Polygonum. 153, The same, full grown; foramen at top. 154, Section showing its two coats, nucleus, and sac. 155, Anatroous ovule, as of Columbine; *a*, foramen. 156, Section of same. 157, Campylotropous ovule, as of Bean; *a*, foramen. 158, Section of a Cherry; ovule anatroous, suspended. 159, Section of carpel of Ranunculus; ovule ascending. 160, Senecio; ovule erect. 161, Hippuris; ovule pendulous.

solitary in each of the two carpels; in the Pea order they are *definite*, being but few; in Mullein and Poppy, *indefinite* (∞), too many to be readily counted. As to

position, the ovule is *erect* when it grows upward from the base of the cell, as in *Compositæ*; *ascending*, when it turns upward from the side of the cell; *horizontal*, when neither turning upward nor downward; *pendulous*, when turned downward; and *suspended*, when growing directly downward from the top of the cell, as in *Birch* (158-161).

140. The ovule at the time of flowering is soft and pulpy, consisting of a nucellus within two coats, supported on a stalk. The stalk is called *funiculus*; the point of its juncture with the base of the nucellus is the *chalaza*. The *nucellus* was first formed; then the *tegmen*, or inner coat, grew up from the *chalaza* and covered it; and lastly the outer coat, the *testa*, invested the whole. Both coats remain open at the top by a small orifice, the *foramen*.

141. In most cases the ovule, in the course of its growth, changes position—curving over in various degrees upon its lengthening *funiculus* or upon itself. When no such curvature exists, and it stands straight, as in the *Buckwheat* order, it is *orthotropous*. It is *anatropous* when completely inverted. In this state a portion of the *funiculus* adheres to the *testa*, forming a ridge called *raphe*, reaching from the *chalaza* to the *hilum*. It is *campylotropous* when curved upon itself. In this state the *foramen* is brought near to the *chalaza*, and both are next the *placenta*, as in the *Pinks* and *Cruciferæ*; and *amphitropous* when half inverted, so that its axis becomes parallel with the *placenta*, as in *Mallow*. Here the *raphe* exists, but is short. In *campylotropous* ovules there is no *raphe*.

142. The ovule contains no young plant (embryo) yet; but a cavity, the *embryo sac*, is already provided

to receive it just within the upper end of the nucellus.

The relations of the ovule to the pollen grain will be more suitably discussed hereafter under the head of fertilization. We briefly remark here that the immediate contact of the two is brought about, at the time of flowering, by special arrangements; and that, as the undoubted result of their combined action, the embryo soon after originates in the embryo sac.

CHAPTER X.

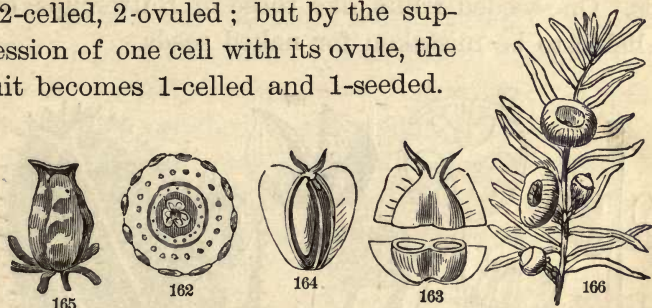
THE FRUIT. — PERICARP.

143. After having received the pollen which the anthers have discharged, the pistil or its ovary continues its growth and enlargement, and is finally matured in the form of the peculiar fruit of the plant. The fruit is, therefore, *the mature ovary*.

144. As to the other organs of the flower, having accomplished their work—the fertilization of the ovary—they soon wither and fall away. Some of them, however, often persist, to protect or become blended with the ripening fruit. Thus the tube of the *superior calyx* (§ 97) always blends with the ovary in fruit; as in Currant, Cucumber, etc. In Compositæ, the persistent limb enlarges into the pappus of the fruit. In Buttercups, the fruit is beaked with the short, persistent *style*. In Clematis and Geum, it is *caudate* (tailed) with the long, feathery *style*. In the Potato tribe, Labiatae, and many others, the *inferior calyx* continues to vegetate like leaves until the fruit ripens. In some cases the fruit, so called, consists of the receptacle and ovaries blended; as in Apple and Strawberry. Again—in Mulberry, Fig, and Pineapple, the whole inflorescence is consolidated into the matured fruit.

145. As a rule, the structure of the fruit agrees essentially with that of the ovary. In many cases, however, the fruit undergoes such changes in the course of its growth from the ovary as to disguise its real structure. An early examination, therefore, is always more reliable in its results than a late one. For example, the acorn is a fruit with but one cell

and one seed, although its ovary had three cells and six ovules! This singular change is due to the non-development of five of its ovules, while the sixth grew the more rapidly, obliterated the partitions by pressing them to the wall, and filled the whole space itself. Similar changes characterize the Chestnut, Hazelnut, and that whole Order. The ovary of the Birch is 2-celled, 2-ovuled; but by the suppression of one cell with its ovule, the fruit becomes 1-celled and 1-seeded.



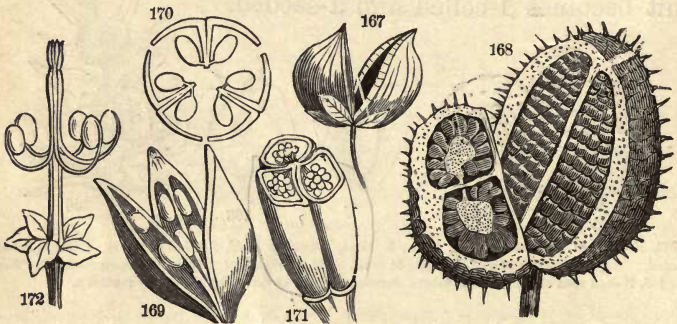
162, Section of the ovary of an acorn, 3-celled, 6-ovuled. 163, Section of ovary of Birch, 2-celled, 2-ovuled. 164, Vertical section of the same in fruit. 165, Pericarp of Mignonette open soon after flowering. 166, Naked seed of *Taxus Canadensis*, surrounded, not covered, by the fleshy pericarp.

On the other hand, the cells are sometimes multiplied in the fruit by the formation of false partitions. Thus the pod of Thornapple (*Datura*) becomes 4-celled from a 2-celled ovary; and the longer pods of some Leguminous plants have cross-partitions formed between the seeds, and the 5-celled ovary of the Flax comes by false partitions to be 10-celled (Fig. 136).

146. The Pericarp.—The fruit consists of the pericarp and the seed. The pericarp (*περί*, around) is the envelope of the seeds, consisting of the carpels and whatever other parts they may be combined with. It varies greatly in texture and substance when mature, being then either dry, as the Pea-pod, or *succulent*, as the Currant. Dry pericarps are *membranous*, or *coriaceous* (leathery), or *woody*. Succulent pericarps may be either wholly so, as the Grape, or partly so, as the Peach and other stone fruits.

147. With very few exceptions the pericarp incloses

the seed while maturing. In Mignonette (165), however, it opens, exposing the seed, immediately after flowering. The membranous pericarp of Cohosh (Caulophyllum) falls away early, leaving the seed to ripen naked. In Yew (Taxus) the seed is never inclosed wholly by its fleshy pericarp; but in most of the other Coniferæ, the close-pressed, carpellary scales cover the seeds. One-seeded fruits, like those of Buttercups, etc., are liable to be mistaken for naked seeds.



Capsule, 167, of *Scrophularia*, 2-celled; 168, of *Datura Stramonium*; 169, of *Iris*; 170, showing its mode of dehiscence (loculicidal). 171, of *Colchicum*, 3-celled. 172, *Regma*, ripe fruit of *Geranium*, the carpels (cooci) separating from the axis and bending upward on the elastic styles.

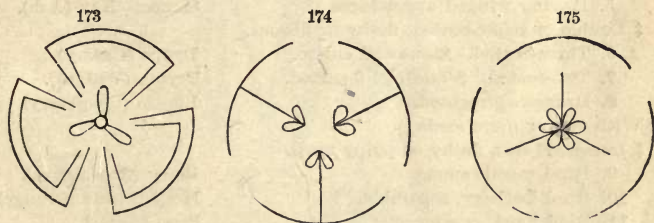
148. **Dehiscence.**—The fleshy pericarp is always *indehiscent*. Its seeds are liberated only by its decay, or bursting in germination. So also in many cases the dry pericarp, as the acorn. But more commonly the dry fruit, when arrived at maturity, opens in some way, discharging its seeds. Such fruits are *dehiscent*. Dehiscence is either *valvular*, *porous*, or *circumscissile*; *valvular*, when the pericarp opens vertically along the sutures, forming regular parts called *valves*. These valves may separate quite to the base, or only at the top, forming teeth, as in Chickweed. We notice four modes of valvular dehiscence, viz. :

1. *Sutural*, when it takes place at the sutures of any 1-celled pericarp, as Columbine, Pea, Violet.

2. *Septicidal* (*septum*, partition, *cædo*, to cut), when it takes place through the dissepiments (which are double, § 132). The carpels thus separated may open severally by sutures (Mallows), or remain indehiscent, as in Vervain.

3. *Loculicidal* (*loculus*, a cell, *cædo*, to cut), when each carpel opens at its dorsal suture directly into the cell (Evening Primrose, Lily). Here the dissepiments come away attached to the middle of the valves.

4. *Septifragal* (*septum*, and *frango*, to break), when the valves separate from the dissepiments which remain still united in the axis (Convolvulus).



Dehiscence: 173, septicidal; 174, loculicidal; 175, septifragal.

149. *Porous* dehiscence is exemplified in the Poppy, where the seeds escape by orifices near the top of the fruit. It is not common. *Circumscissile* (*circum-scindo*, to cut around), when the top of the ovary opens or falls off like a lid, as in Plantain. Some fruits, as the Gerania and Umbelliferæ, are furnished with a *carpophore*, that is, a slender column from the receptacle—a *fusiform torus*, prolonged through the axis of the fruit, supporting the carpels.

CHAPTER XI.

FORMS OF THE PERICARP.

150. The morphology of the pericarp is exceedingly diversified; but it will suffice the learner at first to acquaint himself with the leading forms only, such as are indicated in the following synopsis and more definitely described afterward.

The following is a synopsis of the principal forms of Pericarps, for the blackboard.

§ 1. *Free Fruits (formed by a single Flower).*

* **Pericarps indehiscent.**

† With usually but one seed, and

‡ Uniform, or 1-coated.

1. Separated from the seed.

Akene (Buttercups).

2. Inflated, often breaking away.

Utricle (Pigweed).

3. Inseparable from the seed.

Caryopsis (Grasses).

4. Invested with a cupule (involucre).

Glans, Acorn (Oak).

5. Having winged appendages.

Samara, Key (Ash).

‡ Double or triple-coated, fleshy or fibrous.

6. Three-coated. Stone cell entire.

Drupe (Cherry).

7. Two-coated. Stone cell 2-parted.

Tryma (Walnut).

8. Drupes aggregated.

Frærio (Raspberry).

† With two or more seeds,

‡ Immersed in a fleshy or pulpy mass.

9. Rind membranous.

Berry (Gooseberry).

10. Rind leathery, separable.

Hesperidium (Orange).

11. Rind hard, crustaceous.

Pepo (Squash).

‡ 12. Inclosed in distinct cells.

Pome (Apple).

* **Pericarps dehiscent.**

† 13. Dehiscence circumscissile, seeds ∞ .

Pyxis (Henbane).

† Dehiscence valvular or porous;

‡ Simple, or 1-carpelled,

14. Opening by the ventral suture.

Follicle (Columbine).

15. Opening by both sutures.

Legume (Pea).

16. Legume jointed.

Loment (Desmodium).

‡ Compound pericarps;

17. Placentæ parietal with two cells.

Siliqua (Mustard).

Silicle short.

Silicle (Shepherd's Purse).

18. Placentæ parietal only when 1-celled.

Capsule (Flax).

19. Capsule with carpophore and elastic styles.

Regma (Geranium).

§ 2. *Confluent Fruits (formed of an Inflorescence).*

* 20. With open carpels aggregated into a cone.

Strobile (Pine).

* 21. With closed carpels aggregated into a mass.

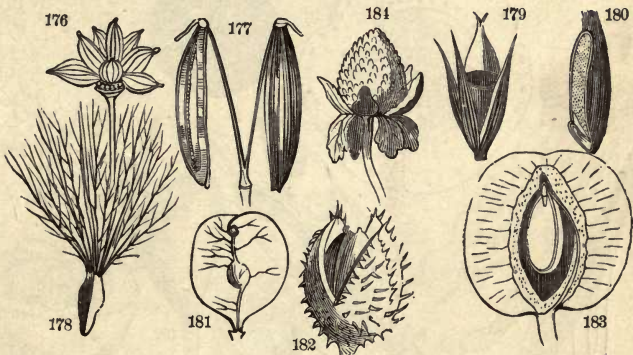
Sorosis (Pineapple).

151. The *akene* is a small, dry, indehiscent pericarp, free from the one seed which it contains, and tipped with the remains of the style (Buttercups, *Lithospermum*).

The double akene of the Umbelliferæ, supported on a *carpophore*, is called cremocarp (177). The akenes of the Compositæ, usually crowned with a pappus, are called *cypsela* (178).

The akenes are often mistaken for seeds. In the Labiatae and Borrage-worts they are associated in fours (141). In *Geum*, *Anemone*, etc., they are collected in heads. The rich pulp of the Strawberry consists wholly of the overgrown receptacle, which bears the dry akenes on its surface (184).

152. The *utricle* is a small, thin pericarp, fitting loosely upon its one seed, and often opening transversely to discharge it (*Pigweed*, *Prince's Feather*).



176, Akenes of *Anemone thalictroides*. 177, Cremocarp of *Archangelica officinalis*, its halves (monocarps) separated and suspended on the carpophore. 178, Cypsela of Thistle with its plumous pappus. 179, Utricle of *Chenopodium* (*Pigweed*). 180, Caryopsis of Wheat. 181, Samara of Elm. 182, Glans of Beech. 183, Drupe of *Prunus*. 184, Fruit of *Fragaria Indica*, a fleshy torus like the Strawberry.

153. *Caryopsis*, the grain or fruit of the Grasses, is a thin, dry, 1-seeded pericarp, inseparable from the seed.

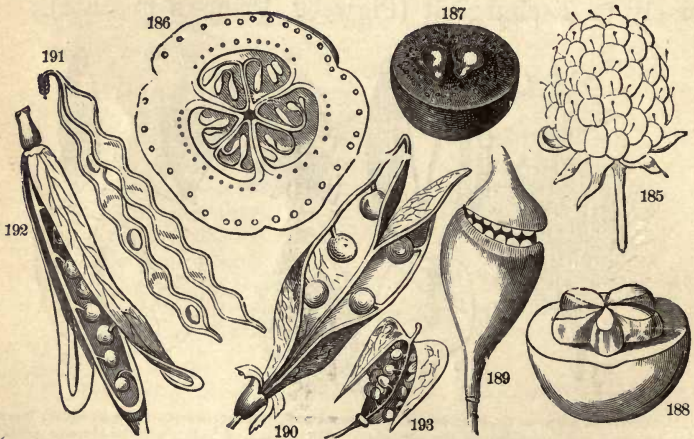
154. *Samara*; dry, 1-seeded, indehiscent, furnished with a membranous wing or wings (*Ash*, *Elm*, *Maple*).

155. *Glans*, or *nut*; hard, dry, indehiscent, commonly 1-seeded by suppression (§ 145), and invested

with a persistent involucre called a cupule, either solitary (Acorn, Hazelnut) or several together (Chestnut).

156. *Drupe*, stone-fruit; a 3-coated, 1-celled, indehiscent pericarp, as the Cherry and Peach. The outer coat (epidermis) is called the epicarp; the inner is the nucellus or endocarp, hard and stony; the intervening pulp or fleshy coat is the sarcocarp ($\sigma\acute{\alpha}\rho\zeta$, flesh). These coats are not distinguishable in the ovary.

157. *Tryma*, a 2-coated drupe; the epicarp fibro-fleshy (Butternut) or woody (Hickory); the nucellus bony, with its cell often deeply 2-parted (Cocoanut).



Fruits.—185, *Etærio* of *Rubus strigosus* (Blackberry). 186, *Pepo*; section of Cucumber. 187, *Berry* Grape. 188, *Pome*; *Cratægus* (Haw). 189, *Pyxis* of *Jeffersonia*. 190, *Legume* of *Pea*. 191, *Loment* of *Desmodium*. 192, *Siliqua* of *Mustard*. 193, *Siliqua* of *Capsella*.

158. *Etærio*, an aggregate fruit consisting of numerous little drupes united to each other (Raspberry) or to the fleshy receptacle (Blackberry).

159. *Berry*, a succulent, thin-skinned pericarp, holding the seeds loosely imbedded in the pulp (Currant, Grape).

160. *Hesperidium*, a succulent, many-carpelled fruit; the rind thick, leathery, separable from the pulpy mass within (Orange, Lemon).

161. *Pepo*, an indehiscent, compound, fleshy fruit, with a hardened rind and parietal placentæ (Melon).

162. The *pome* is an indehiscent pericarp, formed of the permanent calyx and fleshy receptacle, containing several cartilaginous (Apple) or bony (Haw) cells.

163. The *pyxis* is a many-seeded, dry fruit, opening like a lid by a circumscissile dehiscence (Plantain, Henbane, Jeffersonia).

164. The *follicle* is a single carpel, 1-celled, many-seeded, opening at the ventral suture (Columbine, Larkspur, Silk-grass).

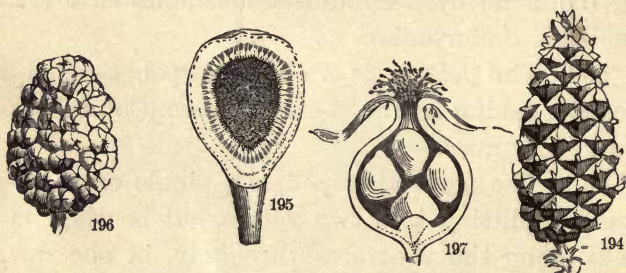
* 165. The *legume*, or pod, is a single carpel, 1-celled, usually splitting into two valves, but bearing its 1— ∞ seeds along the ventral suture only, in one row, as in the Bean and all the Leguminosæ. It is sometimes curved or coiled like a snail-shell (Medicago). The *loment* is a jointed pod, separating across into 1-seeded portions (Desmodium).

166. *Silique*. A pod, linear, 2-carpelled, 2-valved, 2-celled by a false dissepiment extended between the two parietal placentæ. To this false dissepiment on both sides of both edges the seeds are attached (Mustard). The *silicle* is a short silique, nearly as wide as long (Shepherd's Purse). The silique and silicle are the peculiar fruit of all the Cruciferæ.

167. *Capsule* (casket). This term includes all other forms of dry, dehiscent fruits, compound, opening by as many valves as there are carpels (Iris), or by twice as many (Chickweed), or by pores (Poppy).

168. The *Regma* is a kind of capsule like that of the Geranium, whose dehiscent carpels separate elastically, but still remain attached to the carpophore.

169. *Strobile*, or *Cone*; an aggregate fruit consisting of a conical or oval mass of imbricated scales, each an open carpel ($\text{\textit{♀}}$ flower), bearing seeds on its inner side at base, *i. e.*, axillary seeds (Pine and the Gymnosperms generally). The *Cone* (*syncarpium*, $\sigma\upsilon\nu$, together) of the Magnolia tribe is a mass of confluent, closed pericarps on a lengthened torus (Cucumber Tree).



194, Strobile of Pinus. 195, The Fig (*syconus*). 196, Sorosis of Mulberry. 197, Hip of *Rosa*, achenia nearly inclosed in the leathery calyx tube.

170. The *Fig* (*syconium*) is an aggregate fruit, consisting of numerous seed-like akenes inclosed within a hollow, fleshy receptacle, where the flowers were attached.

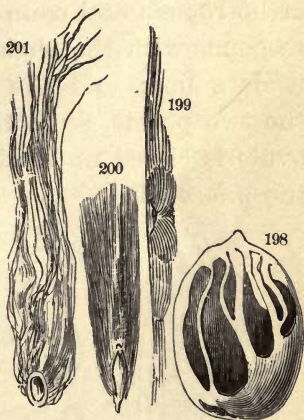
171. Other confluent fruits (*Sorosis*) consist of the entire inflorescence developed into a mass of united pericarps, as in the Mulberry, Osage-orange, Pineapple.

CHAPTER XII.

THE SEED.

172. The seed is the perfected ovule, having an embryo formed within, which is the rudiment of a new plant, similar in all respects to the original. The seed consists of a *nucellus* or kernel, invested with the integuments or coverings. The outer covering is the *testa*, the inner the *tegmen*, as in the ovule. The latter is thin and delicate, often indistinguishable from the testa.

173. The *testa* is either membranous (papery), coriaceous (leathery), crustaceous (horny), bony, woody, or fleshy. Its surface is generally smooth, sometimes beautifully polished, as in Columbine, Indian-shot (Canna), and often highly colored, as in the Bean; or it may be dull and rough. It is sometimes winged, as in Catalpa, and sometimes clothed with long hairs, as in Silk-grass (Asclepias). Such a vesture is called the *Coma*. Cotton is the coma of the Cotton-seed.



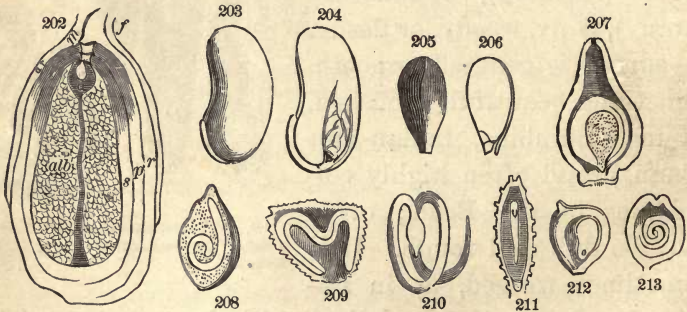
198, Aril of Nutmeg (mace). 199, Seed of Catalpa. 200, Seed of Willow. 201, Seed of Cotton.

174. The coma must not be confounded with the pappus (§ 104), which is a modification of the calyx, appended to the pericarp, and not to the seed, as in the akenes of the Thistle, Dandelion, and other Compositæ. Its intention in the economy of the plant can not be mistaken; serving like the pappus to secure the dispersion of the seed, while incidentally, in the case of the Cotton-seed, it furnishes clothing and employment to a large portion of the human race.

175. The **aril** is an occasional appendage, partially or wholly investing the seed. It originates after fertilization, at or near the hilum, where the seed is attached to its stalk (funiculus). Fine examples are seen in the gashed covering of the Nutmeg, called mace, and in the scarlet coat of the seed of Staff-tree. In the seed of Polygala, etc., it is but a small scale, entire or 2-cleft, called *caruncle*.

176. The position of the seed in the pericarp is, like that of the ovule, *erect, ascending, pendulous*, etc. (§ 149). Likewise, in respect to its inversions, it is *orthotropous, anatropous, amphitropous*, and *campylotropous* (§ 141), terms already defined. The anatropous is by far the most common condition.

177. The **hilum** is the scar or mark left in the testa of the seed by its separation from the funiculus. It is commonly called the *eye*, as in the Bean. In orthotropous and campylotropous seeds, the hilum corresponds with the chalaza (§ 140). In other conditions it does not; and the raphe (§ 141) extends between the two points, as in the ovules. The foramen of the ovule is closed up in the seed, leaving a slight mark—the *micropyle*.



202, Seed of Water Lily (*Nymphaea*), enlarged section; *alb.*, albumen; *a*, the embryo contained in the embryo-sac; *s*, tegmen; *p*, testa; *r*, raphe; *a*, aril; *m*, orifice; *f*, funiculus. 203, Seed of Bean. 204, Same, one cotyledon with the leafy embryo. 205, Seed of Apple. 206, One cotyledon showing the raphe and embryo. 207, Fruit of *Mirabilis*; embryo coiled into a ring. 208, Onion; embryo coiled. 209, *Convolvulus*; leafy embryo folded. 210, Embryo of *Cuscuta*. 211, *Typha*. 212, *Ranunculus*. 213, Hop.

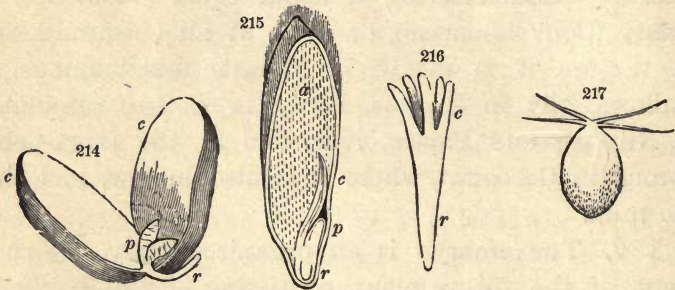
178. The seed-kernel may consist of two parts, the embryo and albumen, or of the embryo only. In the former case the seeds are *albuminous*; in the latter, *exalbuminous*; a distinction of great importance in systematic botany.

179. The **albumen** or endosperm is a starchy or farinaceous substance accompanying the embryo and serving as its first nourishment in germination. Its qualities are wholesome and nutritious, even in poisonous plants. Its quantity, when compared with the embryo, varies in every possible degree; being excessive (Ranunculaceæ), or about equal (Violaceæ), or scanty (Convolvulaceæ), or none at all (Leguminosæ). In texture it is mealy in Wheat, mucilaginous in Mallows, oily in Ricinus, horny in Coffee, ruminated in Nutmeg and Papaw, ivory-like in the Ivory-palm, fibrous in Cocoanut, where it is also hollow, inclosing the milk.

180. The **embryo** is an organized body, the rudiment of the future plant, consisting of root (*radicle*), stem-bud (*plumule*), and leaves (*cotyledons*). But these parts are sometimes quite indistinguishable until germination, as in the Orchis tribe. The *Radicle* is the descending part of the embryo, always pointing toward the micropyle, the true vertex of the seed. The *Plumule* is the germ of the ascending axis, the terminal bud, located between or at the base of the *Cotyledons*. These are the seed-lobes, the bulky farinaceous part of the embryo, destined to become the first or seminal leaves of the young plant. The nutritive matter deposited in the seed for the early sustenance of the germinating embryo, is found more abundant in the cotyledons in proportion as there is less of it in the albumen—often wholly in the albumen (Wheat), again all absorbed in the bulky cotyledons (Squash).

181. The number of the cotyledons is variable; and upon this circumstance is founded the most important subdivision of the *Flowering Plants*. THE

MONOCOTYLEDONS are plants bearing seeds with one cotyledon; or if two are present, one is minute or abortive. Such plants are also called ENDOGENS, because their stems do not grow exogenously (§ 421). Such are the Grasses, the Palms and Lilies, whose leaves are mostly constructed with parallel veins.



214, Dicotyledonous (Bean). 215, Monocotyledonous (Wheat). 216, Polycotyledonous (Pine). 217, Acotyledonous (zospore of one of the Confervæ). (*r*, *r*, *r*, radicle; *p*, *p*, *p*, plumule; *c*, *c*, *c*, cotyledon; *a*, albumen.)

182. THE DICOTYLEDONS are plants bearing seeds with two cotyledons. These are also called EXOGENS, because their stems grow by external accretions; including the Bean tribe, Melon tribe, all our forest trees, etc. These are also distinguished at a glance by the structure of their leaves, which are net-veined (§ 280). More than two cotyledons are found in the seeds of Pine and Fir; while the Dodder is almost the only known example of an embryo with no cotyledon.

183. The position of the embryo, whether with or without albumen, is singularly varied and interesting to study. It may be *straight*, as in Cat-tail and Violet, or *curved* in various degrees (Moonseed and Pink), or *coiled* (Hop), or *rolled* (Spicebush), or *bent* angularly (Buckwheat), or *folded* (Cruciferæ). In the last case

two modes are to be specially noticed. 1. *Incumbent*, when the cotyledons fold over so as to bring the back of one against the radicle (Shepherd's Purse); 2. *Acumbent*, when the edges touch the radicle (Arabis).

184. A few plants, as the Onion, Orange, and Coniferæ, occasionally have two or even several embryos in a seed; while all the Cryptogamia or flowerless plants have no embryo at all, nor even seeds, but are reproduced from *spores* — bodies analogous to the pollen-grains of flowering plants (217).

185. **Vitality of the seed.**—After the embryo has reached its growth in the ripened seed, it becomes suddenly inactive, yet still alive. In this condition it is, in fact, *a living plant, safely packed and sealed up for transportation*. This suspended vitality of the seed may endure for years, or even, in some species, for ages. The seeds of Maize and Rye have been known to grow when 40 years old; Kidney-beans when 100; the Raspberry after 1700 years (Lindley). Seeds of Mountain Potentilla were known to us to germinate after a slumber of 60 years. On the other hand, the seeds of some species are short-lived, retaining vitality hardly a year (Coffee, Magnolia).

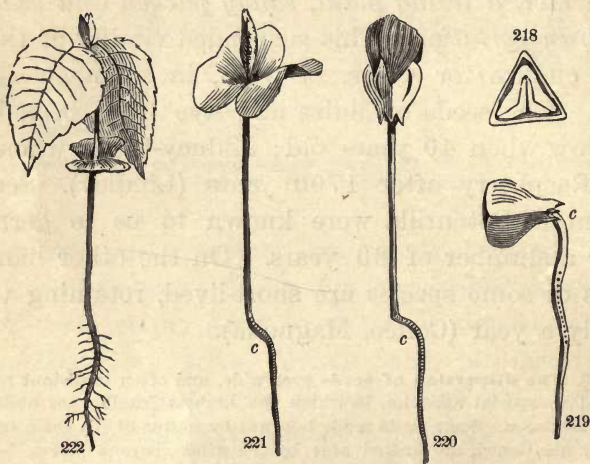
186. **The dispersion of seeds** over wide, and often to distant regions, is effected by special agencies, in which the highest Intelligence and Wisdom are clearly seen. Some seeds made buoyant by means of the coma or pappus, already mentioned, are wafted afar by the winds, beyond rivers, lakes, and seas; as the Thistle and Dandelion. Other seeds have wings for the same purpose. Others are provided with hooks or barbs, by which they lay hold of men and animals, and are thus, by unwilling agents, scattered far and wide (Burr-seed, Tick-seed). Again: some seeds, destitute of all such appendages, are thrown to a distance by the sudden coiling of the elastic carpels (Touch-me-not). The Squinting-cucumber becomes distended with water by absorption, and at length, when ripe, bursts an aperture at the base by separating from the stem, and projects the mingled seeds and water with amazing force.

187. Rivers, streams, and ocean currents, are agents for transporting seeds from country to country. Thus the Cocoa, and the Cashew-nut, and the seeds of Mahogany, have been known to perform long voyages without injury to their vitality. Squirrels laying up their winter stores in the earth; birds migrating from clime to clime and from island to island, in like manner conspire to effect the same important end.

CHAPTER XIII.

GERMINATION.

188. The recommencement of growth in the seed is called *germination*. It is the awakening of the embryo from its torpor, and the beginning of development in its parts already formed, so as to become a plant like its parent.



Germination of the Beechnut.—218, Cross-section, showing the folded cotyledons. 219, The radicle only. 220, The ascending axis, above *c*, appears. 221, The cotyledons expand into the primordial leaves. 222, The first true leaves.

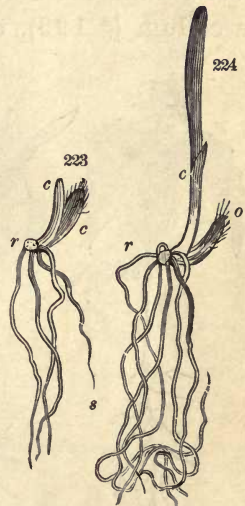
189. All the stages of this interesting process may be conveniently observed, at any season, by an experiment. Let a few seeds, as of flax, cotton, or wheat, be enveloped in a lock of cotton resting upon water in a bulb-glass, and kept constantly at a proper temperature. Or, in Spring, the garden-soil will give us examples of all kinds everywhere.

190. That the seed may begin to grow, or germinate, it is first *planted*; or, at least, placed in contact with warm, moist soil. Concerning the proper depth

of the planted seed, agriculturists are not agreed; but nature seems to indicate that no covering is needed beyond what will secure the requisite moisture and shade. Thus situated, the integuments gradually absorb water, soften, and expand. The insoluble, starchy matter deposited in the cotyledons, or in the albumen, or in both, undergoes a certain chemical change, becoming sweet and soluble, capable of affording nourishment to the embryo now beginning to dilate and develop its parts. First (in the winged seed of the Maple, scattered everywhere) the radicle is seen protruding from the micropyle, or the bursting coverings. A section of this seed would now show the folded embryo, impatient of confinement (225).

191. Soon after, the radicle has extended; and, pale in color, has hidden itself in the dark, damp earth. Now the cotyledons, unfolding and gradually freed from the seed-coats, display themselves at length as a pair of green leaves. Lastly, the plumule appears in open air, a green bud, already showing a lengthening base, its first internode, and soon a pair of regular leaves, lobed as all Maple-leaves. The embryo is now an embryo no longer, but a growing plant, descending by its lower axis, ascending and expanding by its upper.

192. With equal advantage we may watch the germination of the Beech, represented in the figures



Germination of Wheat.—o, the grain, containing the cotyledon; c, plumule; r, radicle; s, rootlets (adventitious).

above; or of the Oak, as displayed in figures 1, 2, 3, 4; or the Pea, or Squash, and other Dicotyledons; and the chief difference observed among them will be in the disposal of the cotyledons. In general, these arise with the ascending axis, as in Maple and Bean, and act as the first pair of leaves. But sometimes, when they are very thick, as in Pea, Buckeye, and Oak, they never escape the seed-coats, but remain and perish at the collum (§ 199), neither ascending nor descending.



Germination of the Maple.—225, Samara; section showing the folded cotyledons at *c*. 226–230, Progressive stages.

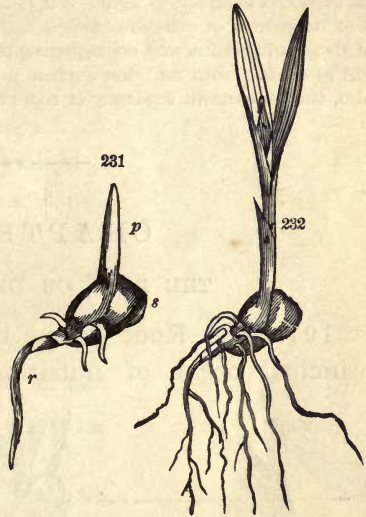
193. The germination of MONOCOTYLEDONS, as seen in Indian Corn, Wheat, and Tulip, is in this wise. The cotyledon is not disengaged from the seed, but remains stationary with it. The radicle (*r*) protrudes slightly, and one or more rootlets (*s*) break out from it and descend. The plumule (*c*) shoots at first parallel with the cotyledon along the face of the seed, but soon ascends, pushing out leaf from within leaf.

194. The conditions requisite for germination are

moisture, air, and warmth. *Moisture* is necessary for softening the integuments, dissolving the nutritive matter, and facilitating its circulation. This is supplied in the rain and dew. *Air*, or rather its oxygen, is required for the conversion of the starch into sugar—a process always depending upon oxidation. The oxygen absorbed unites with a portion of the carbon of the starch, producing heat, evolving carbon dioxide, and thus converting the remainder into grape-sugar, soluble and nutritive.

195. *Warmth* is a requisite condition of all vital action, as well in the *sprouting* of a seed as in the *hatching* of an egg.

The proper degree of temperature for our own climate may be stated at 60° to 90°. Extremes of heat and of cold are not, however, fatal to all germination. In one of the Geysers of Iceland, which was hot enough to boil an egg in four minutes, a species of *Chara* was found in a growing and fruitful state. The hot springs and pools of San Bernardino, California, at the constant heat of 190°, have several species of plants growing within their waters. Many species also arise and flower in the snows of Mt. Hood, along their lower borders. *Darkness* is favorable to germination, as proved by experiment, but not an indispensable condi-



231, 232, Germination of Indian Corn.

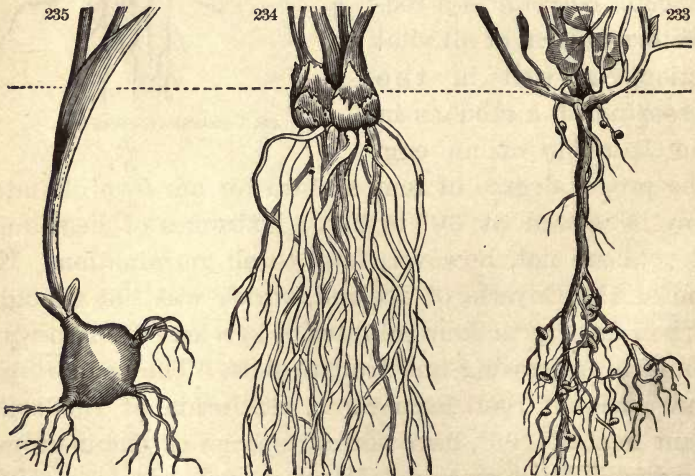
tion. Hence, while the seed should be covered, for the sake of the moisture and shade, the covering should be thin and light, for the sake of a free access to air.

196. The cause of the downward tendency of the root is a theme of much discussion. Some have referred it to the principle of gravitation; others to its supposed aversion to light. But it is a simple and satisfactory explanation that its growth or cell-development takes place most readily on the moist side of its growing-point, and consequently in a downward direction, so long as the soil in contact with its lower surface is more moist than that above. Hence, also, the well-known tendency of roots toward springs and water-courses.

CHAPTER XIV.

THE ROOT, OR DESCENDING AXIS.

197. **The Root** is the basis of the plant, and the principal organ of nutrition. It originates with the



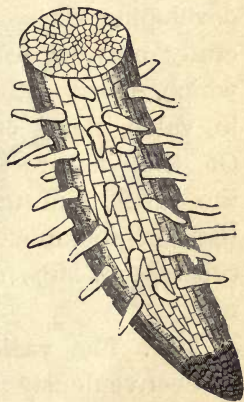
233, White Clover—an axial root (with minute tubers). 234, Buttercup—fibrous roots, inaxial. 235, Eri-
genia—root tuberous.

radicle of the seed, the tendency of its growth is downward, and it is generally immersed in the soil. Its

office is twofold; viz., to support the plant in its position, and to imbibe from the soil the food necessary to the growth of the plant.

198. The leading propensity of the root is to divide itself; and its only normal appendages are branches, branchlets, fibers, and fibrillæ, which are multiplied to an indefinite extent, corresponding with the multiplication of the leaves, twigs, etc., above. This at once insures a firm hold upon the earth, and brings a large absorbing surface in contact with the moist soil.

199. The summit of the root, or that place where the root meets the stem, is called the *collum*; the remote, opposite extremities of the fine rootlets, or fibers, are covered by dry, protective cells, forming a root-cap; the sides of these fibers are chiefly active in absorbing liquid nourishment, and are mostly covered by root-hairs, which increase their absorbing surface. The hairs arise from the tender epidermis or skin, and perish when that thickens into bark. They are developed and perish annually with the leaves, whose servants they are. Few of them remain after the fall of the leaf. This fact plainly indicates that the proper time for transplanting trees or shrubs is the late Autumn, Winter, or early Spring, when there are but few tender fibrillæ to be injured.



236, Extremity of a rootlet of Maple, with its hairs and root-cap (a) magnified 50 diameters.

200. Two modes of root-development are definitely distinguished. First, the AXIAL MODE is that where

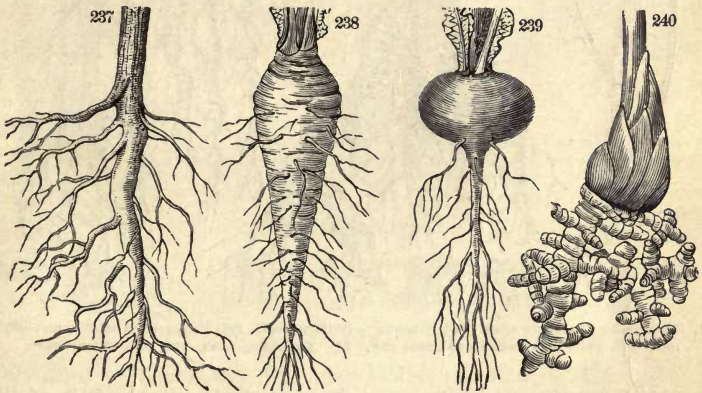
the primary, simple radicle, in growing, extends itself downward in a main body more or less branched, continuous with the stem, and forms the permanent root of the plant. Such is the case with the Maple, Mustard, Beet, and most of the Dicotyledonous Plants (§ 183).

201. Secondly, the **DIFFUSE** development is that where the primary radicle proves abortive, never developing into an axial root; but, growing laterally only, it sends out little shoots from its sides, which grow into long, slender roots, nearly equal in value, none of them continuous with the stem. Of this nature are the roots of all the Grasses, the Lilies, and the Monocotyledons generally, and of the Cryptogamia. Plants raised from layers, cuttings, tubers, and slips are necessarily destitute of the axial root.

202. **The various forms of the root** are naturally and conveniently referred to these two modes of development. The principal axial forms are the ramous, fusiform, napiform, and conical. To all these forms the general name *tap-root* is applied. The *ramous* is the woody tap-root of most trees and shrubs, where the main root branches extensively, and is finally dissolved and lost in multiplied ramifications.

203. **Tuberous tap-roots.**—In herbaceous plants the tap-root often becomes thick and fleshy, with comparatively few branches. This tendency is peculiarly marked in biennials (§ 41), where the root serves as a reservoir of the superabundant food which the plant accumulates during its first year's growth, and keeps in store against the exhausting process of fruit-bearing in its second year. Such is the *Fusiform* (spindle-

shaped) root—thick, succulent, tapering downward, and also for a short space upward. Beet, Radish, and Ginseng are examples. The *Conical* root tapers all the way from the collum downward (Carrot). The *Napiform* (turnip-shaped) swells out in its upper part so that its breadth equals or exceeds its length, as in *Erigenia* (233) and Turnip (239).

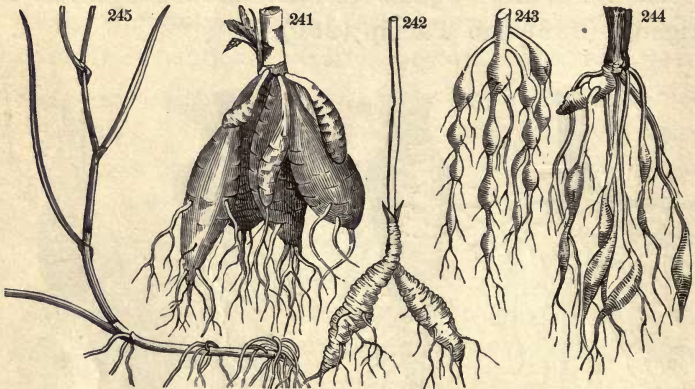


237, Maple—an axial, ramous root. 238, Parsnip—a fusiform root. 239, Turnip—a napiform root. 240, Corallorhiza—a coralline root.

204. The forms of diffuse roots are fibrous, fibrotuberous, tubercular, coralline, nodulous, and moniliform. The *fibrous* root consists of numerous thread-like divisions, sent off directly from the base of the stem, with no main or tap-root. Such are the roots of most Grasses, which multiply their fibers excessively in light sandy soils. *Fibro-tuberous* roots (or fasciculate) are so called when some of the fibers are thick and fleshy, as in the Asphodel, Crowfoot, Pæony, Orchis, and Dahlia. When the fiber is enlarged in certain parts only, it is *nodulous*; and when the enlargements occur at regular intervals, it is *moniliform*.

(necklace-like). When it bears little tubers here and there, as in Squirrel-corn, it is *tubercular*.

205. Deposits of starch, or farinaceous matter, in all these cases, constitute the thickening substance of the root, stored up for the future use of the plant.



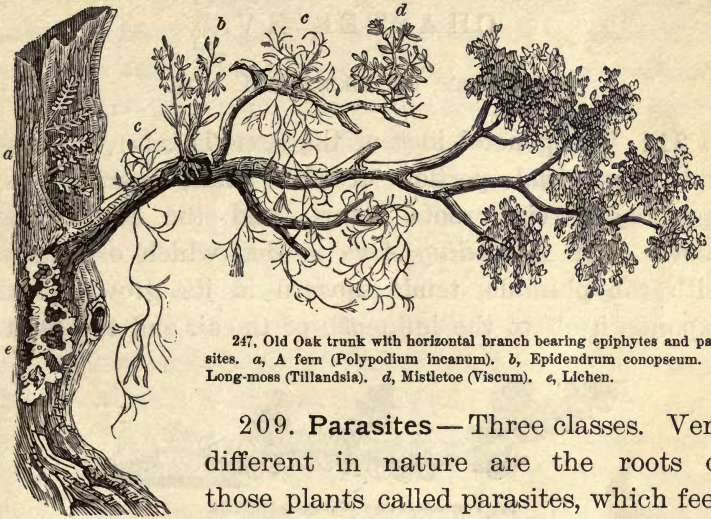
241, *Pæony*—fibro-tuberous roots. 242, *Ginseng*—fusiform root. 243, *Pelargonium triste*—moniliform root. 244, *Spirea filipendula*—nodulous root. 245, A creeping stem, with adventitious roots.

206. **Adventitious roots** are such as originate in some part of the ascending axis—stem or branches—whether above or below the ground. They are so called because their origin is indeterminate, both in place and time. Several special forms should be noticed; as the *cirrhous roots* of certain climbing vines (*European Ivy*, *Poison Ivy*, *Trumpet-creeper*) put forth in great numbers from the stem, serving for its mechanical support and no other known use. Again: the *Fulcra* of certain *Monocotyledonous* plants originate high up the stem, and descending obliquely enter the ground. The *Indian Corn* frequently puts forth such roots from its lower joints, and thereby becomes strongly braced. The *Screw Pine* (*Pandanus*) of the conservatories puts forth *fulcra* often several feet in length.

207. **The *Baniam Tree*** (*Ficus Indicus*) drops “adventitious” roots from its extended branches, which, reaching and entering the ground, grow to supporting columns, like secondary trunks. Thus a single tree becomes at length a grove capable of sheltering an army.

208. **Epiphytes** (*ἐπί*, upon, *φυτόν*, a plant), a class of plants, called also air-plants, have roots which are merely mechanical, serving to fix such plants firmly upon other plants or trees, while they derive their

nourishment wholly from the air. The Long-moss (Tillandsia) and Conopseum are examples.



247. Old Oak trunk with horizontal branch bearing epiphytes and parasites. *a*, A fern (*Polypodium incanum*). *b*, *Epidendrum conopseum*. *c*, Long-moss (*Tillandsia*). *d*, Mistletoe (*Viscum*). *e*, Lichen.

209. **Parasites**—Three classes. Very different in nature are the roots of those plants called parasites, which feed upon the juices of other plants or trees. Such roots penetrate the bark of the nurse-plant to the cambium layer beneath, and appropriate the stolen juices to their own growth; as the Dodder and Mistletoe. Other parasites, although standing in the soil, are fixed upon foreign roots, and thence derive either their *entire* sustenance, as the Beech-drops and other leafless, colorless plants, or a *part* of their sustenance, as the Cow-wheat (*Melampyrum*) and *Gerardia*.

210. **Subterranean stems**.—As there are aerial roots, so there are subterranean stems. These are frequently mistaken for roots, but may be known by their habitually and regularly producing buds. Of this nature are the tubers of the Irish Potato, the rootstock of the Sweet-flag, the bulb of the Tulip. But even the true root may sometimes develop buds—accidentally as it were—in consequence of some injury to the upper axis, or some other unnatural condition.

CHAPTER XV.

THE STEM, OR ASCENDING AXIS.

211. The general idea of the *AXIS* is this: the central substantial portion of the plant, bearing the appendages, viz., roots below, and the leaf-organs above. The *Ascending Axis* is that which originates with the plumule, tends upward in its growth, and expands itself to the influence of the air and the light.

248, Procumbent stem—*Chiogenes hispidula*.

212. Although the first direction of the stem's growth is vertical in all plants, there are many in which this direction does not continue, but changes into the oblique or horizontal, either just above the

249, Decumbent stem—*Anagallis arvensis*.

surface of the ground, or just beneath it. If the stem continues to arise in the original direction, as it most commonly does, it is said to be *erect*. If it grow along the ground without rooting, it is said to be *pro-*

cumbent, prostrate, trailing. If it recline upon the ground after having at the base arisen somewhat above it, it is *decumbent*. If it arise obliquely from a prostrate base, it is said to be *assurgent*; and if it continue buried beneath the soil, it is *subterranean*. Such stems, although buried like roots, may readily be known by their buds, as already explained (§ 210).

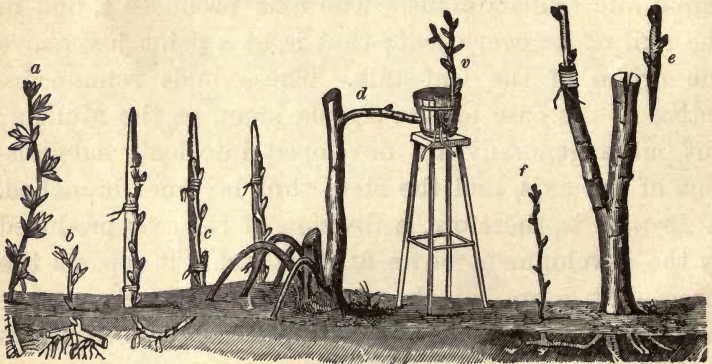
213. Stems are either simple or branched. The simple stem is produced by the unfolding of the primary bud (the plumule) in the direction of its point alone. As this bud is developed below into the lengthening stem, it is continually reproduced at its summit, and so is always borne at the termination of the stem. Hence the axis is always terminated by a bud.

214. The Branching Stem, which is by far the most common, is produced by the development of both terminal and axillary buds. The axis produces a bud in the axil of its every leaf; that is, at a point just above the origin of the leaf-stalk. These buds remain inactive in the case of the simple stem, as the Mullein; but more generally are developed into leafy subdivisions of the axis, and the stem thus becomes branched. A *Branch* is, therefore, a division of the axis produced by the development of an axillary bud. It repeats the internal structure of the stem, but is sometimes peculiar in being bilaterally symmetrical or having its upper and under surfaces unlike.

215. The Arrangement of the Branches upon the stem, depends, therefore, upon the arrangement of the leaves; which will be more particularly noticed hereafter. This arrangement is beautifully regular, according to established laws. In this place we briefly notice three general modes. The *Alternate* arrangement is

where but one branch arises from each joint (node) on different sides of the stem, as in the Elm. The *Opposite* is where two branches stand on opposite sides of the same node, as in Maple. The *Verticillate* is where three or more branches, equidistant, encircle the stem at each node, as in the Pine. Dichotomous branching is where a main or secondary axis forks into two equal divisions, as often occurs in Flowerless Plants.

216. Some plants produce adventitious roots which may become independent. Nurserymen in this way propagate scions, suckers, stolons, offsets, slips, layers, cuttings, and runners. The *Sucker* is a branch issuing from some underground portion of the plant, leaf-bearing above and sending out roots from its own base, becoming finally a separate, independent plant. The Rose and Raspberry are thus multiplied.



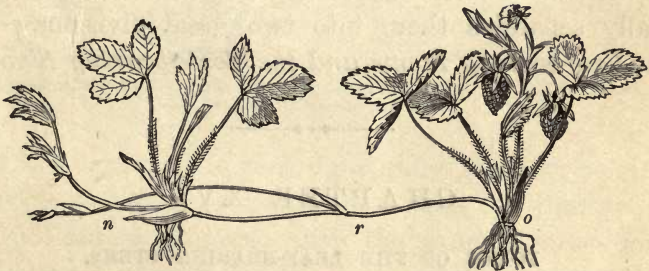
250, a, Slip (Gooseberry) taking root. b, Cutting (Grape) taking root. c, Stolons or layers artificially arranged for propagation. d, A mode of dwarfing; the vessel, v, is filled with soil. e, Scions; process of grafting. f, A sucker.

217. The *Stolon*, or *Layer*, is a branch issuing from some above-ground portion of the stem, and afterward declining to the ground, taking root at or near its extremity, sending up new shoots, and becoming a new

plant. The Hobble-bush and Black-raspberry do this naturally, and gardeners imitate the process in many plants.

218. *The Scion* is any healthy twig or branchlet bearing one or more buds, used by the gardeners in the common process of grafting. Slips and cuttings are fragments of ordinary branches or stems, consisting of young wood bearing one or more buds. These strike root when planted in the ground. So the Grapevine and Hop. The *Offset* is merely a scion severed from the parent and set in the ground to strike root.

219. *The Runner* is a prostrate, filiform branch, issuing from certain short-stemmed herbs, extending itself along the surface of the ground, striking root at its end without being buried. Thence leaves arise, and a new plant, which in turn sends out new runners, as in the Strawberry.



251, A Strawberry plant (*Fragaria vesca*) sending out a runner.

220. *The Node*, or joint of the stem, marks a definite point of a peculiar organization, where the leaf with its axillary bud arises. The nodes occur at regular intervals, and the spaces between them are termed **INTERNODES**. They provide for the symmetrical arrangement of the leaves and branches of the stem. In the

root no such provision is made, and the branches have a less definite arrangement. Now the *growth of the stem* consists in the development of the internodes. In the bud, the nodes are closely crowded together, with no perceptible internodes; thus bringing the rudimentary leaves in close contact with each other. But in the stem, which is afterward evolved from that bud, we see full-grown leaves separated by considerable spaces. That is, while leaves are developed from the rudiments, internodes are pushed out from the growing point.

221. There are, however, many species of plants, especially of herbs, in which the axis of the primary bud does not develop into internodes at all, or but partially in various degrees. See the axis of Trillium, Onion, and Bloodroot. Such stems seldom appear above-ground. They are *subterranean*. This fact makes a wide difference in the forms of stems, and naturally separates them into two great divisions—viz., *the Leaf-bearing Stems and the Scale-bearing Stems*.



CHAPTER XVI.

FORMS OF THE LEAF-BEARING STEMS.

222. **The leaf-bearing stems** are those forms which, with internodes fully developed, rise into the air crowned with leaves. The principal forms are the caulis, culm, trunk, caudex, and vine. They are either herbaceous or woody. Herbaceous stems bear fruit but one season and then perish, at least down to the root, scarcely becoming woody; as seen in Mustard, Radish,

and Grasses. But woody stems survive the Winter, and often become firm and solid in substance in after years; as do all the forest trees.



252, Scale-stem (*Dicentra cucullaria*). 253, A flower of the same. 254, A flower of *D. Canadensis*. 255, Leaf-stem (*Chimaphila maculata*).

223. **CAULIS** is a term generally applied to the annual leafy stems of herbaceous plants. "Haulm" is a term used in England with the same signification. *Caullescent* and *acaulescent* are convenient terms, the former denoting the presence, and the latter the absence of the caulis or aerial stem.

224. **THE CULM** is the stem of the Grasses and the Sedges, generally jointed, often hollow, rarely becoming woody; as in Cane and Bamboo.

225. **THE TRUNK** is the name of the peculiar stems of arborescent plants. It is the central column or axis

which supports their branching tops and withstands the assaults of the wind by means of the great firmness and strength of the woody or ligneous tissue with which it abounds. The trunk is usually seen simple and columnar below, for a certain space, then variously dividing itself into branches. Here it is cylindrical, straight, and erect, as in the Forest Pine; prismatic often, as in the Gum-tree; gnarled and curved, as in the Oak; or inclined far over its base, as in the Sycamore.



256, *S*, Spruce. *B*, Beech. *E*, Elm; to illustrate excurrent and deliquescent axis.

226. In dividing itself into branches, we observe two general modes, with their numerous variations, strikingly characterizing the tree forms. In the one, named by Lindley the **EXCURRENT**, the trunk, from the superior vigor of its terminal bud, takes precedence of

the branches, and runs through to the summit, as in the Beech, Birch, Oak, and especially in the Spruce—trees with oval or pyramidal forms. But in the other, the DELIQUESCENT AXIS, as seen in the Elm and Apple-tree, the trunk suddenly divides into several subequal branches, which thence depart with different degrees of divergency, giving the urn form to the Elm, the rounded form to the Apple-tree, the depressed form to the Sloe-tree (*Viburnum*) and Dogwood.

227. CADEX is a term now applied to the peculiar trunk of the Palms and Tree-ferns, simple, branchless columns, or rarely dividing in advanced age. It is produced by the growth of the terminal bud alone, and its sides are marked by the scars of the fallen leaf-stalks of former years, or are yet covered by their persistent bases. The *stock* or *caudex* of the cactus tribe is extraordinary in form and substance. It is often jointed, prismatic, branched, always greenish, fleshy, and full of a watery juice. Instead of leaves, its lateral buds develop spines only, the stem itself performing the functions of leaves. These plants abound in the warm regions of tropical America, and afford a cooling acid beverage to the thirsty traveler when springs dry up under the torrid sun.

228. THE VINE is either herbaceous or woody. It is a stem too slender and weak to stand erect, but trails along the ground, or any convenient support. Sometimes, by means of special organs for this purpose, called *tendrils*, it ascends trees and other objects to a great height; as the Grape, Gourd, and other climbing vines.

229. The *twining vine* having also a length greatly disproportioned to its diameter, supports itself on other plants or objects by entwining itself around them, being destitute of tendrils. Thus the Hop ascends into the air by foreign aid, and it is a curious fact that the direction of its winding is always the same, viz., *with the sun*, from left to right; nor can any artificial training induce it to reverse its course. This is a general law among twining stems. Every individual plant of the same species revolves in the same direction, although opposite directions may characterize different species. Thus the Morning-Glory revolves always *against the sun*,

CHAPTER XVII.

FORMS OF SCALE-BEARING STEMS.

230. The **Scale-bearing stems** are those forms which, with internodes partially or not at all developed, and generally clothed with scales for leaves, scarcely emerge from the soil. They are the *creeper* and *rhizoma* (developed), the *crown*, *tuber*, *corm*, and *bulb* (undeveloped). Their forms are singular, often distorted in consequence of their underground growth and the unequal development of the internodes. They commonly belong to perennial herbs, and the principal forms are described as follows; but intermediate connecting forms are very numerous, and often perplexing.

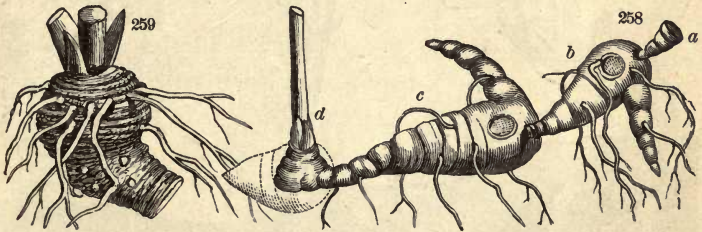


257, Creeper of "Nimble Will" or Witch-grass; a, Bud; bb, bases of culms.

231. THE CREEPER is either subaerial or subterranean. In the former case, it is prostrate, running and rooting at every joint, and hardly distinguishable otherwise from leafy stems; as the Twin-flower, the Partridge-berry. In the latter case, it is more commonly clothed with scales, often branching extensively, rooting at the nodes, exceedingly tenacious of life, extend-

ing horizontally in all directions beneath the soil, annually sending up from its terminal buds erect stems into the air. The Witch-grass is an example. Such plants are a sore evil to the garden. They can have no better cultivation than to be torn and cut to pieces by the spade of the angry gardener, since they are thus multiplied as many times as there are fragments.

232. Repent stems of this kind are not, however, without their use. They frequently abound in loose, sandy soil, which they serve to bind and secure against the inroads of the water and even the sea itself. Holland is said to owe its very existence to the repent stems of such plants as the Mat-grass (*Arundo arenaria*), *Carex arenaria*, and *Elymus arenarius*, which overrun the artificial dykes upon its shores, and by their innumerable roots and creepers apparently bind the loose sand into a firm barrier against the washing of the waves. So the *turf*, chiefly composed of repent Grass-stems, forms the only security of our own sandy or clayey hills against the washing rains.



258, Rhizoma of Solomon's Seal (*Polygonatum multiflorum*). *a*, Fragment of the first year's growth; *b*, the second year's growth; *c*, growth of the third year; *d*, growth of the present (fourth) year, bearing the stem, which, on decaying, will leave a scar (seal) like the rest. 259, Premorse root of *Trillium erectum*.

233. THE RHIZOME, OR ROOT-STOCK, differs from the creeper only in being shorter and thicker, having its internodes but partially developed. It is a prostrate, fleshy, rooting stem, either wholly or partially subterranean, often scaly with the bases of undeveloped leaves, or marked with the scars of former leaves, and yearly producing new shoots and roots. Such is the fleshy, horizontal portion of the Blood-root, Sweet-flag, Water-lily, and Bramble (the latter hardly different from the creeper).

234. *The growth of the rhizome* is instructive, marking its peculiar character. Each joint marks the growth of a year. In Spring, the terminal bud unfolds into leaves and flowers, to perish in Autumn—a new bud to open the following Spring, and a new internode, with its roots, to abide several years. The number of joints indicates, not the age of the plant, but the destined age of each internode. Thus if there are three joints, we infer that they are triennial, perishing after the third season, while the plant still grows on.

235. THE PRÆMORSE ROOT, OR ROOT-STOCK, is short, erect, ending abruptly below, as if bitten square off (præmorsus). This is mostly owing to the death of the earlier and lower internodes in succession, as in the horizontal rhizome. The root of Scabious and the rhizomes of *Viola pedata* and Benjamin-root are examples.



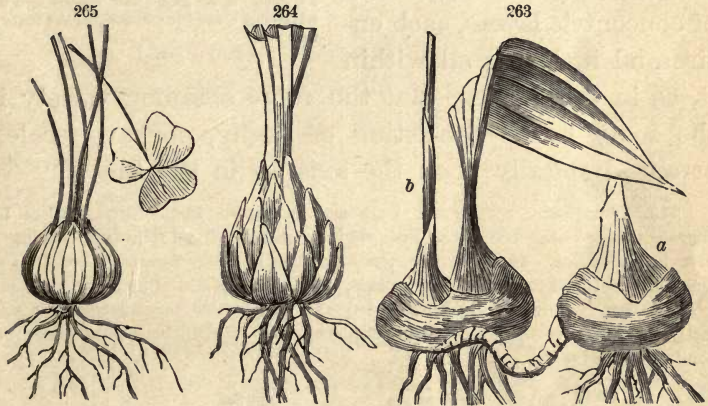
Tubers as they grow.—260, The common Potato (*Solanum*). 261, Artichoke (*Helianthus*). 262, Sweet Potato (*Convolvulus*).

236. CROWN OF THE ROOT designates a short stem with condensed internodes, remaining upon some perennial roots, at or beneath the surface-soil, after the leaves and annual stems have perished.

237. THE TUBER is an annual thickened portion of a subterranean stem or branch, provided with latent

buds called eyes, from which new plants ensue the succeeding year. It is the fact of its origin with the ascending axis, and the production of buds, that places the tuber among stems instead of roots. The Potato and Artichoke are examples.

238. The stem of the Potato-plant sends out roots from its base, and branches above, like other plants; but we observe that its branches have two distinct modes of development. Those branches which rise into the air, whether issuing from the above-ground or the under-ground portion of the stem, expand regularly into leaves, etc.; while those lower branches which continue to grope in the dark, damp ground, cease at length to elongate, swell up at the ends into tubers with developed buds and abundance of nutritious matter in reserve for renewed growth the following year.



263, Corms of Putty-root (*Aplectrum*); *a*, of last year—*b*, of the present year. 264, Scale-bulb of White Lily. 265, Scale-bulb of *Oxalis violacea*.

239. THE CORM is an under-ground, solid, fleshy stem, with condensed internodes, never extending, but remaining of a rounded form covered with thin scales. It is distinguished from roots by its leaf-bud, which is either borne at the summit, as in the *Crocus*, or at the side, as in the *Colchicum* and Putty-root (*Aplectrum*).

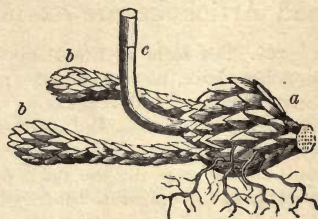
240. THE BULB partakes largely of the nature of the bud. It consists of a short, dilated axis, bearing an oval mass of thick, fleshy scales, closely packed

above, a circle of adventitious roots around its base, and a flowering stem from the terminal or a lateral bud.

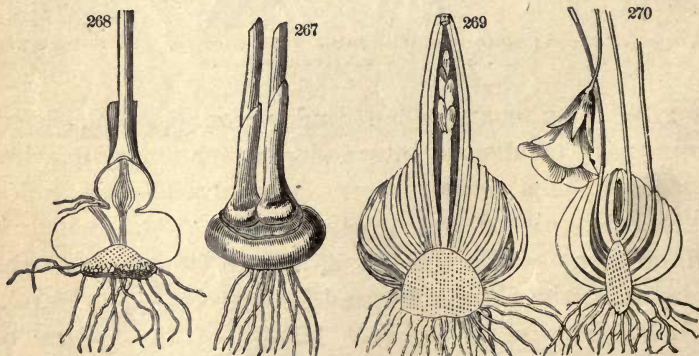
241. *How multiplied.*—Bulbs are renewed or multiplied annually at the approach of Winter by the development of bulbs from the axils of the scales, which increase at the expense of the old, and ultimately become detached. Bulbs which flower from the terminal bud are necessarily either annual or biennial; those flowering from an axillary bud may be perennial, as the terminal bud may in this case continue to develop new scales indefinitely.

242. Bulbs are said to be *tunicated* when they consist of concentric layers, each entire and inclosing all within it, as in the Onion. But the more common variety is the *scaly* bulb—consisting of fleshy, concave scales, arranged spirally upon the axis, as in the Lily

243. The tuber, corm, and bulb are analogous forms approaching by degrees to the character of the bud, which consists of a little axis bearing a covering of scales. In the tuber, the axis is excessively developed, while the scales are reduced to mere linear points. In the corm the analogy is far more evident, for the axis is less excessive and the scales more manifest; and lastly, in the bulb the analogy is complete, or overdone, the scales often becoming excessive.



266, Bulb of *Lilium superbum*, with habit of a rhizome; *a*, full grown bulb sending up a terminal stem *c*, and two offsets *bb*, for the bulbs of next year.



267, Corm of *Crocus*, with new ones forming above. 268, Vertical section of the same. 269, Section of bulb of *Hyacinth*, with terminal scape and axillary bulblet. 270, Section of bulb of *Oxalis violacea*, with axillary scapes.

CHAPTER XVIII.

THE LEAF-BUD.

244. It is but a step from the study of the bulb to that of the leaf-bud. Buds are of two kinds in respect to their contents—the *leaf-bud* containing the rudiments of a leafy stem or branch, the *flower-bud* containing the same elements transformed into the nascent organs of a flower for the purpose of reproduction.

245. The leaf-bud consists of a brief, cone-shaped axis with a tender growing point, bearing a protecting covering of imbricated scales and incipient leaves.

246. The leafy nature of the scales is evident from a careful inspection of such buds as those of the Rose, Currant, Tulip-tree, when they are swollen or bursting in Spring. The student will notice a gradual change from the outer scales to the evident leaves or stipules within, as seen in Fig. 273. As a further protection against frost and rain, we find the scales sometimes clothed with hairs, sometimes varnished with resin. This is abundant and very aromatic in the buds of the Balm-of-Gilead and other Poplars.

247. In regard to position, buds are either terminal or axillary, a distinction already noticed. *Axillary*



271, Branch of Pear-tree. The terminal bud *a*, having been destroyed, an axillary bud supplied its place, and formed the axis *b*. *c*, Thickened branch with flower-buds; *d*, branch with leaf-buds. 272, *t*, section of terminal bud; *l*, of axillary bud.

buds are especially noted as being either *active* or *latent*. In the former case they are unfolded into branches at once, or in the Spring following their formation. But latent buds suspend their activities from year to year, or perhaps are never quickened into growth. Axillary buds become terminal so soon as their development fairly commences; therefore each branch also has a terminal bud, and, like the



273, Bud of Currant unfolding,—the scales gradually becoming leaves. 274, Bud of Tulip-tree,—the scales unfolding into stipules.

main axis, is capable of extending its growth as long as that bud remains unharmed. If it be destroyed by violence or frost, or should it be transformed into a flower-bud, the growth in that direction forever ceases.

248. The suppression of axillary buds tends to simplify the form of the plant. Their total suppression during the first year's growth of the terminal bud is common, as in the annual stem of Mullein and in most perennial stems. When axillary buds remain permanently latent, and only the terminal bud unfolds year after year, a simple, branchless trunk, crowned

with a solitary tuft of leaves, is the result, as in the Palmetto of our southern borders.

249. A partial suppression of buds occurs in almost all species, and generally in some definite order. In plants with opposite leaves, sometimes one bud of the pair at each node is developed and the other is suppressed, as in the Pink tribe. When both buds are developed, the branches, appearing in pairs like arms, are said to be brachiate, as in the Labiates. In many trees the terminal buds are arrested by inflorescence each season, and the growth is continued by axillary buds alone, as in the Catalpa and Horse-chestnut. In all trees, indeed, buds are suppressed more or less, from various causes, disguising at length the intended symmetry of the branches, to the utter confusion of twigs and spray.

250. *Accessory buds*, one or more, are sometimes found just above the true axillary bud, or clustered with it, and only distinguished from it by their smaller size; as in the Cherry and Honeysuckle.

251. *Adventitious* or accidental buds are such as are neither terminal nor axillary. They occasionally

appear on any part of the plant in the internodes of the stem or branches, on the root or even the leaves. Such buds generally result from some abnormal condition of the plant, from pruning or other destruction of branches or stem above, while the roots remain in full vigor; thus destroying the equilibrium of vital force between the upper and lower axis. The leaf of the Walking-fern emits rootlets and buds at its apex; the leaf of Bryophyllum from its margin, each bud

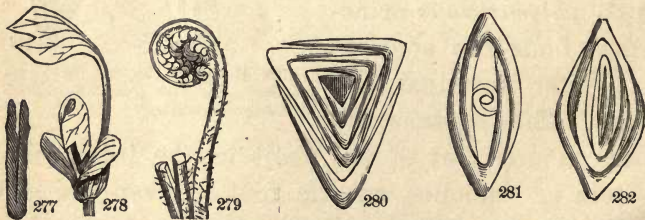


275, *Hypericum sarothra*, with brachiate branches. 276, Pink (*Dianthus*)—axillary buds alternately suppressed.

here also preceded by a rootlet. Some plants are thus artificially propagated in conservatories from the influence of heat and moisture on a leaf or the fragment of a leaf, as *Begonia*.

252. **Vernation** or **præfoliation** are terms denoting the mode of arrangement and folding of the leaf organs composing the bud. This arrangement is definitely varied in different orders of plants, furnishing useful distinctions in systematic botany. It may be studied to excellent advantage by making with a keen instrument a cross-section of the bud in its swollen state, just before expansion; or it may be well observed by removing one by one the scales. The Forms of Vernation are entirely analogous to those of *Æstivation*, and denoted by similar terms.

253. Vernation is considered in two different aspects—first, the manner in which the leaf itself is folded; second, the arrangement of the leaves in respect to each other. This depends much upon the *Phyllotaxy*. (§ 261.)



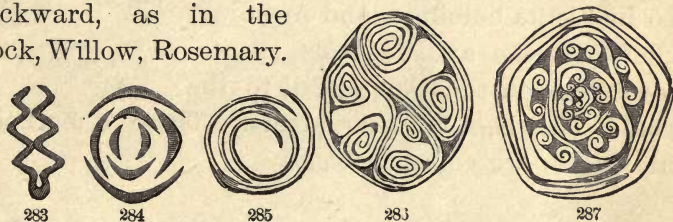
Vernation, 277, of Oak leaf; 278, of *Liriodendron* (Tulip-tree). 279, of Fern; 280, of *Carex*; 281, Sage; 282, Iris.

254. Each leaf considered alone is either *flat* and *open*, as in the *Mistletoe*, or it is *folded* or *rolled*, as follows: viz., *Reclined*, when folded crosswise, with apex bent over forward toward the base, as in the *Tulip-tree*; *Conduplicate*, when folded perpendicularly,

with the lateral halves brought together face to face, as in the Oak; **Plaited*, or *Plicate*, each leaf folded like a fan, as in Birch.

255. *Circinate* implies that each leaf is rolled or coiled downward from the apex, as in Sundew and the Ferns.

256. The *Convolute* leaf is wholly rolled up from one of its sides, as in the Cherry; while the *Involute* has both its edges rolled inward, as in Apple, Violet; and the *Revolvute* has both margins rolled outward and backward, as in the Dock, Willow, Rosemary.



Vernation, 283, of Birch leaf; 284, of Lilac (imbricate); 285, Cherry leaves (convolute); 286, Dock bud (revolute); 287, Balm of Gilead (involute).

257. The general vernation is loosely distinguished in descriptive botany as *valvate* (edges meeting), and *imbricate* (edges overlapping), terms to be noticed hereafter. The *valvate* more often occurs in plants with opposite leaves; as in the St. John's-wort family, *Hypericum Sarrhotra* (275).

258. **Imbricate** vernation is *Equitant* (riding astraddle), when conduplicate leaves alternately embrace—the outer one the next inner by its unfolded margins, as in the Privet and Iris (282). It is *Obvolvute* when it is half-equitant; that is, the outer leaf embraces only one of the margins of the inner, as in the Sage (281). Again, it is *Triquetrous* where the bud is triangular in section and the leaves equitant at each angle, as in the Sedges (280).

259. *The principle of budding.*— Each leaf-bud may be regarded as a distinct individual, capable of vegetating either in its native position, or when removed to another, as is extensively practiced in the important operation of *budding*.



288, Vernatum of Sycamore bud.



290



289

289, 290, Showing the process of "budding."

260. *Bulblets.*— In the Tiger-lily, also in *Cicuta bulbifera*, and *Aspidium bulbiferum*, the axillary buds spontaneously detach themselves, fall to the ground, and become new plants. These remarkable little bodies are called *bulblets*.

CHAPTER XIX.

PHYLLOTAXY, OR LEAF-ARRANGEMENT.

261. As the position of the leaf upon the stem marks the position of the axillary bud, it follows that the order of the leaf-arrangement will be the order of the branches also. Phyllotaxis, or leaf-arrangement (from *φύλλον*, leaf, *τάξις*, order), depends chiefly on the mode of origin of the leaves at the apex of growth, and on the subsequent elongation and twisting of the axis on which they grow.

262. In regard to position, leaves are *radical* when they grow out of the stem at or beneath the surface of the ground, so as to appear to grow from the roots; *cauline*, when they grow from the stem; and *ramal*

(*ramus*, a branch), when from the branches. Their arrangement on the axis is according to the following general modes:

Alternate, one above another on opposite sides, as in the Elm.

Scattered, irregularly spiral, as in the Potato vine.

Rosulate, clustered regularly, like the petals of a Rose, as in the Plantain and Shepherd's-purse.



291, Lady's-slipper (leaves alternate); 292, *Synandra grandiflora* (leaves opposite); 294, *Medeola Virginica* (leaves verticillate); 293, *Larix Americana* (leaves fasciculate).

Fasciculate, tufted, clustered many together in the axil, as seen in the Pine, Larch, Berberry.

Opposite, two, against each other, at the same node. Ex., Maple. When successive pairs of opposite leaves cross each other at right angles, they are said to be *decussate*.

Verticillate, or whorled, more than two in a circle at each node, as in the Meadow-lily, Trumpet-weed. We may reduce all these modes to TWO GENERAL TYPES,

—the *alternate*, including all cases with one leaf at each node; the *opposite*, including cases with two or more leaves at each node.

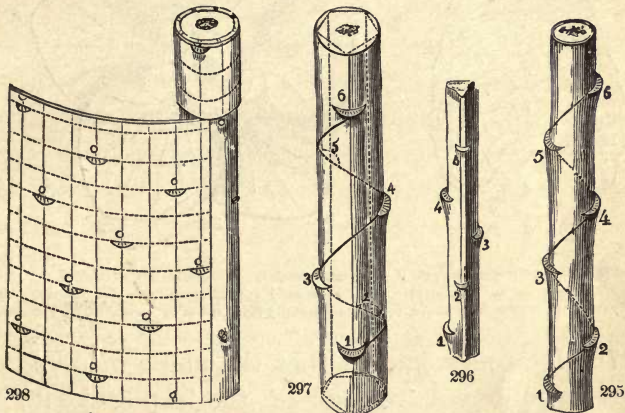
263. The character of the alternate type of leaf-arrangement is sometimes represented by a spiral, which was at one time supposed to be invariable. This generating spiral, as it was called, is illustrated by Figures 295–300. Take a straight leafy shoot or stem of the Elm or Flax, or any other plant with seemingly scattered leaves, and beginning with the lowest leaf, pass a thread to the next above, thence to the next in the same direction, and so on by all the leaves to the top; the thread will form a regular *spiral*.

264. **The Elm cycle.**—In the strictly alternate arrangement (Elm, Linden, Grasses) the spiral thread makes one complete circuit and commences a new one at the third leaf. The third leaf stands over the first, the fourth over the second, and so on, forming two vertical rows of leaves. Here (calling each complete circuit a *cycle*) we observe, first, that this cycle is composed of two leaves; second, that the angular distance between its leaves is $\frac{1}{2}$ a circle (180°); third, if we express this cycle mathematically by $\frac{1}{2}$, the numerator (1) will denote the turns or revolutions, the denominator (2) its leaves, and the fraction itself the angular distance between the leaves ($\frac{1}{2}$ of 360°).

265. **The Alder cycle.**—In the Alder, Birch, Sedges, etc., the cycle is not complete until the fourth leaf is reached. The fourth leaf stands over the first, the fifth over the second, etc., forming three vertical rows. Here call the cycle $\frac{1}{3}$; 1 denotes the turns, 3 the

leaves, and the fraction itself the angular distance ($\frac{1}{3}$ of 360°).

266. **The Cherry cycle.**—In the Cherry, Apple, Peach, Oak, Willow, etc., neither the third nor the fourth leaf, but the *sixth*, stands over the first; and in order to reach it the thread makes two turns around the stem. This arrangement is very frequent; but more or less disguised by the torsions which the axis experiences in process of growth.



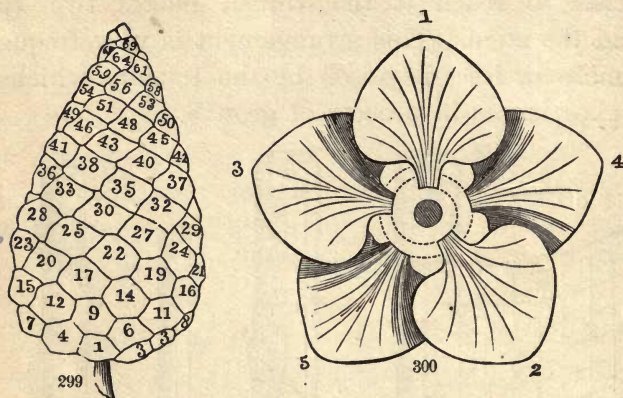
295, 296, 297, Showing the course of the spiral thread and the order of the leaf-succession in the axes of Elm, Alder, and Cherry. 298, Axis of Osage-orange with a section of the bark peeled, displaying the order of the leaf-scars (cycle $\frac{2}{3}$).

267. In the Osage-orange, the Holly, and some other plants, the attempt has been made to find spirals of a higher order.

268. In the leaves of House-leek and the cones of Pine-trees the number of members is very large.

269. The common arrangement is represented by a series of fractions, each fraction indicating the proportion borne by the angular divergence to the entire circumference. Thus $\frac{2}{3}$, for the Cherry, indicates that the angular divergence between successive leaves is

two fifths of a circle, or 144° . It also shows that in following the spiral from any particular leaf to one directly above it, you must go round the stem twice and pass to the fifth leaf above, and that there are five orthostichies or vertical rows of leaves (Fig. 297).



299, Phyllotaxy of the cone (cycle $\frac{3}{2}$) of *Pinus serotina*. The scales are numbered (1, 2, 3, etc.) in order as they occur in the formative cycle. Between 1 and 22 are 8 turns and 21 scales, etc. 300, Cherry cycle ($\frac{3}{2}$) as viewed from above, forming necessarily that kind of aestivation called quincuncial.

270. It is now known that the angle of divergence varies in different regions of the same shoot; and that frequently a shoot beginning with a simple arrangement, afterward passes on to a more complicated pattern.

CHAPTER XX.

MORPHOLOGY OF THE LEAF.

271. The leaf constitutes the verdure of plants, and is by far the most conspicuous and beautiful object in the scenery of nature. It is also of the highest importance in the vegetable economy, being the organ of *digestion* and *respiration*. It is characterized by a

thin and expanded form, presenting the largest possible surface to the action of the air and light, which agents are indispensable to the life and increase of the plant.

The leaf may be regarded as an expansion of the substance of the stem, extended into a broad thin plate by means of a woody frame-work or skeleton, connected with the inner part of the axis. The expanded portion is called the lamina or blade of the leaf, and it is either *sessile*, that is, attached to the stem by its base, or it is *petiolate*, attached to the stem by a footstalk called the petiole.

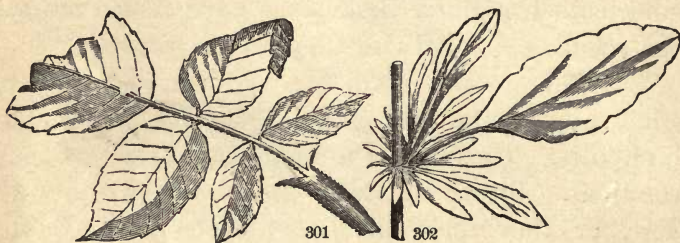
272. The regular petiole very often bears at its base a pair of leaf-like appendages, more or less apparent, called *stipules*. Leaves so appendaged are said to be *stipulate*; otherwise they are *exstipulate*.

273. Therefore a complete leaf consists of three distinct parts—the lamina or blade, the petiole, and the stipules. These parts are subject to endless transformations. Either of them may exist without the others, or they may all be transformed into other organs, as pitchers, spines, tendrils, and even into the organs of the flower, as will hereafter appear.

274. **The Petiole** in form is rarely cylindrical, but more generally flattened or *channeled* on the upper side. When it is flattened in a vertical direction, it is said to be *compressed*, as in the Aspen or Poplar. In this case, the blade is very unstable, and agitated by the least breath of wind. The *winged petiole* is flattened or expanded into a margin, but laterally instead of vertically, as in the Orange. Sometimes the margins outrun the petioles, and extend down the stem, making that winged, or *alate*, also. Such leaves are said to be *decurrent* (*decurro*, run down). Ex., Mullein.

275. *The amplexicaul* petiole is dilated at the base into a margin which surrounds or clasps the stem, as in the Umbellifers. Frequently we find the stem-clasping margins largely developed, constituting a *sheath*—with free edges in the Grasses, or closed into a tube in the Sedges.

276. The petiole is simple in the simple leaf, but compound or branched in the compound leaf, with as many branches (*petiolules*) as there are divisions of the lamina. A leaf is *simple* when its blade consists of a single piece, however cut, cleft, or divided; and *compound* when it consists of several distinct blades, supported by as many branches of a compound petiole.



301, Rose leaf, odd-pinnate, with adnate stipules. 302, Violet (*V. tricolor*), with simple leaf (1), and free compound stipules.

277. **Stipules** are certain leaf-like expansions, always in pairs, situated one on each side of the petiole near the base. They do not occur in every plant, but are pretty uniformly present in each species of the same natural order. In substance and color they usually resemble the leaf; sometimes they are colored like the stem, often they are membranous and colorless. In the Palmetto the leaf-base is a coarse net-work resembling canvas.

278. Stipules are often *adnate*, or adherent to the petiole, as in the Rose; more generally they are free,

as in the Pea and Pansy. In these cases and others they act the part of leaves; again they are often very small and inconspicuous.

279. An *Ochrea* is a membranous sheath inclosing the stem from the node upward, as in the Knot-grass family (Polygonaceæ). It is formed of the two stipules



303, Leaf of *Selinum*, tripinnate, with sheathing petiole. 304, Leaf of *Polygonum Pennsylvanicum*, with its (*o*) ochrea. 305, Culm of Grass, with joint (*j*), leaf (*l*), ligule (*s*). 306, Leaf of Pear-tree, with slender stipules.

cohering by their two margins. In case the two stipules cohere by their outer margin only, a double stipule is formed opposite to the leaf, as in the Button-wood. If they cohere by their inner margin, the double stipule appears in the leaf axil, as in the Pondweed (*Potamogeton*). The *Ligule* of the Grasses is generally regarded as a double axillary stipule. The leaflets of compound leaves are sometimes furnished with little stipules, called *stipels*.

280. *Inter-petiole* stipules occur in a few opposite-leaved tribes, as the *Galium* tribe. Here we find them as mere bristles in *Diodia*, while in *Galium* they look like the leaves, forming whorls. Such whorls, if complete, will be apparently 6-leaved, consisting of two true leaves and four stipules. But the adjacent stipules are often united, and the whorl becomes 4-leaved, and in some the whorl is 8-leaved.

281. Stipules are often *fugacious*, existing as scales in the bud, and falling when the leaves expand, or soon after, as in the Magnolia and Tulip-tree.

282. **Nature of veins.**—The blade of the leaf consists of, (1) the *frame-work*, and (2) the tissue commonly called the *parenchyma*. The frame-work is made up of the branching vessels of the footstalk, which are woody tubes pervading the parenchyma, and conveying nourishment to every part. Collectively, these vessels are called *veins*, from the analogy of their functions. **VENATION** is the division and distribution of the veins. The several organs of venation, differing from each other only in size and position, may be termed the midvein, veins, veinlets, and veinulets. (The old terms, *midrib* and *nerves*, being anatomically absurd, are here discarded.)

283. The *Midvein* is the principal axis of the venation, or prolongation of the petiole, running directly through the lamina, from base to apex, as seen in the leaf of the Oak or Birch. If there be several similar divisions of the petiole, radiating from the base of the leaf, they are appropriately termed *Veins*; and the leaf is said to be three-veined, five-veined, as in Maple. The primary branches sent off from the midvein or the veins we may term the *Veinlets*, and the secondary branches, or those sent off from the veinlets, are the *Veinulets*. These also branch and subdivide until they become too small to be seen.

284. Botanists distinguish three modes of venation, which are in general characteristic of *three Grand Divisions* of the Vegetable Kingdom—viz.:

Reticulate or *Net-veined*, as in the DICOTYLEDONS (called also EXOGENS). This kind of venation is char-

acterized by the frequent reunion or inosculation of its numerous branching veins, so as to form a kind of irregular net-work.



Varieties of venation.—307, Feather-veined,—leaf of *Betula populifolia* (White Birch), lying upon a leaf of Plum-tree: same venation with different outlines. 308, Palmate-veined,—leaf of White Maple, contrasted with leaf of *Cercis Canadensis*. 309, Parallel venation,—plant of “three-leaved Solomon’s seal” (*Smilacina trifoliata*). 310, Forked venation,—Climbing Fern (*Lygodium*).

Parallel-veined, as in the MONOCOTYLEDONS (called also ENDOGENS). The veins, whether straight or curved, run parallel, or side by side, to the apex of the leaf or to the margin, and are connected by simple transverse veinlets hardly seen.

Fork-veined, as in the Ferns (and other CRYPTOGRAMS where veins are present at all). Here the veins divide and subdivide in a forked manner, and do not reunite.

285. Of the Reticulate venation the student should carefully note three leading forms: viz., The *Feather-veined* (pinni-veined) leaf is that in which the venation consists of a midvein giving off at intervals lateral veinlets and branching veinulets, as in the leaf of

Beech, Chestnut. In the *Radiate-veined* (palmi-veined) leaf, the venation consists of several veins of nearly equal size radiating from the base toward the circumference, each with its own system of veinlets. Ex., Maple, Crowfoot. Lastly, the *Tripli-veined* seems to be a form intermediate between the two former, where the lowest pair of veinlets are conspicuously stronger than the others, and extend with the midvein toward the summit (see Fig. 319).

286. In parallel-veined venation the veins are either *straight*, as in the linear leaf of the Grasses; *curved*, as in the oval leaf of the Orchis; or *transverse*, from a midvein, as in the Canna, Calla, etc.

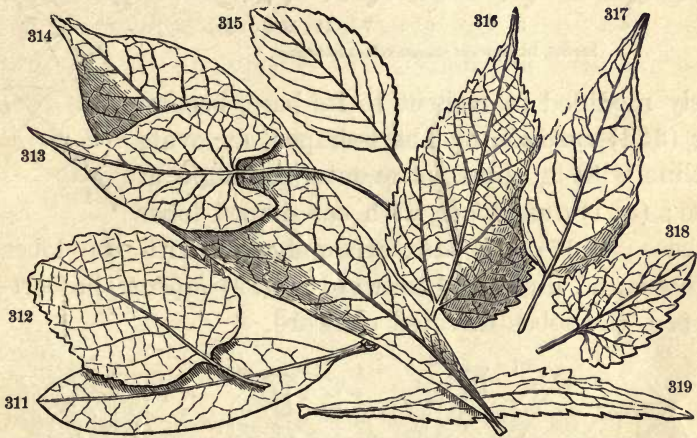
CHAPTER XXI.

MORPHOLOGY OF THE LEAF—CONTINUED.

287. That infinite variety of beautiful and graceful forms for which the leaf is distinguished becomes intelligible to the student only when viewed in connection with its venation. Since it is through the veins alone that nutriment is conveyed for the development and extension of the parenchyma, it follows that there will be the greatest extension of outline where the veins are largest and most numerous. Consequently the *form* of the leaf will depend upon the direction of the veins and the vigor of their action in developing the intervening tissue. In accordance with this theory, leaf-forms will be classed in respect to their venation.

288. **Feather-veined leaves.**—Of these, the following forms depend upon the length of the veinlets in

relation to each other and to the midvein. *When the lower veinlets are longer than the others, the form of the blade will be* (1) *ovate*, with the outline of an egg, the broad end at the base; (2) *lanceolate*, or lance-shaped, narrower than ovate, tapering gradually upward; (3) *deltoid*, or triangular-shaped, like the Greek letter Δ .

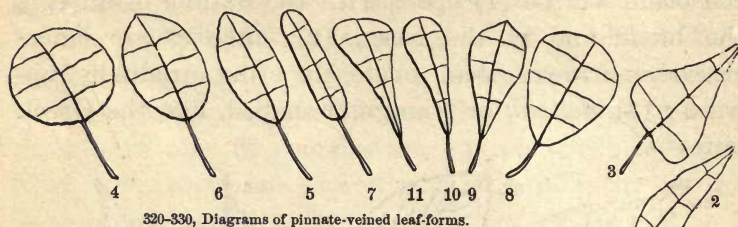


Forms of leaves.—311, *Rhododendron maximum*. 312, *Alnus glutinosa* (cult.). 313, *Polygonum dumetorum*. 314, Papaw. 315, *Impatiens fulva*. 316, *Celtis Americana*. 317, *Circæa Lutetiana*. 318, Catmint. 319, *Solidago Canadensis*—a tripli-veined leaf.

289. If the middle veinlets exceed the others in length, the leaf will be (4) *orbicular*, roundish, or quite circular; (5) *elliptical*, with the outline of an ellipse, nearly twice longer than broad; (6) *oval*, broadly elliptical; (7) *oblong*, narrowly elliptical.

290. *When the veinlets are more largely developed in the upper region of the leaf, its form becomes* (8) *obovate*, inversely ovate, the narrow end at base; (9) *oblanceolate*, that is, lanceolate with the narrow end at base; (10) *spatulate*, like a spatula, with a narrow base and a broader, rounded apex; (11) *cuneate* or *cuneiform*, shaped like a wedge with the point backward.

291. Again: *if the lowest pair of veinlets are lengthened and more or less recurved, the leaf will be vari-*



320-330, Diagrams of pinnate-veined leaf-forms.

ously modified in respect to its base, becoming (334) *cordate*, or heart-shaped, an ovate outline with a sinus or re-entering angle at base; (331) *auriculate*, with ear-shaped lobes at base; (337) *sagittate*, arrow-shaped, with the lobes pointed, and directed backward; (332) *hastate*, halbert-shaped, the lobes directed outward.

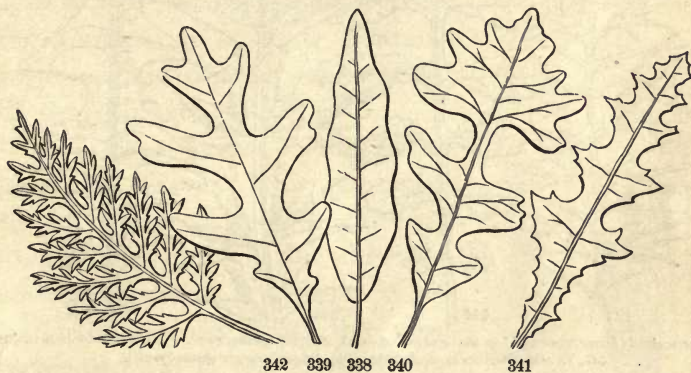


Forms of leaves.—330, *Silene Virginica*. 331, *Magnolia Fraseri*. 336, *Arabis dentata*. 337, *Polygonum sagittatum*. 332, *Hepatica acutiloba*. 333, *Asarum Virginicum*. 334, *Hydrocotyle Americana*. 335, *H. umbellata*.

292. **Pinnatifid forms.**—The following pinnate-veined forms, approaching the compound leaf, depend less upon the proportion of the veinlets than upon the

relative development of the intervening tissue. The prefix *pinnate* is obviously used in contrast with *palmate* among palmate-veined forms.

293. *Pinnatifid* (*pinna*, feather, *findo*, to cleave), feather-cleft, the tissue somewhat sharply cleft between the veinlets about half-way to the midvein, forming oblong segments. When the segments of a pinnatifid leaf are pointed and curved backward, it becomes *run-cinate*, *i. e.*, re-uncinate (346). When the terminal segment of a pinnatifid leaf is orbicular in figure and larger than any other, presenting the form of the ancient lyre, the form is termed *lyrate* (340).



Feather-veined leaves, approaching the compound.—338, *Quercus imbricaria*—undulate. 339, *Q. alba* (White Oak)—lobate-sinuate. 340, *Q. macrocarpa*—lyrate. 341, *Mulgedium* (Milkweed). 342, Bipinnatifid leaf of *Ambrosia artemisifolia* (Hogweed).

294. *Pinnately parted* implies that the incisions are deeper than pinnatifid, nearly reaching the midvein. In either case the leaf is said to be *sinuate* when the incisions (sinuses) as well as the segments are rounded and flowing in outline. Such segments are *lobes*, and the leaves *lobate* or lobed, a very generic term.

295. **Palmate forms.**—The palmate venation presents us with a set of forms which are, in general,

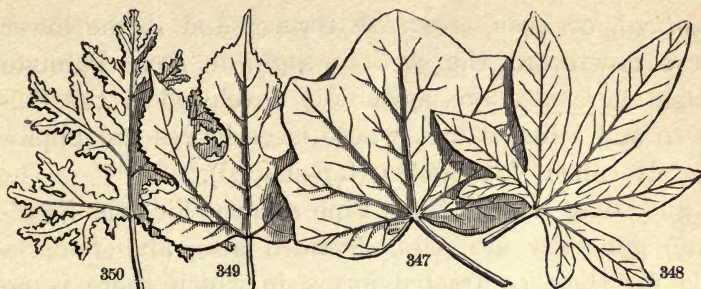
broader in proportion than the pinnate, having the breadth about equal to the length. Such a leaf may be rarely *broadly ovate*, or *broadly cordate*, terms which require no further explanation. Or it may be *Reniform*, kidney-shaped, having a flowing outline broader than long, concave at base; or *Peltate*, shield-form, the petiole not inserted at the margin, but in the midst



Feather-veined leaves approaching the compound.—343, *Nigella* (pinnatisect). 344, *Cheledonium majus*.
345, Thistle (*Cirsium lanceolatum*). 346, Dandelion (runcinate-lyrate).

of the lower surface of the blade. This singular form evidently results from the blending of the base lobes of a deeply cordate leaf, as seen in *Hydrocotyle*. It may be orbicular, oval, etc.

296. The following result from deficiency of tissue, causing deep divisions between the veins. Leaves thus dissected are said to be *palmately-lobed* when either the segments or the sinuses are somewhat rounded and continuous. The number of lobes is denoted by such terms as *bilobate*, *trilobate*, *five-lobed*, etc. Leaves are



Palmate-veined leaves.—347, *Menispermum Canadense*. 348, *Passiflora cerulea*. 349, *Broussonetia papyrifera*. 350, Oak *Geranium*.

palmately cleft and *palmately parted*, according to the depth of the incisions as above described. But the most peculiar modification is the *Pedate*, like a bird's foot, having the lowest pair of veins enlarged, recurved, and bearing each several of the segments (348).

297. The forms of the **parallel-veined leaves** are remarkable for their even, flowing outlines, diversified solely by the direction and curvature of the veins. When the veins are straight, the most common form is the *Linear*, long and narrow, with parallel margins, like the leaves of the Grasses—a form which may also occur in the pinnate-veined leaf, when the veinlets are all equally shortened. The *ensiform*, or sword-shaped, is also linear, but has its edges vertical, that is, directed upward and downward.



351, *Ensiform leaves of Iris*. 352, *Acerose leaves of Pinus*. 353, *Subulate leaves of Juniperus communis*.

298. If the veins curve, we may have the *lanceolate*,

elliptical, or even *orbicular* forms; and if the lower curve downward, the *cordate*, *sagittate*, etc. Palmate forms there also are, splendidly developed in the Palmetto and other Palms, whose large leaves are appropriately called *flabelliform* (fan-shaped).

299. The leaves of the Pine and the Fir tribe (Coniferæ) generally are parallel-veined also, and remarkable for their contracted forms, in which there is no distinction of petiole or blade. Such are the *Acerose* (needle-shaped) leaves of the Pine, the *Subulate* (awl-shaped) and scale-form leaves of the Cedars, etc.



CHAPTER XXII.

THE COMPOUND LEAF, ETC.

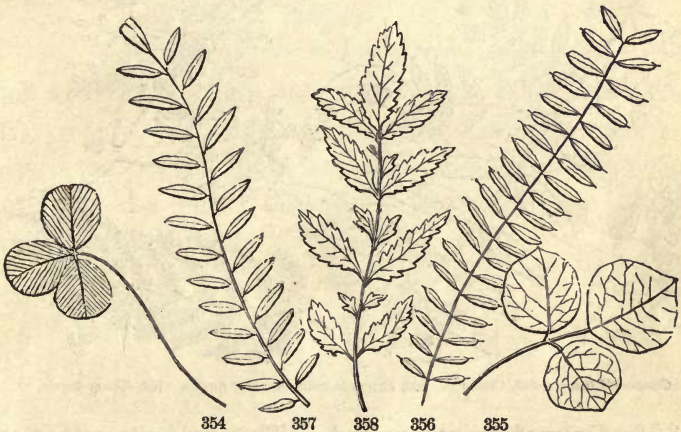
300. If we conceive of a *simple* leaf becoming a *compound* one, on the principle of "deficiency of tissue between the veins," it will be evident that the same forms of venation are represented by the branching petioles of the latter as by the veins of the former. The number and arrangement of the parts will therefore in like manner correspond with the mode of venation.

301. The divisions of a compound leaf are called *leaflets*; and the same distinction of outline, margin, etc., occur in them as in simple leaves. The *petiolules* of the leaflets may or may not be articulated to the main petiole, or *rachis*, as it is called.

302. **Pinnately compound.**—From the pinnate-veined arrangement we may have the *pinnate* leaf, where the petiole (midvein) bears a row of leaflets on each side, either sessile or petiolulate, generally equal in number

and opposite. It is *unequally pinnate* (357) when the rachis bears an odd terminal leaflet, and *equally pinnate* (356) when there is no terminal leaflet, and *interruptedly pinnate* when the leaflets are alternately large and small (358).

303. The number of leaflets in the pinnate leaf varies from thirty pairs and upward (as in some *Acacias*), down to three, when the leaf is said to be *ternate* or *trifoliate*; or two, becoming *binate*; or finally



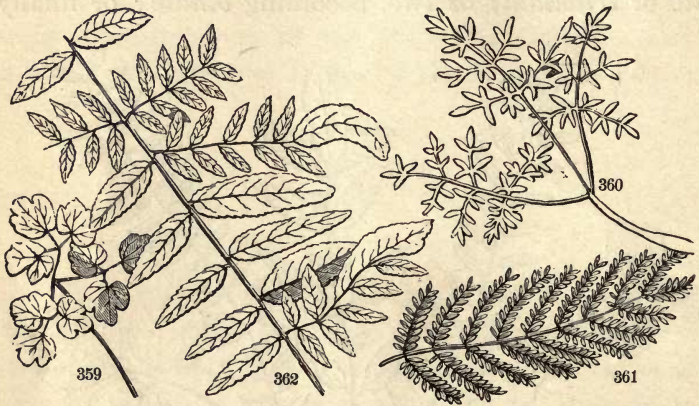
Compound leaves—354, *Trifolium repens*. 355, *Desmodium rotundifolium*. 356, *Sesbania*. 357, *Cassia*. 358, *Agrilmonia*.

even to *one* leaflet in the Lemon. Such a leaf is theoretically compound, on account of the leaflet (blade) being articulated to the petiole.

304. A *bipinnate leaf* (twice pinnate) is formed when the rachis bears *pinnæ* or secondary pinnate leaves, instead of leaflets (361), and *tripinnate* (thrice pinnate) when *pinnæ* take the places of the leaflets of a bipinnate leaf (360). When the division is still more complicated, the leaf is *decompound*. Different degrees of division often exist in different parts of the same

leaf, illustrating the gradual transition of leaves from simple to compound in all stages. The leaves of the Honey-locust and Coffee-tree (*Gymnocladus*) often afford curious and instructive examples (362).

305. A *biterminate leaf* is formed when the leaflets of a ternate leaf give place themselves to ternate leaves (359), and *triternate* when the leaflets of a biterminate leaf again give place to ternate leaves.

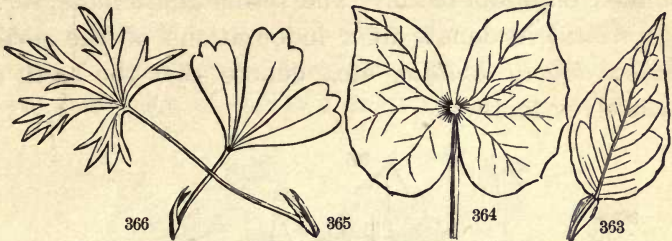


Compound leaves.—359, Clematis. 360, *Erigenia bulbosa*. 361, *Acacia*. 362, Honey-locust.

306. **Palmately compound.**—The palmate venation has also its peculiar forms of compound leaves, as ternate, quinate, septenate, etc., according to the number of leaflets which arise together from the summit of the petiole. Ternate leaves of this venation are to be carefully distinguished from those of the pinnate plan. The palmately ternate leaf consists of three leaflets, which are either all sessile or stalked alike; the pinnately ternate has the terminal leaflet raised above the other two on the prolonged rachis (354, 355).

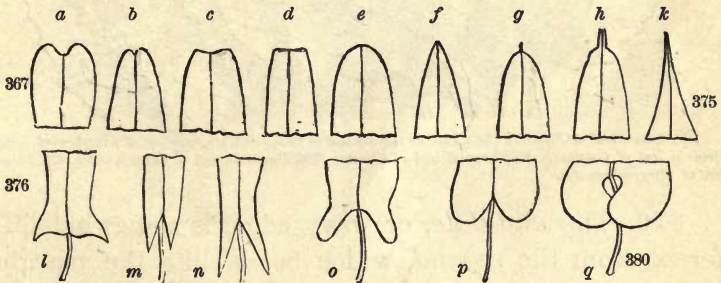
307. **Apex.**—In regard to the termination of a leaf or leaflet at its apex, it may be *acuminate*, ending

with a long, tapering point; *cuspidate*, abruptly contracted to a sharp, slender point; *mucronate*, tipped with a spiny point; *acute*, simply ending with an angle; *obtuse*, rounded at the point. Or the leaf may



363, Lemon. 364, Jeffersonia. 365, Potentilla anserina. 366, P. tridentata.

end without a point, being *truncate*, as if cut square off; *retuse*, with a rounded end slightly depressed where the point should be; *emarginate*, having a small notch at the end; *obcordate*, inversely heart-shaped, having a deep indentation at the end.



367-375, *Apex of leaves*.—a, obcordate; b, emarginate; c, retuse; d, truncate; e, obtuse; f, acute; g, mucronate; h, cuspidate; k, acuminate.

376-380, *Bases of leaves*.—l, hastate; m, n, sagittate; o, auriculate; p, cordate; q, reniform.

308. Margin.—The following terms are used to define the margin of the leaf or leaflet, with no reference to the general form. If the leaf be even-edged, having the tissue completely filled out, the appropriate term is *entire*. Sometimes a vein runs along such a margin as if a *hem*,

309. But when the marginal tissue is deficient, the leaf becomes *dentate*, having sharp teeth pointing outward from the center; *serrate*, with sharp teeth pointing forward, like the teeth of a saw; *crenate*, with rounded or blunt teeth. The terms *denticulate*, *serrulate*, *crenulate* denote finer indentations of the several kinds; *doubly dentate*, etc., denote that the teeth are themselves toothed.

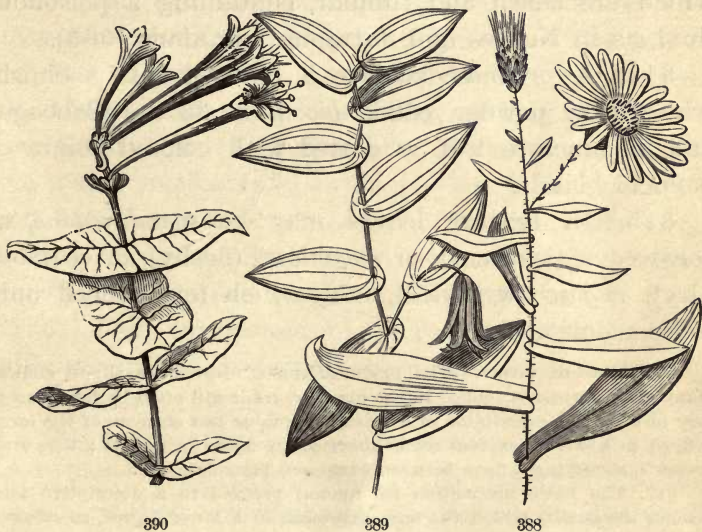


381, Serrate leaf of Chestnut. 382, Doubly serrate leaf of Elm. 383, Dentate leaf of Arrow-wood. 384, Crenate leaf of Catmint. 385, Repand leaf of *Circæa*. 386, Undulate leaf of Shingle Oak. 387, Lobed leaf of *Chrysanthemum*.

310. The *undulate*, or wavy edge, is somewhat different from the *repand*, which bends like the margin of an umbrella. If the veins project, and are tipped with spines, the leaf becomes *spinous*. Irregularly divided margins are said to be *erose* or jagged, *lacinate* or torn, *incised* or cut. Often, instead of a deficiency, there is a superabundance of marginal tissue, denoted by the term *crispate* or crisped.

311. **Insertion.**—Several important terms descriptive of the various modes of leaf-insertion must here

be noticed. A sessile leaf is said to be *amplexicaul* when its base-lobes adhere to and clasp the stem. Should these lobes extend quite around the stem and on the other side become blended together, a *perfoliate* leaf will be formed (*per*, through, *folium*, leaf), the stem seeming to pass through the leaves. When the bases of two opposite sessile leaves are so united as to form one piece of the two, they are said to be *connate*. 390



Insertion of leaves.—388, *Aster lævis* (amplexicaul). 389, *Uvularia perfoliata*. 390, *Lonicera sempervirens* (connate).

312. **Surface.**—The following terms are applicable to any other organs as well as leaves. In the quality of surface the leaf may be *glabrous* (smooth), destitute of all hairs, bristles, etc., or *scabrous* (rough), with minute, hard points, hardly visible. A dense coat of hairs will render the leaf *pubescent* when the hairs are soft and short; *villous* when they are rather long and weak; *sericeous*, or silky, when close and satin-like;

such a coat may also be *lanuginose*, woolly; *tomentose*, matted like felt; or *floccose*, in soft, fleecy tufts.

313. Thinly scattered hairs render the surface *hirsute* when they are long; *pilose* when short and soft; *hispid* when short and stiff. The surface will be *setose* when beset with bristly hairs called *setæ*; and *spinose* when beset with spines, as in the Thistle and Horse-nettle. Leaves may also be armed with *stinging* hairs which are sharp and tubular, containing a poisonous fluid, as in Nettles and *Jatropha stimulan*s (503).

314. A *pruinose* surface is covered with a bluish-white waxy powder, called *bloom*, as in the Cabbage; and a punctate leaf is dotted with colored points or pellucid glands.

315. In **texture** leaves may be *membranous*, or *coriaceous* (leathery), or *succulent* (fleshy), or *scarious* (dry), *rugose* (wrinkled), etc., which terms need only to be mentioned.

316. **Double terms.**—The modifications of leaves are almost endless. Many other terms are defined in the glossary, yet it will often be found necessary in the exact description of a plant to combine two or more of the terms defined in order to express some intermediate figure or quality; thus *ovate-lanceolate*, signifying a form between ovate and lanceolate, etc.

317. The Latin preposition *sub* (under) prefixed to a descriptive term denotes the quality which the term expresses, in a lower degree, as *subsessile*, nearly sessile, *subserrate*, somewhat serrate.



CHAPTER XXIII.

TRANSFORMATIONS OF THE LEAF.

318. Hitherto we have considered the leaf as foliage merely—constituted the fit organ of aeration by its large expansion of surface. This is indeed the chief, but not the only aspect in which it is to be viewed. The leaf is a typical form; that is, a type, or

an IDEA of the Divine Architect, whence is derived the form of every other appendage of the plant. To trace out this idea in all the disguises under which it lurks, is one of the first aims of the botanist. Several of these forms of disguise have already been noticed—for example:

319. **The scales** which clothe the various forms of scale-bearing stems are leaves, or more usually *petioles*, reduced and distorted, perhaps by the straitened circumstances of their underground growth. The scales of corms and rhizomes are mostly mere membranes, while those of the bulb are fleshy, serving as depositories of food for the future use of the plant. That these scales are leaves is evident—1st, from their position at the nodes of the stem; 2d, from their occasional development into true leaves. Of the same nature are the brown scales of Winter buds.

320. **The cotyledons** of seeds or seed-lobes are readily recognized as leaves, especially when they arise above-ground in germination, and form the first pair upon the young plant; as in the Beechnut and Squash seed. Their deformity is due to the starchy deposits with which they are crammed for the nourishment of the embryo when germinating, and also to the way in which they are packed in the seed.

321. **Phyllodia** are certain leaf-forms, consisting of petioles excessively compressed, or expanded vertically into margins, while the true lamina is partly or entirely suppressed. Fine examples are seen in our greenhouse Acacias from Australia. Their vertical or edgewise position readily distinguishes them from true leaves.

322. **Ascidia**, or *pitchers*, are surprising forms of

leaves, expressly contrived, as if by art, for holding water. The pitchers of *Sarracenia*, whose several species are common in bogs North and South, are evidently formed by the blending of the involute margins of the broadly winged petioles, so as to form a complete vase. The broad expansion which appears at the top may be regarded as the lamina. These pitchers contain water, in which insects are drowned, being



Ascidia.—391, *Nepenthes*. 392, *Sarracenia psittacina*. 393, *S. purpurea*. 394, *S. Gronovii*, β . *Drummondii*. 395, *Acacia heterophylla*—its phyllodia.

prevented from escaping by the deflexed hairs at the mouth. Other pitcher-bearing plants are equally curious; as *Darlingtonia* of California, *Nepenthes* and *Dischidia* of the East Indies. In *Dionæa* of North Carolina, the leaves are transformed to spiny, snapping fly-traps!

323. Many weak-stemmed water-plants are furnished with *Air-bladders*, or little sacks filled with air to buoy them up near to the surface. Such are the bladders of the common *Bladderwort*, formed from the leaf-lobes. In the *Horned-bladderwort*, the floats are

made of the six upper inflated petioles lying upon the surface of the water like a wheel-shaped raft and sustaining the flower upon its own elevated stalk.

324. **The Tendril** is a thread-like, coiling appendage, furnished to certain weak-stemmed plants as their means of support in place. Its first growth is straight, and it remains so until it reaches some object, when it immediately coils itself about it, and thus acquires a firm though elastic hold. This beautiful appendage is finely exemplified in the Cucurbitaceæ and Grape,



396, Leaf of Greenbrier, with tendrils in place of stipules. 397, Leaf of Everlasting Pea—tendrils at end of rachis. 398, Leaf of Gloriosa—apex ends in a tendril. 399, Air-bladder of Horn Pondweed.

above cited; also in many species of the Pea tribe (Leguminosæ), where it is appended to the leaves. It is not a new organ, but some old one transformed and adapted to a new purpose. In *Gloriosa superba*, the midvein of the leaf is prolonged beyond the blade into a coiling tendril. In the Pea, Vetch, etc., the tendrils represent the attenuated leaf-blades themselves. Again, the entire leaf sometimes becomes a tendril in *Lathyrus*, while the stipules act as leaves.

325. The petiole of the leaf of *Clematis*, otherwise unchanged, coils like a tendril for the support of the vine. In the Greenbrier, the stipules are changed to tendrils, which thus arise in pairs from the base of the petioles. So probably in the Gourd.

326. But the tendrils of the Grape vine are of a different nature. From their position opposite the leaves, and the tubercles occasionally seen upon them, representing flower-buds, they are inferred to be abortive, or transformed flower-stalks.

327. Many plants are armed, as if for self-defense with hard, sharp-pointed, woody processes, called *spines* or *thorns*. Those which are properly called spines originate from leaves. In *Berberis* the spines are evidently transformed leaves, as the same plant exhibits



Thorns—400, *Cratægus parvifolia* (thorns axillary). 401, Honey-locust. 402, Common Locust. 403, *Berberis*—*a*, *a*, its thorns.

leaves in every stage of the metamorphosis. In Goat's-thorn (*Astragalus tragacanthus*) of S. Europe, the petioles change to spines after the leaflets fall off. In the Locust (*Robinia*), there is a pair of spines at the base of the petiole, in place of stipules.

328. *Thorns* originate from axillary buds, and are abortive branches. This is evident from their position in the Hawthorn and Osage-orange. The Apple and Pear tree in their wild state produce thorns, but by cultivation become thornless; that is, the axillary buds, through better tillage, develop branches instead of thorns. The terrible branching thorns of the Honey-locust originate just above the axil, from *accessory* buds. *Prickles* differ from either spines or thorns, growing from the epidermis upon stems of leaves, at no determinate point, and consisting of hardened cellular tissues, as in the Rose, Bramble.

329. By a more gentle transformation, leaves pass into *Bracts*, which are those smaller, reduced leaf-forms situated near and among the flowers. So gradual is the transition from leaves to bracts—in the Peony, *e. g.*—that no absolute limits can be assigned. Equally gradual is the transition from bracts to sepals of the flower—affording a beautiful illustration of the doctrine of metamorphosis (§ 330, etc.). Bracts will be further considered under the head of Inflorescence.

CHAPTER XXIV.

METAMORPHOSIS OF THE FLOWER.

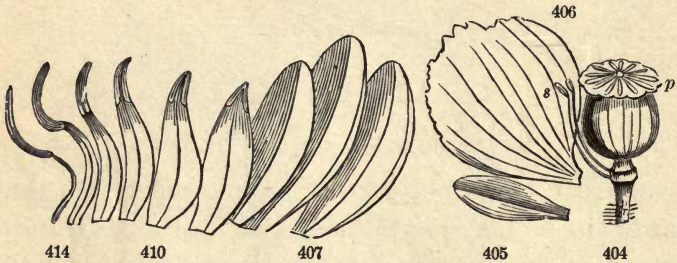
330. It has already been announced (§ 37) that a flower is a metamorphosed, that is, a transformed branch. No *new* principle or element was devised to meet this new necessity in the life of the plant, viz., the perpetuation of its kind; but *the leaf*, that same protean form which we have already detected in shapes so numerous and diverse, THE LEAF, is yet once more in nature's hand molded into a series of forms of superior elegance, touched with colors more brilliant, and adapted to a higher sphere as *the organs of reproduction*.

331. Proofs of this doctrine appear on every hand, both in the *natural* and in the *artificial* development of plants. We mention a few instances. The thoughtful student will observe many more.

332. In most flowers, as in the Poppy, very little evidence of the *metamorphosis* appears, simply because it has been so complete. Its sepals, petals, stamens, and pistils—how unlike! Can these be of one and the

same element? Look again. Here is a double flower, a Poppy of the gardens, *artificially* developed; its slender white stamens have indeed expanded into broad red petals!

333. The argument begins with the sepals. In the Rose and Pæony, and in most flowers, the sepals have all the characteristics of leaves—color, form, venation, etc. The transition from leaves to bracts and from bracts to sepals is so gradual as to place their identity



404, *Papaver* (poppy)—*s*, stamens; *p*, stigmas. 405, sepal. 406, Petal—all very different. 407 to 414, Petals of the Water-lily (*Nymphæa*) gradually passing into stamens.

beyond doubt. Again, in *Calicanthus*, the sepals pass by insensible gradations into petals; and in the Lilies these two organs are almost identical. Hence, if the sepals are leaves, *the petals are leaves also*. In respect to the nature of the stamens, the Water-lily is particularly instructive. Here we see a perfect gradation of forms from stamens to petals, and thence to sepals, where, half-way between the two former, we find a narrow petal tipped with the semblance of an anther (410). Finally, cases of close resemblance between stamen and pistil, so unlike in the Poppy, are not wanting. For example, the Tulip-tree.

334. **Teratology.**—Cases in ARTIFICIAL DEVELOPMENT where organs of one kind are converted into those of another kind by cultivation, afford undeniable evidence of the doctrine in question—the *homology of all the floral organs with each other and with the leaf*. Such cases are frequent in the garden, and,

however much admired, they are *monstrous*, because unnatural. In all double flowers, as Rose, Pæony, Camellia, the stamens have been reconverted into petals, either wholly or partially, some yet remaining in every conceivable stage of the transition. In the double Buttercup (416) the pistils as well as stamens revert to petals, and in the garden Cherry, Flowering Almond, a pair of green leaves occupy the place of the pistils. By still further changes all parts of the flower manifest their foliage affinities, and the entire flower-bud, after having given clear indications of its floral character, is at last developed into a leafy branch (417). Further evidence of this view will appear in the—

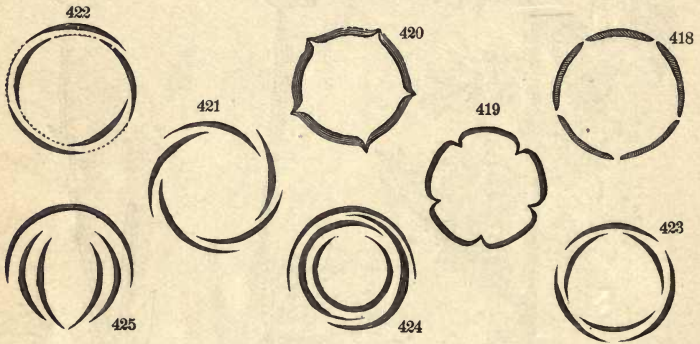


415, *Ranunculus acris*; a single flower. 416, *R. acris*, β . plena, a double flower. 417, *Epacris impressa*, the flowers changing to leafy branches (Lindley).

335. *Æstivation of the flower-bud.*—This term (from *æstivus*, of summer) refers to the arrangement of the floral envelopes while yet in the bud. It is an important subject, since in general the same mode of *æstivation* regularly characterizes whole tribes or orders. It is to the flower-bud what *vernation* (*vernus*, spring) is to the leaf-bud. The various modes of *æstivation* are best observed in sections of the bud made by cutting it through horizontally when just ready to open. From such sections our diagrams are copied.

336. Separately considered, we find each organ here folded in ways similar to those of the leaf-bud; that is, the sepal or the petal may be *convolute*, *involute*, *revolute*, etc., terms already defined. Collectively considered, the æstivation of the flower occurs in four general modes with their variations—the valvate, the contorted, imbricate, and plicate.

337. In **valvate æstivation** the pieces meet by their margins without any overlapping; as in the sepals of the Mallow, petals of Hydrangea, valves of a capsule.



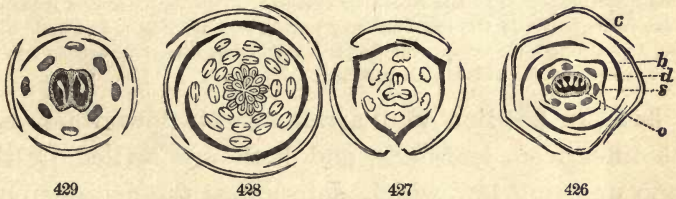
418-425, Modes of æstivation. 424, Petals of the Wall-flower.

The following varieties of the valvate occur: *Induplicate*, where each piece is involute—*i. e.*, has its two margins bent or rolled inward, as in Clematis; or *reduplicate*, when each piece is revolute—having its margins bent or rolled outward, as in the sepals of Althea.

338. **Contorted æstivation** is where each piece overlaps its neighbor, all in the same direction, appearing as if twisted together, as in Phlox, Flax, Oleander (421).

339. **Imbricated æstivation** (*imbrex*, a tile) is a term restricted to those modes in which one or more of the petals or sepals is wholly outside, overlapping two others by both its margins. This kind of æstivation

naturally results from the spiral arrangements so common in phyllotaxy, while the valvate and contorted seem identified with the opposite or whorled arrangement. The principal varieties are the following: The *Quincuncial*, consisting of five leaves, two of which are wholly without, two wholly within, and one partly both, or one margin out, the other in, as in the Rose family (422). This accompanies the *two fifths cycle* in phyllotaxy, and corresponds precisely with it, each quincunx being in fact a cycle with its internodes



Diagrams of flowers (as seen by cross-sections).—426, *Jeffersonia diphylla*—*o*, ovary; *s*, stamens; *d*, inner row of petals, æstivation triquetrous; *b*, outer row of petals, æstivation contorted; *c*, sepals, æstivation quincuncial. 427, Lily. 428, Strawberry. 429, Mustard. The pupil will designate modes of æstivation.

suppressed. (Fig. 300, § 266.) The *Triquetrous*, consisting of three leaves in each set, one of which is outside, one inside, and the third partly both, as in Tulip, *Erythronium*, agreeing with the *two thirds*, or Alder Cycle (§ 265). The *Convolute*, when each leaf wholly involves all that are within it, as do the petals of *Magnolia*; and lastly, the *Vexillary*, when one piece larger than the rest is folded over them, as in Pea (425).

340. **Plicate** or folded æstivation occurs in tubular or monopetalous flowers, and has many varieties, of which the most remarkable is the *supervolute*, where the projecting folds all turn obliquely in the same direction, as in the Morning-glory, Thorn-apple.

Different modes of æstivation may occur in the different whorls of the same flower.

CHAPTER XXV.

INFLORESCENCE.

341. Inflorescence is a term denoting the arrangement of the flowers and their position upon the plant.

All the buds of a plant are supposed to be *originally* of one and the same nature, looking to the production of vegetative organs only. But at a certain period, a portion of the buds of the living plant, by an unerring instinct little understood, are converted from their ordinary intention into *flower-buds*, as stated and illustrated in the foregoing Chapter. The flower-bud is incapable of extension. While the leaf-bud may unfold leaf after leaf, and node after node, to an indefinite extent, the flower-bud blooms, dies, and arrests forever the extension of the axis which bore it.

342. In position and arrangement, flower-buds can not differ from leaf-buds, and both are settled by the same unerring law which determines the arrangement of the leaves. Accordingly, the flower-bud is always found either *terminal* or *axillary*. In either case, a single bud may develop either a *compound* inflorescence, consisting of several flowers with their stalks and bracts, or a *solitary* inflorescence, consisting of a single flower.

343. The *Peduncle* is the flower-stalk. It bears no leaves, or at least only such as are reduced in size and changed in form, called *bracts*. If the peduncle is wanting, the flower is said to be *sessile*. The simple peduncle bears a single flower; but if the peduncle be divided into branches, it bears several flowers, and the final divisions, bearing each a single flower, are called *pedicels*. The main stem or axis of a compound peduncle is called the *rachis*.

344. The *Scape* is a flower-stalk which springs from a subterranean stem, in such plants as are called

stemless, or acaulescent; as the Primrose, Tulip, Blood-root. Like the peduncle, it is leafless or with bracts only, and may be either simple or branched. The flower-stalk, whether peduncle, scape, or pedicel, always terminates in the *torus* (§ 57).



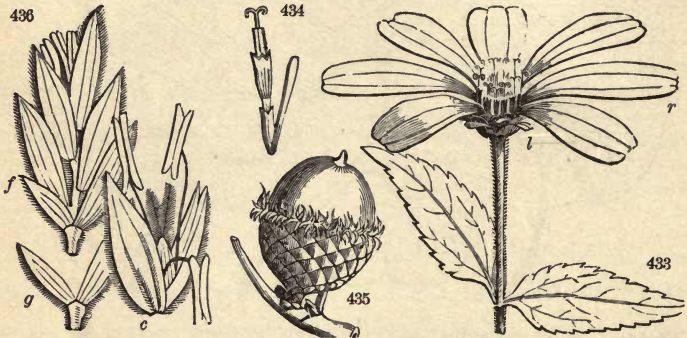
Bracts (c, d, e).—430, *Cornus Canadensis*, with an involucre of four colored bracts. 431, *Hepatica triloba*, with an involucre of three green bracts. 432, *Calla palustris*, with a colored spathe of one bract.

345. **Bracts.**—The branches of the inflorescence arise from the axils of reduced leaves, called *bracts*. Those leaves, still smaller, growing upon the pedicels, are called *bractlets*. Bracts are usually simple in outline and smaller than the leaf, often gradually diminishing to mere points, as in *Aster*, or even totally suppressed, as in the *Cruciferae*. Often they are colored, sometimes brilliantly, as in *Painted-cup*. Sometimes they are scale-like, and again they are evanescent membranes.

346. The *Spathe* is a large bract formed in some of the *Monocotyledons*, enveloping the inflorescence, and often colored, as in *Arum*, *Calla*; or membranous, as in *Onion* and *Daffodil*.

347. Bracts also constitute an *Involucre* when they are collected into a whorl or spiral group. In the

Phlox, Dodecatheon, and generally, the involucre is green, but sometimes colored and petaloid, as in Dogwood and Euphorbia. Situated at the base of a compound umbel, it is called a *general* involucre; at the base of a partial umbel it is a *partial* involucre or *involucel*, both of which are seen in the Umbelliferæ.



433, *Helianthus grosse-serratus*—*l*, involucre; *r*, rays, or ligulate flowers. 434, One of the disk-flowers with its chaff-scale (bract). 435, A corn of Moss-cup Oak (*Q. macrophylla*). 436, *Poa pratensis*—*f*, spikelet entire; *g*, glumes separated; *c*, a flower separated, displaying the two pales, three stamens, and two styles.

348. In the Compositæ, where the flowers are crowded upon a common torus, forming what is called a *compound flower*, an involucre composed of many imbricated scales (bracts) surrounds them as a calyx surrounds a simple flower. The chaff also upon the torus are bracts to which each floret is axillary (434).

349. In the Grasses, the bracts subsist under the general name of *chaff*. At the base of each *spikelet* (436) of flowers we find two bracts—the *Glumes*. At the base of each separate flower in the spikelet are also two bractlets—the *Pales*—enveloping as a calyx the three stamens and two styles (*c*).

350. The cup of the Acorn is another example of involucre, composed of many scale-like bractlets. So, also, perhaps the burr of the Chestnut, etc.

351. The forms of inflorescence are exceedingly various, but may all be referred to two classes, as already indicated—the *axillary*, in which all the flowers arise from axillary buds; the *terminal*, in which all the flower-buds are terminal.

352. *Axillary inflorescence* is called *indefinite*, because the axis, being terminated by a leaf-bud, continues to grow on indefinitely, developing bracts with their axillary flowers as it grows. It is also called *centripetal*, because in the order of time the blossoming commences with the circumference (or base) of the inflorescence, and proceeds toward the central or terminal bud, as in Hawthorn or Mustard.

353. *Terminal inflorescence* is *definite*, implying that the growth of the axis as well as of each branch is definitely arrested by a flower. It is also *centrifugal*, because the blossoming commences with the central flower and proceeds in order to the circumference, as in the Sweet-William, Elder, Hydrangea.

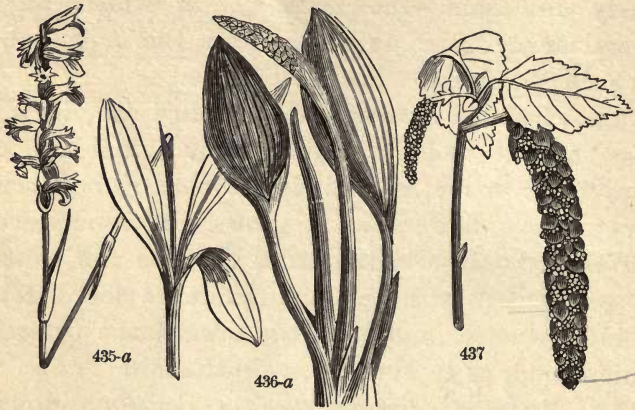
354. Both kinds of inflorescence are occasionally combined in the same plant, where the *general* system may be distinguished from the *partial* clusters which compose it. Thus in the Compositæ, while the florets of each head open centripetally, the general inflorescence is centrifugal, that is, the terminal head is developed before the lateral ones. But in the Labiatae the partial clusters (verticillasters) open centrifugally, while the general inflorescence is indefinite, proceeding from the base upward.

CHAPTER XXVI.

SPECIAL FORMS OF INFLORESCENCE.

355. Of *centripetal* or *axillary inflorescence* the principal varieties are: the spike, spadix, catkin, raceme, corymb, umbel, panicle, thyrse, and head. The *spike* is a long rachis with sessile flowers either scattered,

clustered, or crowded upon it, as Plantain, Mullein, Vervain. The so-called spikes of the Grasses are *com-*



435-a, *Spiranthes cernua*—flowers in a twisted spike. 436-a, *Orontium aquaticum*—flowers on a naked spadix. 437, *Betula lenta*—flowers in aments.

pond spikes or spike-like panicles, bearing little spikes or *spikelets* in place of single flowers (440).



438, *Andromeda racemosa*—flowers in a secund raceme. 439, *Verbascum Blattaria*—raceme. 440, *Lolium perenne*—a compound spike or a spike of spikelets. 441, *Dipsacus sylvestris*—head with an involucre of leaves. 442, *Osmorhiza longistylis*—a compound umbel. 443, Its fruit.

356. The *spadix* is a thick, fleshy rachis, with flowers closely sessile or imbedded on it, and usually with a spathe, as in Calla (432), or without it, as in Golden-club (436).

357. The *catkin* or *ament* is a slender, pendent spike with scaly bracts subtending the naked, sessile flowers, all caducous (falling) together, as in Birch, Beech, Oak, Willow.

358. The *raceme* is a rachis bearing its flowers on distinct, simple pedicels. It may be erect, as in Hyacinth, Pyrola; or pendulous, as in Currant, Blackberry. The *corymb* differs from the raceme in having the lower pedicels lengthened so as to elevate all the flowers to about the same level. The corymb often becomes compound by the branching of its lower pedicels, as in Yarrow.



444



445

444. *Staphylea trifolia*—a pendulous, paniculate cyme. 445, *Catalpa*—a panicle.

359. An *umbel* consists of several pedicels of about equal length radiating from the same point—the top of the common peduncle, as Milk-weed, Onion. When

the pedicels of an umbel become themselves umbels, as in Caraway and most of the Umbelliferæ, a *compound umbel* is produced. Such secondary umbels are called *umbellets*, and the primary pedicels, *rays*.

360. The *panicle* is a compound inflorescence formed by the irregular branching of the pedicels of the raceme, as in Oats, Spear-grass, Catalpa. A *thyrs*e is a sort of compact, oblong, or pyramidal panicle, as in Lilac, Grape.

361. A *head* or *capitulum* is a sort of reduced umbel, having the flowers all sessile upon the top of the peduncle, as in the Button-bush, Clover. But the more common examples of the capitulum are seen in the Compositæ, where the summit of the peduncle, that is, the receptacle, is dilated, bearing the sessile flowers above, and scale-like bracts around, as an involucre.

362. The *capitulum* of the Compositæ is often called a compound flower from its resemblance, the involucre answering to a calyx, the rays to the corolla. The flowers are called florets—those of the outer circle, *florets of the ray*, generally differing in form from those of the central portions, the *florets of the disk*.

363. Of **terminal inflorescence** the following varieties are described: cyme, fascicle (verticillaster), and glomerule.



446, *Vernonia fasciculata*—flowers in a discoid head with an imbricated involucre. 447, A single flower remaining on the receptacle. 448, A fruit crowned with the pappus. 449, *Mulgedium*—a head. 450, A single flower remaining on the receptacle. 451, A fruit with pappus.

364. *Cyme* is a general term denoting any inflorescence with centrifugal evolutions, but is properly applied to that level-topped or fastigate form which

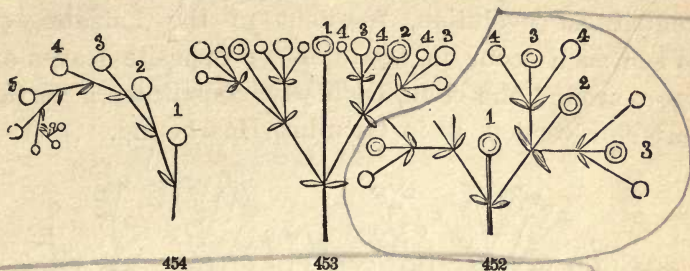


Diagram (452) of cyme flowers numbered in the order of their development.—453, Cyme fastigate. 454, Cyme half developed—a scorpioid raceme.

resembles the corymb, as in the Elder. If it is loosely spreading, not fastigate, it is called a *cymous panicle*, as in the Chickweed, *Spergula*, etc. If it be rounded, as in the Snowball, it is a *globose cyme*.



455



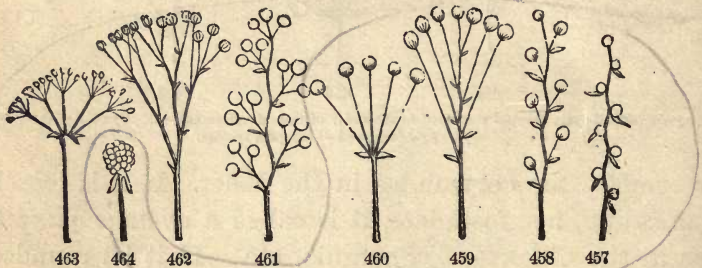
456

455, *Myosotis palustris*—scorpioid racemes. 456, *Stellaria media*—a regular cyme.

365. A *scorpioid cyme*, as seen in the Sundew, *Sedum*, and Borage family, is a kind of coiled raceme, unrolling as it blossoms. It is understood to be a half-developed cyme, as illustrated in the cut (454). The *fascicle* is a modification of the cyme, with crowded

and nearly sessile flowers, as in Sweet-William (*Dianthus*).

366. *Glomerule*, an axillary tufted cluster, with a centrifugal evolution, frequent in the Labiatae, etc. When such occur in the axils of opposite leaves and meet around the stem, each pair constitutes a verticillaster or verticil, as in Catmint, Hoarhound.



367. The above diagrams show the mutual relations of the several forms of centripetal inflorescence—how they are graduated from the spike (457) to the head (464). Thus the spike (457) + the pedicels = raceme (458); the raceme with the lower pedicels lengthened = corymb (459); the corymb - the rachis = umbel (460); the umbel - pedicels = head (464), etc.

(For the phenomena of Flowering, Coloring, the Floral Calendar, the Floral Clock, see the Class Book of Botany, pp. 75-77.)

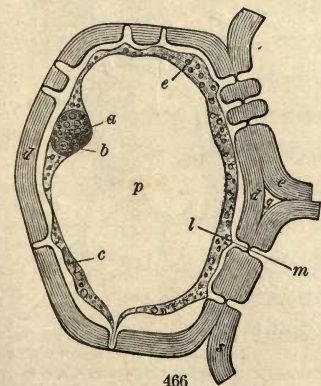
PART SECOND.

PHYSIOLOGICAL BOTANY.

CHAPTER I.

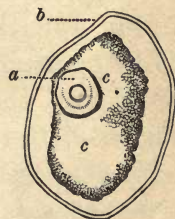
VEGETABLE HISTOLOGY AND PHYSIOLOGY.

368. The vegetable cell is the foundation of all plant structure, and when complete is a sac or bag-like body containing a semi-fluid substance called Protoplasm. The cell-wall increases by expansion.



466, Section of pith-cell of *Taxodium* ; *a*, nucleus ; *b*, nucleolus ; *c*, *e*, protoplasm sac contracted toward the wall, from which it has been separated by reagents ; *p*, cell-sap in a large vacuole ; *l*, *m*, channel between adjacent cells ; *d*, cell-wall ; *e*, *s*, adjacent cell-walls ; *g*, intercellular space.

Spaces (vacuoles) appear among the particles of protoplasm, which are occupied by a watery substance called cell-sap. In some part of the cell



465

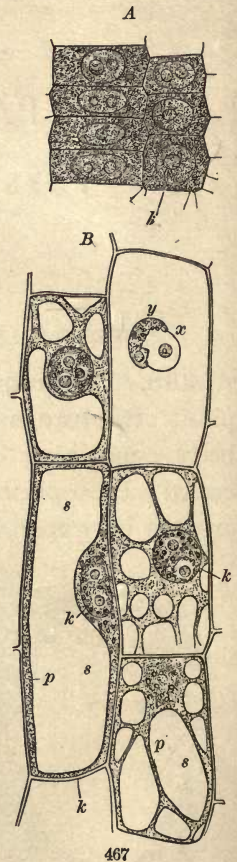
465, Mature cell of *Orchis* ; *a*, nucleus, with nucleolus ; *b*, cell-wall ; *c*, *c*, protoplasm mass separated from the cell-wall by alcohol.

a spot appears where the granules of Protoplasm are crowded together, forming a nucleus. The cell is now complete, and thus furnished is an organism capable of exercising vital functions, and possesses the ability to multiply itself or produce new

cells. In the early stages of the plant's life, the Protoplasm is a naked mass, but it very soon surrounds itself with a wall, as in Figs. 465 and 466. Inside the cell-wall it arranges itself into a great variety of forms.

In Fig. 467, *A* shows new cells, with the protoplasm evenly distributed, and nuclei forming, *k*. Fig. 467, *B*, great changes have taken place, cell-sap has been introduced, and the protoplasm is much vacuolated, and appears either floating freely in the cell-sap, spread along the cell-wall, or otherwise aggregated. In Fig. 468, *A*, the protoplasm seems to be aggregating, and spots or vacuoles are appearing in its midst. Fig. 468, *B*, the protoplasm is forming in globular masses around portions of sap. These little vesicles are frequently furnished with the green coloring matter of the plant. Fig. 468, *C*, highly magnified cell, in which the protoplasm has retreated from the cell-wall under the action of weak sulphuric acid and iodine.

369. **Protoplasm** is complex and constantly changing in its constitution. It yields to chemical analysis materials similar to egg albumen, and is the living substance of the cell; its appearance under the microscope is shown in Figs. 465-468.

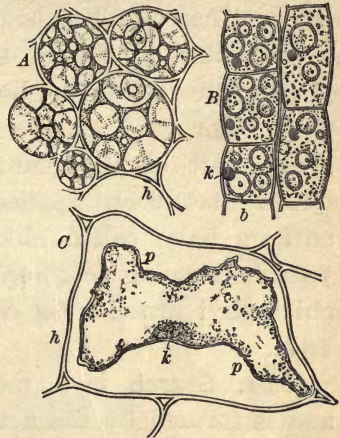


467, *A*, Very young cells from near the tip of the root of *Fritillaria*; *B*, cells from a part a little higher up in the root; *s, s, s*, sap; *k, x, y*, nuclei and nucleoli forming; *p*, protoplasm.

The *chemical substances* that have been detected in **Protoplasm** are *Oxygen, Hydrogen, Carbon, Nitrogen, Sulphur, Potassium, Calcium, Magnesium, Iron, Phosphorus, Chlorine*, and frequently *Silicon* and *Sodium*.

The relative proportions of these substances differ in different orders, and are not constant in the same plant.

370. **The wall of the cell** (Fig. 466) is produced by some action of the protoplasm. When first formed it is very thin, soft, and uniform in thickness; but as it grows older, it is thickened by additional coatings, or strata, upon the inner surface; sometimes of uniform thickness, but more frequently in veins, rings, spots, or ridges, forming the foundation for the tissues and vessels of plants hereafter to be considered.



468
468, Forms of Protoplasm; A and B, cells from the stalk of Indian Corn; C, from a tuber of Jerusalem Artichoke after action of iodine and sulphuric acid; h, cell-wall; k, nucleus; b, nucleolus; p, protoplasm.

371. **Cellulose** is the substance of which the cell-wall is formed. It yields to the chemist the same elements that are found in starch, whose formula is $C_6H_{10}O_5$; besides these, several other mineral substances are present in minute quantities.

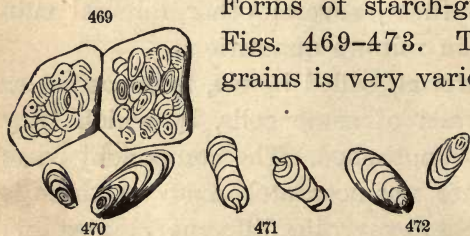
372. **Woody material**, called *lignin*, is deposited or formed upon the walls of some cells, by which they are hardened and strengthened. The component parts of this substance are not accurately known; there is reason to believe they vary in different plants, and even in different parts of the same plant. Mineral substances, principally silica and lime compounds, also thicken the cell-walls and increase their induration and strength.

373. **Chlorophyl.** — In the living cells of those parts of plants exposed to sunlight, granules appear, resembling protoplasm grains in all respects except color. These minute bodies are green, and furnish the green color to leaves and all other green parts of plants; the name applied to these granules is due to their color, and as the leaf is the most conspicuous green part of the plant, the term Chlorophyl (Leaf Green) has been applied to this *green color*. Some authors have called chlorophyl grains *stained protoplasm*, viewing chlorophyl as the *stain*, and the chlorophyl *granule* as colored protoplasm (Figs. 466, 467).

374. **Starch** is a most important plant product, and is formed by the action of protoplasm and chlorophyl under sunlight; it is found sparingly in the leaf, and when more than enough to supply the plant's daily wants is produced, the surplus is stored up in some other part of the plant, as the tuber of the Potato, the grains of Wheat, and other cereals, in which form it is utilized for animal food. Its component parts are identical with those of cellulose.

Forms of starch-grains are shown in Figs. 469-473. The form of starch-grains is very various, differing in dif-

ferent plants, and even in the same parts of the same plant. Fig. 473, *A, a, b, c, to g*, are starch-grains from



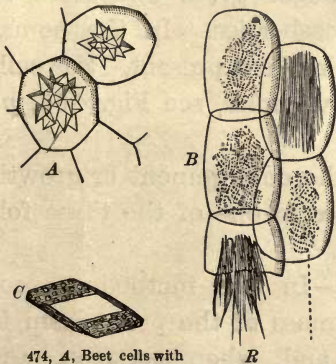
469, Cells of Potato containing starch-grains. 470, Starch grains from the Potato. 471, from the E. Indian Arrowroot. 472, Starch granules from W. Indian Arrowroot.

a grain of Indian Corn. Fig. 473, *B*, shows starch-grains from a grain of Wheat; these are more nearly

uniform in shape and size and somewhat lens-shaped.

375. Crystals of a great variety of shape are found in some of the cells of most plants of the higher orders ; the most simple of these forms are cubical or prismatic ; but they occur in almost every variety of polyhedral form. In some orders they appear in slender needle-shaped bodies called Raphides. They usually occur, solitary or in masses, in the *cell cavity*, but are not unfrequently found in the *cell-wall* (Figs. 474, 475).

Plant crystals are the residua of the materials used in the chemical combinations that have taken



474, A, Beet cells with stellate masses of crystals ; B, R, inner cells, with raphides escaping ; C, aleurone crystal.



473, A, is a cell from the endosperm of a grain of Indian Corn, crowded with starch-grains ; the grains marked a, b, c, etc., to g are also from the interior of a grain of corn. The grains marked B are from the interior of a grain of Wheat.

place in the cell under the action of sunlight, and are usually composed of *lime carbonate* or *lime oxalate*. Other *calcic* combinations are, however, frequently present. The difficulties attending the separating of plant crystals from their surroundings have thus far rendered it impossible in

some cases to determine with accuracy their chemical constituents.

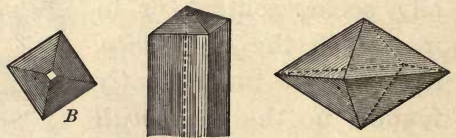
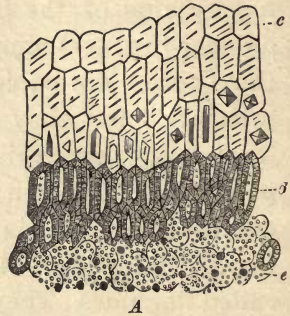
376. **Cell-sap** is the watery fluid in the cell which suspends the food and working material taken into the cell from the air and the soil and the soluble substances which the plant produces, and is the medium by which food is conveyed throughout the plant's structure. All parts of the active cell are filled with water; it constitutes a large part of the cellulose, and forms the greater part of the bulk of protoplasm. Sugar

is a prominent substance in the cell-sap, both cane and grape. Cane-sugar abounds in the cells of Sugar Cane, Sugar

Maple, Beet, Sorghum, Indian Corn, and most of the higher plants; while grape-sugar gives sweetness to grapes, cherries, figs, and gooseberries. In the pomeaceous and drupe fruits both kinds are present. For cell-sap in both large and small vacuoles, see Fig. 466, *p*; Fig. 467, *B*, *s*, *s*.

377. **New cells**, to which the enlargement or growth of the plant is due, are formed in one of the three following typical modes:

378. 1, **Rejuvenescence**.—In this method of producing new cells, the entire mass of the protoplasm is expelled from the old cell, and, when set free, surrounds itself with a wall, thus becoming a new cell.



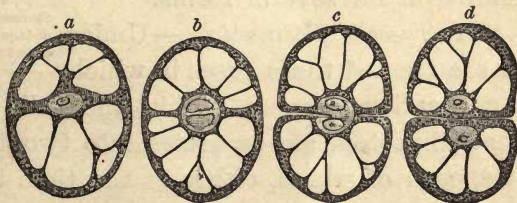
475, *A*, cross-section of oak-gall; *d*, sclerenchymatous cells; *c*, outside tissue, with oxalate crystals, *e*, inner tissue containing starch and resin. *B*, forms of calcium oxalate crystals.

379. 2, **Conjugation**.—New cells are also produced by the union of the protoplasm of two or more cells; the contents of which having commingled, the combined mass incloses itself with a cellulose covering, and becomes a new cell.

380. 3, **Fission** is the name applied to the mode of cell production by which two or more new cells are formed out of one. This is the usual mode, and may be treated under three heads.

381. *a*, **Fission Proper**.—A young complete cell (Figs. 465, 466) possesses the power to multiply. The most simple case of this process is the division of the cell into two equal, or nearly equal, parts. The protoplasm forms two nucleus-like spots; a stricture then commences in the wall between the spots, and the cell seems to pinch itself into two. This process is shown in the fission of Bacterium cells (Figs. 511, 512).

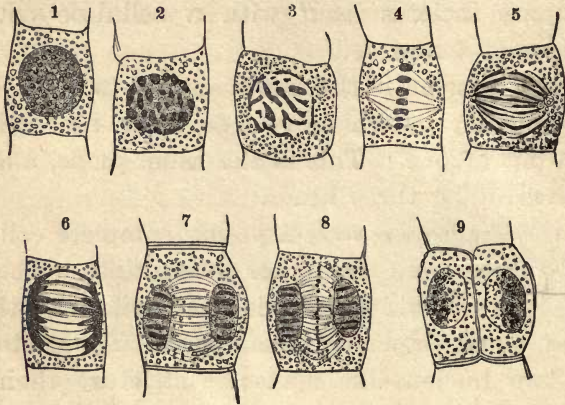
In most cases the process is accompanied by a stricture more or less prominent; at the same time an equatorial septum appears between the nuclear spots, and divides the old cell into two nearly equal new cells (Fig. 476). In this case the stricture in the cell-wall is barely visible. The new cells round up and soon become sub-globular in form.



476

476, Phases of a cell undergoing the process of fission; *a*, complete cell with drops of cell-sap among the protoplasm, nucleus, and nucleolus; *b*, same, with nucleus and nucleolus divided; *c*, with stricture and wall forming across between the nuclei; *d*, same, with the septum completed, and the fission accomplished; two separate cells have been formed by dividing the old cell into two.

The process of cell division depends first upon the nucleus which forms a spindle of radiating fibrils with an equatorial disk. A middle wall, or partition, is formed at the disk, whereby two distinct cells are produced (477).—*Macloskie's Elementary Botany.*



477

477, No. 1, mature cell; 2, 3, 4, 5, 6, 7, 8 show the changes through which No. 1 passes preparatory to the final act of fission; seen completed in No. 9.

382. *b, Budding* is another form of plant multiplication. In this mode the plant cell puts forth a protrusion which enlarges until it is about the size of the old cell, when a partition wall is thrown across at the juncture, making the new cell complete and independent. In Fig. 478 the process of budding is shown in its several forms.



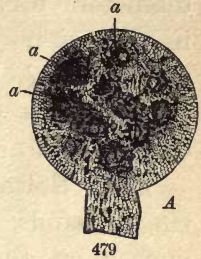
478

478, Yeast-plant, *Saccharomyces cerevisiae*, undergoing the process of budding.

383. *c, Intra-cell Formation.*—Under this head are treated those cases in which several aggregations appear within the cell and the entire mass of protoplasm separates into two, three, or more parts, each of which, either at the time the division is going on or soon after, becomes inclosed in a cellulose envelope, and speedily assumes a globular form, as an independent complete cell.

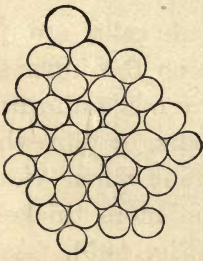
In the preparation for cell division nucleus-like formations usually appear in the mother cell. The whole protoplasmic body breaks up into two, three, four, or more parts, and each quickly takes on a spherical form (Fig. 479).—*Sachs' Text-book of Botany.*

All these modes of cell multiplication and formation are subject to great variation; each has a tendency to run into one of the others; the last is especially liable to vary as to number of daughter cells.

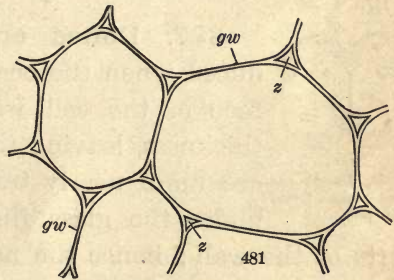


479, Showing cell formation in *Achlya*—mother cell, showing a number of nuclei in the mass of protoplasm which is preparing to break up into a number of independent or daughter cells; a, a, a, etc., nuclei.

384. The form of cells varies to suit the use for which they are intended and the amount and direction of the pressure to which they are subjected. The normal shape is globular or spheroidal when free from pressure (Fig. 480); when pressure

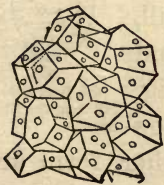


480



481

480, Form of cells in loose parenchyma. 481, Cross-section of parenchyma cells from stalk of Indian Corn ($\times 550$), showing form under slight pressure; gw, gw, partition walls; z, z, intercellular spaces.



482

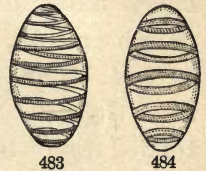
482, Form of cells under greater pressure from all directions.

from surrounding cells is exerted, they become ellipsoidal, egg-shaped, prismatic, or polyhedral (Figs. 481, 482). In the trunks and branches of trees and stems of herbaceous plants the cells become elongated in the direction of growth (Fig. 467).

385. The size of the cells in the soft tissue varies; the largest is about $\frac{1}{60}$ of

an inch in diameter. From this cells occur whose diameters range all the way down to $\frac{1}{5000}$ of an inch in diameter. In the more solid tissues they range from $\frac{1}{4}$ to $\frac{1}{10}$ of an inch in length, and from $\frac{1}{1500}$ to $\frac{1}{3000}$ in their cross-sections. Cells of the long staple cotton wool are from one to two inches in length.

386. **Spiral and annular cells** are formed when rings, bands, or hoop-like processes appear on the inner surfaces of the walls; in the *spiral cell* an uninterrupted fibrous process extends the whole length of the cell in a spiral coil (Fig. 483). The *annular cell* has bands or hoop-like markings as though the spiral fiber had been interrupted at several points (Fig. 484).



483, Spiral cell from Orchid. 484, Annular cell from Mistletoe.

387. **Dotted or pitted cells** are produced when the coatings on the inner surface of the cell wall are not uniform in thickness, leaving thin spots, or pits, which are more nearly transparent when viewed under the glass, than the more thickened parts of the wall; hence the name (Fig. 485).



485, Dotted or pitted cells from Elder pith.

388. **Reticulated cells** are produced by coatings which are deposited or formed upon the inner surface of the cell-wall, where they at first appear in spots and lines, of different sizes and lengths (Fig. 486). As the cell grows older, the markings increase in length, and touching each other, form an irregular net-work.

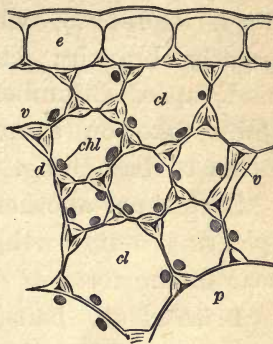


486, Reticulated cell from the Mistletoe.

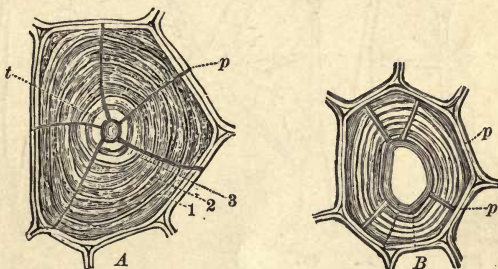
389. **Collenchyma cells** are cubical, cylindrical, or irregular in form, whose walls are much thickened

at the angles, while they are of ordinary thickness in other parts. These cells occur in most plants of the higher orders and in some ferns, and are found in the tissues just beneath the epidermis.

390. **Sclerenchyma cells**, sometimes called *grit* or *stony* cells, have hardened walls produced by deposition upon them of the horny substance found in the pits of the Cherry, Peach, and Plum and the shells of nuts; sometimes found in the fleshy parts of the Pear.



487, Collenchyma cells from leaf stalk of *Begonia*; *e*, epidermal cells; *cl*, collenchyma cells; *chl*, chlorophyll grains; *v*, thickened angles where these cells meet; *p*, part of parenchyma cell.



488, Sclerenchyma cells; *PP*, canals connecting the cavity *t* with the outer surface or adjacent cells; 1, 2, 3, thickened layers; *p*, in *B*, cell walls.

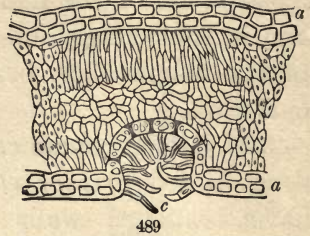
391. **Epidermal cells** appear in plate-like expansions forming the outer coverings of leaves and young bark; their edges are in contact; their boundaries are either straight or sinuous; and they are elongated in the direction of growth. The edges are so firmly knit together that the entire covering of one side of a leaf may be removed intact. The epidermis at first is usually formed of a single layer, but later it is sometimes made up of two or more layers (Fig. 489).

392. **Hairs** are outgrowths of epidermal cells, and are composed usually of greatly elongated single cells (Figs. 490-497), which frequently branch; others are made up of a number of cells. Hairs take on a number of forms by branching.

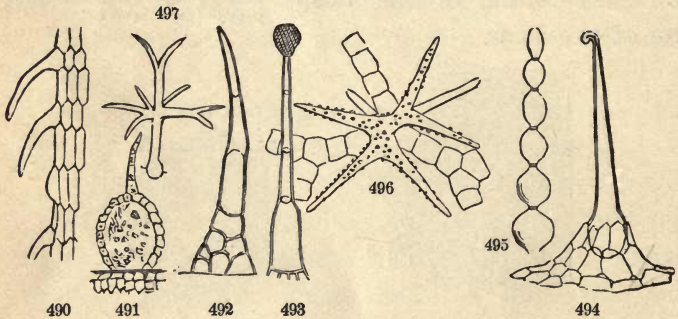
Scales are another form of epidermal outgrowth, and appear in the form of disks.

Bristles are hair-like processes, the walls of whose cells are hardened.

Prickles are outgrowths of a still firmer character.



489, Is a vertical section of a leaf of *Banksia*; *a, a*, show two layers of cells in the epidermis; *c*, hairs found in little cavities on the under side of the leaf.



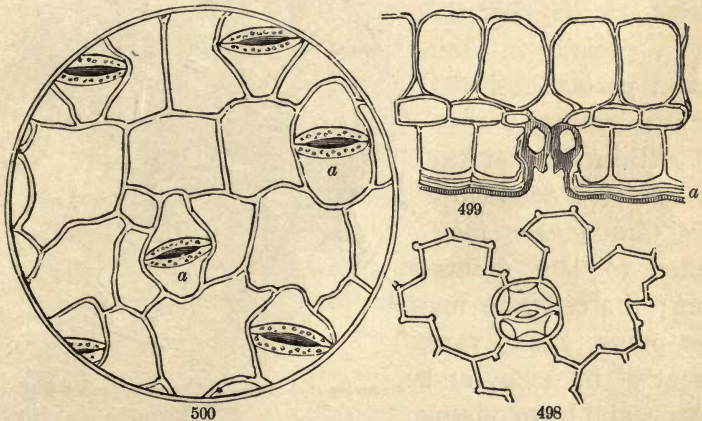
490, Rootlet of Madder, showing cells expanded into hair-like processes. 491, Section of a glandular hair of *Fraxinella*. 492, Hair of *Brionia*, composed of several cells. 493, Hair surmounted by a gland, *Antirrhinum majus*. 494, Stinging hair of *Urtica dioica*. 495, Jointed hair from a stamen of *Tradescandia*. 496, Star-shaped hair from the petiole of *Nuphar advena* ($\times 200$). 497, Branched hair of *Arabis*.

393. **Glands** are processes consisting of a single cell or an aggregation of cells, situated a little above, at, or just beneath the surface, the function of which is to secrete and discharge peculiar substances, as oils, nectar, etc. Glands sometimes terminate in a hair-like process (Fig. 493).

Stinging hairs are usually setaceous and sufficiently rigid to perforate animal tissue; having entered, the

apex breaks off and the contained irritating liquid is discharged into the wound, producing the sting.

394. **Stoma-cells** are epidermal. Stomata are mouths or openings into the intercellular spaces of the leaves and young bark, sometimes called breathing-pores. They are guarded each by two half-moon-shaped cells whose concave sides lie next each other; when filled with liquids, their concavity increases, leaving an orifice between the guard cells. For the passage of air and moisture when the atmosphere is dry and the plant can not afford to part with its fluids, the guard cells lose their concavity, the sides become straight, the orifice closes, and evaporation is arrested. The number of these openings is very great, many thousands appearing in a square inch of surface (Figs. 498-500).



498, Cells of epidermis with a stoma from leaf of *Helleborus foetidus*. 499, Vertical section of a stoma of *Narcissus*; *a*, cuticle. 500, Epidermis cells with stomata of *Tradescantia Virginica*—*a*, *a*, guard cells.

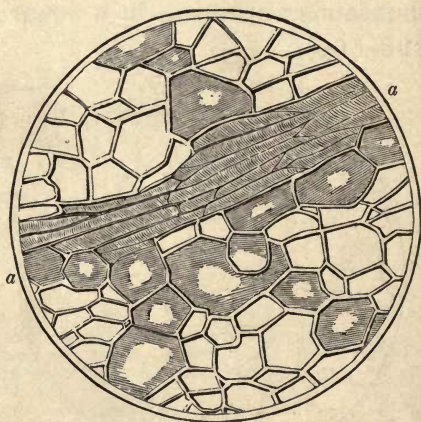
395. **Cork cells** are cubical or tabular, and fit closely together; in the outer layers they are dead and empty, and constitute the outer bark layers of old trees, prominent in the *Quercus suber* (Cork Oak).

CHAPTER II.

TISSUES.

396. **Parenchyma** is a tissue composed of short cells, usually with intercellular spaces among them, and is the foundation of vegetable structure. All cells may be regarded as modifications of parenchyma; the various markings and forms being due to alterations which go on by degrees to fit them for the functions they are to exercise in the tissues of the plant.

397. In the lower plants the entire individual consists of parenchyma, and it is found throughout the structure of the higher plants, mingled and interlaced with other tissue, especially in their green parts. Fig. 501 is a microscopic view of a thin slice of the rhizome of *Sanguinaria Canadensis*, magnified to 100 diameters; the cells are under pressure, and vary greatly in size and shape, and have a bundle



501

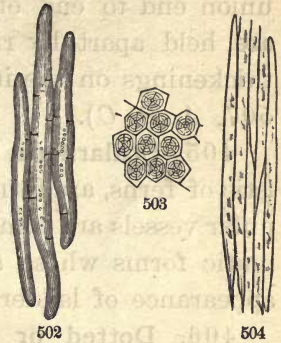
501, Section of the rhizome of Bloodroot; a, a, a bundle of wood-cells.

of wood-cells imbedded among them. For forms and size of cells see No. 385; also see Figs. 480-482.

398. **Prosenchyma** is the generic name of the *elongated*, pointed cells or fibers without intercellular spaces that form plant tissues,

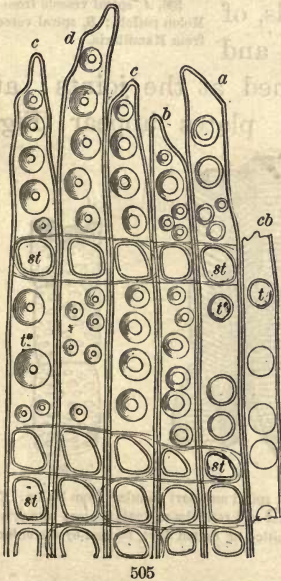
399. **Woody tissue** is made up of slender, lengthened, lignified cells, which taper at the ends, and are found in woody plants overlapping each other, and packed in bundles (Figs. 502-504).

400. **Bast tissue** is composed of elongated cells, with thickened walls, not sufficiently lignified to be hard; they are flexible and tough, and abound in the inner bark of dicotyledonous trees and shrubs.



502, Wood-cells. 503, Cross-section of same. 504, Wood-cells in combination forming a fibro-vascular bundle.

401. **Disk-bearing tissue** is constituted of lengthened cells, which have pits or lens-shaped markings, found in the Pine and other gymnosperms (Fig. 505).



505

505, Lengthwise section of (Scotch Pine) *Pinus Sylvestris*, showing disk-bearing tissue; *cb*, Cambium wood-cells; *a*, *b*, *c*, etc., older cells; *t*, *t'*, *t''*, bordered pits; *st*, large pits ($\times 225$).—*Sachs*.

402. **Vessels or ducts** are tubes or passages through which the fluids pass from one part of the plant's structure to another. In the formation of these passages elongated cells arrange themselves end to end, become anastomosed; the walls in the ends of the cells are ruptured or disappear, and uninterrupted passages are produced.

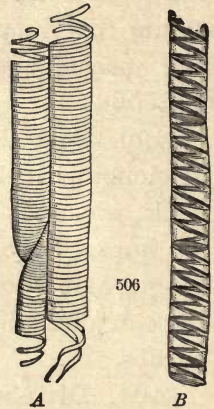
403. **Spiral vessels** are constructed by the union of spiral cells, in the manner described in the last article (Fig. 506).

404. **Annular or ringed ducts** are produced by the union end to end of annular cells, the walls of which are held apart by rings or hoop-like thickenings on the inner surface (Fig. 507, *A, B, C*).

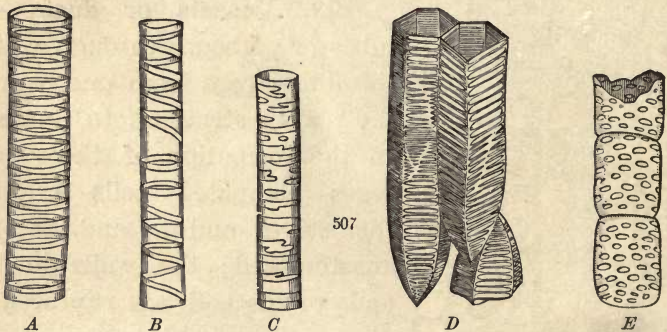
405. **Scalariform ducts**, characteristic of ferns, are formed when the annular vessels are compressed into prismatic forms whose sides present the appearance of ladders (Fig. 507, *D*).

406. **Dotted or pitted ducts** are formed of dotted or pitted cells, as in the case of annular cells (Fig. 507, *E*).

407. **Sieve ducts or tubes** are formed of colorless elongated cells, of large diameter; the walls are soft and very much enlarged and thickened at the joints; at the junctions finely perforated plates appear (Fig.

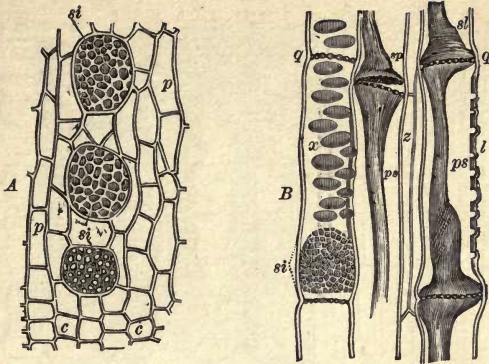


506, *A*, spiral vessels from a Melon petiole; *B*, spiral vessel from Mamillaria.



507, *A*, annular vessel from leaf-stalk of Melon; *B*, duct, part spiral and part annular, from Melon; *C*, part annular and part reticulated duct from Melon; *D*, annular and reticulated ducts pressed into prismatic shape, forming scalariform vessels, from Tree-fern; *E*, pitted or dotted duct, formed by the union of pitted cells from melon-stalk.

508, *A*); also on the internodes are spots of fine perforations and slits (Fig. 508, *B*). These spots of perforations are like a strainer or sieve; hence the name.



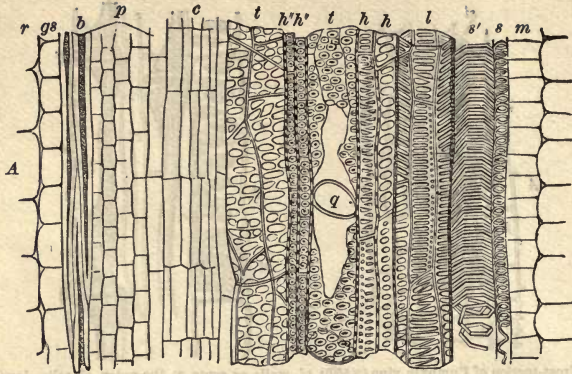
508, *A*, Cross-section of Pumpkin vine ($\times 550$); *st*, walls or septa at the union of cells, developing into sieve plates; *c*, *c*, cambium cells; *p*, *p*, parenchyma. *B*, Lengthwise section, showing the enlarged joints; *q*, an edge view of sieve septa; *st*, sieve spot on the side-wall.

408. **Latex vessels** are produced by the union end to end of latex cells; by anastomosing and branching a reticulated tissue is formed which conveys the milky juices of the plant through its structure. In the tissues of the *Ficus elastica*, *Euphorbia* and the *milk weeds*, besides the Latex tubes, numerous closed cells are present, charged with the same milky fluids as the ducts (Fig. 509). The free cells frequently elongate, and sometimes branch.

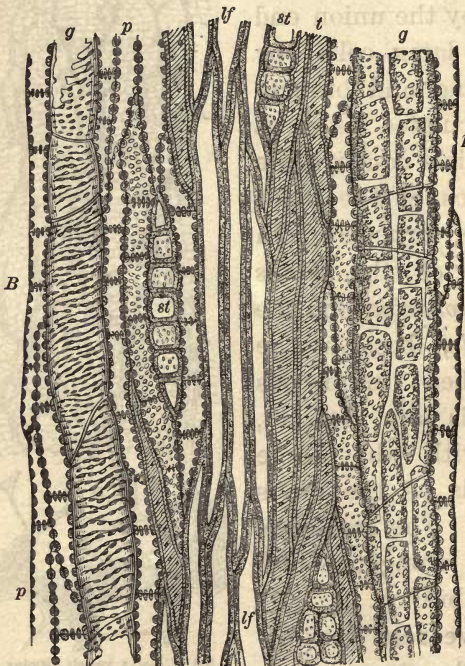
These vessels are arranged in the stem as represented in Fig. 510.



509, *A*, Latex vessels forming an irregular network in a transverse section of the bark of *Scorzonera Hispanica*. *B*, A fragment of a latex vessel more highly magnified.—*Sachs*.



510, *A*, Lengthwise section of the Castor-oil plant. Beginning with the bark, *r*, cortical cells; *gs*, bundle sheath; *b*, bast fibers; *p*, bast parenchyma; *c*, cambium; the cells between *c* and *p* become sieve tubes; *t*, *t*, pitted vessels; *q*, shows an absorbed septum; *h'*, *h''*, annular ducts; *h*, *h'*, pitted vessels, resembling annular ducts; *l*, vessel apparently made up partly of annular cells and partly of reticulated cells; *s*, spiral vessel, of very small caliber, next to the pith; *s'*, larger calibered spiral vessel; *m*, pith-cells.



510, *B*, Lengthwise slice of wood from an *Ailanthus glandulosa*, highly magnified; *g*, *g*, pitted ducts; *p*, *p*, wood parenchyma; *w*, woody fibers; *st*, *st*, cross-section of medullary rays; *t*, annular ducts.

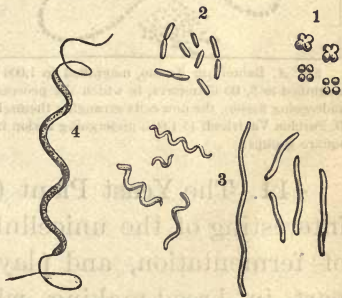
CHAPTER III.

SYSTEMS OF TISSUES AND PLANT GROWTH.

409. The brief account of the cell and its modifications into tissues and ducts, prepares for the consideration of the manner in which these *organs* are arranged in the structure of plants.

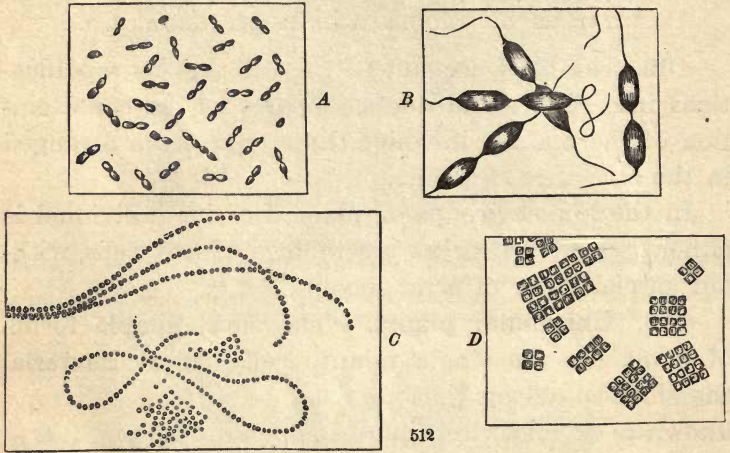
In the lowest groups of plant life the individual is either a *single cell* or an assemblage of soft cells, without special order of arrangement.

410. **Unicellular plants.**—The most simple forms of plant life are single minute cells, called **Bacteria**, the smallest objects that are known to exercise vital functions; they are so small that 50,000 laid on a line side by side would occupy a space less than an inch in length. The typical form is globular, appearing under the microscope as a minute granule or dot, as No. 1 in Fig. 511; they are, however, frequently elongated, and appear in an oval form, as in No. 2; again, they take on the form of a fine line, straight, curved, or crooked, as in No. 3; another time they are spiral, as in No. 4. These minute cells are stored with protoplasm, and swim in fluids from which they obtain nourishment. They increase by fission, and multiply with marvelous rapidity. They are found in the watery fluids of both animals and plants.



511, 1, Sarcine; 2, Bacterium; 3, Vibrio; 4, Spirillum.

Some Bacteria separate into spores; and diseases in men as well as plants are believed to be due to the presence of Bacteria. They are parasitical or saprophytic, feeding on living or decaying matter; they are the agents of decay and revel upon the ruins they produce. As they multiply by fission, they are called Schizomycetes ($\sigma\chi\acute{\iota}\zeta\omega$, to divide, and $\mu\acute{\upsilon}\kappa\eta\varsigma$, a fungus). (Fig. 512.)



512. *A*, Bacterium Termo, magnified to 1,000 diameters, undergoing the process of fission. *B*, Same, magnified to 3,000 diameters, in which the process of fission is nearly completed. *C*, Micrococci ($\times 1,000$) undergoing fission, the new cells arranging themselves in curved and crooked lines or in irregular groups. *D*, Sarcina Ventriculi ($\times 1,000$) undergoing fission in two directions, the new cells arranging themselves in square groups.

411. The Yeast Plant (Fig. 513) is one of the most interesting of the unicellular organisms; it is the agent of fermentation, and plays an important part in bread-making, where it disintegrates the starch-grains in the flour, and thereby liberates carbon dioxide; the gas set free struggles to find its way through the dough, becomes entangled, forms cavities in the mass, and makes it sponge-like or *light*.

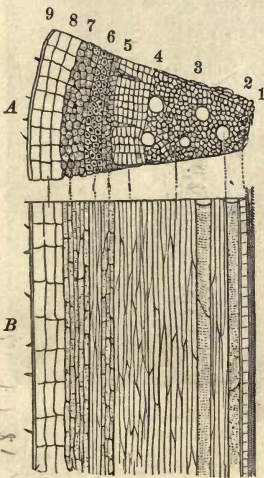
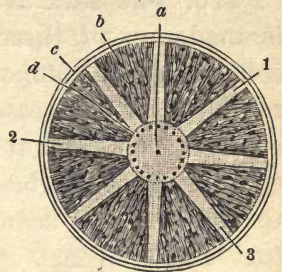


513. Yeast Plant, *Saccharomyces cerevisiae*.

412. The next grade above the plant which is a single cell is one composed of a mass of cells without a special axis of growth; as some of the Sea-weeds, which are mere masses of flat cells arranged in two layers, forming irregular leaf-like expansions.

413. This book is intended to consider the higher plants only; we shall therefore now proceed to describe the manner in which the modified cells and vessels are arranged in the higher organized plant structures.

414. **Exogenous or Dicotyledonous structure.**—Growth in the most highly organized plants is best illustrated by the examination of a tree or shoot of Oak, Maple, Apple, or Cherry at the end of the first year of



515, A, cross-section of the stem of a Maple at the end of the first season's growth; 1, edge of the pith; 2, spiral vessels; 3, wood region made up of woody fiber and dotted ducts and other vessels; 4, cambium layer made up of new cells; 5, liber; 6, larger cells and vessels of the liber or bast region; 7, cellular envelope or green bark; 8, corky envelope or outer bark; 9, the skin, or epidermis. B, shows corresponding vessels and tissues in a vertical section of the same plant.

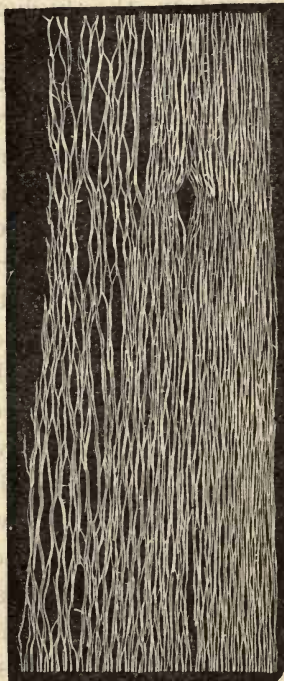
its life. A cross-section of such a scion presents a circle of *pith* in the center, around which are concentric circular rings, the inner one wood, the outer ones bark. In the figure (514), *a*, the pith; *b*, the wood; *c*, the bark. On the inner edge of the wood is a ring of spiral vessels, *d*, which is called the medullary or pith sheath. The pith is made up of parenchyma and extends between the wedges of wood in flat cells connecting the pith with the bark (1, 2, 3, Fig. 514), forming the silver grain seen in Oak and Maple planks, or in a longitudinal section of those and other cabinet woods when split.

415. **The wood** is made up of woody fiber interspersed with tis-

sues composed of the cells, vessels, and ducts which have already been described.

416. The bark at the end of the first year's growth is made up of three *layers*: the one next the wood, called bast, is composed of parenchyma, *sieve* vessels, and liber-cells; on account of the predominance of the *bast ducts* in this layer, it has been called the *bast region* (Figs. 508, 516). The liber-cells are long, strong fibers, and in some plants are very tenacious and flexible, forming the material in *Hemp*, *Flax*, and other textile substances utilized in manufacture of cordage and fabrics.

Next to the bast is the green cellular layer, called phellogen, because by its dividing, it produces outside of it cork, which increases by the addition of new material to the inner surface. The cork is usually of a brown or ashy color, sometimes white or striped; in old trees it is cracked and broken by the growth of the wood, and falls off in scales or strips, as in the shag-bark Hickory; in the Paper Birch it peels off in sheets resembling paper. Upon some trees it develops into thick porous layers, and upon the Cork Oak furnishes the cork of commerce.



516

516, Is a photograph from nature of a layer of bast-fibrous bundles found in the secondary bark of the stem of an old *Carica papaya*. These bundles, originating in the cambium, are arranged in ten to twenty layers one over another like the leaves in a book. These fibers by anastomosing have formed an irregular net-work with elongated sinuous meshes. These meshes during their life were filled with soft secondary cortical tissue which has been removed by maceration.

417. During the season of activity the young stem continues to increase both in height and diameter by the multiplication of cells and the formation of the various tissues required by the conditions of growth (Chap. III., Introduction); hence a mass of infant cells is constantly present between the wood and the bark, and in the buds of the stem and branches.

On the approach of winter the leaves fall, the terminal buds refuse to expand, and the entire process of growth is arrested, until the revivifying warmth of the succeeding spring unlocks the imprisoned forces that have slept during the frosty season, when the fluids from the earth begin to flow upward and outward through the vessels and ducts of the last year's wood to the bark and the leaves; the young cambium cells which have slumbered through the winter are filled with sap and commence another season of growth; the buds burst into leaves or flowers, and the greatest activity succeeds the late period of rest. The young cells multiply and increase in size, most of them being changed into woody fiber and ducts, commencing a new layer of wood on the outside of the last layer, and a new layer of bast on the inside of the old one; also a new layer on the inside of the cortex layer. In this way the work goes on, and layer after layer is added for each period of activity, which in regions of severe frost occurs yearly (Fig. 517). Within the tropics and all regions of no frost, periods of rest and activity may occur more frequently than once a



517. Is a photograph of a cross-section of an oak-stem twenty-five years old, showing the annual circular rings, the whole surrounded by the rough bark.

year, and therefore the number of rings on a cross-section does not always indicate the number of years in the age of a tree. But in the higher latitudes a new tube of wood and one of the inner bark is formed yearly.

That more than one ring of wood may, and sometimes does, form in one season of growth, even in regions of severe frost, has been established by observation.

418. **Sap wood** is a name applied to the *new wood*, and usually includes several of the last formed layers; it is so called because the fluids in moving upward from the ground pass through its vessels. In most trees it is of a lighter color than the older layers, and on that account was called by early botanists *Lignum album*, white wood; now called **Alburnum**, or white wood.

419. **Heart wood** is that part of the trunk or stem near the *center* or *heart*, and for that reason called *Heart wood*. It is usually more dense, and therefore called **Duramen**, hard wood. In some species it is much darker than the sap wood, hence former botanists called it *Lignum nigrum*, *Black wood*. In some plants, as the *Black Walnut*, the Duramen is very dark, while the *Heart wood* of the Maple is not much darker than the sap wood, though they may grow side by side and draw from the earth the same materials. It would seem, therefore, that chemical changes take place either in the plant's structure or upon the materials taken in to suit the necessities of each case.

On account of the mode of growth in Dicotyledonous stems, the name Exogens, or outside growers, was formerly applied to plants of this structure. They are characterized by two or more seed leaves in their embryo, and produce netted-veined leaves. See Dicotyledons, pages 163-166.

Nearly all the trees and shrubs of the temperate zones are Exogens or Dicotyledonous plants, well

represented by the Oak, Pine, Elm, Maple, Apple, Pear, Peach, Cherry, and other fruit and timber trees.

420. The root is that part of the plant that grows downward into the ground and holds the whole firmly in the soil. Its tissues correspond with those of the stem to which it belongs, and it increases in diameter by additional layers, one for each period of activity, succeeded by a rest. The extremity of the root and that of each

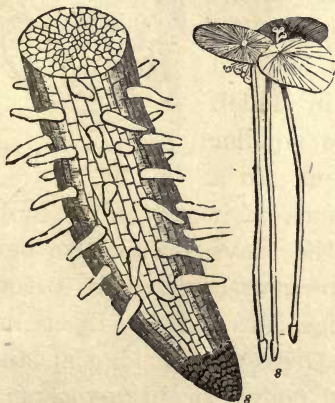


518

518, a, Shrub; b, Fir; c, Oak-tree.

519

520



519, Rootlet of Maple with hairs or fibrillae; s, root cap. 520, Duckmeat, showing the root cap s.

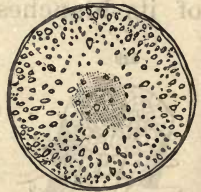
of its branches is encased by a layer of older cells, called the root cap, a contrivance which seems to be intended to protect the tender infant cells just behind it, which during the growing season are increasing and multiplying, to extend the root and rootlets in all directions in the soil. The parts of the root and rootlets near the growing points absorb the fluids which are presented to them in the soil, but this

absorption is largely helped by root hairs, which clothe the root and rootlets, as seen in Figs. 519, 520. Fig. 519, root of a Maple sprinkled with hair-like processes or minute fibrillæ; these are usually each a single elongated cell, and appear on the newer parts of the root, a little distance from the growing point, dying or becoming useless on the older parts. The Root, as to use, form, etc., is treated in another place (see Chapter XIII., Structural Botany).

CHAPTER IV.

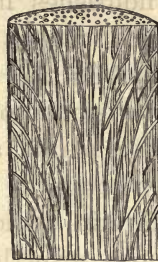
MONOCOTYLEDONOUS STRUCTURE.

421. The woody fibers and vessels that make up the stems of Palms, Indian Corn, Bamboo, Sugar Cane, and all grass-like plants, are not arranged as they are in the Oak, Maple, and Apple, already described. A cross-section of a Palm stem presents a mass of pith, dotted all over with sections of woody fiber and vessels without any apparent order of arrangement (521); the whole inclosed in a circular ring or rind, in which the fibro-vascular *bundles* are smaller than in the body of the stem. In a longitudinal section the threads of woody fiber may be traced from the bases of the leaves in a curve out toward the center, and in a recurve back again to the side whence they started (Figs. 522, 523). In stems like the Indian Corn and the Grasses, with long spaces between the leaves and closed nodes, the fibro-vascular threads extend in straight lines from node to node,

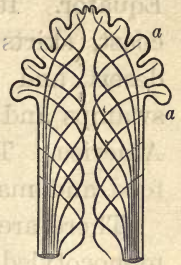


521
521, Cross-section of the trunk
of a Palm.

where they unite with those of the next internode. The rind of the Corn stalk, Bamboo, Reed, etc., is smooth and flinty, due to the deposition of silica on the walls of the cells that compose it. This mode of growth is well shown in the Palms of tropical and sub-tropical regions, as the Palmetto of the Carolinas, the Coconut Palm, many thousands of which have been planted on the coast of Florida.



522



523

522, Vertical section of a Palm stem, showing course and direction of fibers. 523, Theoretical plan of the direction of fibers in a vertical section of a Palm stem: *a, a*, bases of leaves, showing direction of fiber growth

422. The Palm, which is the type of the monocotyledonous division of the vegetable kingdom, reaches perfection only in tropical or sub-tropical regions. There some of the members of this great division tower to the height of one hundred and fifty feet, straight, unbranched cylindrical columns, crowned with a mass of green foliage, presenting to the eye magnificent objects of the picturesque and beautiful. The Palm is one of the most important ornaments in planted grounds in tropical countries, occupying a belt all around the



524

524, Palm, Agave, etc.

globe of about thirty-five degrees both sides of the Equator. It flourishes in the bare sands of the sea-coast, skirts arid plains, beautifies the oasis of the desert, and inhabits the murky bottoms of southern swamps and low islands of Southern Asia and tropical America. These plants are of vast utility, producing food and many domestic and economic products.

There are certain noticeable things in the mode of monocotyledonous growth. The stem has no proper bark, does not increase in diameter after it is perfectly formed, and, with few exceptions, consists of an unbranched cylindrical column, made up of pith intermingled with fibro-vascular threads, generally without any order of arrangement, the whole inclosed in a rind or false bark (521-524), well illustrated in a cross-section of a stalk of Indian Corn. There are a few plants that seem to be connecting links between these two modes of growth; a notable example of which is *Dracæna draco*, or Dragon-tree, which has a cambium region, and continues to increase in diameter.

Formerly these plants were called *Endogens*, meaning **Inside growers**, in contradistinction to *Exogens*, or **Outside growers**, because the new material of growth was then supposed to be deposited *always inside* of the last deposit of woody bundles; but as it is now known that the additions are interspersed among the former ones, in most cases without special order, the name is not expressive. Plants of this mode of growth have but one cotyledon, or seed leaf; their flowers are mostly three-parted, and their leaves generally parallel-veined. See *Monocotyledons*, pages 168-170.

423. **Tissues of the Pteridophyta.**—The Ferns and their allies have a complicated and well-marked organization; the outer bark is similar to that of the flowering plants, and vascular-woody fiber extends throughout the stem, and leaf stalks ramifying in the fronds, to which the great beauty of this division of the vegetable world is due.

A cross-section of a Fern stem shows a mass of parenchyma, supported by an outer sheath or tube of vascular-woody bundles, the whole inclosed by a cortex of dense sclerenchyma, the leaf stems presenting the same structure (Fig. 525).

424. **Tissues of Bryophyta**, moss-like plants.—The higher types of this division, while largely made up of cellular masses, have a semi-vascular-fibro arrangement, and in some mosses the fibers are so strong as to approach a woody character.



525

525, Section of an Acrogenous stem of Tree-Fern (*Cyathea*), showing the vascular bundles imbedded near the circumference of the cellular mass.

CHAPTER V.

LEAF STRUCTURE.

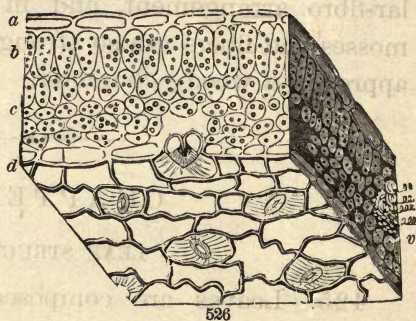
425. Leaves are composed of the same general structure as the stems and branches which they clothe and adorn, and are made up of vessels and tissues already described: 1, *woody* fiber, which constitutes the frame-work; 2, *cellular* tissue, which fills up the spaces between the ribs or frame-work formed by the woody part. The leaf of a Maple, Elm, or Apple is composed of: 1, the *leaf-stalk*, by which it is attached to the stem or branch; 2, the *blade*, the expanded part. The leaf-stalk or petiole is a column of bundles of woody fiber and green tissue, covered by the epidermal tissue. These bundles extend in length to suit the size of the blade, throwing off branches and branchlets to construct the frame, making an irregular net-work, the meshes of which are filled up by the

green tissue. (See Structural Botany, Chapters XX.-XXIII. inclusive.)

426. An important function of the leaf is to expose a large surface; consequently, the blade is thin and so formed as to present the largest number of cells to the air and sunlight.

The layer on the upper side of the blade is made up of oblong cells, closely packed with their ends next to the surface. The lower layers are made up of smaller, more irregular and more loosely arranged cells, and have their

longer diameters in the direction of the surface of the blade. The deep green color of the upper surface of leaves is largely due to the compactness of the green cells in the upper layer, while the paler color of the under side is the consequence of the loose arrangement of

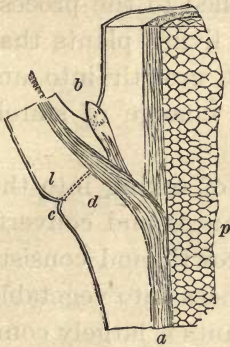


526, Magnified portion of the leaf of *Viola tricolor* in perspective; *a*, cells of the epidermis, sometimes called plate cells; *b*, compact layer of green cells next to the upper surface; *c*, loose cells below; *d*, epidermal cells of the lower surface, with stomata, one of which is cut to show its opening into the intercellular passages.

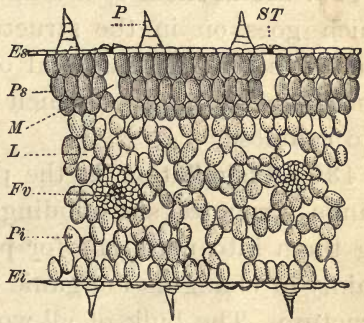
those in the lower strata. The epidermal covering of the leaf, as before described, is a thin membrane made up of one, two, or three layers of empty thick-walled cells (Figs. 489-524 inclusive).

427. **Respiration** is the act of drawing air into the lungs and casting it out again. (From the Latin *re*, again, and *spirare*, to blow or breathe.) The air while in the lungs is known to part with some of its oxygen, and what is breathed out is charged with substances which it did not possess when taken in; therefore the

taking in of oxygen and its combination with other substances while in the lungs and the liberation of substances thus formed constitute *respiration* in animals. So with plants; they suck or draw in air through openings in the epidermis already described, and when it is discharged it is found to be changed in character, having been robbed of its oxygen or of its carbon dioxide. The oxygen of the air while among



527



528

527, Is the section of a young stem or branch showing, at *p*, the pith; *a*, vascular-fibro bundle, passing off from the stem to form the leaf-stalk and frame-work of the blade; *d*, the swelling just below the foot of the stalk; *l*, the base of the foot stalk; *b*, the axillary bud; *c*, the articulation or point where the leaf-stalk is attached to the branch or stem. 528, Magnified section of a leaf perpendicular to its surface; *P*, hair on the upper surface; *ST*, stoma; *Es*, epidermis of the upper surface made up of plate cells (§ 391); *Ps*, oval cells closely packed with longer ones perpendicular to the epidermis; *M*, interspace beneath the stoma; *L*, interspaces among the irregular shaped, loosely packed cells of the lower stratum *Pi*; *Fv*, cross-section of fibro-vascular bundle; *El*, lower epidermis with hairs. (See Figs. 489 to 500.)

the tissues unites with substances found there, and new material for plant growth is thus formed; in the night carbon dioxide is breathed out. It has been shown by experiment that air is not only required for the health of plants, but that they can not exist without it; for when placed in a vacuum, they invariably perish. *Respiration* is therefore necessary to the life of plants as well as to animal life.

428. **Breathing** goes on in all parts of plants exposed to the air, at night as well as in the daytime;

and at night especially oxygen is consumed and carbon dioxide is set free. This fact has led to the inference that

Potted plants in a living room render the air unfit to breathe; but carefully conducted experiments have shown that one hundred ordinary stove plants would not injure the air of a moderate sized sitting or living room to an extent that could be in any way injurious.

429. **Metabolism** is the name applied to the process which goes on in the structure of living plants that alters one kind of material of plant growth into another; an example of which is the change of starch into cellulose.

430. **Assimilation** is the process of taking into the plant's structure surrounding substances and converting them into materials for plant growth, and consists mainly in changing inorganic substances into vegetable structure. The bulk of all woody plants is largely composed of carbon, hence assimilation in such plants consists mainly in disintegrating carbon dioxide, and appropriating the carbon. *Assimilation* is carried on in the cells of the green tissue and in sunlight.

Some of the substances suspended in the watery fluids of plants and the constituents of water itself are used directly by the protoplasm in the preparation of food; carbon dioxide, however, must first be decomposed, in which process its oxygen is set free, and the carbon enters into the ligneous structure, or both oxygen and carbon enter into new combinations which the protoplasm can use. For example, water and carbon dioxide contain all the materials found in starch. These compounds having been separated into their constituents, the elements reunite in quantities that

produce *starch* and other carbohydrates, as oils, sugars, gums, etc. These are either used to supply the plant's immediate wants or stored in some of its organs for future use.

The decomposition of water and carbon dioxide liberates oxygen, which may be seen in bubbles on the submerged parts of water plants; this gas escaping into the air, helps to keep it pure.

431. Movements of fluids.—The root takes up from the earth the watery substances which are presented to it; the cells at the extremities of the root and rootlets are first gorged; these impart to the cells and vessels next in contact, which take up the fluids by infiltration, and so they are passed on up the stem largely through the cells and vessels of the last season's wood, and outward through the same class of cells and ducts, along the branches to the leaves and new twigs. Having reached these green parts, much of the water passes off by evaporation; what remains becomes changed by the action of sunlight and fitted for building up the plant's structure. It then by some mode of transfusion finds its way back to all the growing parts of the plant where new material is needed.

432. Circulation.—Careful observation and experiment have demonstrated that there is an upward current of water or watery fluids through the stem, by way principally of the fibro-vascular tissues; but no downward movement has been detected answering to a current. Hence there is not a circulation which corresponds to what takes place in the higher animals. Yet the prepared sap reaches parts of the plant's structure lower than the points where it was prepared; hence it must go downward.

How the elaborated sap passes back and even downward through the cells and vessels that are at the same time employed conveying the crude watery fluids up from the root is not understood. We are not acquainted with any physical or chemical force which causes the crude sap to creep through the cells and ducts of the trunks and branches of great trees, hundreds of feet in height; nor is the transfusion of the prepared fluids and cell materials to every part of the plant's structure where food is required less difficult to explain.

In fact, observation and experiment have thus far failed to account for these mysterious movements.

CHAPTER VI.

FERTILIZATION.

433. The higher plants produce seeds, each of which contains an embryo of a new plant. The seed has already been defined as the ripened ovule or as the fertilized and mature ovule. The *fertilization* of the ovule is accomplished by the mingling of the protoplasm of the pollen cell with the protoplasm of the ovule, which is brought about in the following manner:

434. **Process of Fertilization.**—The ripened anther opens and discharges its pollen grains, some of which, by the action of the wind or the aid of insects, reach the stigma; when one has secured a lodgment, influenced by the moist surface of the stigma, it germinates, sends down through the tube of the style a tube as the radicle of the seed penetrates the earth

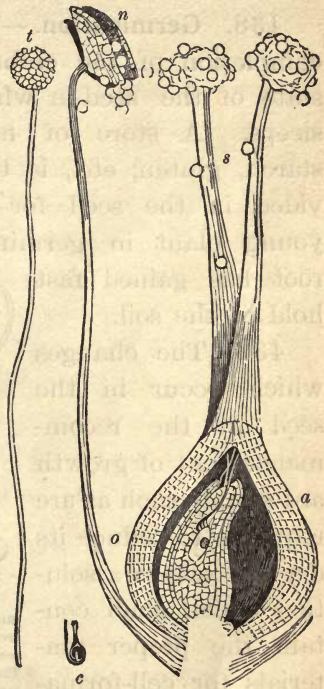
(Chapter III., Introduction). This delicate tube prolongs itself downward till it reaches the ovary, entering it; comes in contact with the ovule, which it penetrates, and discharges the protoplasm of the pollen grain upon the protoplasm of the germ cell, or ovule, and thus fertilizes it. The protoplasm of the two cells having mingled, the ovule ripens into a seed, in which resides the embryo of a new plant.

The quantity of protoplasm in the ovule or germ cell is greater than that contained in the pollen grain.

435. **Gamogenesis** (Greek γάμος, marriage, γένεσις, production).—Formation by marriage is the name applied to this mode of fertilization.

436. **Conjugation** is the name of another mode, which is accomplished by the union of two similar cells side by side, the combination resulting in a germinating cell.

437. The ovule fertilized becomes a new center of growth. First it expands to a proper cell, attached to the wall of the sac near the micropyle. It then, by division and subdivision, multiplies itself, and begins to take form according to the species, showing cotyledon, plumule, etc., until fully developed into the embryo.



529

529, Section of the ovary of *Polygonum pennsylvanicum*, in process of fertilization. (Magnified 20 diameters.) *c*, Natural size; *n*, one of the stamens, having discharged its pollen; *t*, a grain of pollen and its tube; *s*, styles and stigmas; *o*, ovary, ovule, embryo sac containing the embryonic globule. The extremity of a pollen-tube is seen in contact with the embryo sac.

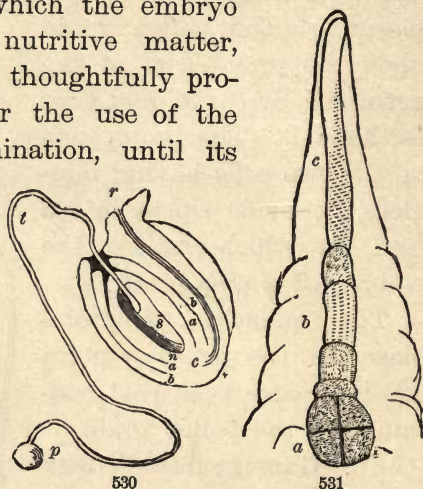
In the case of the CONIFERS (Pines, Cedars, Firs), where no styles or stigmas exist, the pollen falls directly into the microphyle of the naked ovule, and its tubes settle into the tissue of the nucleus. •

438. **Germination.**—The ovule matures with the completion of the embryo, and passes into the fixed state of the seed in which the embryo sleeps. A store of nutritive matter, starch, gluten, etc., is thoughtfully provided in the seed for the use of the young plant in germination, until its root has gained fast hold of the soil.

439. The changes which occur in the seed at the recommencement of growth are simply such as are requisite to reduce its dry deposits to a solution which shall contain the proper materials for cell-formation or growth. Gluten

and other nitrogenous matters, oil, starch, etc., are to be changed to *diastase* and *dextrine*. To accomplish this, water is taken up, oxygen absorbed, plant-food dissolved and moved to points where it is needed, and used in constructing new cells and tissues.

440. **Ripening of Fruits.**—After the fruit has attained its full growth the process of ripening commences, during which the pulp becomes gradually sweetened and softened, chiefly by the change of the starch into more or less of soluble sugar. Thus ripening is to the pericarp what germination is to the seed. In its earliest stage the pericarp consists of structure similar to that of green leaves, composed of cellular, vascular, and woody tissues, and epidermis and stomata. Its distended growth afterward results from the accumulation of the flowing sap, which here finds an axis incapable of extension. Thus



530, Ovule of *Viola tricolor*, showing the process of fertilization; *p*, pollen; *t*, tube; *r*, raphe; *c*, chalaza; *b*, primine; *a*, secundine; *n*, nucleus; *s*, sac, which the tube appears to have penetrated. 531, Growth of the embryo in *Hippuris vulgaris*. The fertilized cell has divided itself into several, of which *c*, *b* constitute the suspensor attached to the apex of the sac; *a*, embryo dividing into two, then into four cells.

arrested in its progress, it gorges the pistil and adjacent parts, is condensed by exhalation, assimilated by their green tissues, which still perform the office of leaves. Cell-formation goes on rapidly within, and the excess of cellulose is deposited in the cells as starch. Oxygen is usually absorbed in excess, acidifying the juices.

441. In the same way we account for the production of *honey* in the flower. Copious deposits of starch are provided in the receptacle and disk (§ 85). At the opening of the flower, this is changed to sugar, to aid in the rapid development of those delicate organs which have no chlorophyl wherewith to assimilate their own food. The excess of sugar flows over in the form of honey. The wise economy of the honey is seen in fertilization. For, attracted by it, the insect enters the flower, rudely brushes the pollen from the now open anthers, and inevitably lodges some of its thousand grains upon the stigma!

442. Experiment has proved that in all these cases of the formation of sugar from starch, a molecule of water is absorbed—a process which we might expect, since starch ($C_{12} H_{20} O_{10}$), or $n(C_6 H_{10} O_5)$ contains proportionably two less hydrogen and one less oxygen than sugar ($C_{12} H_{22} O_{11}$) contains.

443. **Pollination, cross-fertilization, etc.**—Pollen is essential to the fertilization of the flower. It must not only be produced, but must also in some way be conveyed to the stigma, and lodged on its surface. Another requisite is that the pollen and pistil shall either be: 1st, parts of the same flower; or, 2d, of other flowers of the same plant; or, 3d, of the same species; or, 4th, of closely related species. In the first and second cases the process may be called *self-fertilization*; in the third case, *cross-fertilization*; in the fourth case, *hybridization*.

444. Whether the first, second, or third process shall prevail in any given species will depend on the

structure, number, or arrangement of the floral organs. In the few flowers which never open,—the *Cleistogamous*, such as the late apetalous flowers of the Blue Violet, and also probably those of *Gentiana Andrewsii*, only self-fertilization is possible. But in the multitude of *open* flowers with both stamens and pistils exposed, as in the Lily, Rose, Morning Glory, either self or cross fertilization is possible unless determined by some other special circumstance. The stigma may receive pollen directly from its own stamens, or indirectly from other flowers near or remote, through the agency of winged insects, humming-birds, or of the wind. Again there are flowers in which the organs are so situated that self-fertilization is very difficult, or even impossible. Of this class are the Asclepiads and Orchids, whose pollen, cohering in masses (pollinia), is inclosed in cavities, and only dragged forth by insects to be carried to other flowers. So in Iris, where the extrorse anthers and petaloid stigmas are averted from each other, the former beneath, and shedding its pollen downward.

445. **Dichogamous Plants.**—In some species the stamens and pistils are not cotemporary in the same plant, but the stamens of one plant mature at the same time with the pistils of another plant, and *vice versa*. This necessitates cross-fertilization, and the agency of the wind or of insects. We have examples in the Grasses, the common Plantain, in Scrophularia, etc.

446. **Dimorphous Plants** are such as the Mints (*Mentha*), the Yellow Jessamine (*Gelsemium*), *Houstonia cærulea*, etc. In these the flowers assume two forms, with the stamens and pistils cotemporary in

both. In some the stamens are exerted and pistil included, while in others the stamens are included and style exerted. This arrangement also favors cross-fertilization through insect agency.

447. The service thus performed by insects in behalf of vegetation is very important. Numerous species are wholly dependent on bees, moths, flies, for the dissemination of their pollen, and consequently for their very existence. Many other species, although capable of self-fertilization, are still greatly benefited by the intercrossings of pollen which the visits of insects occasion. Of course the bees have no idea of these benefactions. They visit the flowers solely for their own good. The nectar which they seek is always so situated as to oblige them to disturb the pollen or pollinia as they pass and repass, get besprinkled with it, and so encounter the stigmas from flower to flower.

448. It would seem important that the bee or moth should confine its visits during any one excursion to plants of the same species. And this it often does, as shown^e by observation, avoiding the mingling of its nectars as well as the confusion of its pollens. In accomplishing this, the insect may be led by habit, becoming accustomed, for the hour, to one form of nectary; or it may be drawn by uniform odor of the flowers, or by their gay and special colors. For we observe that the flowers of grasses and of forest trees whose pollen is wafted by the wind, requiring no aid from insects, are destitute both of bright colors and of fragrance, and of honey.

449. From these observations and many others of similar import, it is inferred that Nature insists on the fertilization of the stigma in every plant *by all means*,

at least when growing in its native home; also, that of the two general modes, *self*, or *cross*, she greatly prefers the latter.

450. What are the reasons for this preference? The solution of this inquiry has engaged the attention of many skillful investigators, until it seems to be proved that the offspring of cross-fertilization are as a rule decidedly superior in size, vigor, and variety.

PART THIRD.

SYSTEMATIC BOTANY.

CHAPTER I.

GENERAL PRINCIPLES OF CLASSIFICATION.

451. Systematic Botany has for its object the arrangement of Plants into Groups and Families according to their characters, for the purpose of facilitating the study of their names, affinities, habits, history, properties, and uses. In this department the principles of Organic and Physiological Botany are applied and brought into practical use.

452. But there is another and higher import in the study of Systematic Botany. It shows us Plants as related to each other and constituting one magnificent system. It reveals the Almighty Creator at once employed in the minutest details and upon the boundless whole; equally attentive to the perfection of the individual in itself, and to the completeness of the System of which that individual forms a necessary part.

453. The necessity for such an arrangement of the Species will appear when we consider their immense number. They meet us in ever-varying forms at every step, clothing the hills, mountains, valleys, and plains. They spring up in hedges and by the way-side. They border the streams and lakes, and sprinkle over their surface. They stand assembled in forests, and cover with verdure even the depths of the Ocean. Not less than 150,000 kinds are already distinguished, and the catalogue is still growing.

454. Into this vast kingdom of Nature the student is introduced, and proposes to acquaint himself with each and every object. How shall he begin? Evidently he must *begin* with the individual—a single individual plant. But (thanks to Him who created both the plant and the mind—the object and the subject), he is not left to *continue* the study in a method so endless and so hopeless. As if in special regard to the measure of the human intellect and the means of its culture, the Great Author of Nature has grouped these myriads of individuals into the following divisions:

455. **Species** are individuals of a common origin or parentage capable of producing their kind, though frequently differing from each other in size, form, and other unimportant characters. A species has been defined as a “succession of individuals which reproduces and perpetuates itself.”

456. **Variety, or Race**, is a sub-species. This term is applied to individual plants that possess marked variations from specific characters, but not of sufficient constancy to entitle them to the rank of *species*. These differences are frequently brought about by the quality of the soil or locality, but especially by cultivation.

Race characters are perpetuated and become constant by grafting, budding, and carefully selecting well-marked individuals from which to obtain seed.

The desirable characters of most of our fruits and table vegetables are made constant in this way.

457. **Genus** is the name for a *Group* of individual plants which resemble each other in the form and structure of their organs of *Fructification* and *Reproduction*.

Illustration.—The individuals of the *Crowfoot Kind* differ in the size and color of their flowers, some of which are yellow, others white; in the size and form of their stems, some of which grow erect, others prostrate and in the shape of their leaves. Their organs of Fructification, however, are all constructed upon the same plan, and the function of polination is performed in

the same manner; hence they are grouped together and constitute the **Genus Ranunculus**.

458. **Orders.**—But natural affinities do not end here. The genera are yet too numerous for the ready and systematic study of the naturalist. He, therefore, would generalize still further, and reduce the genera to still fewer and broader groups. On comparing the genera with each other, he finds that they also possess in common certain important characters which are of a more *general* nature than those which distinguish them from each other. By these general characters the genera are associated into Orders.

459. For example: comparing such genera as the Mustard, Radish, Cabbage, Cress, Wallflower, etc., it is seen that, while they differ sufficiently in their generic characters, yet they all have certain marked resemblances in their didynamous stamens, siliquous fruit, whereby they are obviously associated in the same Order—the Cruciferæ. So, also, the Pines, the Spruces, the Cedars, the Larches, and the Cypress, while as genera they are obviously distinct, yet all bear cones of some form, with naked seeds; hence they are naturally grouped into one Order—the Coniferæ.

460. **Classes.**—In like manner the Orders, by traits of resemblance still more general, are associated in a few groups, each of great extent, called Classes.

461. **Intermediate Groups**, formed on the same principles, are recognized as Subgenera, Suborders or Tribes, and Subclasses or Cohorts, which will be particularly noticed in another place. Of the same nature, also, are Varieties, which are groups subordinate to species, already described in § 28.

462. **Systems.**—Two independent and widely different methods of classifying the genera have been generally approved—the Artificial Method of Linnæus, and the Natural System of Jussieu. The former is founded solely on characters relating to the organs of fructification, leaving all other natural affinities out of view. It is simply an arrangement devised by Linnæus for convenience in the analysis of plants—as words in a dictionary, for convenience of reference, are arranged *alphabetically*, without regard to their nature. It is now superseded by—

463. **The Natural System.**—This method or system of classification, on the contrary, makes use of every natural character and takes for its basis all those natural affinities and resemblances of plants whereby Nature herself has distinguished them into groups and

families. It seizes upon every character wherein plants agree or disagree, and forms its associations only upon the principle of natural affinity. Hence, each member of any natural group resembles the other members; and a fair description of one will serve, to a certain extent, for all the rest.

464. The species and genera are formed on this principle of classification, as above stated, and are truly natural associations. Individuals altogether similar—cast, as it were, in the same mold—constitute a species. Species agreeing in nearly all respects, and differing but in few, constitute a genus. Thence the genera, associated by their remaining affinities in groups of few or many, by this same method are organized into Natural Orders and other departments of the System.

CHAPTER II.

NATURAL SYSTEM.

465. Botanists during the last two hundred years have labored to group and arrange the individuals of the vegetable kingdom so that the natural characters of each group shall be most like those of the next preceding group.

466. In 1694, Tournefort, a French physician and botanist, published a method of arrangement in which he defined and established the term genus as we now understand it.

467. Early in 1700, John Ray, an English naturalist, separated the vegetable kingdom into the following general groups:

I. **Phanerogamia.**—Plants that bear **Flowers.**

II. **Cryptogamia.**—Plants that do not produce **Flowers.**

Sub-divisions of Flowering Plants.

1. Dicotyledones—Plants whose embryo has two seed leaves, or more than two.
2. Monocotyledones—Plants whose embryo has one seed leaf.

468. **Linnæus**, a Swedish botanist, in 1736, while only twenty years of age, published the outlines of his celebrated sexual system, based upon the number, situation, and relative length of the pistils and stamens, which, though artificial and misleading, earned for its author a deathless fame.

469. In 1789, A. L. de Jussieu, embodying the grand features of Ray with those of Tournefort, laid the foundation of the natural system which, under various modifications, has come down to us.

470. August P. de Candolle greatly modified the arrangement of Jussieu, especially by reversing the sequence, placing the most highly organized plants first in order.

The following is a brief sketch of the latest arrangement, and is substantially the one mapped out by Sachs; the order of sequence, however, is changed:

471. **Phanerogamia.**—*Flowering* plants, or plants whose flowers or organs of fructification are exposed to view.

Plants of this class have roots, stems, and leaves through which bundles of woody fiber extend; they bear *flowers*, in special parts of which reproductive organs are produced that form embryonic bodies

called *seeds*; these *seeds* germinating, become new plants.

472. **Cryptogamia.** — *Flowerless* plants or plants that do not produce seeds; their reproductive apparatus forms cell-like bodies, without *cotyledons*, called spores, which germinate indifferently from any part of the cell; these spore-like seeds of the Cryptogams germinating, produce new plants.

These plants are called flowerless, because their organs of reproduction are concealed or obscure; hence the name Cryptogamia, or concealed nuptials.

VEGETABLE KINGDOM.

SUB-KINGDOM I.

473. **Phanerogamia.** — Plants that bear proper flowers and produce seeds, derived from the Greek words *φανερός*, open, and *γάμος*, marriage, signifying open marriage.

474. **CLASS I. Dicotyledones.** — Plants with two seed leaves or *cotyledons*. From the Greek words *δίς*, two, and *κοτυληδών*, a hollow disk, alluding to the shape of the coatings or walls of the seed leaves.

475. **Angiosperms.** — Plants whose seeds are inclosed in a pericarp or vessel. From the Greek *ἀγγεῖον*, a vessel, and *σπέρμα*, a seed, signifying plants whose seeds are inclosed by a covering; as, the Apple, Maple, Oak, etc.

476. **COHORT 1, A. Polypetalæ.** — Dicotyledonous plants whose flowers have both calyx and corolla; corolla composed of separate petals, which are sometimes slightly coherent at their bases; as, the flowers of the Buttercup, Apple, Strawberry, etc.

477. **COHORT 2, B. Gamopetalæ.** — Dicotyledonous

plants whose flowers have both calyx and corolla, with petals more or less united; as, Elder, Arrow-wood, etc.

478. COHORT 3, C. **Apetalæ**.—Dicotyledonous plants, whose flowers have a calyx but no corolla, and sometimes neither; as, Ragweed, Goosefoot, etc.

479. CLASS II. **Gymnosperms**, *Dicotyledones* or *Polycotyledones*.—Plants whose seed is not inclosed by a vessel or pericarp, derived from the Greek words *γυμνός*, naked, and *σπέρμα*, seed, naked seed. Stem elongated, solid; leaves nearly parallel-veined; flowers not perfect; pistil scale-like; no stigma; ovules not inclosed in a vessel; embryo with two or more opposite or whorled cotyledons.

480. COHORT 4, D. **Coniferæ**.—Pines, Spruces, and other cone-bearing trees and shrubs.

481. CLASS III. **Monocotyledones**.—Plants whose embryo has one cotyledon, or one seed leaf. Greek *μόνος*, alone or one, and *κοτυληδόν*. Blade of the leaf usually divided into two parts by a prominent midrib, with veins extending from the base to the apex parallel to the midrib; flowers usually three-parted; root not axial.

This class is separated into three cohorts.

482. COHORT 5, E. **Spadicifloræ**.—*Monocotyledonous* plants, with flowers on a spadix, frequently enveloped by a spathe; Palms, Calla, and pond weeds.

483. COHORT 6, F. **Petaloidæ**.—*Monocotyledonous* plants whose flowers are usually perfect and complete; floral envelope three-parted and double; outer whorl colored green; as, Lily, Lily of the Valley, etc.

484. COHORT 7, G. **Glumiferæ**.—*Monocotyledonous* plants whose floral envelope is chaff-like; ovary single, with one ovule; as, grass-like plants, Wheat, Rye, the Sedges, etc.



Fig. 532, c, A Fern; *Polypodium vulgare*. a, Club-moss; *Lycopodium dendroideum*. b, *Equisetum* (Scouring Rush or Horse Tail). d, a Liverwort Moss; *Marchantia*. e, a Fungus or Mushroom; *Agaricus*, in three stages of growth.

SUB-KINGDOM II.

485. **Cryptogamia.**—Plants that do not produce proper flowers. From the Greek *κρυπτός*, hidden, and *γάμος*, marriage.

486. CLASS I. **Pteridophyta.**—*Vascular cryptogams*—*Ferns* and their allies. From Greek words *πέρις*, a fern, and *φυτόν*, a plant, signifying a fern-like plant.

This class is divided into three cohorts.

487. COHORT 1, H. **Lycopodinæ** (Club Mosses).—Stem herbaceous, rooting at the nodes and creeping, simple or branched, sometimes tree-shaped; foliage small; leaf one-nerved; fructification at the base of the leaf or in terminal catkins on the branches. Name from Greek words *λύκος*, a wolf, and *πούς*, a foot, due to the fancied resemblance of the roots to the foot of a wolf.

488. COHORT 2, I. **Equisetacæ** (Horse Tails).—Stem straight, simple or branched, cylindrical, channeled; stiff-jointed; sheathed at the joints; tops of the sheaths toothed. From Latin *equus*, a horse, and *seta*, a bristle or hair; *Equisetum*, scouring rush.

489. COHORT 3, J. **Filicinæ**.—*Ferns* proper. Stem a horizontal creeping rhizome, sometimes erect; foliage pinnate or variously divided; veins forked; fructification on the back or edge of the frond. Name from Latin *filiæ*, a fern; *Osmunda*, Flowering Fern.

THE FOLLOWING FIVE CLASSES

are not treated in this book, and therefore will be briefly noticed only.

490. CLASS II. **Bryophyta**.—Mosses and their allies (Greek *βρύον*, a moss, *φυτόν*, a plant).

Sub-class 1. **Hepaticæ**, Liverworts.

Sub-class 2. **Musci**, Mosses.

491. CLASS III. **Carpophyta**.—Spore-fruited plants (Greek *καρπός*, fruit, *φυτόν*).

Sub-class 1. **Coleochæteæ**, Green fresh-water plants with few spores.

Sub-class 2. **Florideæ**, Red or purple marine plants.

Sub-class 3. **Ascomycetes**, Parasites, spores in sacs.

Sub-class 4. **Basidiomycetes**, Spores on stalks.

Sub-class 5. **Characeæ**, Green fresh-water plants.

492. CLASS IV. **Oöphyta**.—Plants with egg-shaped spores (Greek *ώόν*, an egg, and *φυτόν*).

Sub-class 1. **Zoösporæ**, Spore cells locomotive.

Sub-class 2. **Ædogonieæ**, Thread-like cellular body.

Sub-class 3. **Cœloblasteæ**, Thread-like tubular body.

Sub-class 4. **Fucaceæ**, Large, color olive green.

493. CLASS V. **Zygomphyta**.—Unisexual plants (Greek

ζυγόν, a pair, and φυτόν), plants in which the sexes are united.

Sub-class 1. Zoosporeæ, Cells capable of motion.

Sub-class 2. Conjugatæ, Cells fixed.

494. CLASS VI. **Protophyta**.—First or most simple class of plants (Greek πρῶτος, first, and φυτόν). These plants are the lowest vegetable organisms, and consist of single cells, or strings of cells.

Sub-class 1. Myxomycetes, Slime molds, naked protoplasm, without regular form.

Sub-class 2. Schizomycetes, Bacteria minute cells.

Sub-class 3. Cyanophyceæ, Green Slimes.

495. **Orders** or **Families** succeed to the Cohorts. The *Natural Order* is perhaps the most important of all the associations. On the accuracy and distinctness of the characters of these groups botanists have bestowed the highest degree of attention, and the student's progress will largely depend upon his acquaintance with them.

496. Orders are formed by associating together those genera which have the most intimate relations to each other, or to some one genus previously assumed as the type. As species form genera, so genera form Orders. In regard to extent, they differ widely; some consisting of a single genus, as, *Platanaceæ*, while others comprehend hundreds of genera, as, *Compositæ*. For convenience in analysis, the larger Orders are broken up into Sub-orders or Tribes.

The Flowering plants of the whole world, known to botanists, have been grouped under 200 Orders, 7,500 Genera, and 100,000 species. About 80,000 of these species are Dicotyledons, and the remaining 20,000 are Monocotyledons.

It is a high accomplishment in a botanist to possess an extensive acquaintance with individual plants. The ability to determine readily the genus and species to which a plant belongs depends largely upon an accurate knowledge of the characters of the orders and tribes.

497. The Natural System, then, with all its divisions, groups, and subordinations, may be exhibited at one view, as follows:

KINGDOM,
 SUB-KINGDOMS,
 CLASSES,
 COHORTS,
 ORDERS,
 SUB-ORDERS, OR
 TRIBES,
 GENERA,
 SUB-GENERA,
 SPECIES, OR
 RACES.

CHAPTER III.

RULES IN NOMENCLATURE.

498. **The Names of the Orders** are Latin adjectives, feminine, plural (to agree with *plantæ*, plants, understood), usually derived from the name of the most prominent, or leading genus, by changing or prolonging the termination into *aceæ*, as *Rosaceæ*, the Rose tribe, *Papaveraceæ*, the Poppy tribe, from *Rosa* and *Papaver*. Earlier names, however, derived from some leading character in the Order, and with various terminations, are still retained. Thus, *Compositæ*, with compound flowers; *Labiataæ*, with labiate flowers.

499. **Generic Names** are Latin substantives, arbitrarily formed, often from some medicinal virtue, either supposed or real, or from some obvious character of the genus; sometimes from some peculiar form of the flower, or from the name of some distinguished bot-

anist, or patron of botany, to whom the genus is thus said to be dedicated. Also the ancient classic names, either Latin or Greek, are often retained. Examples of all these modes of construction will be seen hereafter.

500. **Specific Names** are usually Latin adjectives, singular, and agreeing in gender with the name of the genus to which they belong. They are mostly founded upon some distinctive character of the species; as, *Viola blanda*, Sweet-scented Violet; *V. cucullata*, Hood-leaved Violet. Frequently the species is named after some other genus, which, in some respect, it resembles; as, *Viola delphinifolia*, Larkspur Violet.

501. **Commemorative Specific Names.**—SPECIES, like genera, are also sometimes named in commemoration of distinguished persons. The rules given by Lindley, for the construction of such names, are: 1st. If the person is the discoverer, the specific name is a substantive in the genitive case, singular number; as, *Viola Selkirkii*, Selkirk's Violet; *Lobelia Kalmii*, Kalm's Lobelia. 2d. If the name is merely conferred in honor of the person to whom it is dedicated, it is an adjective ending in *nus*, *na*, or *num* (according to the gender of the generic name); as, *Tulipa Gesneriana*, Gesnerian Tulip, or Gesner's Tulip; *Erica Linnæana*, Linnæus' Heath.

502. **Rules for the use of Capitals.**—The names of the order, the sub-order or tribe, and of the genus, should always commence with a capital letter. The name of the species should never commence with a capital except in the following cases: (1), when it is derived from the name of a person or of a country, as *Phlox Drummondii*, *Aquilegia Canadensis*; (2), when it is a substantive, as *Delphinium Consolida*.

503. **Synonyms.**—Very frequently, the same species has been described by different (or even by the same) authors, under different names. In such cases it becomes a question, often of difficult solution, which name is to be adopted. Obviously, the *prior* name, that is, the original one, if it can be ascertained, is entitled to the most respect; and it is a rule with botanists to adopt this name, unless it has been previously occupied, or be strongly objectionable on some other account. All other names are *synonyms*.

504. **Authorities.**—In the *flora* which accompanies this work, immediately after the Genus we insert the abbreviated name of the author by whom it was originally published, with a comma between, thus: **Trifolium**, Tourn. After a *species* the authority is inserted *without a comma*, as **T. repens** L.,—that is to say, *Trifolium repens* (of) Linnæus. In changing the *generic* relations of a species (as subsequent writers often deem necessary), it is a custom for the author of the change to annex his own name, or a blank, instead of the original authority. The custom is often unjust, and always liable to abuse. It offers a bribe for innovations in the Genera, and recent works abound in changes which otherwise could scarcely be accounted for. When such changes become *necessary*, the just and proper rule (actually adopted in *Conchology*) is the following. Let the original specific name and authority both be retained, the latter in parenthesis, thus, *Lychnis Githago* (Linn.)—originally *Agrostemma Githago* Linn. This method is often but not always used in the present work.

Authorities for our species of exotic cultivated plants, for want of space, have all been here omitted.

CHAPTER IV.

BOTANICAL ANALYSIS.

505. Botanical Analysis is the application of the rules and principles of botany to the study of the natural plant, in order to determine its place in the system, its names, history, uses—all that is on record concerning it. In the flowering months, the learner will constantly meet with new forms of bloom; and if he is duly interested in the science, he will not fail to seize and analyze each new flower while the short hour of its beauty may last. Thus in a few seasons, or even in one, he may become well acquainted with the *flora* of the vicinity where he dwells.

506. Suppose, now, the pupil to be in possession of an unknown plant in flower and fruit. The first

requisite is, its Natural Order, and the first step in *analysis* is an examination of the several organs, one by one, until the general structure is well understood. This done, the *experienced* botanist, who has in memory the characters of all the Orders, might determine at once to which of them the plant in question belongs. But the *beginner* must be content with a longer course of inquiry and comparison,—a course which might be indefinitely long and vague without the use of—

507. **Analytical Tables.**—These are designed to shorten and define to exactness the processes of analysis. Those which appear in the present work are peculiar in form, and more copious and complete than the tables of any other similar work. These tables, with proper use in connection with the specimen, will very rarely fail to conduct the inquirer almost immediately to the right Order, Genus, and Species.

We subjoin a few examples of the analysis of particular species by the aid of these tables. If the exercise be conducted in the class-room, the successive steps in the process (indicated by the numbers 1, 2, 3, etc., below) may be assigned, in order, to each pupil in the class.

ANALYSIS OF A POLYPETALOUS HERB.

508. **To determine the Cohort.**—A good specimen of a little yellow-flowered herbaceous plant, common in the grassy fields of cool regions, is supposed to be now in the hands of each pupil of the class. (1.) The first pupil, reading (if necessary) the characteristic of each sub-kingdom, pronounces the plant one of the Phænogamia, and refers the next pupil to the Classes I., II., or III.

(2.) The next reads the characters of those Classes, and comparing the specimen (which has *net-veined leaves* and *5-merous flowers*), concludes that it is an Exogen. Refer next to the Class I.

(3.) "Stigmas present. Seeds inclosed in vessels."

"Stigmas none. Seeds naked. (Pines, Spruces, etc.)" Our plant has stigmas, etc., and, moreover, is not a Pine, Spruce, etc. It is, therefore, an Angiosperm. Refer next to Cohorts 1, 2, or 3.

(4.) "Corolla with the petals distinct." This characterizes our plant, and it is pronounced one of the Polypetalæ. Refer them to **A**.

509. **To determine the Order**, the (5th) pupil reads the first *alternative*, or triplet, noted by a star (*), and comparing his plant, finds it to correspond with the first line, for it is an "herb with alternate leaves." Pass now to (12).

(6.) "Flowers regular or nearly so. Fruit never a legume."

"Flowers irregular," etc. The flower is regular. Pass to (14).

Again, a (7th) pupil reads, "Stamens 3—10 times as many as the petals." "Stamens few and definite." The stamens are many. Pass to (15).

(8.) The next pupil reads, compares, and determines that the stamens are "perigynous on the base of the calyx," and announces the letter (*d*) as the reference to the next alternative. (9.) Next, the pupil reads and compares his specimen with the triplet (*d*), and concludes that the sepals are 5, and imbricated in the bud. Consequently, it is announced that the plant in hand belongs to the Order ROSACEÆ.

510. **To determine the Genus**.—After a careful comparison of their specimen with the diagnosis of the Roseworts (Order 44), in order to verify the analysis thus far, the learner or the *class* will then consult the table of the Genera. (10.) A pupil reads the couplet marked **A**, and determines that the "Ovary is superior, fruit not inclosed," etc. Pass to (*a*).

(11.) "Carpels ∞ . Calyx persistent, with 5 bractlets added," characterizes our plant. Pass to (*f*), which is Tribe V. Pass on to (*g*). (12.) The next pupil determines that the "style is deciduous." Pass to (*k*). (13.) "Torus spongy or dry," is true of our specimens. Pass to (*l*). (14.) "Bractlets 5" reads the next, and announces the plant to be a *Potentilla*. Now all turn to Genus 13, and together verify this result by reading and comparing the stated character of the genus.

511. **To determine the Species**.—(15.) As our plant has "stamens ∞ and flowers yellow" it must be a *true* *Potentilla*. Pass to (*a*). (16.) "Leaves palmately 3-foliolate" suits our plant. It is, therefore, either species No. 3, 4, or 5. Lastly (17), after a due comparison of their plant with each of these three species, it is determined that it is *P. Norvegica*.

ANALYSIS OF A MONOCOTYLEDON.

512. A grass-like, blue-flowered herb is now supposed to have been discovered and distributed to the Class for analysis. Having (1) determined that it is a Monocotyledon (for it has "parallel-veined leaves and 3-parted flowers"), they would now (2) determine its Class, which is III.

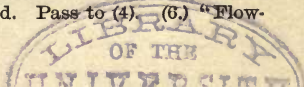
"Flowers without glumes, and colored," etc.

"Flowers with green alternate glumes, and no perianth." The first line is adopted, and the plant agrees with Petaloideæ. Pass next to (†) Cohorts 5th or 6th, and read,

(3.) "Cohort 5. Flowers on a spadix, apetalous or incomplete."

"Cohort 6. Flowers complete, with a double perianth"—which answers to the specimens in hand, and it is seen to belong to the Petaloideæ. Pass to **F**.

(4.) The next pupil having read and compared the first couplet under "**F**, Cohort 6, Petaloideæ," chooses the second line. Pass to No. 2. (5.) "Perianth tube adherent to the ovary" is adopted. Pass to (4). (6.) "Flow-



ers perfect." The second line of this couplet is true of our plant. Next pass to (b). The (7.) pupil reads "Anthers 3 or 6," which is true of the plant. Pass to (c). (8.) "Perianth glabrous outside" is true. Next read (d). (9.) "Anthers 3, opening lengthwise, outward," is also true, and our plant is thus traced to the order IRIDACEÆ.

513. To determine the Genus and Species under the Irids, Order 146, is the next and the last step. Having carefully compared their specimens with the characters ascribed to the Irids, the pupils next apply to the Table of the Genera. (10.) "Flowers regular and equilateral," in the first dilemma, is chosen. Read the (*) couplet next. (11.) "Sepals similar to the petals in form, size, and position" is true. Next to (a). (12.) "Stamens monadelphous. Flowers small, blue. Plants grass-like," describes the plant truly, and it must be a *Sisyrinchium*. They turn to Genus 7, and verify by reading its characters. Lastly, the brief diagnoses of the two species are compared, and the plant is found to be *S. Bermudiana*.

INDEX AND GLOSSARY.

a (*a*, privative), prefixed to a Greek word, signifies without; as aphyllous, without leaves.

āb brē vī ā'tions, page 2, Part IV.

a bōr'tion, non-development of a part.

ab sōrp'tion, 199.

āe'āu lēs'cent, or ā eāu lēs'cent, apparently stemless, 223.

ae cēs'so ry, something superadded.

ae erēs'cent, growing after flowering, 109.

ae eūm'bent, lying against a thing, 183.

āc'er ōse or āc'er oūs, needle-shaped, 299.

a ehē'ni ūm, plural, a ehē'ni ā, 151.

ach'lā mūd'e oūs, without floral envelopes.

a cīc'ū lar, finely needle-shaped.

a cot y lēd'o nous, without cotyledons.

āc'ro gēns, summit growers.

a eū'le āte, armed with prickles.

a eū'mi nāte, drawn out into a point, 307.

a eū'te', ending in a sharp angle, 307.

ad hēr'ent, growing to, 82, 94.

ād'nāte, growing fast to, 114.

ad ven'tiōūs, growing out of the usual or normal position, as roots, 206.

ā er ā'tion, same as respiration, 483.

ae tī vā'tion, 335.

af fin'ī ty, resemblance in essential organs.

age of trees, 47.

āg'gre gāte, assembled close together.

a glū mā'ceoūs, without glumes, the same as pēt'al oid, 483.

air-bladders, 323.

air-plants, 208.

ā'la, wing; ā'lā, wings, 101.

a'lāte, winged, 274.

al bū'men, 179.

al bū'mi noūs, 178.

al bū'rnum, sap-wood, 418.

āl'gæ, seaweeds.

āl'ter nate, 215, 262.

āl've o late, with pits like the honey-comb.

ām'ent, a deciduous spike, 357.

a mōr'phoūs, without definite form.

am phī'tro poūs, 141.

a m plēx'ī caul, stem-clasping, 275, 311.

a nāl'y sis, botanical, 510.

a nās to mō'sis, reunion of vessels or veins.

a nāt'ro poūs, 141.

an cīp'ī tal, two-edged.

an drē'cium, 110.

an drōg'y noūs, stamens and pistils on the same peduncle.

ān'gi o spērms, 475.

ān'ī mal, 15.

ān'nu al, yearly (sc. plants), 40.

ān'nu lar cells, 378.

an tē'ri or, parts (of a flower) adjacent to the bract.

ān'thel mīn'tic, expelling or killing worms.

ān'ther, 111, 113.

an thē'sis, the opening of the flower; flowering.

a pēt'al læ, 478.

a pēt'al oūs, without petals.

āph'yl loūs or a ph'yl'loūs, without leaves.

a pōph'y sis, a swelling, e.g., under the theca of some mosses.

āp pa rā'tus, 4.

ap pen diē'd lar organs, 77.

ap prēssed', closely applied but not adhering to; the same as adpressed.

āp'ter oūs, without wings.

a quāt'ic, living in water.

ā rāch'noid, resembling cobwebs.

ār'bor oūs, arborescent, tree-like.

āre'd ate, arched or curved like a bow.

a rē'o late, having the surface divided into little spaces or areas.

ār'īl, an extra seed-covering, 175.

a rīs'tate, with an arista or awn (barley).

armed, bearing prickles, spines, etc.

ār'tie'ū lāt ed, jointed, as the culm of wheat.

ās cēnd'ing, arising obliquely; assurgent.

ās cīd'ī ā, leaves holding water, 322.

ās sīm'ī ā'tion, 430.

at tēn'ū āte, becoming slender or thin.

āu rīe'ū lāte, ear-bearing, 291.

āwn, the beard of barley and the like.

āx'ī al root, 200.

āx'īl (arm-pit), the angle between the petiole and the branch, on the upper side.

āx'īl la ry, growing out of the axils.

āx'is, ascending, 211, 212; erect, procumbent,

prostrate, trailing, decumbent, 212; excurrent, solvent, 226; descending, 197.

bāe'eat, berry-like; covered with pulp.

bān'ner, same as vexillum, 101.

bān'yan tree, 207.

bārk, 416.

bās'ī lar, basal, attached to the base, 186.

bāst-cells, wood-cells of bark, 416.

bēaked, ending in an extended tip.

bēard'ed, with tufts of long, weak hairs.

bēr'ry, 159.

bī, bis, twice (in compound words).

bī'eōl or, two colored.

bī eūs'pid ate, with two points or cusps.

bī dēn'tate, with two teeth.

bī ēn'ni al, of two years, 41.

bī'fid, cleft into two parts.

bī fō'li ate, with two leaflets.

bī fūr'eat, twice forked, or merely forked.

bī lā'bi ate, two-tipped.

bī'nate, 303.

bī pīn'nate, 304.

bī pīn nāt'ī fid, twice pinnatifid. (Fig. 342.)

bī tē'rate, twice ternate, 305.

bī'valved, two-valved.

blāde. See lamina, 271.

- blanched plants, *whitened for the want of light.*
 bloom, *a fine white powder, on some plants.*
 border, 91, 92.
 botany defined, 18.
 botany, elementary, 20, 368, etc.
 botany, physiological, 21, 368.
 botany, systematic, 22, 153.
 brāsh'ī ate, *with opposite, spreading branches (arms).* (Fig. 275.)
 brāet, 329, 345.
 brāe'te ate, *having bracts.*
 brāe'te oles or bractlets, 345.
 branches, 34, 214.
 bristles, *stiff, sharp hairs.*
 bry ōph'y tā, 490.
 bud, 33.
 budding, 259.
 buds, axillary, 247; accessory, 250.
 buds, adventitious, 251.
 buds, suppression of, 248.
 bud-scales, 246, 319.
 bulb, 240; tunicated, 242; scaly, 242.
 būlb'lets, 260.
 ca dā'coūs, *dropping off early,* 103.
 cās'pi tōse, *forming tufts or turf.*
 cāl'ce o late, *slipper-shaped.*
 cāl'y cine, *calyx-like.*
 ca lyc'ū late, *having an outer calyx or calyx-like involucre.*
 ca lyp'trā, *the hood of the sporange (spore-case) of a moss.*
 cā'lyx, *the outer floral envelope,* 51.
 cām'bl ūm, 417.
 cam pān'ū late, *bell-shaped,* 102.
 cām'py lōt ro poūs, 141.
 cām'a līc'ū late, *channeled.*
 ca nēs'cent, *grayish white.*
 cāp'īl la ry, *capillaceous, hair-shaped.*
 cāp'ī tāte, *head-shaped, growing in close clusters or heads.*
 ca pīt'ū lūm, *a little head,* 361.
 cāp're o late, *bearing tendrils.*
 capsule, 167.
 eār'bon dī ōx'īde, 411.
 ca rī'nā, 101.
 cār'ī nate, *boat-shaped, having a sharp ridge beneath.*
 cār'pel, *carpellary,* 126.
 cār'po phōre, 149, 151. (Fig. 177.)
 cār'tī lāg'ī noūs, *firm and tough in texture, like cartilage.*
 cār'un cle, 175.
 cār'y o phyl lā'ceoūs, 100.
 cār'y ōp'sis, 153.
 cāt'kin, 357. (See ament.)
 cāu'dex, 227.
 cāu'lēs'cent, 223.
 cāu'lis, 223.
 cāu'line, *relating to the stem,* 262.
 cēl'lū lar tissue, 396.
 cell, 368.
 cell-growth, 377-384.
 cēl'lū lar bark, 416.
 cēl'lū lōse, 371.
 cen trif'ū gal inflorescence, 35.
 cen trip'e tal inflorescence, 352.
 cēph'a loūs, *same as capitata.*
 cē're al, *relating to grains, corn, etc.*
 cēr'nu oūs, *nodding (less inclined than pendulous).*
 chaff, chaffy, 349. (See paleaceous)
 eha lā'zā, 140.
 channeled, *hollowed out like a gutter.*
 ehar tā'ceous, *with the texture of paper.*
 chlō'ro phyl, 373, 381, 435.
 chor'ī sis, 76.
 cīl'ī ate, *fringed with marginal hairs.*
 cī'on or sion, 218.
 cī nē're oūs, *ashy-gray, ash color.*
 cīr'cī nate, *rolled inward from the top,* 255.
 cīr cu lā'tion of sap, 432.
 cīr'cum scīs'sile, 149.
 cīr'rhōse, *furnished with a tendril.*
 cirrhose roots, 206.
 classes, natural, 501.
 elas si fi cā'tion, artificial, 503.
 clā'vāte, *club-shaped.*
 co ārc'ate or cō ārc'tāte, *contracted, drawn together.*
 eō'e'us, *a berry; eoe'cī (plural), the 1-seeded carpels of separable fruits.*
 eōeh'le ate, *spiral, like the snail-shell.*
 co hē sion, 82.
 cō'horts, 461.
 cōl lāt'er al, *placed side by side.*
 cōl'lum, 199.
 cōl'ored, *of any color except green, which in botany is not a color, while white is.*
 cōl'um, *the combined stamens and styles.*
 eō'mā, 173.
 cōm'mis sūre, *the joined faces of the carpels of the cremocarp,* 151.
 com'mon, *belonging alike to several.*
 complete flower, 60.
 com'pli cate, *folded up upon itself.*
 compound leaf, 300.
 compound flower, 348.
 com pressed', *flattened on the sides,* 274.
 com dī'pli cate, *folded on itself lengthwise.*
 cone, 169.
 cōn'fū ent, *uniting; same as coherent.*
 con glōm'er ate, *clustered or crowded.*
 cōn'ju gate, *coupled, joined by pairs.*
 cōn'nate, 311.
 con nēc'tile, *connective,* 113, 114.
 con nīv'ent, *converging, coming together.*
 con tīn'u oūs, *the reverse of jointed.*
 con tōrt'ed, *twisted,* 338.
 cōn'vo lūte, 256, 339.
 cōr'date, *heart-shaped,* 291.
 cō'rī ā'ceoūs, *leather-like,* 315.
 cōrm, 239.
 cōr'ne oūs, *horn-like in texture.*
 cor nic'ū late, *with a small horn or spur.*
 co rōl'la, 52, etc.
 cōr'ol line, *pertaining to the corolla.*
 co rō'na, *crown.*
 cōr'tī cal bark, 416.
 cōr'y mb, *co rym'bose,* 358.
 cōs'tate, *ribbed, with rib-like ridges.*
 cōt'y lē'dons, 180, 320.
 crās'sū la, *a genus of plants,* 63.
 cra tēr'ī fōrm, *of the form of a goblet.*
 creep'er, *creeping stems,* 231.
 erēm ō cārp', 151.
 crē nate, *bordered with rounded teeth.*
 crēn'ū late, 309.
 crēst'ed or crīs'tāte, *with an elevated ridge.*
 crīs'pāte or crisped, 310.
 crown of the root, 236.
 cry'cī fōrm (*corolla*), 100.
 crude sap, 368.
 crus tā'ceous, *hard, thin, and brittle.*
 cryp'to gā'miā, 472.
 cū'cul late, *rolled up into a hood shape.*
 cūlm, *the straw of grasses,* 224.
 eū'ne ate, *cū'nē ī form, wedge-shaped,* 290.
 cup-shaped, 102.

- eġ'pŭle, a *little cup* (sc. *acorn*), 155.
 eŭs'pi dāte, with a *sharp, stiff point*, 307.
 eġ'ti ele, *outer lamina of wall of epidermis*, 399.
 çy an'le, *blue, or any color except yellow*
 çy āth'i fōrm, *cup-shaped*.
 çy'cle (in *Phyllotaxy*), 263, 264.
 çy clō'sis, *same as Rotation, currents in the cell*.
 çyme, *cymous*, 363.
 çym'bi fōrm, *boat-shaped*.
 çyp'sel ā, 151.
 dēe'ā (in *Greek composition*), *ten*.
 de çid'ŭ oŭs, *falling at the end of the season*.
 dēe'li nate, *bent downward*.
 dē'eom pound', *much compounded or divided*, 304.
 de eŭm'bent, 212. (Fig. 240)
 de eŭr'rent, 274.
 de eŭs'sate (*leaves*), *opposite, and the pairs at right angles*.
 dēf'i nite, 118.
 dē flex'ed, *bent downward*.
 de fō li ā'tion, *the casting off of leaves*.
 de his'çence, 113, 148.
 dēl i quēs'çent (*axis*), *same as solvent*, 226.
 dēl told, *form of the Greek letter Δ*, 283.
 dēn'droid, *tree-like in form*.
 dēn'dron (in *Greek compounds*), *a tree*.
 dēn'tate, 309.
 den tŭe'ŭ late, 309.
 de nŭ ded, *become naked*.
 de pgu'per āte, *less developed than usual*.
 de pēnd'ent, *hanging down*.
 de pŕessed', *flattened from above; low*.
 dēx'trine, *a gummy substance produced by the action of diastase upon starch*.
 dex'torse (*twining*), *turning to the right*.
 di (in *Greek numerals*), *two*.
 dŭ a dēl'phoŭs, 120.
 dŭ ag nō'sis, *a brief statement of the distinctive character of a plant or group*.
 dŭ āph'a noŭs, *transparent or translucent*.
 dŭ ān' droŭs, *with two stamens*, 118.
 dŭ ā tŭse, *a peculiar ferment in malt, altering starch into dextrine*.
 dŭ çhōg'a moŭs, 120.
 dŭ çhōt'o moŭs, *forked or two-forked*.
 dŭe'li noŭs, 67.
 dŭ çōt'y lē dons, *dicotyledonous*, 182, 284.
 dŭd'y moŭs, *double*.
 dŭ dŭn'a moŭs, 119.
 dŭf fūse', *much divided and spreading*.
 dŭg'i tate, *with several distinct leaflets palmately arranged (as in the leaf of the Horse-chestnut)*.
 dŭ mid'i ate (*anther*), *halved*, 114.
 dŭ mor'phoŭs plants, 446.
 dŭ ō'çioŭs (*flowers*), 67.
 dŭp'ter oŭs, *having two wings*.
 disk, 85, 362.
 dis'eoid, *no rays*. (Fig. 446.)
 disk-bearing tissue, 401.
 dis sēt'ed, *cut into deep lobes*.
 dis sēp'i ment, *same as partition*, 132.
 dis'tieh oŭs, *arranged in two rows*.
 dis tinet, *separate, not united*, 82.
 dŭ vār'i cate, *wide-spread, straggling*.
 dŭ vēr'gent, *spreading with a less angle*.
 dōr'sal, *on or relating to the back*.
 dotted cells, 284.
 dotted ducts, 406.
 double terms, 301.
 downy, *clothed with short, weak hairs*.
 drupe, 156.
 dru pā'çeŭs. (See *tryma*.)
 drying-press, 6.
 ducts, 402.
 dŭ'pli ate, *in pairs, double*.
 du rā'men, *heart-wood*, 418.
 dwarf'ing. (Fig. 250, d.)
 E, ex (in *composition*), *without; as*.
 e brāç'te ate, *without bracts*.
 ēeh'i nāte, *prickly with rigid hairs*.
 ef fēte, *sterile, exhausted*.
 el'a ters, *spiral, elastic threads accompanying certain spores*.
 el lip'tie, *elliptical (leaf)*, 289.
 e lōn gā'tēd, *lengthened, extended*.
 e mār'gi nate, 307.
 ēm'brŭ o, 31, 180.
 embryo sac, 142.
 ēn'do çārp, 156.
 ēn'do çhrōme, *the coloring matter of plants*. See *chlorophyl*.
 en dōg'e noŭs structure, 421.
 ēn'do gēns, 180, 421, 422, 424.
 en'do pleu'rā, *same as tegmen*, 172.
 ēn dos' mōse, *a thrusting, which causes liquids of different densities to pass through thin membranes, and mingle*.
 ēn'si fōrm, *sword-shaped*, 297.
 entire, *even-edged*, 308.
 e phēm'e ral, *enduring for one day*.
 ēp'i (in *Greek composition*), *upon; as*.
 ēp'i çārp, 156.
 ēp'i derm is, *outside layer of cells*, 391.
 ē pig'y noŭs, *upon the ovary*, 97, 119.
 ēp'i pēt'al oŭs, *on the petals*, 119.
 ēp'i phytes, *plants on other plants*, 208.
 ēp'i spērm, *the skin of the seed*.
 ēq'ui tant (*astraddle*), 258.
 e rōse', *eroded, as if gnawed*, 310.
 e tŭe'r ō, 158.
 ē'ti o lā ted, *colorless for want of light*.
 ēx'al bū mi noŭs, *without albumen*, 178.
 ex çŭr'rent, 226.
 ex çōg'e nāe, *exogens*, 182.
 ex çōg'e noŭs structure, 416-418.
 ēx'os mōse, *flowering out*.
 ex sērt'ed, *projecting out of, or beyond*.
 ex stŭp'ŭ late, *without stipules*, 272.
 ex'tŕā (in *composition*), *beyond; as*.
 extra-axillary, *same as supra axillary*.
 ex trōrse', *turned outward*, 114.
 fāl'eāte, *scythe-shaped, curved*.
 fār'i nā'çaoŭs, *flour-like in texture*.
 fār'i noŭs, *mealy on the surface*.
 fās'çi ele, *a bundle*, 365.
 fas cle'ŭ late (*leaves*), 262.
 fēath'er-veined, 285.
 fer ru'gŭl noŭs, *of the color of iron-rust*.
 fēr'tŭe (*flower*), *seed-producing*, 67.
 fēr'ti li zā'tion, etc., 433, 434, 447.
 fib'ril læ, *fibrils*, 199, 428.
 fl'a ment, *the stalk of a stamen*, 111, 112.
 fl i cŭ'næ.
 fl'i fōrm, *slender like a thread*.
 fim'bri ate, *fringed, having the edge bordered with slender processes*.
 fis'sion, *a splitting into parts*.
 fist'ŭ lar, *hollow, as the leaf of onion*.
 fla bēl'li fōrm, *fan-shaped*, 298.
 fla gēl'li fōrm, *whip-shaped; long, taper, and supple*.
 fla vēs'çent, *yellowish, turning yellow*.
 flēx'ŭ oŭs, *zig-zag or wavy*.

- floe eōse', with hairs in soft fleecy tufts.
 flo'ra, (a) the spontaneous vegetation of a country; (b) a written description of the same, 23.
 flo'ral, relating to flowers.
 floral envelopes, 50, 87.
 flo'rets, the flowers of a compound flower, 302.
 flow'er, 49, etc.; origin of, 37.
 flower-bud, 244, 335, etc.
 fo'li ā'ceōūs, leaf-like in texture or form.
 fo'li ā'tion, the act of leafing.
 fo'li ele, 164.
 fo rā'men, same as micropyle, 140.
 fo've o late, having shallow pits.
 free, not adherent nor adnate, 81, 94.
 fringed. (See limbriate.)
 frōnd, an organ which is both stem and leaf, as in duckmeat, fern.
 fron des'cent, bursting into leaf.
 frū'e'ti fi eā'tion, flower and fruit as a whole.
 fruit, 33, 143.
 fru'tēs'cent, shrubby, becoming shrubby.
 fu gā'ceōūs, soon falling off.
 fūl'erā (roots), accessory, 206.
 fu lig'i noūs, smoky brown, blackish.
 fūl'voūs, dull yellowish brown.
 fu nī'e'ū lus (a little rope), 140.
 fūn'nel-fōrm. (See infundibuliform), 102.
 fūr'cate, forked, fork-veined, 284.
 fūr fu rā'ceōūs, scurfy.
 fūr-rowed', marked with channels lengthwise.
 fūs'eōūs, grayish or blackish brown.
 fū'si fōrm, spindle-shaped, 203.
 gā'le ā, galeate, 103.
 gām'o pēt'ā lā, 477.
 gām'o pēt'āl oūs, with the petals united, 99.
 ga mōph'yl loūs, of united perianth leaves.
 gām'o sēp'al loūs, with the sepals united.
 gēm'i nate, twin, two together.
 gem mā'tion, state of budding (Latin, gemma, bud), 382.
 ge nī'e'ū late, bent as the knee (genu).
 gē'nūs, 23, 457.
 gē'n'e rā, plural of genus, 457.
 germ, the ovary. (The term is obsolete.)
 gēr mi nā'tion, 188, 438.
 gē'rb'ōūs, more tumid in a certain place.
 glā'broūs, smooth, not hairy, 312.
 glād'i ate, sword-shaped, ensiform.
 gland, glandular, 80, 393.
 glans, 155.
 glaū'eōūs, with a bloom, or whitish, waxy powder, seen on the under side of cabbage leaves, and on fresh plums, etc.
 glo bōse', in form nearly spherical.
 glōm'er ate, collected into close heads.
 glōm'er ūle, 363.
 gloss ōl'o gē, the explaining of technical terms.
 glumes, 108, 349.
 glūm if'e rā, 484.
 graft'ing. (Fig. 250, e.)
 grand divisions, 65.
 grān'ū lar, composed of grains.
 gym'nōs (a Greek prefix), naked; as.
 gym'nō sper'mā, gymnosperms, 479.
 gym'nō spēr'm'oūs, with naked seeds.
 gē'nān drouūs, 119.
 gē'nō bāse, a process of the torus on and around which the carpels are suspended (sc. Geranium, Fig. 172).
 gē'y nōe'ci ūm, 123.
 gē'y'nō phōre, a produced torus, bearing the ovary on its summit. (Fig. 112.)
 gē'y rāte', same as circinate, 255.
 gē'y rōse', strongly bent to and fro.
 hāb'it, the general aspect of a plant.
 hāb'itāt, the natural locality or place of growth of a wild plant.
 hāirs, 392. Hairy, hirsute.
 hal berd-shaped, hastate. (Fig. 313.)
 hālvēd, one-half apparently deficient.
 hās'tate, with the base-lobes abruptly spreading, as in a halbert, 291.
 heart-shaped, 291.
 heart-wood, 419.
 herb, herbaceous, 40, 41.
 her bā'ceōūs, green and cellular in texture.
 her bā'rī ūm, 3.
 hes'per id'ū ūm, 160.
 her māph'ro dte (flower), with both stamens and pistils.
 hēt'ēr ō cēph'ā loūs, heads of two sorts in the same plant, some ♂ and some ♀.
 hēt'er ōg'ā moūs, two sorts of flowers in the same head, some ♂ and some ♀.
 hēx'ā (Greek numeral), six; as in,
 hex āg'o nāl, 6-sided or 6-angled.
 hex ām'er oūs, 6-parted.
 hex ān'drouūs, having 6 stamens.
 hē'lum, the eye or scar of the seed, 177.
 hir sūtē', hairy, with rather long hairs, 313.
 his'pid, bristly with stiff hairs, 313.
 his tōl'o gy, description of cells and tissues, 368.
 hōar'y, frost-colored, grayish-white.
 ho mōg'a moūs, head with all the flowers alike, as to the stamens and pistils.
 hō'mo gē'nē oūs, of the same kind.
 hōn'ey, honey-bee, 458.
 hood. (See calyptra, 518.)
 hooded. (See cucullate.)
 hōrn'y, of the texture of horn.
 hōr'tus siccus, the herbarium, dry garden, 3.
 hū'mi fūse, spreading on the ground.
 hū'a line, transparent, or nearly so.
 hū'brid, a cross-breed between two species.
 hū'per bō'rean, inhabiting northern regions.
 hū'po (in Greek compounds), under; as,
 hū'p'o era ter'i fōrm, salver-form, 102.
 hū'p'o gē'an, growing under ground.
 hū'pōg'y noūs, 95, 119.
 im'bri cate, imbricated, 257, 339.
 im mār'gūn ate, having no rim or border.
 im mērsēd'. (See submersed.)
 in āx'i'al root, 201.
 in cised, divided deeply as if cut, 310.
 in cised'ed, enclosed within, or shorter than, as the stamens in the corolla.
 in erās'sāte, thickened.
 in eūm'bent (sc. embryo), 183.
 in'de his'cent', not opening, 148.
 in dēf'i nte, 118.
 in dī'e noūs, native of a country.
 in dū'pli cate, 337.
 in dū'gī ūm, the shield of the fruit-dot (sorus) of a fern.
 in fē'ri or, lower in position.
 in fīcēt'ēd, bent inward, inflexed.
 in flu rēs'cence, 341, etc.
 in fun dib'ū li fōrm, funnel-shaped, 102.
 in fū'lo (sc. anther), 114.
 in nāte (sc. insertion), refer to the point of junction or apparent origin.
 in tēg'ū ment, a coat or covering.
 in'ter nōde, 220.
 in'ter pēt'i o lar, between the petioles.

in'ter rüpt'ed ly pinnate, 302. (Fig. 358.)
 in trösré' (*anthers*), turned inward, 114.
 in'vo lä'ere, involuclé. 247.
 in'vo löte, rolled inward, 256. (Fig. 287.)
 ir rég'ü lar flowers, 83, 101.

joint'ed, *having joints, separable pieces.*
 jü'gum, a pair; as, bijugous, with two pairs
 of leaflets; trijugous, three pairs.

keel, keeled. (See carinate.)
 kidney-shaped. (See reniform, 295.)
 kingdoms of Nature, 12-14.

la bël'lum, the odd petal of an orchid, 101.
 lä'bi ate, lip-shaped, 103.
 läç'er ate, torn irregularly by deep incisions.
 la çin'i ate, slashed, with deep incisions.
 lae tés'cent, containing lac, or milk.
 läe ü nöse', having lacunæ or holes.
 la eüs'trine, growing in lakes.
 läm'i ná, the blade of a leaf, a thin plate, 271.
 län'çe o late, lance-shaped. (Fig. 317.)
 la nü'gi nöse, woolly, 312.
 lä'tex, (1) the turbid or milky juice of plants;
 (2) vessels.

lac tíf'er öüs tissue, 408.
 latin names of plants, 25, 26.
 layer. (See stolon, 217.)
 leaf, 271, etc.; structure of, 431, etc.
 leaf-bud, 244, etc.
 leaf'let, the piece of a compound leaf, 301.
 leaf-stems, 222.
 lég'time, 165.
 lens, 7.
 len tíf'e'ü lar, shaped like a convex lens.
 lí'ber, the inner bark, 412.
 lí'chens, lí kens', 519.
 lig'ne öüs system, 399.
 lig'ü late, strap-shaped, 103.
 lig'ü les, the stipules of grasses, 279.
 lí'i ä'ceöüs flower, 100.
 limb, the border, 91.
 lín'e ar, long and narrow, 297.
 lín næ'üs, 468.
 lív'id, clouded with bluish, brown, and gray.
 lö'bate, lobed, 294.
 lö'e'ü lí çí'däl, opening into the cell, 148.
 lö'eüs'tá, a spikelet of the grasses.
 lö'ment, a jointed legume, 165.
 lö'rate', thong-shaped.
 lö'nate, crescent-shaped.
 ly'eo pó'dí ä'çe æ, 487.
 ly'rate, pinnatifid, with the upper lobes much
 larger than the lower, 233.

mæ ros (*in Greek compounds*), long.
 mæ'ü late, spotted or blotched.
 male (flowers), same as staminate.
 mar çés'cent, withering, but persistent, 109.
 mär'gin al, belonging to the border.
 mär'gin äte, having the border different.
 me dü'l'lá, pith.
 mëd'ul la ry rays, 414.
 mëd'ul la ry sheath, 414.
 mëm'bra nä'ceöüs, membranous, thin and
 pellucid, 315.
 mër'i çärp, one of the carpels of a cremocarp
 of an umbellifer. (Fig. 177.)
 mër öüs, consisting of parts.
 më täb'ö lísm, 429.
 më'ero pýle, 177; same as foramen.
 më'ero seöpe, 8.
 mëd'rib, the central vein of a leaf, 282.
 mëd'vein (used in this work), 283,

mín'er al, 13.
 mít'ri förm, formed like a conical cap.
 monos (*in Greek compounds*), one only; as,
 mön'a dëlph'öüs, 120.
 mö nän'dróüs, 1-stamened, 118.
 mö níl'i förm (roots), 204.
 mön'o çä'rpic herbs, 42.
 mön'o çhla mýd'e öüs (flowers), 66.
 mön'o çöt'y lé'döns, 180, 284.
 mö næ cioüs, 67.
 mö nöç'y nöüs, with one style, 124.
 mön'o pét'a læ. (See gamopetalæ, 513.)
 mön'o pét'a löüs, 90, 91.
 mö nöph'yl löüs, 1-leaved.
 mön'o sëp'al löüs, 90, 91.
 mön'ströüs flowers, 334.
 mör phöl'o gy, 19; of the leaf, 271.
 movements of fluids, 431.
 mü'ero, a sharp, small, abrupt point.
 mü'ero nate, 307.
 mü'l'ti (*in composition*), many.
 mü'l'ti fid, cut half-way into many segments.
 mü'ri eate, bearing short, hard points.
 mü'ri förm, like a wall of mason-work.
 mü se'ol'o gy, a treatise on mosses.
 mü'ti cose, pointless, not pointed.
 mü çë'li ün, the thallus of the fungi, usually
 concealed, 519.

nä'ked seeds, 147. (Fig. 166.)
 nä'pi förm (root), 503.
 nä'tant, swimming; under water.
 nä't'ü ral Ized, growing spontaneously, but not
 native.
 nä't'ü ral orders, 458, 463, 465, 497.
 natural system, 504, 506, etc.
 næ'tar, honey.
 nectary, 77.
 næ pën'thës, 322. (Fig. 301.)
 nerves, the veins (282) are sometimes so called.
 në't'ed or net-veined. (See reticulate, 284.)
 nëü'tral flower, 68.
 nö'd'ing, nutant, the summit bent over, as in
 snowdrop.
 nöde, a joint of the stem, 220.
 nö döse', knotted, large-jointed.
 nö'd'ü löse (root), 204.
 nö'men clät'üre, 25, 498, etc.
 nö'r'mal, according to rule, regular.
 nü'çi förm, nut-like.
 nü çel'lüs, kernel (sc. of ovule), 140, 172, cen-
 tral body in cell.
 nü elë'o lüs, dense body within a nucleus.
 nü'ele üs, dense spherical mass of protoplasm
 in a cell.
 nut. (See glans, 155.)

öb (*in composition*) denotes inversion; as,
 öb'eöm prëssed', flattened back and front.
 öb'eör'date, 307.
 öb län'çe o late, 290.
 öb lique', unequal-sided, as the leaves of elm.
 öb'long, 289.
 öb ö'vate, 290.
 öb tüse', 307.
 öb'vo löte (*in æstivation*), 258.
 öch'rea, sheathing stipules, 279.
 öeh'ro leä'eose, cream color, pale yellow.
 octo (*in Greek composition*), eight.
 oc tän'drose, having 8 stamens.
 oe toç'y nöse, having 8 styles.
 off sët, a short lateral shoot, 218.
 oligos (*in Greek composition*), few; as,
 öl'i gän dría, with few stamens.
 öl'i vä'ceöüs, olive-green, brownish-green.

- o pāque', *dull, not shining.*
 o pēr'en lar, *with a lid*, 114.
 ōp'po site, *two at a node*, 215, 262.
 o bī'e'fī lar, *orbiculate, circular*, 289.
 ōr'ehi dā'ceōūs, 101.
 o gān'ic world, 12.
 ōr'gan ōg'ra phy, 19. *See structural botany.*
 o thōt'ro poūs (ovule), *erect*, 141.
 ōs'se oūs, *bony, as the peach-stone*.
 ō'val, 289.
 ovate, 288.
 ō'va ry, 125.
 ō'void, *egg-shaped, as in fruits*.
 ō'vūle, *the young seed*, 138.
- pā'lē æ or pales, 108, 349.
 pā'le ā'ceōūs, *chaffy, having pales*.
 pālm, 422.
 pāl'mi-veined, 285.
 pāl'mate, 295.
 pan dū'ri fōrm, *saddle-shaped*.
 pān'ī ele, 360.
 pa nī'e'ū late, *panicked*.
 pa pī'io nā'ceōūs, 101.
 pāp'pus, *the calyx of composites*, 104.
 pār'al lel-veined, 284.
 pār'a sites, 209.
 pa rēn'ehy mā, 396.
 pa rī'e tal, *on the wall (paries)*, 133.
 pārt'ed, *deeply divided into parts*.
 pāt'ent, *wide open*.
 pāt'fī loūs, *half open*.
 pear-shaped, *obovoid, larger above*.
 pēc'ti nate, *combed, finely pinnatifid*.
 pēd'ate, *shaped like a bird's foot*, 296.
 pēd'ī cēl, *peduncle*, 343.
 pēl'tate, *shield-form*, 295.
 pēnd'ent, *pendulous, hanging, drooping*.
 pēn'ī cēl'lāte, *with a tuft of hairs, as if a camel's-hair pencil*.
 pen tām'er oūs, *5-parted*.
 pen tān'droūs, *with 5 stamens*, 118.
 pen'tē (in Greek composition), *five*.
 pē'po, *a fruit like a melon*, 161.
 per ēū'nī al, *living several years*, 43.
 perfect flower, (♂) *with both stamen and pistil*.
 per fō'li ate, *through the leaf*, 311.
 peri (in Greek composition), *around*; as,
 pēr'ī ānth, 53, 87; forms of, 99.
 pēr'ī eārp, 146; forms of, 150.
 pēr'ī gŷn ī ūm, 107.
 pe rīg'y noūs, 96, 119.
 pēr'ī spērma, *same as albumen*, 179.
 per sīst'ent, *remaining long in place*, 109.
 pēr'son āte, 103
 pēt'al or pēt'al, *from πεταλον, one of the foliaceous expansions of the corolla*, 52; forms of, 89.
 pēt'al oid, *resembling petals*.
 pēt'al oī'de æ, 483.
 pēt'ī ōle, 274.
 pēt'ī o late, 271.
 pēt'ī o lūle, 276.
 phān'e ro gā'miā, 467, 471, 472.
 phyl lō'di ūm (plural phyllodia), 221.
 phyl lo tāx'y, *leaf-arrangement*, 201.
 phŷ's'es, 16.
 phŷs ī ōī'o gŷ, 21, 368.
 phŷ tōī'o gŷ (Greek, *phytos, a plant*), 23.
 pī lose', *with erect, thin hairs*, 122.
 pīn'nate, 303.
 pin nāt'ī fīd, 293.
 pin nāt'ī sēct. *See pinnatifid*.
 pīs'til, 56, 123.
- pitch'ers (leaves). (*See ascidia*, 322.)
 pith, 414.
 pitted cells, 387.
 pl't'ed, *with depressions or excavations*.
 pla cēn'tā, 127; free axile, 135.
 plan of the flower, 58.
 plant defined, 14.
 plant growth, 409.
 pl't'ate, *plaited lengthwise as a fan*, 254, 340.
 plu mōse', *feathery*.
 plū'mūle, *a little plume*, 81, 180.
 pōl'en, 111, 121.
 pollen-tube, 450.
 pōl li nā't'ion, 443.
 pōl līn'ī ā, *masses of pollen*, 434.
 pōl'ī (in Greek compounds), *many*; as,
 pōl'y a dēl'phoūs, 120.
 pōl'y ān'droūs, *having many stamens*.
 po lŷg'a moūs, *with some imperfect flowers*.
 pol'y pēt'āl æ, 476.
 pōl'y pēt'āl oūs, pōl'y sēp'āl oūs, 90.
 pōme, *a fruit like an apple*, 162.
 pōs tē'ri or, *next the axis*.
 potted plants, 428.
 po tā'to, *manner of its growth*, 238.
 pre cō'clōūs, *flowering before the leaves*.
 prē'fo lī ā't'ion, *vernation*, 252.
 pre mōrse', *ending abruptly*, 235.
 press for drying plants, 6.
 prick'les, 392.
 prī'mine, *same as testa*, 173.
 prīz māt'ic, *prism-shaped, having several parallel, longitudinal angles*.
 pro cūm'bent (stem), 212. (Fig. 248.)
 pro dūcēd', *extended more than usual*.
 pro līf'er oūs, *reproducing*; as *cymes from the midst of a cyme, flowers from the midst of a flower*.
 pros'ēn'ehŷ mā, 398.
 prō'tōph'y tā, 494.
 prō'to plāgm, 368, 369.
 pru'ī nose, *powdered, as if frosted*, 314.
 prŷ'rī ens, *causing an itching sensation*.
 pseŷ'do (in Greek composition), *spurious, false*.
 pū bēs'cent, *downy, with short, soft hairs*.
 pū bēr'ū lent, *minutely downy*.
 pū'mī lose (pumilus), *dwarfed in size*.
 pūne'tate, *seeming as if perforate, or marked with minute dots*.
 pūn'gent, *piercing, sharp-pointed*.
 pū tā'men, *the bony nucleus of a drupe*.
 py rām'ī dal, *form of a cone or pyramid*.
 pŷr'ī fōrm, *of the form of a pear*.
 pŷx'is, *a pericarp with a lid*, 163.
- quād'ri (in composition), *four*; as,
 quad rān'gu lar, *four-angled*.
 quād'ri fō'li ate, *four-leaved*.
 quād'ri jū'gate, *with four pairs of leaflets*.
 quad'ri lāt'er al, *four-sided*.
 quīn'que (in composition), *five*.
 quī'nate, *growing in fives*, 306.
 quīn eun'cial, 333. (Fig. 300.)
 quīn'tu ple, *five-fold*.
- rāce (Latin, *stirps*), *a permanent variety, as red-cabbage*, 456.
 ra cēme', 358.
 rā'ehis, *axis of the inflorescence*, 301, 343.
 rē'dī āte, *diverging from a common center*.
 radiate (in the composites), *the outer row of florets ligulate*. (Fig. 388.)
 rā'dī ant, *outer flowers enlarged (and often neutral, Fig. 271)*.

- răd'f eal, *from the root*, 262.
 radical (of the flower), 65.
 răd'f ele, *rootlet (of the embryo)*, 31, 180.
 ră'măl (of a branch), 262.
 ră'phe (of the ovule or seed), 141.
 răph'i dēs, 375.
 rays, 359, 362.
 re çep'ta ele, 57. (*See* torus.)
 re e'f'urvd', *bent (not rolled) backward*.
 re flēxed', *curved backward excessively*.
 re frăct'ed, *bent back suddenly, as if broken*.
 rēg'mă, *fruit as of geranium*, 168.
 rēg'f lar, *like parts similar, corresponding*.
 rēn'f fōrm, *kidney-shaped*, 295.
 re pând' (margin), 310.
 rē'pēt, *creeping (sc. stems)*, 232).
 rēs'pi ră'tion, 427.
 re sū'pi nate, *reversed, upside down*.
 re tic'f late, *netted*, 388.
 re trōrse, *backward, downward*.
 re tūse' (apex), 307. (Fig. 367, c.)
 rēv'o lūte, *rolled backward*, 256.
 rhă'chis, *same as rachis*.
 rhī zō'mă, *rhizome*, 230, 233.
 rhōm'bie, *rhomboidal, in the figure of a rhomb, or approaching it*.
 ribs, *the chief veins of a leaf, ridges*.
 rin'gēt (corolla), 103.
 rings of wood, 414.
 root, 197.
 root-cap, 419.
 root-stock, 233.
 ro să'ceoūs (corolla), 100.
 rōs'trate, *beaked, with a beak*.
 rō su'late (leaves), *arranged around the base of the stem, as the petals of a rose*, 262.
 rō'tăte, *wheel-shaped*, 102.
 ro tă'tion, *circulation of fluids in the cell*.
 ru'bi eund, *blushing, rosy red*.
 ru'di ment, *a minute part*.
 ru'gōse, *wrinkled*, 315.
 ru'mi nă'ted (albumen), *full of chinks, as if composed of numerous folds*.
 rŭn'çi'nate, *hooked backward*, 293.
 rŭn'ner, 219.
 săe ehă rōm'y'çes, 410.
 săg'it tate, *arrow-shaped*, 291.
 săl'ver-shaped. (*See* hypocrateriform, 102.)
 sa mără, 154.
 sap, *the watery fluid taken up by the root and moved through the vessels up to the leaves*, 431.
 sap-wood.
 sār'eo cărp (of the drupe), 156.
 seă'broūs, *rough*, 312.
 sea lăr'f fōrm (cells), *ladder-shaped*, 378.
 scales, 319.
 scale-stems, 79, 230.
 seăn'dent, *climbing*.
 scape, 344.
 scarious, 315.
 seă't'ered, *sometimes used for alternate*.
 sc'ion or c'ion, 218.
 selē'en' eh'y'mă, 390.
 selē'rose, *hard, bony*.
 seł'pi oid (inflorescence), 365.
 sero bie'f late, *pitted, with little depressions*.
 sea-green, *light bluish green, glaucescent*.
 se'e'und, *all on one side, or turned one way*.
 see'un dine, *same as tegmen*, 172.
 seed, 172; vitality of, 185; dispersion of, 186.
 seed-coverings, 173.
 sēm'f (in composition), *half; as,*
 sēm'f cōr'date, *half of cordate*.
 sēm'f lŭ'nar, *half-moon shaped*.
 sēm'f săg'it tate, *partly sagittate*.
 se'pal or sē'pal, *one of the foliaceous parts of the calyx*, 51.
 sēp'a loid, *sepal-like*.
 sēp'ti çid'al (dehiscence), 148.
 sep tif ra gal (dehiscence), 148.
 sēp'tum, *a partition between two spaces*.
 se rī'ceoūs, *silky*, 312.
 se rōt'i noūs, *occurring late in the season*.
 sér'rate, serrulate, 309.
 sēs'sile, *sitting, not stalked*, 125, 271.
 se'ta, 106.
 se'tă'ceous, *bristle-form*.
 se'toūs, *setigerous, bearing bristles*, 313.
 sheath, sheathing, *as the leaves of the grasses*, 275.
 shrub, 45.
 sil'ique, *silicle*, 166.
 sil'f quōs, *bearing siliques (as the crucifers)*.
 silver-grain (of wood), 414.
 simple, *of one piece, not compound*.
 sîn'is trōrse', *twining from right to left*.
 sîn'f ate, 294.
 slips, 218.
 sōl'f tă ry, *growing alone, or singly*.
 sōlv'ent axis, 47.
 sō'ri, *patches of fruit in ferns*.
 sō rō'sis, 171.
 spă'dix, 356.
 spăthe, *spathaceous*, 346.
 spăt'f late (leaf), 290.
 spē'ciēs, 27, 455.
 spe çif'ic name, 26.
 spec'i mens (of plants), 2, 5.
 spike, *spicate*, 355.
 spike'let, *a little spike, as in a grass*.
 spine, *a woody thorn*, 327.
 spin'dle-shaped (root), 203. (Fig. 238.)
 spirăl arrangement (of leaves), 263.
 spirăl cells or vessels, 386.
 spōnge'let, *spongiole*, 199.
 spores, 184.
 spur, *a projecting, slender appendage*, 78.
 squar rōse', *spreading widely, as the involu-
 cral scales of some composites*.
 stages of plant life, 31.
 stă'mens, 55, 110.
 stăm'f tate flower, 67.
 stăm'f nō di a, 117.
 starch, 374.
 stem, or ascending axis, 211.
 stēr'ile, *not bearing seeds*, 67.
 stīg'mă, *stigmatic*, 125, 129.
 stings, 393.
 stipe, *the stalk of the ovary or ovaries; also, the stem of a mushroom*.
 stī'pels, *stipellate*, 279.
 stīp'f tate, *on a stipe*.
 stīp'fles, *stipulate*, 272, 277.
 stō'lon, 217.
 stōl'o nif'er oūs, *producing stolons*.
 stō'mă, 394, etc.
 strap-shaped, *flat, narrow, and straight*.
 strict, *erect and very straight*.
 strī'gōse', *with sharp, close, rigid hairs*.
 strōb'ile (fruit), 169.
 strō'phi o late, *having an appendage (stro-
 phide or caruncle) about the hilum*.
 strūc'turăl botany or organography, *treats of the organs or parts of plants, of their forms and uses*.
 style, 125.
 sty'loid, *style-like*.
 sub (in composition), *slightly*, 317.
 sŭb'e rōse, *corky in texture*.

- sub-kingdoms, 473.
 sū' bī late, *awl-shaped*, 299.
 sū'e' eu lent, *very juicy and cellular*, 315.
 sūck' er, 216.
 suf fru tes' cent, *woody at the base only*.
 sūl' eāte, *furrowed*.
 su pē ri or, 97, 98.
 superior calyx, *calyx adherent to ovary*.
 superior ovary, *ovary free from calyx*.
 sū' per vo lūte', 340.
 sū prā, *above*.
 sū pra-āx' il la ry, *situated above the axil*.
 sū pra de eōm pound, *very much divided*.
 sus pēnd ed (ovule), 139. (Fig. 158.)
 sūl' ūr al (dehiscence), 148.
 sword-shaped, *as the vertical leaves of iris*.
 sŷ eō nūs, *fruit, such as the Fig.*, 170.
 symmetry (of the flower), 60, c, 69.
 sŷm pēt' āl oūs, *with petals united*.
 sŷm phyl' loūs, *with perianth leaves united*.
 sŷn (in Greek compounds), *together, union*.
 sŷn ān' ther oūs, *with anthers united*.
 sŷn eār' pi ūm, 169.
 sŷn eār' poūs, *with carpels united*.
 sŷn' ġe nē' si oūs, 120.
 sŷs' tem at' ic botany, 451, etc.
- taper-pointed. (See acuminate, 307.)
 tap-root, 203.
 taw' ny, *fulvous, dull yellowish-brown*.
 tax ōn' o my, *the science of classification*.
 tēg' men, *the inner seed-coat*, 140, 172.
 tēn' dril, 228, 324.
 tēr' a tōl' o ġy, 334.
 te rēte', *cylindrical, or nearly so*.
 term of plant life, 39, etc.
 tēr' mi nal, *situated at the end or apex*.
 tēr' mi nōl' o ġy. See nomenclature, 498.
 tēr' nate (leaves), *in threes*, 303.
 tēs' sel lā' ted, *checked, as a pavement*.
 tēs' tā, *the outer seed-coat*, 140, 172, 173.
 tēt' rā (in Greek composition), *four*.
 tēt' ra dŷn' a meūs, 119.
 te trāg' o nal, *with four corners*.
 te trāg' y noūs, *with four pistils*.
 thē' cā, thecæ, *sporangia or spore-cases*.
 thorn, 327.
 throat, *orifice of a monopetalous corolla*.
 thyrse (thirs), 360.
 tis sŷes, 409.
 tŷ' men tōse', *with short, dense, woolly hairs*, 312.
 top-shaped, *inversely conical*.
 tō' rus, *same as receptacle*, 57, 84.
 tōr' ū lose, *swollen at intervals*.
 tree, 46.
 tri (in Greek compounds), *three; as,*
 tri' a dēlph' oūs, *the stamens in three sets*.
 tri' ān' droūs, *having three stamens*.
 tri eō'e' oūs (fruit), *with three 1-seeded car-*
pels.
 tri' eol ored (tricolor), *with three colors*.
 tri' ēn' ni al, *lasting three years*.
 tri' fid, *split half-way into three parts*.
 tri' fō li ate, *with three leaflets*, 303.
 trig' y noūs, *having three styles*, 124.
 tri' lō' bate, *having three lobes*, 296.
 tri' mē' roūs, *3-parted*, 65.
 tri' pārt' a ble, *separable into three parts*.
 tri' pārt' ite, *more deeply split than trifid*.
 tri' p' le-veined, 235. (Fig. 319.)
 tri' plū' nate, *thrice pinnate*, 304.
 tri' quē' trōūs, *three angled*, 258, 339.
 tri' tēr' nate, *thrice ternate*, 305.
 trūne' āte, 307. (Fig. 367, d.)
- trunk (of a tree), 225.
 trŷ' mā, *fruit, as the hickory-nut*, 157.
 tube, 91.
 tū' ber, 237.
 tu bē' eu lar, 204.
 tu bē' eu late, *covered with warts (tubercles)*.
 tū' bū lar corolla, 102.
 tū' mid, *swollen or inflated*.
 tū' ni eate, *coated, as the bulb*, 242.
 tŷr' bī nāte, *shaped like a top*.
 tŷr' i on, *young shoot, as of asparagus*.
 tŷp' ie al flower, 60. (Figs. 8-11.)
- ūm' bel, 359.
 ūm' bel late, *bearing umbels*.
 ūm' bel let, *a partial umbel*.
 um bil' i eate, *with a sharp depression at end*.
 un armed', *with no stings, thorns, etc*.
 ūn' cī nāte, *hooked*.
 ūn' der shrub, *a low shrub*, 45.
 ūn' dŷ late, *wavy*, 310.
 un ē' qual ry pinnate, 302.
 un ġule' ū late (petal), *having a claw*, 88.
 uni (in compounds), *one; as,*
 ū ni cēl' lū lar plants.
 ū ni fō' li ate, *with one leaf or leaflet*.
 ū' ni fōrm, *of one form*.
 u ni lāt' er al, *1-sided*.
 ū ni lō'e' ū lar, *1-celled*.
 ū ni vālvud, *with but one valve*.
 ūr' ce o lāte, *urn-shaped*, 102.
 ū' tri ele (fruit), 152.
- vāġ' i nāte, *sheathing; the flattened petiole*
involving the stem.
 vālv ate, 257, 337.
 valves, valvular, 114, 148.
 va ri' e ties, 28.
 vās' eu lar tissue, 396.
 vāult' ed, *arched*.
 vēġ' e tā' tion, or physiology of plant life, 368.
 veins, 282.
 vein' lets, vein' u lets, 283.
 ve nā' tion (of the leaf), 282.
 vēn' tri cōse, *swelling out on one side*.
 vēn' tral, *belonging to the front side*.
 vēr' nal, *appearing in the Spring-time*.
 vēr nā' tion (of the leaf bud), 252.
 vēr' rŷ cose, *covered with warts (verruca)*.
 vēr' sū tile (anther), 114.
 vēr' tex, *the summit, same as apex*.
 vēr' tie al, *in the direction up and down, or*
parallel with the axis.
 ver tiġ' il late, *whorled*, 215, 262.
 vēr' ti cil lās' ter, 366.
 ves' per tŷne, *appearing in the evening*.
 ves' sels, 402.
 vēx' il la ry (estivation). (Fig. 425.)
 vex' il lum, *banner*, 101. (Figs. 59, 60.)
 vil lōsc', *with long, weak hairs*, 312.
 vī min' e oūs, *with long, flexible shoots, oster-*
like.
 vir' gate, *twiggly, long, slender*.
 vine, 228.
 vīs' cid, *viscous, sticky or glutinous*.
 vī tāl' ity of seeds, 185.
 vīt' tā, vittæ, *the minute oil-tubes in the fruit-*
coat of the umbelliferae.
 vōlvā, *membrane inclosing the young fungus*.
 wedge-shaped, *tapering to the base*.
 whorl, *a circle of similar organs*.
 witch-grass, 231.
 wood, 372, 415.
 wood-cells, 399.
 woody plants, 44.

xān thīe, *yellowish.*

xēn og a my, *the fertilization of a flower, by pollen from a flower of another plant, of the same species; cross-fertilization.*

xēr'ō philes, *plants that require great heat and little moisture, or plants especially adapted to arid regions. ξερος, dry, φιλεω, I love; hence, plants that delight in dry places.*

xŷ'lēm, *wood. From ξυλον.*

xŷ'lō eārp, ξυλον, *wood, καρπος, fruit; hence, hard and woody fruit.*

yeast plant, 411. (Fig. 513.)

zo ōl'ō ġy, 17.

zo ōf' il ūs, *from the Greek ζῶον, animal, and φυτοι, plant; pertaining to plants whose pollination is accomplished by the agency of insects or other animals.*

zō'ō phyte, 493.

zō'ō spōre, 493.

zŷg'ō spōre, *spore formed by the union of two cells. ξύμον, a yoke, σπορα, a seed; hence, a yoked or united seed.*

ABBREVIATIONS AND SIGNS

§ BOTANICAL TERMS OFTEN RECURRING IN DESCRIPTIONS.

<p><i>ach.</i> achenia. <i>ast.</i> aestivation. <i>alter.</i> alternate. <i>amplex.</i> amplexicaul. <i>anth.</i> anther. <i>axill.</i> axillary. <i>cal.</i> calyx. <i>caps.</i> capsule. <i>cor.</i> corolla. <i>cyp.</i> cypsela. <i>decid.</i> deciduous. <i>diam.</i> diameter. <i>ellip.</i> elliptical. <i>emarg.</i> emarginate. <i>epig.</i> epigynous. <i>f.</i> or <i>ft.</i> feet. <i>fil.</i> filaments. <i>f.</i> flower; <i>fls.</i> flowers.</p>	<p><i>fr.</i> fruit. <i>gl.</i> glume; <i>gls.</i> glumes. <i>hd.</i> head; <i>hds.</i> heads. <i>hyp.</i> hypogynous. <i>imbr.</i> imbricate. <i>inf.</i> inferior. <i>invol.</i> involucre. <i>irreg.</i> irregular. <i>leg.</i> legume. <i>lf.</i> leaf; <i>lvs.</i> leaves. <i>lflets.</i> leaflets. <i>lom.</i> loment. <i>opp.</i> opposite. <i>ova.</i> ovary. <i>pap.</i> pappus. <i>ped.</i> peduncle. <i>pet.</i> petals. <i>perig.</i> perigynous.</p>	<p><i>perig.</i> perigynium. <i>pls.</i> pales. <i>pn.</i> pinnæ. <i>pnl.</i> pinnulæ. <i>recep.</i> receptacle <i>reg.</i> regular. <i>rhiz.</i> rhizoma. <i>rt.</i> root. <i>sc.</i> scale, scales. <i>sds.</i> seeds. <i>seg.</i> segment. <i>sep.</i> sepals. <i>st.</i> stem. <i>sta.</i> or <i>stam.</i> stamens <i>stig.</i> stigmas. <i>stip.</i> stipules. <i>sty.</i> styles. <i>var.</i> variety.</p>
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§ TIMES OF FLOWERING, AND LOCALITIES.

1. Names of the Months and Seasons are abbreviated in the usual manner, as, *Jan.* January; *Apr.* April; *Spr.* Spring; *Aut.* Autumn; *Sum.* Summer; &c.
2. The names of States and Territories of the U. S. are abbreviated precisely as in other works, thus:—*Ala.* Alabama; *Ark.* Arkansas; *Conn.* Connecticut, &c.
3. Sections of States are thus designated:—*N. N. Y.* Northern New York; *W. Pa.* Western Pennsylvania; *E. Fla.* East Florida; *S. Ill.* Southern Illinois, &c.
4. Names of foreign Countries:—*Eur.* Europe; *Afr.* Africa; *S. Afr.* South Africa; *Aust.* Australia; *Can.* Canada; *Mex.* Mexico; *S. Am.* South America &c.
5. *E.* East, Eastward, indicates the States of the Atlantic seaboard from Maine to Virginia inclusive; *N-E.* or *N. Eng.* denotes the New England States.
6. *M.* is used to denote the Middle States; viz., N. Y., Penn., N. J., and Del.
7. *N.* North, Northward, indicates generally the territory north of 42° N. latitude.
8. *N-W.* Northwest, indicates Wis., Minn., and parts of Ill. and Mich.
9. *S.* South, Southward, is used to indicate the Southern States in general,—all lying south of Virginia and Kentucky.
10. *S-W.* Southwest, viz., Miss., La., Ark., and perhaps Tennessee and Texas
11. *W.* West, denotes the States lying due north of Tennessee and Arkansas.

§ SIGNS.

- ① An annual Herb.
- ② A biennial Herb.
- ⌘ A perennial Herb.
- ⌘ An undershrub, deciduous.
- ⌘ An undershrub, evergreen.
- ⌘ A Shrub, deciduous.
- ⌘ A Shrub, evergreen.
- ⌘ A Tree, deciduous.
- ⌘ A Tree, evergreen.
- ⌘ An herbaceous Vine, ① or ②.
- ⌘ A perennial Vine, ⌘.
- ⌘ Woody Vine, deciduous.

- ⌘ Woody Vine, evergreen.
- ⌘ Trailing Herb, ① or ②.
- ⌘ Trailing Herb, ⌘.
- ⌘ An aquatic Plant.
- ⌘ Flowers perfect.
- ♂ Flowers staminate.
- ♀ Flowers pistillate.
- ♂ Monœcious.
- ♂ ♀ Diœcious.
- ♂ ♀ Polygamous.
- ⊖ Wanting, or none.
- ∞ Numerous, or indefinite

- § A Plant introduced and naturalized ;
 - † Plant cultivated for ornament ;
 - ‡ Plant cultivated for use ;
 - o— Cotyledons accumbent ;
 - o| Cotyledons incumbent ;
 - o)) Cotyledons conduplicate ;
 - ! (Note of exclamation), used technically, denotes certainty.
 - ? (Note of interrogation), implies doubt or uncertainty.
 - f (with or without a period), a foot.....
 - ' (a single acute accent), an inch.....
 - " (a double accent), a line =1-12 of an inch..
- } at the end of the description.
- } used only in the Crucifere. (Page 34.)
- } after a number.

§ AUTHORS' NAMES CITED IN THIS WORK.

<i>Adans.</i>	Adanson.	<i>Dill.</i>	Dillenius
<i>A. DC.</i>	Alphonse De Candolle.	<i>Desv.</i>	Desvaux.
<i>Att.</i>	Aiton.	<i>Dougl.</i>	Douglas.
<i>All.</i>	Allione.	<i>Ehrh.</i>	Ehrhart.
<i>Anders.</i>	Andersson.	<i>Ell.</i>	Elliott.
<i>Arn.</i>	Arnot.	<i>Endl.</i>	Endlicher.
<i>Aub.</i>	Aublet.	<i>Engel.</i>	Engelmann.
<i>Bart.</i>	Barton.	<i>Fisch.</i>	Fischer.
<i>Bartl.</i>	Bartling.	<i>F. & M.</i>	Fischer & Meyer
<i>Beauv.</i>	Beauvois.	<i>Frœl.</i>	Frœlich.
<i>Benth.</i>	Bentham.	<i>Gært.</i>	Gærtner.
<i>Bernh.</i>	Bernhardt.	<i>Gmel.</i>	Gmelin.
<i>Berl.</i>	Berlandier.	<i>Good.</i>	Goodenough.
<i>Bois.</i>	Boissier.	<i>Gr.</i>	A. Gray.
<i>Bong.</i>	Bongard.	<i>Gre.</i>	Greville.
<i>Bork.</i>	Borkhausen.	<i>Griseb.</i>	Grisebach.
<i>Br.</i>	Brown.	<i>Gron.</i>	Gronovius.
<i>Bw.</i>	Bigelow.	<i>Hedw.</i>	Hedwig.
<i>Cass.</i>	Cassin.	<i>Hoffm.</i>	Hoffman.
<i>Cav.</i>	Cavanilles.	<i>Hook.</i>	Hooker (W. J.)
<i>Cham</i>	Chamisso	<i>Hook. f. (Miss)</i>	Hooker (J. D.)
<i>Darl.</i>	Darlington.	<i>Hornem.</i>	Hornemann.
<i>DC</i>	DE CANDOLLE.	<i>Huds.</i>	Hudson. [Kuntz
<i>Desf.</i>	Desfontaines.	<i>H. B. &</i>	Humboldt, Bonpland &
<i>Dew.</i>	Dewey.	<i>Jacq</i>	Jacquin.

AUTHORS' NAMES—(CONTINUED).

<i>Juss.</i>	JUSSIEU.	<i>Richn.</i>	Richardson.
<i>A. Juss.</i>	Adrien Jussieu.	<i>Ram.</i>	Rœmer.
<i>L. or Lam.</i>	LINNÆUS.	<i>Salisb.</i>	Salisbury.
<i>Lag.</i>	Lagasca.	<i>Schk.</i>	Schkuhr.
<i>Lam.</i>	Lamarck.	<i>Schrad.</i>	Schrader.
<i>Lamb.</i>	Lambert.	<i>Schreb.</i>	Schreber.
<i>Ledeb.</i>	Ledebour.	<i>Schult.</i>	Schultes.
<i>Lehm.</i>	Lehmann.	<i>Schw.</i>	Schweinitz.
<i>Lesq.</i>	Lesquerenx.	<i>Scop.</i>	Scopoli.
<i>Lestib.</i>	Lestibudois.	<i>Ser.</i>	Seringe.
<i>L'Her.</i>	L'Heritier.	<i>Soland.</i>	Solander.
<i>Lindl.</i>	Lindley.	<i>Spreng.</i>	Sprengel.
<i>Mart.</i>	Martins.	<i>Steud.</i>	Steudel.
<i>Mich.</i>	Michell.	<i>Sulliv.</i>	Sullivant.
<i>Michx. or Mx.</i>	Michaux.	<i>Thunb.</i>	Thunberg.
<i>Mx. f.</i>	Michaux (the younger).	<i>Torr.</i>	Torrey.
<i>Mill.</i>	Miller.	<i>T. & G.</i>	Torrey & Gray
<i>Mitch.</i>	Mitchell.	<i>Tourn.</i>	Tournefort.
<i>Muhl.</i>	Muhlenberg.	<i>Trautv.</i>	Trantvetter.
<i>Nees.</i>	Nees von Esenbeck.	<i>Trin.</i>	Trinius.
<i>Nutt. or N.</i>	Nuttall.	<i>Tuckm.</i>	Tuckerman.
<i>Pal.</i>	Pallas.	<i>Vaill.</i>	Vaillant.
<i>Pav.</i>	Pavon.	<i>Vent.</i>	Ventenat.
<i>Pers.</i>	Persoon.	<i>Vill.</i>	Villars.
<i>Ph.</i>	Pursh.	<i>Wahl.</i>	Wahlenberg.
<i>Pluk.</i>	Plukenet.	<i>Walp.</i>	Walpers.
<i>Plum.</i>	Plumier.	<i>Walt.</i>	Walter.
<i>Poir.</i>	Poiret.	<i>Wangh.</i>	Wangenheim
<i>R. Br.</i>	ROBERT BROWN.	<i>Willd.</i>	Willdenow.
<i>Raf.</i>	Rafinesque.	<i>With.</i>	Withering.
<i>Reichenb.</i>	Reichenbach.	<i>Wulf.</i>	Wulfen.
<i>Rich.</i>	Richard.		

ANALYSIS OF THE NATURAL ORDERS.

Founded on the most obvious or artificial characters: designed as a key for the determination of the Order of any plant, native, or naturalized, or cultivated, growing within the limits of this Flora.

KINGDOM.

- Sub-kingdom I. Flowering Plants.....**PHANEROGAMIA.**
Class 1. Leaves net-veined. Flowers never completely 3-parted (mostly ψ and ψ'). Embryo with 2 cotyledons. Wood (if any) in annual circles. Seed in a vessel. Stigmas present.....**ANGIOSPERMS, DICOTYLEDONES.**
Cohort 1. (A) Calyx and corolla present, petals separate.....**Polypetalæ.**
Cohort 2. (B) Calyx and corolla present, petals more or less united..**Gamopetalæ.**
Cohort 3. (C) Calyx present, but no corolla, or both wanting.....**Apetalæ.**
Class 2. Stigma wanting. Seed naked. Embryo with two or more cotyledons.....**GYMNOSPERMS.**
Cohort 4. (D) Cone-bearing plants (Pines, etc.).....**Coniferæ.**
Class 3. Leaves parallel-veined (rarely netted). Flowers 3-parted. Bark, wood, and pith commingled. Embryo with but one cotyledon. Root not axial.....**MONOCOTYLEDONES.**
Cohort 5. (E) Flowers on a spadix.....**Spadicifloræ.**
Cohort 6. (F) Floral envelope in two 3-parted whorls, outer one green (Lillies, etc.).....**Petaloidæ.**
Cohort 7. (G) Floral envelope, chaff-like (Grasses and Grains).....**Glumiferæ.**
Sub-kingdom II. Flowerless Plants.....**CRYPTOGAMIA.**
Class 1. Vascular Cryptogams (Ferns, and their allies).....**PTERIDOPHYTA.**
Cohort 1. (H) Stem, herbaceous, rooting, or tree-like.....**Licopodinæ.**
Cohort 2. (I) Stem, stiff, channeled (Rushes).....**Equisetacæ.**
Cohort 3. (J) Stem a creeping Rhizome or erect leaves pinnate-veined, veins forked (Ferns proper).....**Filicinæ.**

A. COHORT I. POLYPETALOUS DICOTYLEDONES.

- * Herbs with the leaves alternate or all radical..(12)
- * Herbs with the leaves opposite on the stem..(9)
- * Shrubs, trees, or undershrubs..(2)
 - 2 Flowers regular or nearly so..(8)
 - 2 Flowers irregular (or the fruit a legume) (§ 165)..(7)
 - 3 Polyandrous,—stamens 3—10 times as many as the petals..(4)
 - 3 Oligandrous,—stamens 1—2 times as many as the petals or fewer..(6)

- 4 Leaves opposite. (*s*)
 4 Leaves alternate..(*5*)
 5 Stamens on the torus or the hypogynous corolla..(*t*)
 5 Stamens and petals on the calyx tube..(*v*)
 6 Ovaries simple, distinct, or one only. Vines or erect shrubs..(*w*)
 6 Ovary compound, and wholly adherent to the calyx (*x*)
 6 Ovary compound and free from the calyx or nearly so..(*7*)
 7 Stamens opposite to the petals and of the same number..(*y*)
 7 Stamens alternate with the petals or of a different number..(*8*)
 8 Leaves opposite on the stems..(*z*)
 8 Leaves alternate, and compound..(*yy*)
 8 Leaves alternate and simple..(*zz*)
 9 Polyandrous—stamens 3—10 times as many as the petals..(*m*)
 9 Oligandrous,—stamens 1—2 times as many as the petals or fewer..(*10*)
 10 Pistils separate and distinct, few or solitary, simple..(*n*)
 10 Pistils united into a compound ovary free from the calyx..(*11*)
 10 Pistils united into a compound ovary adherent to the calyx..(*o*)
 11 Stamens opposite to the petals and of the same number..(*p*)
 11 Stamens alternate with the petals or of a greater number..(*q*)
 12 Flowers regular or nearly so. Fruit never a legume..(*14*)
 12 Flowers irregular (rarely regular and the fruit a legume)..(*13*)
 13 Stamens numerous, 3 or more times as many as the petals..(*k*)
 13 Stamens few and definite, 4—12..(*l*)
 14 Stamens (or anthers) 3—10 times as many as the petals..(*15*)
 14 Stamens few and definite. Ovary free from the calyx..(*17*)
 14 Stamens few and definite. Ovary adherent to the calyx..(*f*)
 15 Stamens hypogynous—inserted on the torus..(*16*)
 15 Stamens perigynous—inserted on the corolla at the base..(*c*)
 15 Stamens perigynous—inserted on the calyx at the base..(*d*)
 16 Pistils few or many, distinct (at least as to the styles)..(*a*)
 16 Pistils (and styles if any) completely united..(*b*)
 17 Pistils *one*, or indefinite and distinct, simple..(*e*)
 17 Pistils definitely—* 2 united, the short styles combined into *one*..(*f*)
 —* 2, 3 or 4 united, styles or stigmas, 2, 3, 4 or 6..(*g*)
 —* 5, distinct or united, with 5 distinct styles..(*h*)
 —* 5, united and the styles also combined into *one*..(*i*)
a Petals 5 or more, deciduous. Leaves never peltate.....RANUNCULACEÆ.
a Petals 3 or numerous. Water plants with peltate leaves.... } NYMPHÆACEÆ.
b Sepals 4—6, equal. Petals ∞, imbricated in the bud.... }
b Sepals 5, equal. Petals 5, imbricate. Leaves tubular.....SARRACENIACEÆ. 8
b Sepals 5, unequal. Petals 5, convolute. Flowers of 2 sortsCISTACEÆ. 15
b Sepals 2, with—*bb* 5 petals imbricated in the budPORTULACACEÆ. 20
 —*bb* 4 or 8 petals usually crumpled in budPAPAVERACEÆ. 9
c Filaments united into a tube. Anthers 1-celled.....MALVACEÆ. 23
d Sepals 2, persistent, capping the lid of the pyxisPORTULACACEÆ. 20
d Sepals 3—5, valvate in the bud. Pod long, 2-carpelled.....TILIACEÆ. 25
d Sepals 3—5.—*dd* Petals imbricate in bud. Fruits simple.....ROSACEÆ. 44
 —*dd* Petals convolute in bud. Fruit compound.....LOASACEÆ. 55
e Stamens opposite to the petals and of the same number. Pistil 1 only..BERBERIDACEÆ. 6
e Stamens alternate with the petals or more numerous.....RANUNCULACEÆ. 1
f Stamens 6, tetradynamous. Pod 2-celled. Flowers cruciform.....CRUCIFERÆ. 11
f Stamens 4—32, not tetradynamous. Pod 1-celled.....CAPPARIDACEÆ. 12
g Sepals 5, unequal. Flowers perfect, numerous, minute.....CISTACEÆ. 15
g Sepals 5, equal. Flowers monœcious. Herbs woolly or scurfy.....ORDER 113

- g* Sepals 5, or 3, equal, and the stamens twice as many.....GERANIACEÆ. 30
- g* Sepals 5, and the stamens (anthers) of the same number..(*gg*)
- gg* Sterile flam. numerous, in several whorls. Climbing...PASSIFLORACEÆ. 57
- gg* Sterile filaments numerous, in 5 clusters. Herb erect....SAXIFRAGACEÆ. 45
- gg* Sterile filaments 0..(*)
- * Flowers white, racemed. Climbing..... ORDER 106
- * Flowers yellow. Plants erect.....TURNERACEÆ. 56
- * Flowers cyanic. Herbs stemless.....DROSERACEÆ. 17
- h* Stamens 5, alternate with the 5 petals. Styles 5 or 3. Seeds ∞LINACEÆ. 28
- h* Stamens 5, opposite to the 5 petals. Styles 5, but the seed 1..... ORDER 83
- h* Stamens twice as many as the petals..(*hh*)
- hh* Stamens 6. Leaves peltate..... NYMPHEACEÆ. 7
- hh* Stamens 6—24, distinct..... CRASSULACEÆ. 46
- hh* Stamens 10, united at base..... GERANIACEÆ. 30
- i* Ovary 1-celled. Leaves all radical, spinescent, irritable..... DROSERACEÆ. 17
- i* Ovary 3-5 celled. Leaves mostly radical, not dotted..... ORDER 73
- i* Ovary 3-5 celled. Leaves cauline, pinnate, dotted..... RUTACEÆ. 31
- j* Style 1, but the carpels as many as the petals (2—6)..... ONAGRACEÆ. 54
- j* Styles 3—5, ovary 3-5-celled, 3-5-seeded, wholly adherent..... ARALIACEÆ. 64
- j* Styles 3—8, ovary 1-celled, half adherent. Sepals 2..... PORTULACACEÆ. 20
- j* Styles 2, carpels 2, fewer than the (5) petals.—* Seeds several....SAXIFRAGACEÆ. 45
- * Seeds 2..... UMBELLIFERÆ. 63
- k* Ovaries many, or few, rarely 1, always simple..... RANUNCULACEÆ. 1
- k* Ovary compound, 3-carpelled, open before ripe..... RESEDACEÆ. 13
- l* Sepals (4 or 5) produced into 1 slender spur behind, petals 2 or 5.... GERANIACEÆ. 30
- l* Sepals 2 (or vanished), petals 4 (2 pairs) with 1 or 2 blunt spurs..... FUMARIACEÆ. 10
- l* Sepals 5, very unequal; petals 3. Stamens 6 or 8. No spur..... POLYGALACEÆ. 42
- l* Sepals and petals each of the same number, viz..(*ll*)
- ll* 4, the flowers slightly irregular. Stamens 6—32. No spur.... CAPPARIDACEÆ. 12
- ll* 4, the flowers moderately irregular. Stamens 8. A vine..... SAPINDACEÆ. 37
- ll* 5, with 5 stamens, and generally a blunt spur..... VIOLACEÆ. 14
- ll* 5, with 10 or more stamens. No spur. Fruit a legume..... LEGUMINOSÆ. 43
- m* Pistils many, entirely distinct, simple..... RANUNCULACEÆ. 1
- m* Pistils 3—5, united more or less completely..... HYPERICACEÆ. 16
- m* Pistils 5—10, united, with sessile stigmas and many petals..... FICOIDEÆ. 61
- n* Pistil solitary, simple. Petals 6—9. Stamens 12—18..... BERBERIDACEÆ. 6
- n* Pistil 3 or more, distinct, simple. Flowers all symmetrical... CRASSULACEÆ. 46
- n* Pistils 2, consolidated with the 5 stamens. Juice milky..... ORDER 100
- o* Carpels as many as the sepals. (*nn*)
- o* Carpels fewer in number than the sepals..(*oo*)
- nn* Anthers opening at the top. Flowers 4-parted..... MELASTOMACEÆ. 52
- nn* Anthers opening laterally. Styles united into 1..... ONAGRACEÆ. 54
- nn* Anthers opening laterally. Styles or stigmas distinct... HALORAGACEÆ. 48
- oo* Each carpel ∞ -seeded. Styles 2..... SAXIFRAGACEÆ. 45
- oo* Each carpel 1-seeded. Styles 2 or 3..... ARALIACEÆ. 64
- oo* Each carpel 1-seeded. Style 1 (double)..... CORNACEÆ. 65
- p* Style 3-cleft at the summit. Flowers 5-parted..... PORTULACACEÆ. 20
- p* Style and stigma 1, undivided. Flowers 7-parted..... ORDER 81
- q* Leaves pinnate, with interpetiolar stipules... ZYGOPHYLLACEÆ. 29
- q* Leaves simple, toothed or lobed. Flowers cruciform. Stamens 6... CRUCIFERÆ. 17
- q* Leaves simple, toothed or lobed. Flowers 5-merous. Stamens 10... GERANIACEÆ. 30
- q* Leaves simple, entire..(*qq*)
- qq* Petals and stamens on the throat of the calyx..... LYTHRACEÆ. 123
- qq* Petals on the torus..(*)

- * Flowers irregular, unsymmetrical.....POLYGALACEÆ. 42
- * Flowers regular, 2-(or 3-)parted throughout.....ELATINACEÆ. 18
- * Flowers regular, 5-parted. Leaves punctate.....HYPERICACEÆ. 16
- * Flowers regular, 5-parted. Leaves dotless.....CARYOPHYLLACEÆ. 19
- r Pistil a simple carpel, becoming a legume. Stamens 10—100.....LEGUMINOSÆ. 43
- r Pistil compound, viz. (rr)
 - rr 3-carpelled. Flowers perfect. Leaves digitate.....SAPINDACEÆ. 37
 - rr 3-carpelled. Flowers monœcious. Cultivated.....BEGONIACEÆ. 59
 - rr 5-carpelled.—* Stipules present. Cultivated.....GERANIACEÆ. 30
 - * Stipules none. Native.....ORDER 78
- s Stamens on the receptacle, in several sets. Leaves dotted.....HYPERICACEÆ. 16
- s Stamens on the receptacle, in 1 set. Lvs. fleshy. (S. Fla.)..*Cusia*. GUTTIFERÆ. (21)
- Stamens on the calyx. (ss)
 - ss Sepals, petals, and ovaries indefinite.....CALYCANTHACEÆ. 3
 - ss Sepals, &c., definite. Leaves dotted, entire.....MYRTACEÆ. 51
 - ss Sepals, &c., definite. Leaves dotless, entire.....LYTHRACEÆ. 53
 - ss Sepals, &c., definite. Leaves dotless, subdentate.....SAXIFRAGACEÆ. 45
- t Filaments united into 1 set (monadelphous). Petals convolute. (u)
- t Filaments united into 1 or several sets. Petals imbricate. (uu)
- t Filament distinct. (tt)
 - tt Petals 6, valvate, lurid. Erect shrubs.....ANONACEÆ. 4
 - tt Petals 3—9, imbricate. Trees or shrubs.....MAGNOLIACEÆ. 2
 - tt Petals 4—8, imbricate. Climbing or trailing.....MENISPERMACEÆ. 5
 - tt Petals 4, imbricated. Shrubs, S.....CAPPARIDACEÆ. 12
 - u Anthers 1-celled. Sepals valvate in the bud.....MALVACEÆ. 23
 - u Anthers 2-celled. Sepals valvate. Handsome treeSTERCULIACEÆ. 24
 - u Anthers 2-celled. Sepals imbricate. A large tree in S. Fla..CANELLACEÆ. (22)
 - uu Leaves punctate with pellucid dots, jointed to stalk..AURANTIACEÆ. 32
 - uu Leaves opaque. (*)
 - * Sepals valvate. Flowers small.....TILIACEÆ. 25
 - * Sepals imbricate. Flowers large.....CAMELLIACEÆ. 26
 - v Style 1, with many stigmas. Green fleshy shrubs.....CACTACEÆ. 60
 - v Styles several or 1, each with 1 stigma. Woody trees or shrubs....ROSACEÆ. 44
 - v Style 1, with 1 stigma. Stam. in 5 sets, long, red, very showy....MYRTACEÆ. 51
- w Trailing vines, with crimson fls. Ovaries ∞ , in a little spike.....MAGNOLIACEÆ. 2
- w Climbing vines, with white-greenish fls. Ova. 2—6, capitate....MENISPERMACEÆ. 5
- w Erect shrubs, with yellow flowers, 6-parted. Pistil only 1.....BERBERIDACEÆ. 6
- w Erect shrubs (S. Fla.) with yellow fls. Pistils 5, 2-ovuled, 1-sided...SURIANACEÆ. (62)
- w Trees, with greenish fls.,—* and pinnate lvs. Pist. 3-5, 1-ovuled...SIMARUBACEÆ. 34
- * and simple leaves. Follicles 3—5....STERCULIACEÆ. 24
- x Flowers 4-parted. Stamens 8. (Fls. red or roseate, drooping)...ONAGRACEÆ. 54
- x Flowers 4-parted. Sta. 8. Fls. light yellow. Coasts, S. Fla..RHIZOPORACEÆ. (49)
- x Flowers 4-parted. Stamens 4. Flowers whitish, in cymes.....CORNACEÆ. 65
- x Flowers 5-parted. (xx)
 - xx Ovary 5-carpelled, 5-styled, 5-seededARALIACEÆ. 64
 - xx Ovary 5-carpelled, 1-styled, 1-seeded. S. Fla.....COMBRETACEÆ. 50
 - xx Ovary 2-4 carpelled, ∞ -seededSAXIFRAGACEÆ. 45
 - y Leaves opposite. Stem climbing with tendrils or radicles...VITACEÆ. 41
 - y Lvs. alternate. St. erect, or climbing without tendrils..RHAMNACEÆ. 40
- z Leaves simple. Stamens 5. Carpels 3—5, style 1, short.....CELASTRACEÆ. 38
- z Leaves simple. Sta. 10. Carpels and sty. 3. S. Fla..*Byrsonima*, MALPIGHIACEÆ. (39)
- z Leaves pinnate, or palmately lobed. Carpels and styles 2 or 3.....SAPINDACEÆ. 37
- z Leaves pinnate. (*)
 - * Stamens 10. Small tree with blue flowers. S. Fla.....ZYGOPHYLLACEÆ. 29
 - * Stamens 2. Carpels 1 or 2. Style 1.....ORDER 101

- * Stamens 8. Carpel and style 1.....BURSERACEÆ. 35
- yy Filaments 10, united into a tube or cup. Flowers in panicles.....MELIACEÆ. 27
- yy Filaments 6—10, distinct. Flowers small, white, in racemes.....BURSERACEÆ. 35
- yy Filaments 6—10, distinct. Fls. small, white or hoary, paniculate..SAPINDACEÆ. 37
- yy Filaments 5, distinct..(*)
- * Leaves pellucid-punctateRUTACEÆ. 31
- * Leaves opaque. Ovary 1-celled, 1-seeded.....ANACARDIACEÆ. 36
- zz Petals 4, yellow, strap-shaped, appearing in late Autumn.....HAMAMELACEÆ. 47
- zz Petals 4—7, cyanic (rarely yellow), rounded or short..(†)
- † Style 0, the stigmas 1, 4, or 5, sessile. Drupe 4-6-seeded.....ORDER 74
- † Styles (or stigmas) 3, but the drupe only 1-seeded.....ANACARDIACEÆ. 36
- † Styles 3, capsule many-sided. Lvs. minute and scale-form..TAMARISCINEÆ. 24 & 4
- † Style 1,..(‡)
- ‡ Capsule 3-seeded. Seeds with a scarlet aril.....CELASTRACEÆ. 38
- ‡ Caps. ∞-seeded. Clusters fragrant. Lvs. evergreen. Cult...PITTOPOACEÆ.
- ‡ Capsule with few or many seeds. Native shrubs.....ORDER 75

B. COHORT 2. GAMOPETALOUS DICOTYLEDONES.

- ‡ Stamens (6—∞) more numerous than the lobes of the corolla..(9)
- ‡ Stamens (2—12) fewer than the corolla lobes or of the same number..(2)
- 2 Ovary inferior,=adherent to the tube of the calyx..(3)
- 2 Ovary superior,=free from the tube of the calyx..(4)
- 3 Stamens cohering by their anthers..(c)
- 3 Stamens entirely distinct..(d)
- 4 Flowers regular and the stamens symmetrical..(5)
- 4 Flowers regular and the stamens reduced to 2 or 4..(n)
- 4 Flowers irregular. Stamens (except in 3 or 4 species) unsymmetrical..(o)
- 5 Stamens opposite to the lobes of the corolla (and distinct)..(e)
- 5 Stamens alternate with the corolla lobes (rarely connate)..(6)
- 6 Shrubs, trees, with the carpels or stigmas 3—6..(f)
- 6 Herbs 1-10-carpelled, or shrubs 2-carpelled..(7)
- 7 Ovary 1, deeply 4-parted or 4-partible, forming 4 achenia..(g)
- 7 Ovaries 2, distinct (often covered by the stamens)..(h)
- 7 Ovary 1. compound,—* one-celled..(k)
- * two-six-celled..(m)
- 9 Flowers irregular (rarely regular and the fruit a legume)..(a)
- 9 Flowers regular and the fruit never a legume (§ 165)..(b)
- a Flowers 1- or 2-sided, with 1 or 2 blunt spurs. Stamens 6, in 2 sets...ORDER 10
- a Flowers 1-sided, no spur..(*)
- * Leaves compound. Fruit a legumeORDER 43
- * Leaves simple. Fruit 2-celled, 2-seeded.....ORDER 42
- * Leaves simple. Fruit 5-celled.....ERICACEÆ. 73
- b Corolla lobes convolute in bud. Stamens ∞, united into 1 tube....ORDER 23
- b Corolla lobes imbricate in bud. Stamens ∞, in 1 or several setsORDER 26
- b Corolla lobes imbricate or valvate..(u)
- u Stamens 10—24. Styles 5—12.....ORDER 46
- u Stamens 5—10. Style 1. Capsule 5-celled.....ERICACEÆ. 73
- u Stamens 8—∞. Style 1. Nut 1-5-seeded.....STYRACACEÆ. 76
- u Stamens 8. Styles 4. Berry 8-seeded.....EUPHORBACEÆ. 71
- u Stamens 8. Style 1. Drupe 1-seeded.....OLACACEÆ. 80 (p. 44T)

- e** Flowers in a compact head surrounded by an involucre.....COMPOSITÆ. 70
c Flowers separate, irregular, perfect. Plants erect or trailing.....LOBELIACEÆ. 71
c Flowers separate, regular, imperfect. Weak vines.....ORDER 58
d Leaves alternate. Flowers 5-parted, regular, separate.....CAMPANULACEÆ. 72
d Leaves alternate. Fls. irregular, 5-parted. S. Fla. *Scævola*. GOODENIACEÆ. (71½)
d Leaves opposite, with stipules between, or verticillate.....RUBIACEÆ. 67
d Leaves opposite. Stipules none..(v)
 v Stamens 5—4. Ovaries 2-5-celled.....CAPRIFOLIACEÆ. 66
 v Stamens 2—3. Ovaries 1-celled.....VALERIANACEÆ. 68
 v Stamens 4. Flowers capitate.....DIPSACEÆ. 69
e Herbs. Ovary with 5 styles and but 1 seed.....PLUMBAGINACEÆ. 83
e Herbs. Ovary with 1 style and many seeds.....PRIMULACEÆ. 81
c Trees or shrubs. Appendages between the stamens.....SAPOTACEÆ. 78
e Trees or shrubs. No appendages between the stam. S. Fla. MYRSINACEÆ. (79)
 f Leaves opposite. Style 1. Drupe 4-seeded. Herbs, shrubs. VERBENACEÆ. 90
 f Leaves alternate..(w)
 w Drupe 4-6-seeded. Shrubs, trees.....AQUIFOLIACEÆ. 74
 w Drupe 1-seeded. Thorny. S. Fla.....Ximenia. OLACEÆ. (80)
 w Capsule 2-5-celled, ∞-seeded.....ERICACEÆ. 73
g Herbs, with alternate leaves, generally rough-hairy.....BORRAGINACEÆ. 92
 h Stigmas connate. Flower bud convolute.....APOCYNACEÆ. 90
 h Stigmas connate. Flower bud valvate.....ASCLEPIADACEÆ. 100
 h Stigmas distinct. Flowers minute, yellow.....CONVOLVULACEÆ. 95
t Ovule solitary. Corolla limb entire.....ORDER 103
k Ovules several. Leaves cleft and lobed.....HYDROPHYLLACEÆ. 93
k Ovules several. Leaves or leaflets entire..(x)
 x Flowers not spicate.....GENTIANACEÆ. 97
 x Flowers spicate..... }
 m Leaves all radical. Flowers spiked ... }PLANTAGINACEÆ. 82
m Leaves opposite. Ovary 2-celled.....LOGANIACEÆ. 98
m Leaves alternate..(y)
m Leaves opposite. Ovary 3-celled. Not twining. }POLEMONIACEÆ. 94
 y Ovary 3-celled. Not twining..... }
 y Ovary 2-4-celled. Twining.....CONVOLVULACEÆ. 95
 y Ovary 2-4-celled, 4-seeded. Erect.....BORRAGINACEÆ. 92
 y Ovary 2-celled, ∞-seeded.—z Styles 2.....HYDROPHYLLACEÆ. 93
 —z Style 1.....SOLANACEÆ. 96
 n Stamens 4. Ova. 4-(rarely 1- or 2)-celled, with as many sds. VERBENACEÆ. 90
 n Stamens 2. Ovary 2-celled, forming 1 or 2 seeds.....OLEACEÆ. 101
o Ovary deeply 4-parted, forming 4 (or fewer) achenia..(p)
o Ovary entire, 4-ovuled, 4- or fewer-seeded. Leaves opposite..VERBENACEÆ. 90
o Ovary entire, ∞-ovuled, ∞- or several-seeded..(s)
 p Leaves opposite. Stems square. Stamens 2—4.....LABIATÆ. 91
 p Leaves alternate. Stems round. Stamens 5.....BORRAGINACEÆ. 92
e Trees or climbing shrubs. Seeds winged.....BIGNONIACEÆ. 86
e Trees. Seeds not winged.....SCROPHUL. 88. Erect shrubs ...ERICACEÆ. 73
 Herbs.—ss Leafless parasites. Native. Ovary 1-celled.....OROBANCHACEÆ. 85
 —ss Leafy at base or in the water. Flowers spurred..LENTIBULACEÆ. 84
 —ss Leafy. Flowers large, spurless. Ovary 1-celled...GESNERIACEÆ. 87
 —ss Leafy. Spurless. Fruit 4- or 5-celled § BIGNONIACEÆ. 86
 —ss Leafy. Fruit 2-celled..(t)
t Seeds on hooks or cups. Corolla mostly convoluteACANTHACEÆ. 89
t Seeds without hooks. Corolla imbricated in the bud.....SCROPHULARIACEÆ. 88
t Seeds without hooks. Corolla mostly plicate.....SOLANACEÆ. 96

C. COHORT 3. APETALOUS DICOTYLEDONES.

- ¶ Plants herbaceous, the flowers not in aments (except *Humulus*, 114)..(2)
 ¶ Plants woody,—shrubs or trees..(8)
 2 Flowers with a regular calyx (or a calyx-like involucre). (3)
 2 Flowers achlamydeous,—neither calyx nor corolla..(k)
 3 Calyx tube adherent to the ovary, limb lobed, toothed, or entire..(8)
 3 Calyx free from the ovary, sometimes enclosing it..(4)
 1 Ovaries several, entirely distinct, each 1-styled, 1-ovuled..(g)
 4 Ovary 1 only, simple or compound..(5)
 5 Style or stigma 1 only..(6)
 5 Styles or stigmas 2—12..(7)
 6 Ovary 1-ovuled, bearing but 1 seed..(c)
 6 Ovary many-ovuled, bearing many seeds..(d)
 7 Ovary 1-3-ovuled, 1-3-seeded..(e)
 7 Ovary 4-∞-ovuled, 4-∞-seeded..(h)
 8 Flowers not in aments, with the leaves opposite..(n)
 8 Flowers not in aments, with the leaves alternate..(10)
 8 Flowers imperfect, the sterile only in aments..(v)
 8 Flowers imperfect, both the fertile and sterile in aments..(x)
 9 Stamens 1—12, as many or twice as many as the stigmas..(a)
 9 Stamens 2—10, not symmetrical with the 1 or 2 stigmas..(b)
 10 Style or stigma 1. Fruit 1-seeded..(11)
 10 Styles or stigmas 2..(s)
 10 Styles or stigmas 3—9..(t)
 11 Calyx free from the ovary..(p)
 11 Calyx adherent to the ovary..(r)
 a Stigmas and cells of the ovary 1—4. Stamens 1—8..... ORDER 48, or 54
 a Stigmas and cells of the ovary 6. Stamens 6 or 12...ARISTOLOCHIACEÆ. 102
 b Styles 2. Ovary many-seeded. Stamens 8—10..... ORDER 45
 b Style 1. Ovary 1- or 2-seeded. Stamens 5.....SANTALACEÆ. 110
 c Flowers perfect. Calyx 4-lobed. Stamens 1—4..... ORDER 44
 c Flowers perfect. Calyx entire, funnel-shaped, colored...NYCTAGINACEÆ. 101
 c Flowers diclinous. Calyx 4-5-parted, green.....URTICACEÆ. 114
 d Stamens 4, opposite to the 4 sepals. Leaves numerous..... ORDER 52
 d Stamens 4, opposite to the 4 sepals. Leaves about 6..... ORDER 145
 d Stamens 5, alternate with the 5 sepals..... ORDER 81
 d Stamens ∞. Leaves large and showy. Cultivated..... ORDER 9
 e Fruit 3-(rarely 6)-seeded, with 3 (often cleft) styles.....EUPHORBACEÆ. 113
 e Fruit 1-seeded. Stipules sheathing the stems.....POLYGONACEÆ. 104
 e Fruit 1-celled, mostly 1-seeded. Stipules none. (f)
 f Calyx with scarious bractlets outside.....AMARANTACEÆ. 107
 f Calyx naked (double in 1 genus). Lvs. alternate..CHENOPODIACEÆ. 106
 f Calyx naked. Leaves opposite..... ORDER 19
 g Stamens hypogynous—on the torus..... ORDER 1
 g Stamens perigynous—on the calyx..... ORDER 44
 h Leaves opposite. Fruit circumscissile, a pyxis..... ORDER 61
 h Leaves opposite. Fruit 4-5-valved, a capsule..... ORDER 19
 h Leaves alternate..(i)
 i Fruit 5-horned, 5-celled, a capsule..... ORDER 40
 i Fruit a fleshy 4-10-seeded berry.....PHYTOLACCACEÆ. 105
 i Fruit circumscissile, a utricle.....AMARANTACEÆ. 107
 k Flowers on a spadix with a spathe. Monocotyledons..... ORDER 130
 k Flowers in a long naked spike. Stamens 6 or 7.....SAURURACEÆ. 115
 k Flowers solitary, axillary, minute. Aquatic plants..(m)

- m* Stamen 1, styles 2. Leaves opposite.....CALLITRICHACEÆ. 116
m Stamens 2, styles 2. Leaves alternate, dissected...PODOSTEMIACEÆ. 117
m Sta. 12-24, style 1. Lvs. verticillate, dissected.. CERATOPHYLLACEÆ. 118
n Fruit a double samara (2-winged).....ORDER 37
n Fruit a single samara (1-winged), or a drupe. Stamens 2.....ORDER 101
n Fruit not winged,—o 3-seeded. Stamens 4.....EUPHORBIACEÆ. 113
 —o 1-seeded. Stamens 4 or 8.....ELEAGNACEÆ. 112
 —o 1-seeded. Stamens 3. Parasites..LORANTHACEÆ. 109
p Anthers opening by valves. Calyx colored.....LAURACEÆ. 108
p Anthers opening by slits.—*q* Calyx colored. Stam. 8...THYMELACEÆ. 111
 —*q* Calyx greenish; racemed.....ORDER 37
 —*q* Cal. green; spiked. S. Fla..COMBRETACEÆ. (50)
r Ovary and seed only 1, in the juicy drupe. Trees.....ORDER 65
r Ovaries 2-4, seed 1. Fruit a drupe or nut. Shrubs...SANTALACEÆ. 110
s Stamens numerous.....ORDER 47
s Stamens as many as the calyx lobes.....§ 1. URTICACEÆ. 114
t Leaves pinnate. Pistils 5, scarcely united.....ORDER 31
t Leaves simple, linear, evergreen. Shrubs heath-like..EMPETRACEÆ. 119
t Leaves simple, expanded. Fls. 3-parted. Fruit dry..EUPHORBIACEÆ. 113
t Leaves simple, expanded. Fls. 4- or 5-parted. Fruit fleshy....ORDER 40
v Nut drupaceous, naked. Leaves pinnate.....JUGLANDACEÆ. 121
v Nut or nuts in a cup or involucre. Leaves simple.....CUPULIFEREÆ. 122
x Fruit fleshy, aggregated (sorosis). Juice (or sap) milky...§ 2. URTICACEÆ. 114
x Fruit dry. Plants with a watery juice or sap..(*y*)
y Aments globular, racemed. Nutlets 2-celled, woolly.....ORDER 65
y Aments globular, solitary. Nutlets 1-celled, 1-seeded....PLATANACEÆ. 120
y Aments cylindrical or oblong..(*z*)
z Ovary 2-celled, 2-ovuled, 1-seeded. Fruit often winged..BETULACEÆ. 123
z Ovary 1-celled, 1-seeded. Fruit often fleshy.....MYRICACEÆ. 124
z Ovary many-ovuled, many-seeded. Seeds comous.....SALICACEÆ. 125

D. COHORT 4. THE CONOIDS.

- * Leaves pinnate. Stem simple, palm-like. Sterile flowers in cones...CYCADACEÆ. 126
 * Leaves simple. Stem branching. Fertile flowers in cones.....CONFEREÆ. 127
 * Leaves simple. Stem branching. Fertile flowers solitary.....TAXACEÆ. 128

E. COHORT 5. THE SPADICEOUS MONOCOTYLEDONES.

- ¶ Trees or shrubs with palmi-cleft leaves all from one terminal bud, } ...PALMACEÆ. 130
 and a branching "spadix" from a spathe.....
 ¶ Herbs with simple, rarely ternate leaves. Spadix simple..(2)
 2 Plants frond-like, minute, floating loose on the water.....LEMNACEÆ. 131
 3 Plants with stem and leaves, rooting and fixed..(3)
 3 Spadix evident, in a spathe or on a scapeARACEÆ. 130
 3 Spadix obscure or spike-like. Stems leafy..(4)
 4 Flowers with no perianth, densely spicate or capitate.....TYPHACEÆ. 133
 4 Flowers with a perianth or not. Plants submersed.....NAIADACEÆ. 133

F. COHORT 6. FLORIDEÆ, OR FLOWERING MONOCOTYLEDONES.

- ¶ Flowers (not on a spadix) in a small, dense, involucrate head..(o)
 ¶ Flowers (not on a spadix) solitary, racemed, spicate, &c..(2)
 2 Perianth tube adherent to the ovary wholly or partly..(4)
 3 Perianth free from the ovary. (3)
 3 Petals and sepals differently colored (except in *Medeola*, 147)..(e)
 3 Petals and sepals similarly colored..(5)
 4 Flowers imperfect ($\delta \text{ } \text{?}$ or $\delta \text{ } \text{?}$)..(a)
 4 Flowers perfect..(b)
 5 Leaves net-veined, broad..(k)
 5 Leaves parallel-veined..(6)
 6 Styles and often the stigmas also united into one..(m)
 6 Styles and stigmas 3, distinct..(n)
- a Low aquatic herbs.....HYDROCHARIDACEÆ. '35
 a Climbing shrubby vines.....DIOSCORIACEÆ. 143
 b Anthers 1 or 2, on the pistil (gynandrous).....ORCHIDACEÆ. 137
 b Anthers 1 or 5, free from the pistil. Leaves ample.....SCITAMINEÆ. 138
 b Anthers 3 or 6..(c)
 c Perianth woolly or mealy outside. Ovary half free....HÆMADORACEÆ. 141
 c Perianth glabrous outside..(d)
 d Anthers 3, opening crosswise, inward.....BURMANNIACEÆ. 136
 d Anthers 3, opening lengthwise, outward.....IRIDACEÆ. 142
 d Anthers 6, opening inward.....AMARYLLIDACEÆ. 139
- e Pistils 3— ∞ , distinct, forming achenia in fruit.....ALISMACEÆ. 134
 Pistils 3 only, more or less united..(g)
 g Leaves verticillate, in 1 or 2 whorls. Stigmas 3.....TRILLIACEÆ. 146
 g Leaves alternate..(h)
 h Stigmas 3. Plants with dry leaves, often epiphytes....BROMELIACEÆ. 140
 h Stigmas united into 1.....COMMELYNACEÆ. 151
- k Flowers perfect, 4-parted.....ROXBURGHIIACEÆ. 145
 k Flowers diœcious, 6-parted.....SMILACEÆ. 144
 m Flowers colored, regular. Stamens 6 (4 in one species)....LILIACEÆ. 147
 m Flowers colored, irregular or else triandrous.....PONTEDERACEÆ. 149
 m Flowers greenish, glume-like or scarious.....JUNCACEÆ. 150
- n Leaves rash-like. Ovary of 3 1-seeded carpels..... }
 n Leaves linear, lanceolate, &c. Ovary 6- ∞ -seeded... } ..MELANTHACEÆ. 148
 o Petals yellow, small but showy. Plant acaulescent.....XYRIDACEÆ. 152
 o Petals white, minute, fringed. Plant acaulescent....ERIOCAULONACEÆ. 154

G. COHORT 7. GRAMINOIDEÆ, OR GRASS-LIKE MONOCOTYLEDONES.

- ¶ Flowers with 6 bracts in 2 whorls (sepals and petals). Culms solidORDER 150
 ¶ Flower with a single bract (glume). Culm solid, sheaths entire.....CYPERACEÆ 153
 ¶ Flower with several bracts (glumes and pales). Culm hollow. }
 Sheaths split on one side. Ovary 1-seeded. Styles 2..... }GRAMINEÆ 155

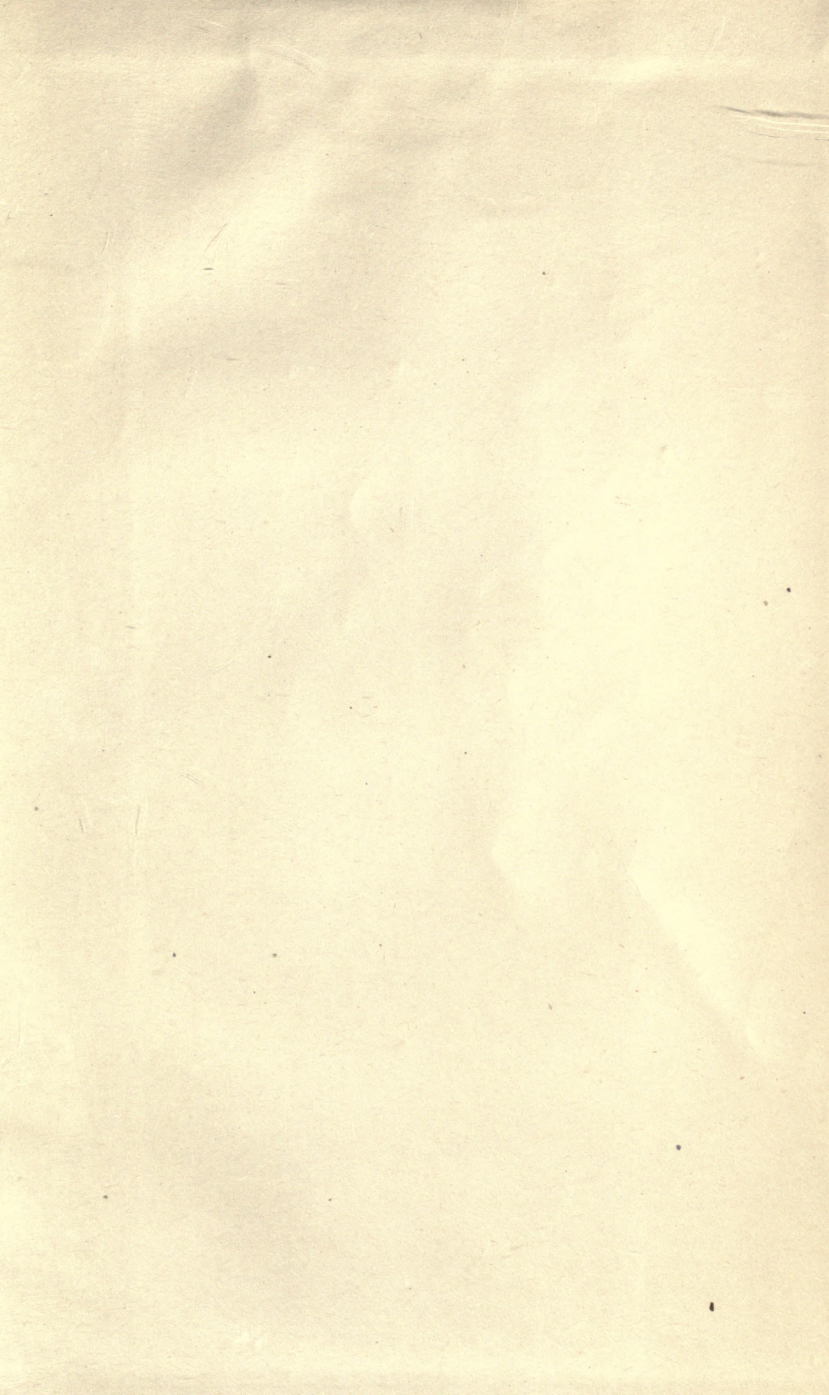
SUB-KINGDOM II. CLASS I. COHORTS 1, 2, and 3.

- § Plants with well-developed foliage..(¶).
 ¶ Leaves few, mostly ample and from subterranean rhizomes..(a)

- α Fruit borne on the leaves which are often more or less contracted..FILICES. 159
 ¶ Leaves numerous, small, mostly spirally imbricated on the stem..(b)
 β Fruit axillary, sessile, opening by a slit.....LYCOPODIACEÆ. 157
 § Plants with verticillate branches instead of leaves..(c)
 c Fruit in terminal spikes.....EQUISETACEÆ. 158







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